Cyclopedia

of

TELEVISION FACTS

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Compiled by

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SUPREME PUBLICATIONS
CHICAGO

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TELEVISION CYCLOPEDIA

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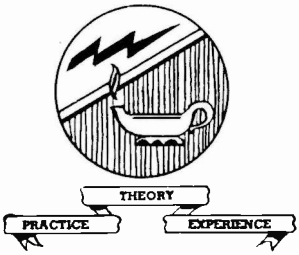

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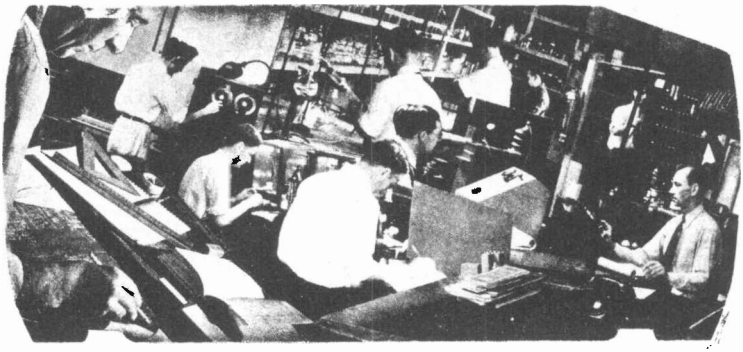


TELEVISION

Television is today's opportunity field. If you are an active radio serviceman, an amateur, or just a radio minded individual, you certainly took the right step in deciding to study this new, most interesting phase of communications. Regular television transmissions are being carried on every day, more and more stations are built daily, and in the laboratories improvements continue to be made. The Television field in the America has been changing so fast, that very few books on the subject have been published. Many are now expected and, of course, the magazines presented the very latest material in every issue. To serve as an introduction and to help you to understand the new terms especially applicable to television, this book has been prepared.

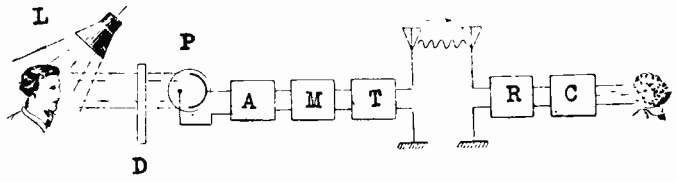
PRINCIPLES of TELEVISION

The transmission of a visual scene by electrical means requires two fundamental processes of changing the light rays to corresponding electrical energy and subdividing the image into many small elements.

The conversion of light energy to electrical current is performed by photo active materials -- the intensity of light varying the current produced. If the light from an entire scene is televised by a single photo cell, the current produced will vary with the average light present. Light from all parts of the image will fall on the photo cell and will exercise its influence.

For intelligent television transmission it is essential to separate the image into many elements and transmit these in a regular order. Since various parts of an object being televised reflect different amounts of light, if each one's light is permitted to act separately, a series of current variations will be produced in accord with the light intensity of the elements scanned. A definite order of scanning these elements must be carried out, so that the image can be reconstructed later at the receiver.

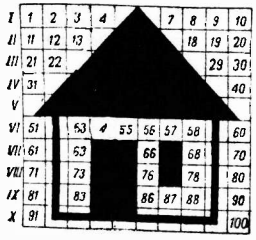
The process of television (no longer used) is shown below. A man's head is located in a strongly illuminated field served by projector lamp L. The revolving Nipkow disc D, permits one element of the image at a time to reflect its light to the photo cell P. The current in the photo cell will vary in accord with the rays. If dark elements, corresponding to sections of the hair, are scanned, low current will be created. If the light elements are scanned much light will be reflected and the photo cell current will increase. These small variations can be amplified in a pre-amplifier A and modulator M, and then placed on the radio carrier produced in transmitter T.

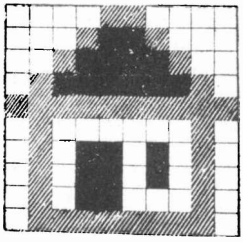


These radio waves modulated with the electrical variations corresponding to the scanned picture may be received by a special radio (television) receiver and used to recreate the picture in a special cathode ray tube having synchronized scanning to remain in step with the transmitter. The light intensity of any element produced will correspond to the signal strength at that moment.

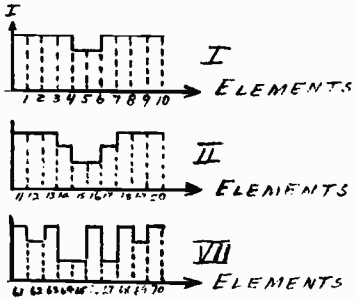
PRINCIPLES of TELEVISION

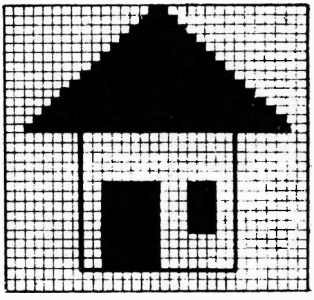
If a block diagram of a house is to be televised by means of 100 elements, we can assume that the illustration is superimposed upon ten horizontal lines each having ten elements.





The scanning may be performed horizontally from line to line, or vertically from row to row. Horizontal method is preferred. If the scanning process is started at the upper left hand corner, the first four elements (1, 2, 3, and 4) will produce maximum current. These elements are white and will reflect a maximum of light. Elements 5 and 6 will reflect less light, being partially covered with the dark roof of the picture. While these elements are scanned less current will be generated by the photo cell. Again elements 7 to 10 of the first line will produce a strong current. These changes are illustrated graphically below. Follow the changes occurring as the other elements are scanned and check your results for the 2nd and 7th lines which are shown below.



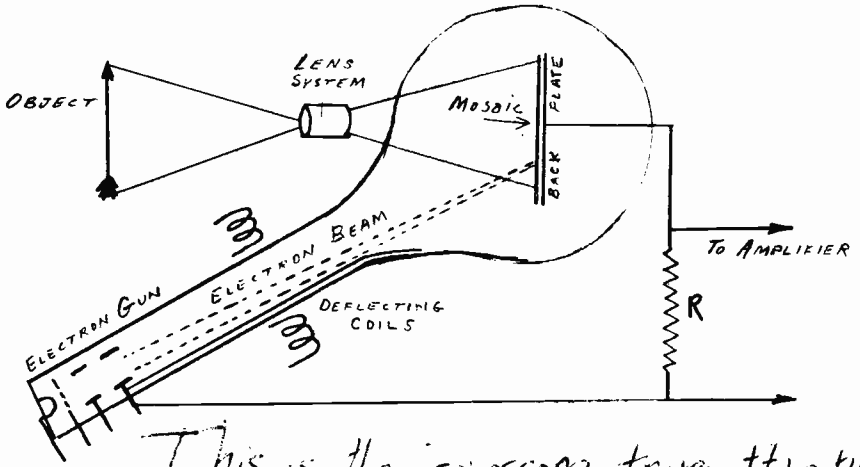


These changes in the photo cell current may be amplified and used to amplitude modulate the transmitter carrier. At the receiver these amplitude changes will produce visual effects along similar 100 elements. Many details will be lost because of the small number of elements employed. Notice that when a change of shade occurs in a single elemental area, this change does not appear at the receiver but simply influences the tone of the entire element. Using 900 elements better definition is obtained as shown in the last illustration above.

PRINCIPLES of TELEVISION

In modern television a cathode ray tube is used for pick up and the scanning is performed automatically. A mosaic is a mica plate having many thousands of photo active globules insulated from each other and from the back conducting plate. Each globule forms a tiny condenser with this back plate; the mica serving as the dielectric. The scene to be televised is projected upon the mosaic. Light sections of the image cause high electron emission from the photo active globules. The globules in the dark parts of the image emit very few electrons.

The mosaic is mounted in the tube as shown. The scene is focused on the mosaic by means of a lens system in the same manner used in photography. An electron gun emitting a stream of electrons is made to scan the mosaic in a regular order. The electron spot falling on the mosaic covers a large number of globules and in some Iconoscopes measures 1/50 of an inch in diameter. The beam may be made to cover the surface of the mosaic in any predetermined order, but under the Radio Manufacturers' Association standards, 441 line scans are used, double interlaced so that the odd lines are scanned first and then the even, the complete image being scanned 30 times per second.



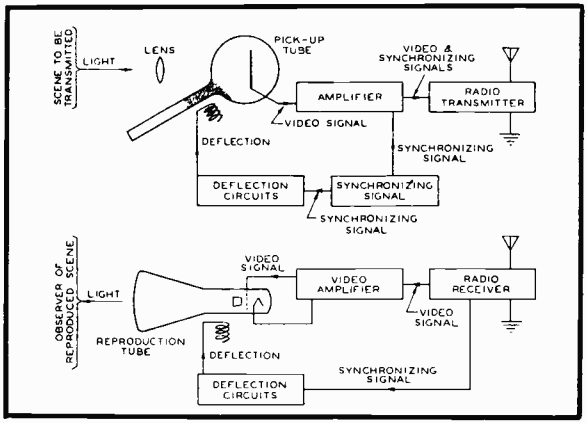
This is the iconoscope, transmitting tube.

Now you will recall that light causes the photo active globules to emit electrons which form a space charge around the corresponding globules. Since each globule is actually one plate of a small condenser (the metal deposit on the back of the mica serving as the other plate), the small condenser so formed will become charged.

PRINCIPLES of TELEVISION

The electron stream sweeps over these charged "condensers" covering a number at a time and discharges the accumulated electrons through resistance R. The voltage across this resistance, therefore, will depend on the charge of the globules covered by the beam during the corresponding instant. Since the charge, in turn, depends on the light intensity of the image, the signal voltage produced will be in exact accord with the light of the elements covered.

Since any one elemental mosaic area is receiving light while the remaining sections are being scanned, the charge is cumulative and excessive amplification is not needed.



You will see from the diagramatical illustration given (reprinted from the Proceedings of the Institute of Radio Engineers) how the synchronizing signals are applied to the pick up tube and are also transmitted to serve at the receiver. These synchronizing signals of all present American stations follow the R.M.A. standards and are explained in the Cyclopedia section.

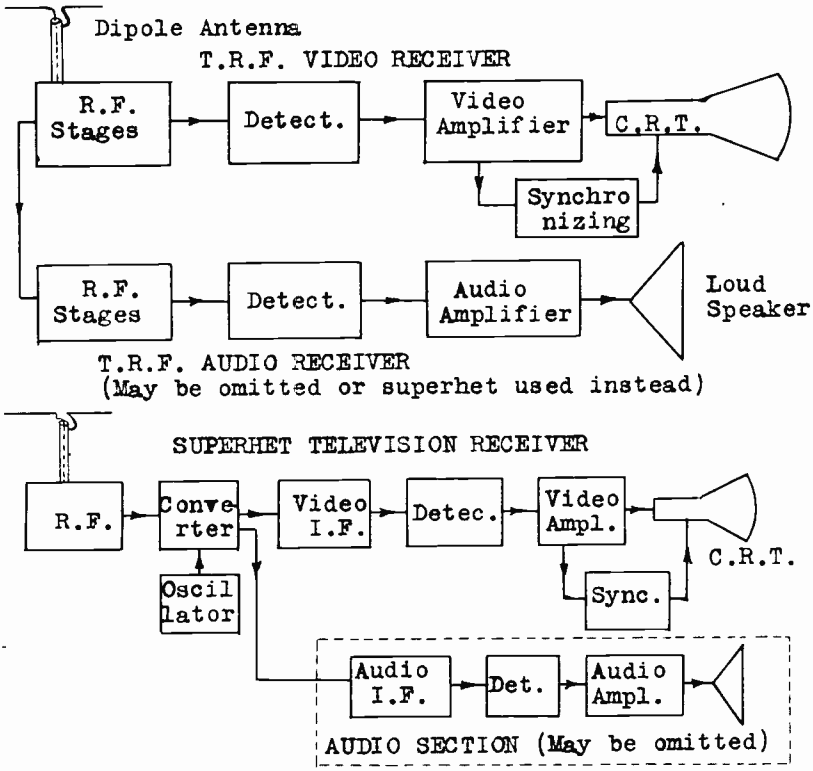
The actual deflection at the cathode ray tubes is accomplished by means of magnetic deflecting coils (electrostatic plates may also be used). Two pairs of coils are employed mounted at right angles to each other. The beam will be deflected as a varying current is applied to the magnetic yokes, and, since electrons have infinitesimal mass, the deflections will be instantaneous.

Ultra high frequencies are used for transmission of television signals. This is essential because of the extremely high frequency of the side bands. The first television channel is from 44 to 50 MC., and the others are at still higher frequencies.

Wavelength $\lambda = \frac{3 \times 10^8 \text{ meters/sec}}{\text{freq.}} = \frac{3 \times 10^8}{5 \times 10^7} = 6$ meters

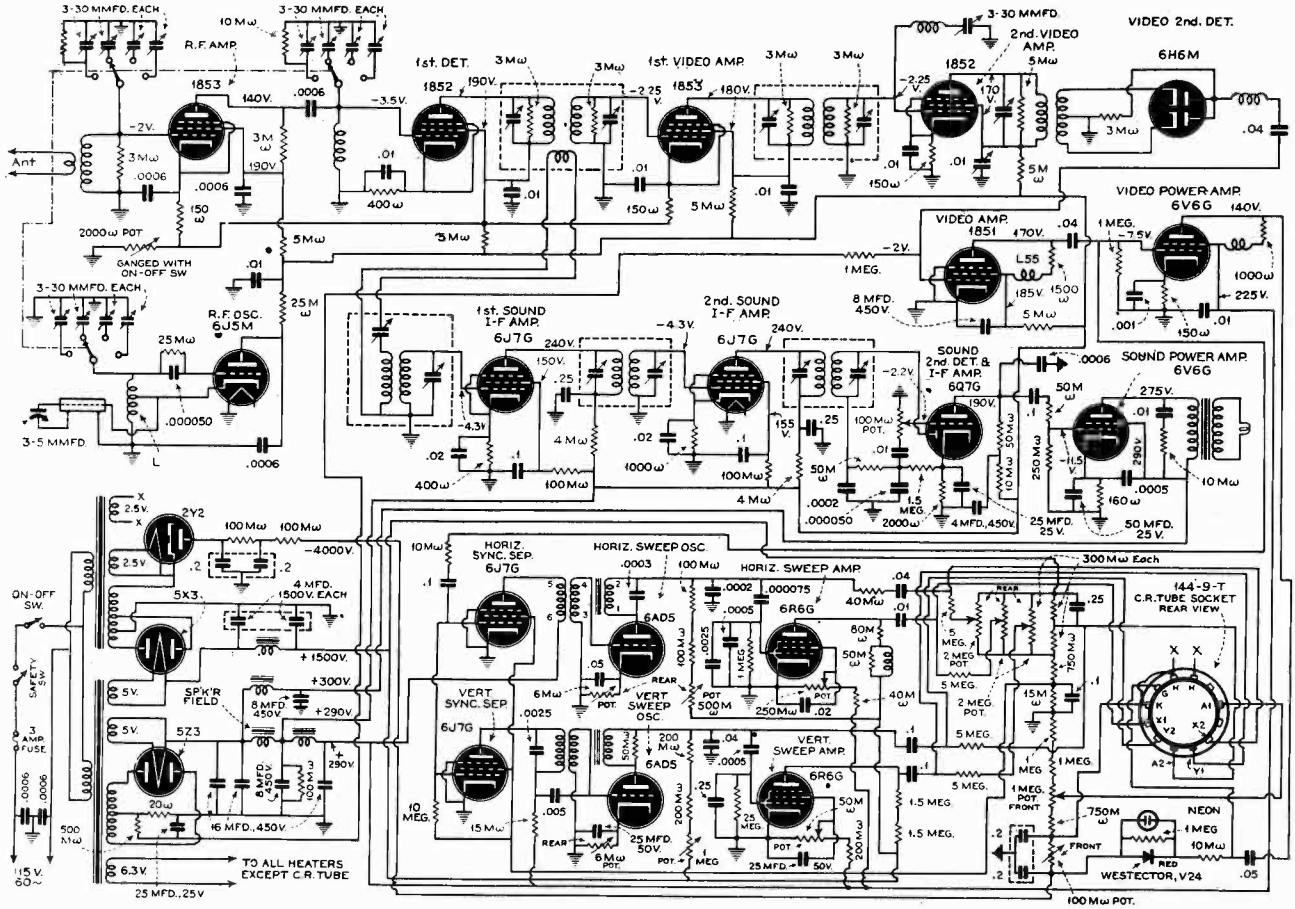
$\therefore$ $\lambda \simeq 5 \times 10$ feet.

PRINCIPLES of TELEVISION



To the practical man the actual function and repair of a television receiver is of prime importance. By dividing the receiver into sections the problem of servicing is greatly simplified. The television receiver may be of the T.R.F. or superhet type, may or may not have the audio channel receiver included. In the T.R.F. type unit an entirely separate receiver is used for audio although the controls may be combined. In the superhet type the R.F. pre-selector and converter-oscillator are common to video and audio channels. If audio is not included simplification of these first stages results and the audio channel I.F., detector, and audio frequency amplifiers are omitted.

Since the majority of present day television receivers combine video and audio and are of the superhet type, we will use this type of set as the basis for our discussion. The Du Mont Model 180 schematic illustrated is an excellent example.


3-30 MMFD. EACH
10 MΩ
3-30 MMFD. EACH
R.F. AMP.
1853
140V.
.0006
-3.5V.
1st. DET.
1852
190V.
3MΩ
3MΩ
1st. VIDEO AMP.
1853
180V.
3MΩ
3MΩ
3-30 MMFD.
2nd. VIDEO AMP.
1852
170V.
5MΩ
VIDEO 2nd. DET.
6H6M
3MΩ
.04
-2V.
3MΩ
.0006
Ant
.0006
150Ω
-2.25 V.
.01
400Ω
.01
150Ω
5MΩ
.01
.01
150Ω
.01
5MΩ
2000Ω POT.
GANGED WITH ON-OFF SW
.01
5MΩ
3MΩ
-2V.
1 MEG.
VIDEO AMP.
1851
170V.
.04
L55
185V.
1500Ω
5 MΩ
8 MFD. 450V.
VIDEO POWER AMP.
6V6G
140V.
1 MEG.
-7.5V.
1000Ω
225V.
.001
150Ω
.01
3-30 MMFD. EACH
R.F. OSC.
6J5M
25MΩ
25M Ω
.000050
3-5 MMFD.
L
.0006
1st. SOUND I-F AMP.
6J7G
240V.
150V.
.25
-4.3V.
.02
.1
400Ω
100MΩ
4 MΩ
2nd. SOUND I-F AMP.
6J7G
240V.
-4.3V.
.02
1000Ω
.1
100MΩ
4 MΩ
155 V.
.25
SOUND 2nd. DET. & I-F AMP.
6Q7G
190V.
-2.2V.
100MΩ POT.
.01
50M Ω
.0002
.000050
1.5 MEG.
2000Ω
4 MFD. 450V.
.0006
SOUND POWER AMP.
6V6G
275V.
50M Ω
.1
.01
250MΩ
-11.5 V.
280V.
10 MΩ
.0005
160Ω
25 MFD. 25 V.
50 MFD. 25 V.
2Y2
100MΩ
100MΩ
-4000V.
2.5V.
.2
.2
4 MFD. 1500V. EACH
.00
+1500V.
+300V.
ON-OFF SW.
5X3
5V.
SPK'R FIELD
8 MFD. 450V.
+290V.
5V.
5Z3
+290V.
SAFETY SW.
3 AMP. FUSE
.0006
.0006
500 MΩ
20Ω
8 MFD. 450V.
100Ω
16 MFD., 450V.
115 V. 60~
6.3V.
TO ALL HEATERS EXCEPT C.R. TUBE
25 MFD., 25V
10MΩ
.1
HORIZ. SYNC. SEP.
6J7G
HORIZ. SWEEP OSC.
.0003
100MΩ
6AD5
.05
6MΩ POT.
REAR
VERT. SWEEP OSC.
.0025
6MΩ
POT.
VERT. SYNC. SEP.
6J7G
10 MEG.
15MΩ
.005
REAR
6MΩ POT.
6AD5
50MΩ
200MΩ
.25
POT.
.1 MEG.
HORIZ. SWEEP AMP.
.0002
.000075
6R6G
.0005
POT. 500M Ω
250MΩ
.02
VERT. SWEEP AMP.
6R6G
.04
200MΩ
.25
25 MEG.
POT.
25 MFD. 50V.
40MΩ
.01
80M Ω
50M Ω
40M Ω
.1
1.5 MEG.
1.5 MEG.
300MΩ Each
REAR
.5 MEG.
2 MEG. POT.
5 MEG.
.25
144-9-T C.R. TUBE SOCKET REAR VIEW
X X
G1 H H A1
K X1 X2
G2 V2
A2 Y1
2 MEG. POT.
5 MEG.
15M Ω
750MΩ
.1
1 MEG.
1 MEG. POT. FRONT
5 MEG.
750M Ω
NEON
.1 MEG
10MΩ
.2
FRONT
.2
RED
WESTECTOR, V24
.05
100MΩ POT.

PRINCIPLES of TELEVISION

Starting at the antenna input you will notice that the secondary is loaded with a 3,000 ohm resistor to flatten out the response curve. The process of loading inductances is used in television equipment to permit the passage of extremely wide side band. Tuning is accomplished by means of pre-set trimmers connected to a push-button switch. The local oscillations produced by the 6J5 tube beat with both the video and audio carriers producing two different useful I.F. frequencies. One is used for the video I.F., while the other corresponds to the audio I.F. frequency. There are two stages of I.F. in each channel. Ordinary receiving type tubes are employed in the audio section, but special low inter-electrode capacity tubes must be employed in the video I.F. channel. The balance of the audio signal receiving equipment is similar to the type used in regular radio sets.

In the video section also, a second detector is used followed by a video amplifier. After the first video stage part of the signal is tapped off and serves the horizontal and vertical sweep circuits. The synchronizing signal received simply controls the local vertical and horizontal oscillators and locks them in step.

By noticing the apparent action of the image, the location of the fault may be detected. J. H. Reyner in his book on "Testing Television Sets" gives a complete list of faults that may be found. His listing will serve as our outline.

If absolutely no fluorescent light is noticed it is probably that the difficulty lies in the cathode ray tube. The anode voltage may be shorted or missing. Emission may be lacking because of heater supply failure. If the scan is deflected completely off the screen this condition may exist. If tests indicate that these faults are not present, the tube itself should be changed.

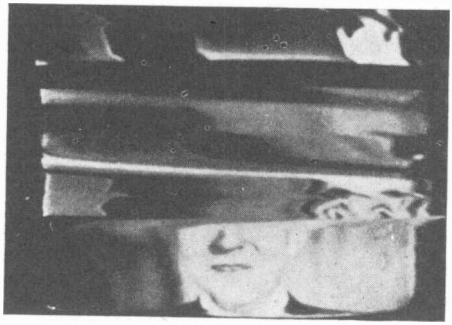
If a point of light does exist, but no image is present be sure to reduce the brilliancy while making tests. If the electron spot remains in one position and has sufficient brilliancy, it may burn through the fluorescent material. The trouble in this case, of course, is due to some fault in the scanning circuits. It may go further in the front section of the receiver. If the intensity of the spot does change in a manner that suggests that it is following the modulation the trouble must lie in the scanning circuits.

Sometimes the scanning is present, but there is no modulation so that the entire image is of one shade. First suspect the final video stage, because this is the only stage that does not carry the synchronizing pulses which are operating correctly. Next proceed testing back to converter

tube. If the audio section is operating correctly the trouble definitely is not in this stage or the antenna. But if the sound channel too is at fault suspect the R.F. stage, converter, oscillator, or the antenna.

Reversed modulation can only occur if the voltage to the control grid of the cathode ray tube is applied 180° out of phase. This can happen is one video stage is not operating, but the voltage does get to the following stage. Usually due to wrong connection.

A confused jumble appearing on the screen is very difficult to diagnose -- there are so many things that could go wrong and cause this symptom. Usually, however, the vertical or horizontal sweep circuit will be found at fault. Certain type of interference may also cause a jumble of light on the screen.



Picture due to operation of receiver with pronounced unstable line synchronism.

Poor focus may be due to poor adjustment. You should try to make the necessary adjustments. Suspect also defective scanning circuits and poor inter-locking with the incoming synchronizing signals.

Uneven brilliance may be due to poor power filtering. This is not common when 60 cycle A.C. power is used with transmission using 60 fields. Inter-action between the scanning voltages and modulation will have this effect. Spots only lacking brilliance are probably due to burnt screen.

With poor overall frequency response considerable loss of definition will result as is apparent from this photograph.

PRINCIPLES of TELEVISION

Picture will be unsteady if the synchronizing is poor. Leakage in the video circuit may cause the same effect.

Picture flickers are very common to loose aerial. Check this first. Variations in the power supply voltage may also cause this effect. Certain difficulties in the synchronizing circuit may make the picture flicker.

You will find that a double or a partial image is always due to errors in the scanning circuits. Ghost images may be due to the scanning circuit or to the reflection of the incoming wave. If the later is the case shifting the antenna will solve the problem.

Effect due to non-linear vertical scan.

These photographs are reprinted from "Television and Short-Wave World" magazine, an English publication.

Effect due to line sweep operating at twice the correct frequency.

Vertical sweep operating at one-half the correct frequency produces this effect.

PRINCIPLES of TELEVISION

Once the defective portion of the television receiver is located the methods used for radio servicing may be applied. The point to point voltage test is about the best. Since very high voltages are present in some circuits your voltmeter should either be able to read to 6,000 volts or else an external series resistor will have to be connected.

If the cathode ray tube is suspected voltage tests should be made. As another alternative, the tubes may be replaced for test. Servicemen experienced in using a cathode ray oscilloscopes should consider the Picture Tube as a special unit of this type. Here sweep frequency is applied both vertically and horizontally at a related rate and interlocked phase. Also the intensity of the beam is influenced by the incoming signal.

The faults in the scanning circuits are ordinarily due to some part failing. This part can be found by one of the regular ways. A cathode ray oscilloscope is a great aid in servicing this section of the television receiver.

Although the individual scanning circuits may not be at fault, there may be interference due to interaction between the vertical and horizontal scans. If the vertical scan influences the horizontal scan, distortion of the trapezoid type will appear. This difficulty is usually due to coupling in the high voltage supply. This is similar to motor boating in an audio receiver and may be eliminated in the same manner.

If the line synchronizing circuit effects the vertical scan the edge of the image seems to lift and bend over. Here too the fault may be due to coupling in the high voltage supply, but is more commonly present because of direct coupling of the two circuits. Shielded leads will help.

An image with ragged edges is produced by very poor line (horizontal) synchronization. The picture may be broken up by horizontal streaks at points where there are high lights in the image. If this defect is slight, the image will hold steady, but will be distorted since the lines will not arrange themselves correctly.

An audio signal generator may be employed to test the operation of the cathode ray tube and also the video stages. Distortion in these stages and also in the C.R.T. tube will be easily detected. To test back before the second detector, modulated high frequency corresponding to the I.F. and carrier respectively should be used. This is a similar process to dynamic testing used in radio receiving sets.

TELEVISION CYCLOPEDIA

Aberration

A defect in lenses that produces inexact focussing is known as aberration. Aberration may also occur in electron optical system causing a halo around the light spot.

Accelerator Anode

An electrode of the cathode ray tube connected to a high positive potential and causing the electron beam to acquire high velocity is called the accelerator anode. Usually it is also known as the second anode.

Achromatic Lens

To overcome chromatic dispertion (different focus point for different colors) achromatic lenses are used. These consist of two lenses, one of converging type and the other of diverging type, so that the dispertion of one lens corrects that of the other.

Afterglow

In cathode ray tubes the screen remains luminous after the exciting electron beam is removed. This is known as the afterglow. Such screens are phosphorescent and are desirable in television work. The table below lists several materials of this type, and also gives the degree of afterglow as well as other characteristics.

Lumens per Watt	Material	Colour	After-glow	Utility
—	Barium platino-cyanide	Blue-violet	Very little	Photographic recording of television
0·23	Calcium tungstate	Blue	Little	Photo-oscillography
0·70	Cadmium tungstate	Green-blue	Little	Photo-oscillography
1·0	Zinc orthosilicate (copper activated)	Green	About 10^{-6} sec.	Visual oscilloscope and television
2·78	Zinc sulphide (copper activated)	Green to yellow-green	Strong	Visual oscilloscope and television
1·6	Zinc cadmium sulphide (silver activated)	Yellow	Fair	Television screen
—	Zinc phosphate	Red-orange (587–668 mμ)	Strong	Colour television
0·15	Manganese silicate	Red	Strong	Colour television
—	Zinc silicate and cadmium tungstate	Bluish-white	Fair	Television screen
0·9	Zinc sulphide and cadmium sulphide (copper and silver activated)	Sepia	Marked	Television screen

Amplification

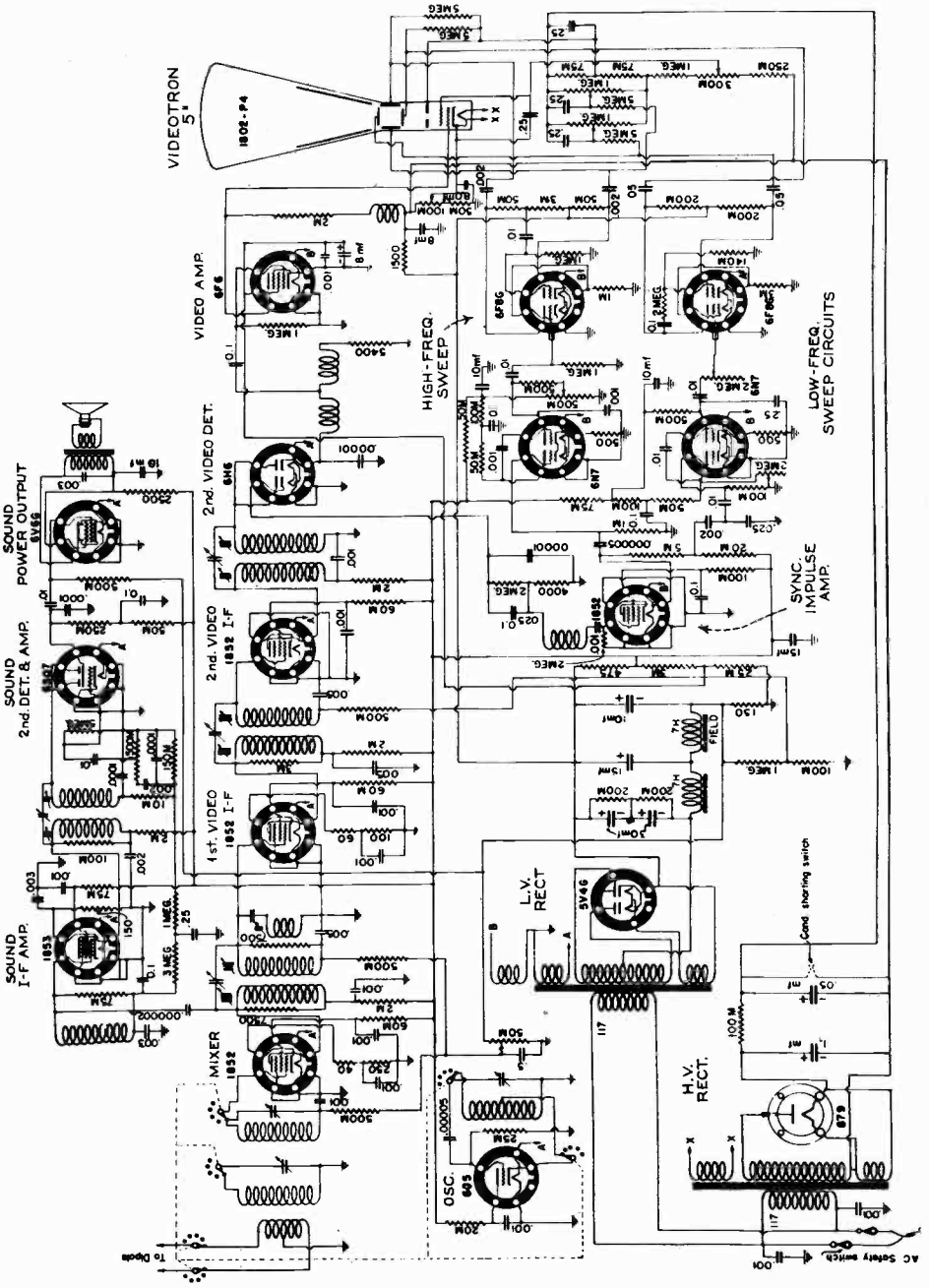
In television as in radio circuits, video signal amplification is accomplished with vacuum tubes. However, because of the much higher carrier frequencies employed, and because the actual video signals are also of higher frequencies than audio frequencies, special circuits and tubes are needed. R.C.A. tubes such as 1851, 1852, and others have been especially developed for such applications. The circuit of a television receiver will aid you in understanding these differences.

Amplitude

The instantaneous intensity of an alternating phenomenon is called its amplitude. However, in some writings the maximum intensity is thought of as the amplitude.

Amplitude Filter

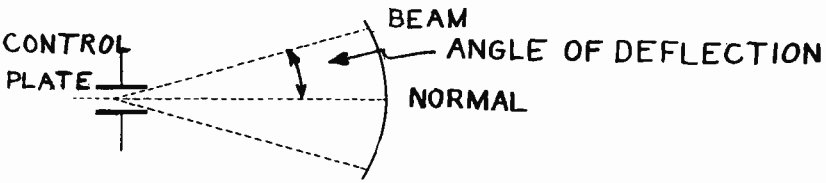
Since the synchronizing impulses are superimposed on the video modulated carrier, they must be separated at the receiver. Black level pick up with negative modulation gives maximum amplitude modulation of the carrier. The synchronizing impulses are 20 to 25% higher in amplitude and can be separated by an amplitude filter. By properly biasing a vacuum tube, the required operating conditions can be secured. Any amplitude of the video signal up to the black level will have no effect on the plate current -- produce no change. The higher amplitude synchronizing impulses, however, will cause a change in the plate current. These current changes, dI_p, can be amplified and used for deflection of the Kinescope.



Meissner 10-1153 Sight and Sound Receiver

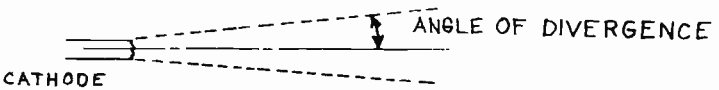
Angle of Deflection

The line formed by the natural position of the electron beam in a cathode ray tube is called the normal. If at any instant the electron beam occupies some position away from the normal, the angle formed between the new position of the beam and the normal is the angle of deflection.



Angle of Divergence

The angle of divergence measures the spreading out of the electron beam at the cathode. Actually it is the angle formed by an imaginary center line and the border line of the electron beam. In good tubes this angle is reduced to less than 2^{0}.



Angstrom Unit

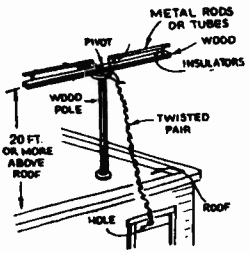
The Angstrom unit is a measurement of the wavelength of light and is equal to one ten-millionth of a millimeter, or about one two-hundred-fifty-millionth of an inch. The visible spectrum extends from about 4,000 to 8,000 Angstrom units. Blue light has a wavelength in the region of 4,700 Angstroms, yellow 5,800, and red 6,500.

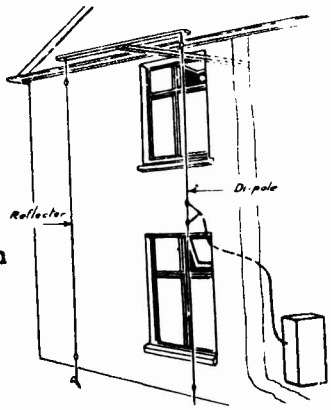
Anode

The electrodes of a cathode ray tube that are connected to a source of positive potential are called anodes. The anodes are used for focusing, concentrating, and accelerating the electrons. See also the explanation of the cathode ray tube.

Antenna (for Television)

The television stations' transmitting antennas have been greatly publicized and they do have weird shapes and forms. Each antenna of the transmitting type is especially designed to give optimum results for the requirements of the particular station.





Above. A typical American television antenna.

To the right. An English dipole with reflector, installed vertically.

For receivers a simple dipole doublet is recommended. In England, the transmitting waves are vertically polarized and antennas are placed in the vertical position. In United States horizontally polarized waves are used and, of course, the doublet should be placed in the horizontal position.

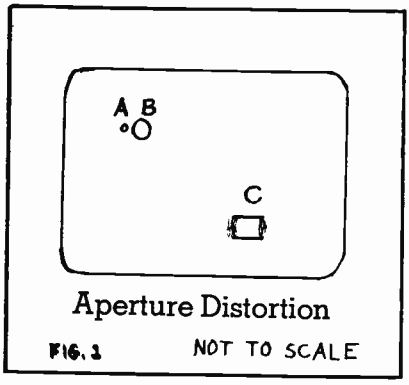
Each leg of the doublet dipole is one-quarter of the wavelength in size -- a dipole is a half wave antenna. The television antenna should be placed as high as possible and away from all surrounding objects. While a reflected signal can be made to serve, if both the original and the reflected signals are picked up, interference will result.

The antenna is coupled to the receiver by means of a twisted lead, or a coaxial cable. The actual physical size of the antenna should be determined from the average frequency of the stations to be received.

Better results, of course, will be obtained if a reflector (1/2 wavelength bar) is mounted parallel to the doublet and about 1/10 of a wavelength away. Also the entire array may be revolved to increase the directional pick up.

Aperture Distortion

Distortion causing sharp changes of shade in the picture to appear uniformly grey is due to the aperture being too large. Consider for example, a single bright spot A, in Fig. 1, focused on the mosaic. The electron beam at any one instant covers area B, (aperture equals area of B). With no other distortion present this spot will be reproduced as C, on the receiving tube's screen. For best results the aperature should be small.



Aperture Distortion

FIG. 1 NOT TO SCALE

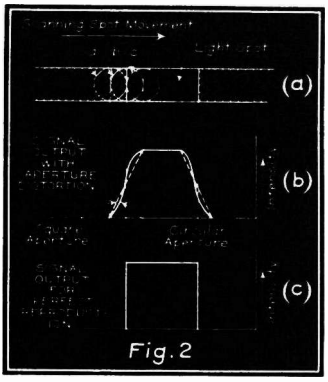


Fig. 2

Aperture

The actual size of the scanning electron beam falling on the mosaic of the Iconoscope tube may be considered as the aperture.

Aqueous Humour

The watery liquid in the anterior chamber of the eye is called the aqueous humour.

Aspect Ratio

Aspect ratio is known as the picture ratio in England and is the mathematical ratio between the width and height of the picture.

$$\text{Aspect Ratio} = \frac{\text{WIDTH}}{\text{HEIGHT}}$$

In the R.M.A. Standard, Aspect Ratio equals 4/3.

Attenuation

The reduction of signal amplitude is known as attenuation. Signals are greatly attenuated in passing from the transmitting radiator to the receiving antenna.

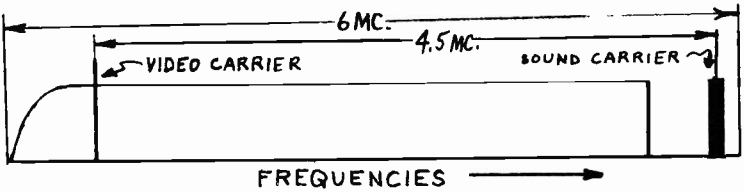
Background Noise

Undesirable stray voltages that may be produced in the television receiver or picked up by the antenna form the background noise. By making the signal to noise ratio high, the effect of background noise is reduced to a negligeble point.

Band Width

In a sound broadcast transmitter frequencies up to 5,000 cycles are superimposed on the carrier frequency, varying the carrier by plus and minus this amount. The band width, in this case, is 2 x 5,000 cycles, or 10 KC.

In a television station we must consider the video signal consisting of 30 frames, 441 lines, and each line having as many as 4/3 x 441 elements. The product of all these factors gives 7.8 MC. for a single side band. Single side band transmission, of course, is used. But the band must be limited in practice to about 4.5 MC.



Beam Current

The actual value of the beam current of a cathode ray tube may be measured. It is usually less than 150 microamperes, but rises quickly with the anode voltage and may be as large as one-quarter of a milliampere.

Black Body

"Black body" is a name given to a radiator that is used for spectrum analysis. It is a hollow cavity having a black interior surface and is provided with a small opening through which the radiation from the interior surfaces can emerge when the temperature is raised.

Blocking Oscillator

A vacuum tube circuit arranged to produce saw-tooth waves for synchronizing is known as a blocking oscillator. A condenser in the plate circuit of the tube is charged linearly, but when fully charged is instantaneously discharged. This varying current through the condenser is used to control synchronization.

Camera (Television)

The television camera resembles in many ways the type of camera used for motion picture work. In fact, the focusing and lens systems are almost the same, but the shutters are not needed for the scanning is performed electrically.

The modern type of camera as illustrated can be raised, lowered, and tilted automatically by means of electrical power. Inside the camera is housed the Iconoscope tube and is connected by means of cables to the associated amplifiers.

It is possible to televise any outdoor scene where sufficient natural light is present for making outdoor movies. Indoors, of course, artificial light is used.

Candle Power

Candle power is a measurement of illumination. The value is based on the light emitted by a candle of standard accepted type. A foot-candle is equal to one lumen per square foot.

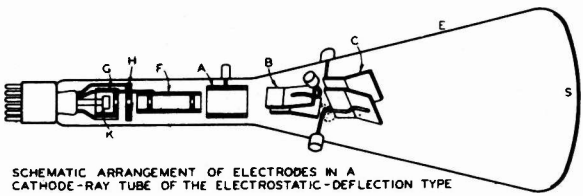
Carrier Frequency

The higher frequency used for transmission and modulated with the video or audio signals is called the carrier frequency.

Cathode Ray Tube

Cathode Ray Tubes are the basis of modern television reception and are also extensively used in the visual analysis of electrical phenomenon. In its simplified form the cathode ray tube consists of an electron gun to generate an electron beam of high velocity, a set of perpendicular electrostatic or magnetic deflecting devices, and a fluorescent screen to make visual the actual path described by the end of this electron beam.

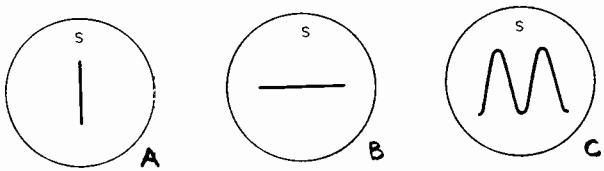
According to the information presented by the R.C.A. Manufacturing Company, the basic type of cathode ray tube may be illustrated by the figure below.



SCHEMATIC ARRANGEMENT OF ELECTRODES IN A CATHODE-RAY TUBE OF THE ELECTROSTATIC-DEFLECTION TYPE

"The tube is seen to possess the following attributes: a containing envelope (E) made of glass for the purpose of maintaining a vacuum in the tube; a cathode (K) for the production of free electrons; an electrode (H) for accelerating the electrons; a focusing electrode (F), identified as anode No. 1, for concentrating the electrons into a "cathode ray" or beam; a high-voltage anode (A), known as anode No. 2, for further accelerating the electrons; a control electrode (G), referred to as grid No. 1, for controlling the beam current; two sets of electrostatic deflecting plates (B) and (C), for deflecting the electron beam; and a screen (S) which is coated on the inner surface of the enlarged end of the bulb with a material which shows a fluorescent glow at the impact point of the electron gun. The electrodes K, G, H, F, and A are collectively called an electron gun.

"Since the electron beam consists of rapidly moving electrons, it constitutes a current having both electromagnetic and electrostatic properties. Because no material conductor is required to carry the electrons, the beam has negligible mass and inertia. Due to this inertialess characteristic, the electron beam can be deflected easily and rapidly by either electromagnetic or electrostatic fields. In the cathode ray shown the deflecting force produced by the phenomenon under investigation takes the form of an electrostatic field produced by a voltage applied across the deflecting plates (B). If this is an alternating voltage, the field produced causes the fluorescent spot viewed from the front of screen (S) to move up and down. This movement of the spot traces a vertical line, as in Figure A. A "time sweep" voltage of suitable wave form is applied across the other deflecting plates (C), causing the beam to move back and forth horizontally, as in Figure B. The combined deflecting forces of the two fields may be caused to produce a pattern such as that in Figure C.



Another type of cathode ray tube uses deflection of the beam both horizontally and vertically accomplished by means of two electromagnetic fields produced by two pairs of coils, X and Y. In other respects, this type of tube functions essentially the same as the electrostatic deflection type."

For television work, the receiving cathode ray tube, also known as the Kinescope or the Picture Tube, is ordinarily supplied in 5, 9, and 12 inch screen sizes. The screen is made of material that has phosphorescent properties and has a color tone that is pleasing and non-tiring to the eye.

Coaxial Cable

A specially constructed cable having one conductor inside another is called coaxial cable. While insulators may be used inside the tubing, air is the main dielectric. Coaxial cables are used to couple antennas of high frequency equipment and may be used for carrying wide band video signals.

Color

Television transmission reproduces shades varying from extreme dark to bright light. Actual colors of televised scenes become shades of grey and suggest the correct outlines, but many times not the correct color. A girl's lips covered with dark red lipstick will appear very pale after being televised; perhaps even lighter in tone than the corresponding televised lips in natural color. It becomes necessary, therefore, to correct these "color into grey" sense values by a make-ready process. For example brown lipstick is used.

Since all colors are made up from the three primary colors, it is possible to transmit by television color pictures. But besides imposing three times the complexities of regular television, color transmission presents other technical problems not easily solved.

Continuous Scanning

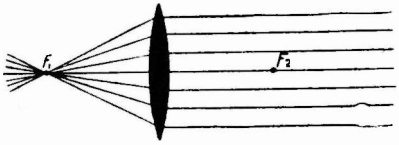
When the exploration of the image is performed in contiguous strips, so that when the beam returns to its original position the entire image has been scanned, a process of continuous scanning is used.

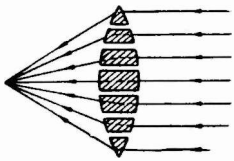
Converging Lens

A converging lens causes light passing through it to converge. If parallel rays of light strike this lens, they will converge in a single point at the focal distance.

Convex Lens

A lens thicker in the center than at the edges is a convex lens. A convex lens is always in the converging lens classification.





Cornea

The transparent layer in the front part of the eye is called the cornea. See explanation of the EYE.

Cross Over

In either light optics or electron optics, the point where the rays are concentrated and from where they again spread out, is known as the cross over point. In a cathode ray tube this occurs between the cathode and the first anode.

Cylindrical Lens

Cylindrical lenses have surfaces that are cylindrical and form the image into a line image. Sometimes a line image can be handled easier and later can be reconstructed into a real image.

Decibel

The decibel, abbreviated as db., is a unit of comparison of two powers and under proper considerations may be used to compare voltages and currents. It is a transmission unit used to measure power related in some way to the auditory sense. It is also used for measuring selectivity of tuned radio circuits and for comparing losses encountered by the signal in being transmitted from the station to the receiver.

The db. is a logarithmic unit inasmuch as it varies as the log of the ratio of the two powers under the comparison.

$$DB = 10 \times \log_{10} \frac{P_1}{P_2}$$

The formula above states that the relation of the log to the base ten of the ratio of the two powers, multiplied by ten will give the difference of the two powers in decibels.

The difference in decibels may also be found from the table below if the ratio of the two powers under consideration is known. Of course, this table is also applicable when the gain or loss in decibels is known and the power ratio is required.

Gain in DB	Power Ratio P_1/P_2	Loss in DB	Power Ratio P_1/P_2
40	10,000	0	1.
35	3,162	1	.8
30	1,000	2	.6
29	800	3	.5
26	400	4	.4
23	200	5	.32
20	100	6	.25
15	32	7	.2
12	16	8	.16
10	10	9	.12
9	8	10	.1
8	6.3	11	.08
7	5	13	.05
6	4	15	.03
5	3.2	17	.02
4	2.5	20	.01
3	2	25	.003
2	1.6	30	.001
1	1.3	35	.0003
0	1	40	.0001

For example, in passing through an audio stage the signal is increased 20 db.; what is the power ratio of the output to the input? An increase of 20 db. is a gain of 20 db., and looking this up in the table, we find the corresponding power ratio equal to 100.

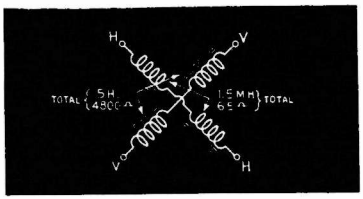
Since db. is always a ratio when we speak of an amplifier as having so many decibels gain, we assign an arbitrary level of comparison. Usually 0.006 watts is taken as this figure. If one amplifier has 75 decibels in comparison with a given arbitrary level, while another has 60 decibels in comparison to this same level, the first has (75-60) or 15 db. more gain.

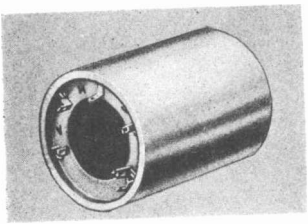
Definition

The resulting definition (quality) of a television picture depends primarily on the number of lines and aspect ratio (number of picture elements). The number of frames per second also influences the resulting definition.

Deflecting Coils

The deflecting coils are also known as magnetic yokes and are used to deflect the electron beam. The beam, of course, acts at right angles to the magnetic lines of force.





Deflection Voltage

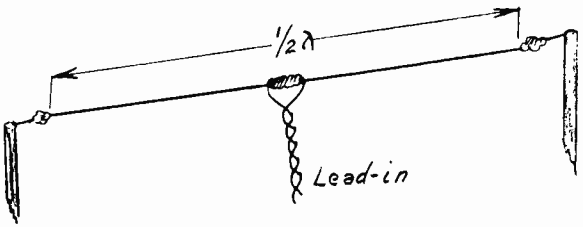
The voltage applied to the electrostatic plates or magnetic yokes to control the movement of the electron beam is called the deflection voltage.

Detector

A detector is a vacuum tube in the receiving circuit used to demodulate (separate) the incoming carrier from the superimposed video or audio signal. For television work power detection or diode detection is used.

Dipole

An antenna having physical length equal to one-half the signal's wavelength is a dipole. A dipole, of course, may be a doublet with each element one-quarter wavelength in size.



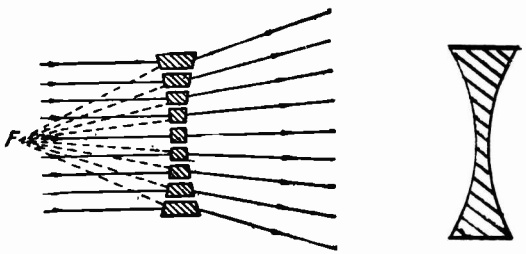
Distortion

Fortunately natural static has no ill effect on ultra high frequency transmission used in television. What distortion we do get is due to natural shortcomings of the television system and man-made static.

The big problem is the interference caused by diothermy equipment (any high frequency generators) and automobile ignition systems. Both of these produce "snow" across the screen.

Diverging Lens

Diverging lenses are thinner in the center than at the edges. This type of lens causes light passing through to spread out -- diverge. See illustration.



Double Image

If two images appear on the screen the scanning process is going on at one half the correct speed. If the horizontal scanning is at fault two images will appear side by side. If the vertical scanning is at fault, then the two images will appear one above the other. Partial images are not obtainable except in one or two unusual developments in the circuit. More commonly when a fault is present in the synchronizing circuit, a jumble of streaks will result.

Electron Beam

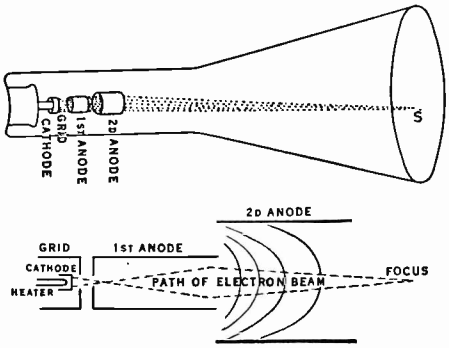
The path of electrons from the cathode to the fluorescent screen or mosaic constitutes the electron beam. The generation of this beam by the electron gun, and the control of the beam by means of electrostatic and electromagnetic fields is of importance. These subjects are more completely treated under their respective heads.

Electron Gun

The electrodes of the cathode ray tube that generate a concentrated beam of high velocity electrons form the electron gun. Included in the "gun" are the cathode, shield, and one or more anodes. See explanation of Cathode Ray Tube for more details.

Electron Lens

An electrical arrangement of electrodes in the cathode ray tube to produce a focusing of the electron beam is known as the electron lens system. Actually the action of the electrostatic fields is such as to resemble the equivalent effect had by optical lenses on a beam of light. By considering a light beam as the physical equivalent of the cathode ray beam, you can readily see the importance of the electron lens system. Light (or electrons) is generated at a point and spreads in all directions.



A double-convex lens would consentrate the rays and have them meet at the point of focus. Several equivalent lenses are used in a cathode ray tube and produce a near-point beam directly on the screen.

Electron Multiplier

An electron multiplier is a specially designed tube that provides a large number of electrons at the output electrode as compared with the number of electrons at the input. The operation depends on secondary emission. A high velocity electron, upon striking a plate, may dislodge several other electrons. By placing several plates at correct angle to each other and at increasingly positive potentials, it is possible to have each "secondary" electron strike the succeeding plate and dislodge a still greater number of electrons. By continuing this process, large amplification can be secured. The original electron emission may be photo-electric or thermionic.

Electron Optics

Electron optics deal with the behavior of the electron beam under the influence of electrostatic and electromagnetic forces. See Electron Lens.

Electron Velocity

The actual velocity of electrons in a cathode ray tube is not constant, but depends primarily on the accelerating anode voltage. The formula used is quite complex and for accelerating anode voltages above 2,000, the changing mass of the electrons must also be considered.

Electrostatic Field

An electrostatic field exists between two conductors charged with different potentials. The corresponding electrostatic deflection plates of a cathode ray tube form a controlling electrostatic field.

Element

The smallest part of a televised picture that still retains its characteristic is called an element. The height of an element is equal to the height of the line scan, i.e. 1/441 of the mosaic height. The width of an element is the aspect ratio (4/3) multiplied by the height of the element.

Emission (Electron)

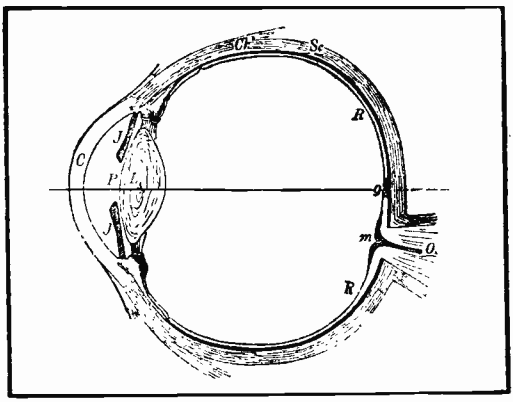
Electron emission may be caused by heat, photo activity, or by primary electron bombardment. The entire process of television is dependent on electron emission. In the Iconoscope, light causes photo electric emission of electrons from the many globules of the mosaic. But in every vacuum tube at both receiver and transmitter, including the Iconoscope and Picture Tube, thermionic emission is of main importance. Secondary emission is present sometimes with undesirable effects, but is of little importance.

The phenomenon of emission of electrons from hot bodies was studied first by Richardson. His and later researches proved that a definite boundry force existed and required each electron to perform a certain amount of work to get through the surface of the hot body. This amount of work is characteristic of each emitting substance. It is measured in volts and is called the work function of the emitting body.

Every hot body is surrounded by a cloud of electrons. As the temperature is increased the electrons move faster and many are able to overcome the work function. Substances having high melting points and low work functions, of course, make the best cathodes.

Eye

The eye is an optical instrument for receiving light pictures and changing them to nerve impulses. If the eye was out of the socket, you would see a white outer coat. This is tough and firm and preserves the shape and serves as an added protection. The inner part of the eye is covered with a black coat to absorb stray light waves. The back part of the eye has a special coating called the retina, shown as R in the drawing. The nerves are spread out on the retina and form a sensitive screen.



The crystalline lens L forms a real, inverted image on the retina. We actually see things up side down, but our concept corrects this illusion. The iris J is a diaphragm to limit the amount of light that will enter the eye. In a dark room this opening is large to admit more light, but in bright light only a tiny center portion of the lens is used.

The actual shape of the lens is altered to bring objects at different distances into focus. Incorrect shapes of the eye require correction with glasses.

Faraday Effect

Named after Michael Faradey, a distinguished English physicist, Faradey effect is the rotation of polarized light by magnetic force. The effect is too minute to be of any commercial use in television.

Field

The scanning of a picture from top to bottom is known as a field. A field does not necessarily cover all the lines that make up the image. In a double scanning system, each field covers but 220½ lines of the total 441. In such a system, two fields form a complete frame.

Field Strength

The effective power of the radiated signal at any one point is the field strength at that point. The field strength decreases as the distance from the transmitter increases. For comparison purposes the field strength must be measured at a given height above ground; greater height will increase the signal strength.

Figure of Merit

Figure of merit is a calculated factor that serves to determine roughly the adaptability of a tube for television work. It takes in consideration mutual conductance and the inter-electrode capacities.

$$\text{Figure of Merit} = \frac{g_m}{C_{gk} + C_{pk} + C_{gp}(1 + G)}$$

G = 3 for triodes, 15 for pentodes.

Flicker

Noticeable flicker is due to presentation of the frames at too slow a rate. Reoccurring phenomenon must be reappearing at least 16 times per second, but the rate used in movie equipment of 24 per second is much better. In using double scanning and 30 frames, not only is flicker entirely eliminated, but 60 cycle power line variations (hum) has no ill effects.

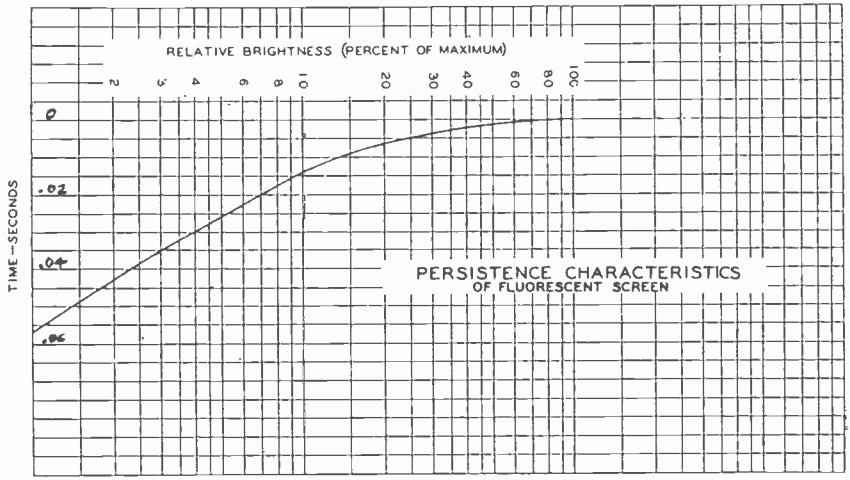
Fluorescent Screen

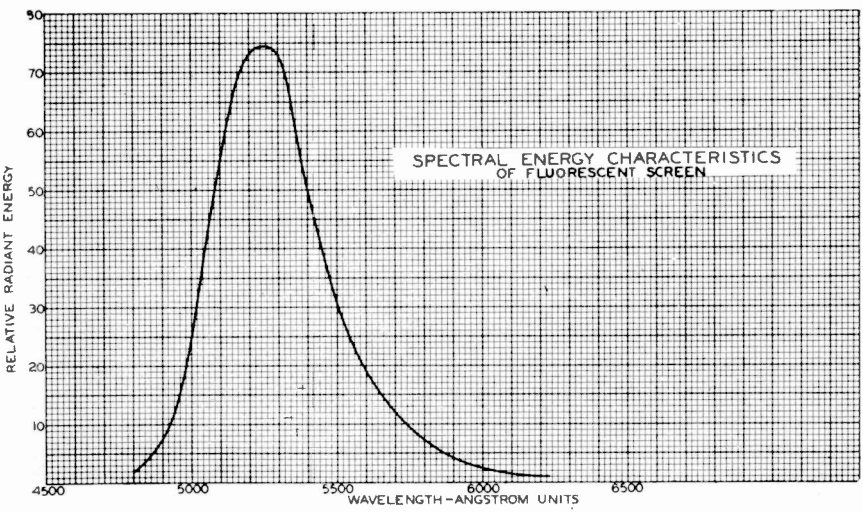
The fluorescent screen is coated with a thin layer of material that fluoresces when bombarded by the electron beam of the cathode ray tube. Materials such as calcium tungstate and barium platinum cyanide are commonly used for this purpose. If the tube is required to have phosphorescent properties zinc sulphide is added. The screen must provide high luminosity in response to small power of the cathode beam. The ray must be kept moving all the time; if the ray is left on one spot it will burn a hole in the screen. Also the fluorescent screen must respond proportionally to the power of the electron beam. Different materials used determine the color as listed in the table:

Sulphide ..... White
Calcium tungstate .. Blue
Willemite ..... Green
Zinc sulphide ..... Red

The thickness of the screen is important. If too thick too much brightness of the spot will be lost in the screen. If too thin, the grain of the material will show up and produce blurred pictures.

AVERAGE FLUORESCENT SCREEN CHARACTERISTICS





Fly Back

The return sweep of the cathode ray beam to re-start the trace of the next line is called the fly back. The fly back time should be as short as possible.

Focus

The point where the rays passing through a lens meet is the focus. In television receivers the control which affects the sharpness of the picture is called "Focus."

Focusing

The electron beam is focused electro-optically by means of the fields set up by the electrodes.

Fourier Series

NO

The Fourier Series is a mathematical analysis that permits the resolution of any complex wave form into a fundamental and ~~a finite~~ number of terms involving the harmonics of the wave. Since the series is ~~not~~ convergent, a small number of terms will give accurate results.

Frame

A complete scan of all picture elements is a frame. In R.M.S. Standards 441 lines form one frame. Double scanned system calls for two fields to complete a single frame.

Fringing

A distortion common to gas-filled cathode ray tubes that causes some of the straight lines to appear wavy is known as fringing. Fringing is caused by the fluctuating potential charges on the internal surface of the glass envelope of the tube.

Ghost Image

A picture made up of two scenes consisting of the real image and the ghost image is due to pick up of the reflected wave. Changing the location of the antenna will solve this problem.

Glass

Care must be exercised in selecting the glass for optical lenses and cathode ray tube screens. Certain errors can be reduced by using glass of correct chemical composition. Quartz glass is used in the Iconoscope in case ultra-violet light is to be transmitted.

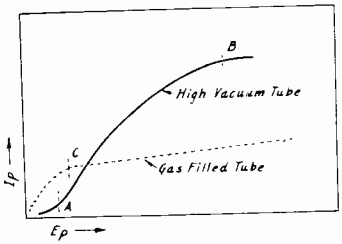
Grid (Cathode Ray Tube)

The grid is the modulating electrode of the cathode ray tube. It may be a metal cylinder or a spiral mesh and is placed adjacent to the cathode.

Grid Glow Tube

Essentially a grid glow tube or Thyratron is a vacuum tube possessing a hot cathode as a source of electrons and is filled with some inert gas or mercury vapor. It also has a grid control element. However, because of the presence of gas, the plate current, plate voltage characteristics are entirely different from the regular type vacuum tubes.

Grid glow tubes are used in sweep circuits and to understand their operation is important. Much of this material has been taken from an article on the Thyratron by the author as published in August, 1935 issue of Radio World.



Current variations with increasing plate potential in high vacuum and gas filled tubes. Up to point A current is limited by space-charge, after point B by limited emission. After a voltage corresponding to C, the current of a gas filled tube is almost constant.

In ordinary vacuum tubes as they are used, the plate current will vary with the voltage as some function of 3/2 power, until the current will be limited by the emission. Due to formation of positive ions, the action of a grid glow tube is entirely different. The electrons do not travel in a continuous path from cathode to plate, but have collisions with gas molecules. These collisions create positive ions and additional free electrons. If the rate of ion generation is large, the voltage change between the cathode and anode is negligible. Such gas filled two element tubes are used as rectifiers and have a small constant potential drop.

The grid may be incorporated to control the starting conductive action. The grid by having a negative potential can prevent the space charge formation, and thereby prevent the flow of electrons from the cathode to plate. There is a critical grid voltage, trigger point, that will just permit the starting of the plate current. Of course, once the current starts the ionization takes place at high rate and the grid exercises no more control even if made negative once more. Should the plate current stop but for an instant, the grid again will control the starting of the current flow.

Besides their use in sweep circuits, grid glow tubes are also used for supplying A.C. from D.C. sources. These tubes are made in many different physical sizes and possessing varied characteristics.

Halation

Halation is a distortion caused by the reflection of the image rays by the back of the screen. Such reflection blurres the image. It is usually due to the fluorescent screen being too thick.

Halo

Halo is the undesirable ring of light around the spot on the fluorescent screen of the cathode ray tube. It may be due to electro-optical aberration. Also secondary emission electrons may return to the screen and form a halo.

Harmonics

Harmonics are overtones or multiples of the fundamental frequency. In almost every oscillator with the generation of frequency f, there appear harmonics 2f, 3f, 4f, etc. The power of the harmonics is much below the fundamental wave, and decreases in the higher order harmonics. Careful and balanced design reduces harmonics to permissible amplitudes.

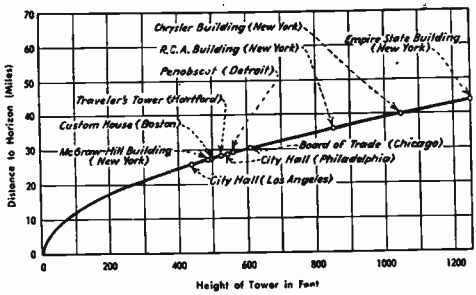
Hollmann Effect

If the frequency applied to the deflector plates of the cathode ray tube is in the order of 500 MC. the deflectional sensitivity will be impaired. This is due to the fact that the electron velocity is in the same order as the changing potential. Any one electron before traveling the space from cathode tc screen may be influenced in several directions. Hollmann effect is this noticeable decreasing deflection with increasing frequency of deflecting voltage.

Horizon Distance

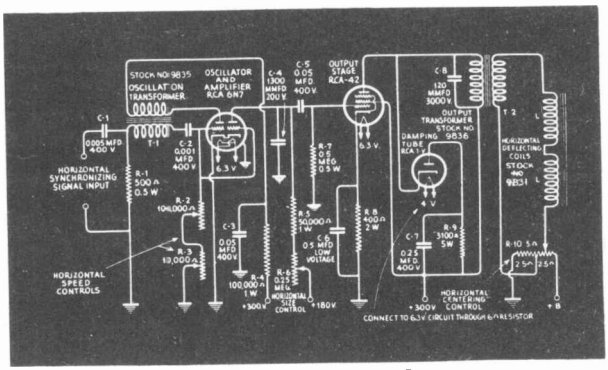
The horizon distance is the space between the furthest visible point from the antenna of the transmitter and the antenna itself. It is the distance over which the ultra high frequency transmission can be successfully received under ordinary conditions with the receiving antenna not elevated. With the N.B.C. transmitting antenna atop the Empire State Building, 50 mile radius coverage is possible. The formula below may be applied for quick calculation:

$$\text{Distance in miles} = 1.22\sqrt{\text{Height of antenna in feet}}$$



Horizontal Scanning

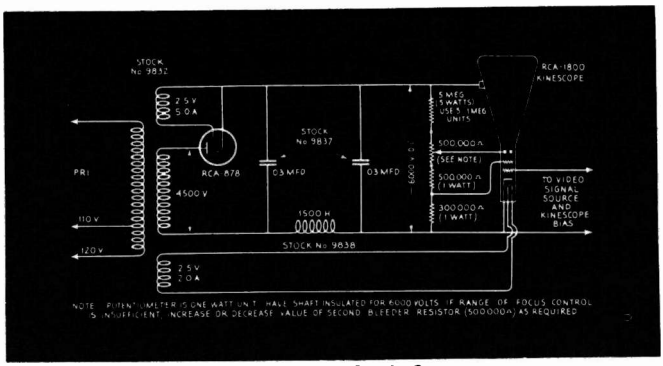
The method used to obtain 441 line horizontal scanning with fast fly back at the receiver, depends on the synchronizing impulses to control the oscillator of the deflecting circuit. See the R.C.A. circuit below.



RCA 1801 Horizontal Deflecting Circuit

Hum Distortion

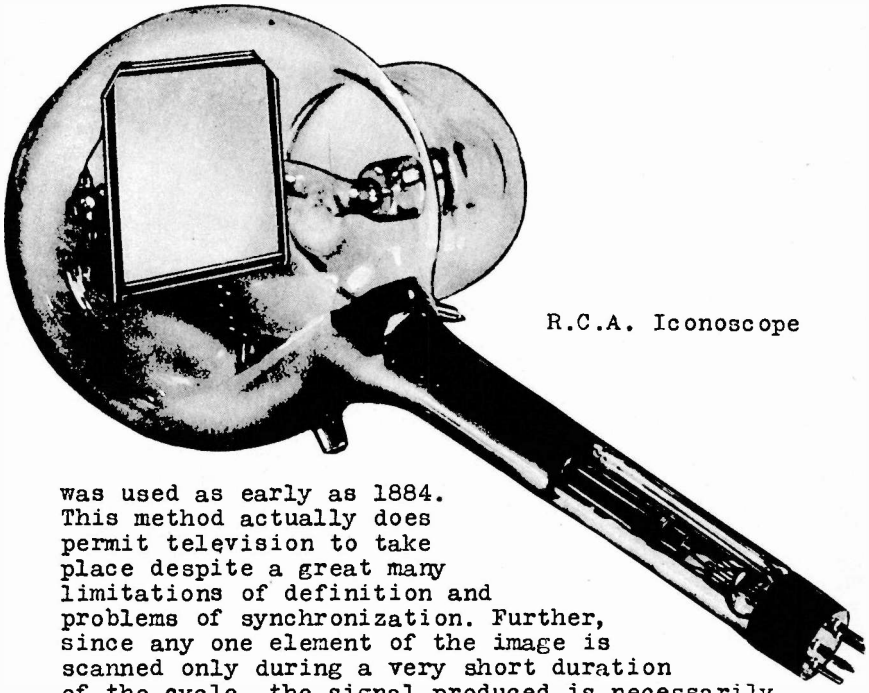
Hum distortion produces a picture having wavy sides and is due to poor filtering of the power line ripple. Good power filters and the use of 60 fields per second (where 60 cycle power line frequency is used) helps to eliminate this problem.



RCA 1800 Power Supply Circuit

Iconoscope

The television principle depends on the success of being able to subdivide any picture into a large number of elements, have these elements produce corresponding electrical energy, and after transmitting this energy have it produce once again the corresponding light images (elements) in the order that the picture was first divided. This, of course, requires photo-electric cell equipment for converting light energy into electrical energy. For dividing the image into a great many elements the Nipkow disc



R.C.A. Iconoscope

was used as early as 1884. This method actually does permit television to take place despite a great many limitations of definition and problems of synchronization. Further, since any one element of the image is scanned only during a very short duration of the cycle, the signal produced is necessarily very weak and considerable amplification is needed.

The Iconoscope is a successful solution to the problems presented by the earlier television methods. Consider a mosaic (see the meaning of this term) placed in an evacuated bulb, so that the light rays of the picture to be transmitted are focused upon this plate with the camera lens system. The light ordinarily strikes the mosaic at an angle and at right angles to the electron beam which is made to scan the mosaic in a regular predetermined order.

This electron beam, of course, is produced by the electron gun which is similar to the electron generator used in the receiving type cathode ray tubes. The actual scanning, according to the R.M.A. Standards is performed at the double interlaced rate of 30 frames per second, each frame having 441 lines.

Ordinary magnetic deflecting yokes are used to influence the beam for this purpose.

The main advantage of the Iconoscope over other methods lies in its ability to be controlled by the same scanning signals that are also transmitted by the carrier and serve to synchronize the receiving tube (Kinescope). Also any one group of photo-electric elements of the mosaic will be receiving the light and accumilating the electrons during that period of the cycle when the electron beam is scanning the remaining sections of the mosaic. This serves to give a larger corresponding discharge when the electron beam does scan the photo-electric element under discussion.

Image

The instantaneous illusion of a picture as it appears on a flat surface (the mosaic or a screen) is called the image. The image is a transient formation of light impulses from the electron beam, or vice versa. By means of secondary emission the intensity of the electron image can be increased.

Infra-Red Rays

The part of the invisible spectrum past the visible red wavelength is known as infra-red. These rays can be detected in several ways and have an effect on photographic film and the Icononscope. The use of these rays permits pick up of a scene in an apparently dark room.

Interference

Natural static has very little effect on ultra short waves and, of course, causes no difficulty to television transmission. Man-made static, however, does create disturbing results. Automobile ignition systems and diothermy equipment is especially bad and cause "snow" and other effects that spoil television reception.

Interlaced Scanning

A non-continuous type of scanning where the lines are scanned in some predetermined order. The more common is the double interlaced system, where the odd numbered lines are scanned first from top to bottom. Then the beam returns, scanning the even numbered lines also from top to bottom. This completes one frame and the process is repeated.

Interlocking

The process of forcing a voltage of one frequency to be in a definite step with a voltage of another frequency is called interlocking. The synchronizing line frequency voltage must be interlocked with the frame frequency voltage, so that the image scanning is carried out in the correct order.

Intermediate Frequency

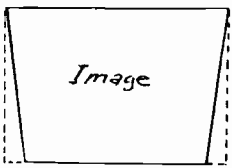
Intermediate frequency is so called because it lies between the carrier and video frequency (carrier and audio frequencies in radio equipment). It is the frequency produced in the mixer tube of the superheterodyne in combining the incoming signal and local oscillations. Numerically the I.F. is equal to the local oscillator frequency less the incoming station frequency. By changing the oscillator circuit in accord with the tuning circuits, the I.F. may be kept at the constant value needed.

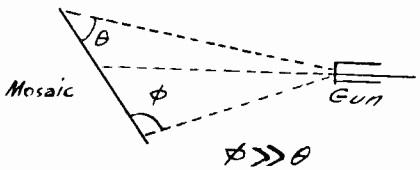
Ionization

An ion is a positively charged particle, i:e. one that lost one or more electrons. Ionization of a gas takes place when the moving electrons bump many particles and knock out many electrons. An ionized gas is conductive.

Keystone Distortion

Distortion producing an image having the outline shape of a keystone is due to angular placement of the mosaic in the pick up cathode ray tube. While this placement is essential this problem can be rectified by adjusting the transmitting equipment.



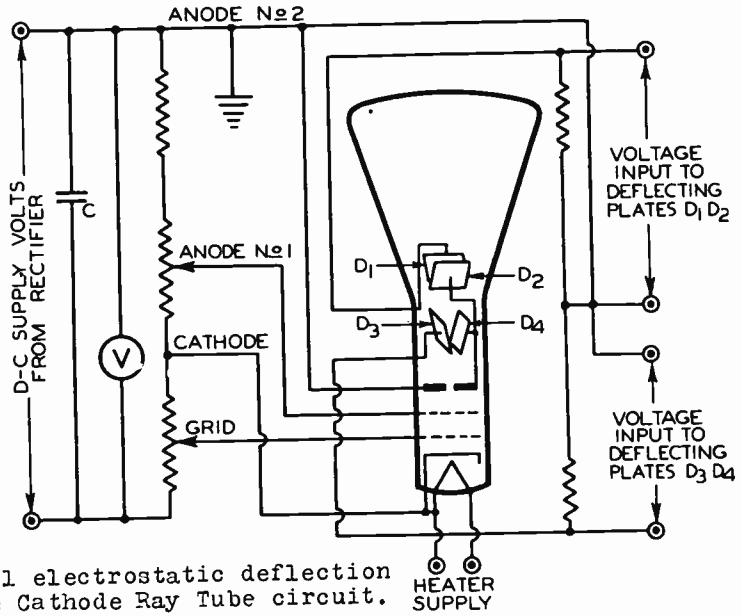


Kinescope (Picture Tube)

The Picture Tube (Philco's name) or the Kinescope (R.C.A. trade name) is also electron operated like the Iconoscope and is essentially a large cathode ray tube. It consists of an electron gun for creating an electron beam, and a grid to control the intensity of the beam in accord with the transmitted signal. A fluorescent screen is used to "create" the image under the electron bombardment.

RCA KINESCOPES

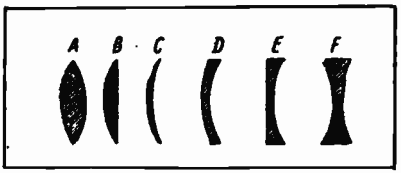
The electron beam is made to sweep across the fluorescent screen in synchronism with the scanning beam of the transmitting Iconoscope. The electron gun of the receiving tube is made to handle much larger currents and operate at a higher voltage. Also since the picture is reproduced by modulating the beam current, the control grid is much more critical. The control grid characteristic is determined by a number of factors such as the grid aperture, the spacing geometry of the cathode, the first anode, etc.



Small electrostatic deflection type Cathode Ray Tube circuit.

Lenses

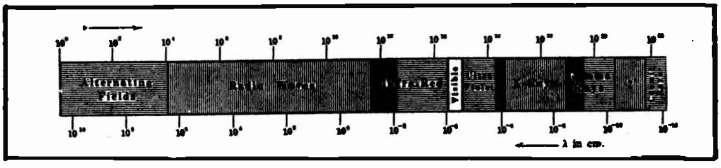
A lens may be defined as a portion of transparent substance bounded by two curved surfaces, or by one curved surface and one plane surface. Lenses are usually made of glass. They may be convex, thicker in the middle than at the edges, types A, B, and C; or they may be concave, thinner in the middle than at the edges, types D, E, and F.



Light Theory

From the early times when man has begun to pay attention to light, there has been a number of different explanations of this interesting phenomenon. As late as the beginning of the 19th century the corpuscular theory met with greatest favor. This theory assumed light to consist of actual small material particles which moved in straight lines. However, as far back as 1678, Huyghens introduced the wave theory of light. This theory with minor changes is today's accepted understanding of light behavior.

Probably you already have a fair understanding of electromagnetic waves used for radio transmission. These waves vary in length from a few inches to several miles. You will notice from the chart that the visible and invisible light waves are much shorter (have greater frequency) than radio waves. The visible spectrum is of course of greater importance to us, for it is here that light of colors we see exists.



Light is another form of energy radiated from luminous bodies. Luminous bodies radiate also ultra-violet, X-rays, and infra-red rays, but only "light" effects our sight.

The main natural source of light is the sun; the stars are also luminous bodies but are very far away and supply very little light to the earth. Many different artificial light sources are possible and are used. The incandecent lamp using electrical power is most common.

There are many bodies that seem to emit light but really are not luminous. For example, the moon only reflects light and is called an illuminated body.

Let us see what happens when light falls upon a body. Some rays may be reflected -- turned back. A mirror reflects a great deal of the light that strikes it. Some of the rays are always absorbed by the substance and this is especially true of dark objects. A part of the light may be transmitted through the substance. Bodies that permit an easy passage to light are transparent. Translucent bodies pass a good deal of light, but they diffuse the light and objects cannot be distinguished through them. Frosted glass is translucent. Opaque substances do not transmit light.

We have used the term, "a ray of light." Just what does it mean? A single line of light coming from a point on a luminous body is called a ray. Several rays expanding or converging form a pencil of light. Parallel rays form a beam.

The fact that an opaque body forms a shadow serves to illustrate that light travels in a straight line. (Light may not travel in a straight line if the source or the obstacle is not much larger than the wavelength of light).

Lines

The horizontal scanning subdivision of the picture is called a line. The use of a large number of lines increases the definition, but also increases the technical problems of transmission. The scanning disc of the old television days used 48 lines; modern television uses 441 lines, although as late as 1936 experimentation was carried on with 333 line scanning.

Lumen

The lumen is the unit of light (luminous) flux and is equal to the flux emitted in a unit solid angle by a point source of one candle power.

Magnetic Field

The magnetic field is created by the magnetic coils that are used to sweep the electron beam in accord with the synchronizing impulses received from the transmitter.

Magnetic Sensitivity

The relationship between the voltage impressed on the magnetic deflecting coils and the space the electron beam describes on the screen determines the magnetic sensitivity.

Micron

A micron is a measurement of very short lengths. One micron is equal to 1/1000 of a millimeter.

Mirror Drum

A scanning device for low definition television using mirrors and rotated at high speed is known as the mirror drum. British magazines still carry articles about units of this type, but in America mechanical television of this type is not used.

Mixer Tube

As in radio superhet circuits the mixer tube performs the function of combining the incoming signal and the signal generated by the local oscillator. A single tube may perform this mixing and also serve as the oscillator, or a separate oscillator may be used. This tube is also known as the first detector.

Modulation

Modulation is a process of controlling the amplitude of the carrier wave in accord with the intensity of the audio or video signal. The ideal performance is obtained when this amplitude is varied from zero to twice its unmodulated value. This is known as 100% modulation. Of course, in the R.M.S. Standard, negative modulation is used, so that a bright image element will produce a lower amplitude carrier. At the receiver a process of demodulation at the detector takes place and separates the video (or audio) from the carrier.

Molecule

Molecule is the smallest particle of any substance that still retains the physical and chemical characteristics of that substance. A molecule consists of one or more atoms of one or more elements. Sometimes two entirely different substances may have similar chemical elements, but have the atoms arranged in a different order.

Mosaic

Light receiving element of the Iconoscope is called the mosaic. It consists of a very large number of photo-sensitive particles mounted on a thin sheet of mica or a coating of vitreous enamel, and these particles are insulated from each other. In case mica is used, the back is coated with conducting metallic film. If vitreous enamel is used, it is painted on a metal plate. In one type of mosaic the silver globules are formed by reducing particles of silver oxide dusted over the mica. Under proper treatment,

the silver particles will form individual droplets. These droplets are photo sensitized with cesium vapor. Photo-electric response similar to that of a high vacuum cesium photo cell is obtained.

The mosaic is mounted in the tube with the photo sensitive side facing the electron beam and light rays from the object.

Motion Picture Reproduction

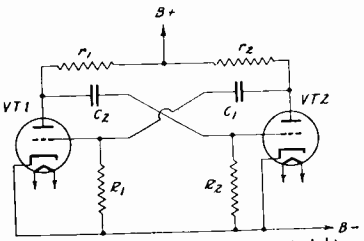
Since the hook-up of television stations presents many problems and also since the programs must be economical in production, motion picture reproduction is commonly used for television. Regular type projectors may be used, but more commonly special projectors are employed for minimum flicker.

Multiple Scanning

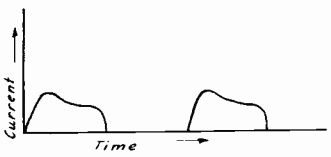
Multiple scanning is another name for interlaced scanning. In United States double interlaced scanning is used.

Multivibrator

The multivibrator is one form of a relaxation oscillator used to control scanning at the television transmitter. One of its simpler forms is nothing more than two capacity-resistance coupled amplifiers, so connected that the output of one is coupled to the input of the other, while the output of the second is coupled to the input of the first. This type of oscillator employs no inductance and was originally due to Abraham and Bloch as described in "Comptes Rendus" in 1919.



Basic circuit above. wave pattern at right.



The wave pattern.

The basic circuit of such a simple multivibrator is shown. On first examination it would seem that upon connecting the filament and plate supply, the two tubes would draw steady current. However, this is far from what actually takes place. The circuit oscillates violently, producing waves that approach a square shape. This represents sudden rise and fall of current and is exactly what might be expected from a closer examination of the circuit.

Once the circuit is connected a steady current will begin flowing through the two vacuum tubes and the associated plate resistors r_1 and r_2. Suppose that through some outside disturbance (no matter how minute) the current through r_1 is increased. Since the voltage drop across this resistor is equal to the product of the resistance by the current, the voltage across r_1 will increase with the increase of current.

The condenser C_2 will act as a short circuit for the sudden change of voltage, and a higher negative voltage will be placed on the grid of VT-2, reducing the current through it.

You can see that the increase of current in one tube will decrease the current in the other, so that the reduction of the plate current in VT-2 will further increase the current in VT-1 and resistor r_1. This action will continue until finally, in this case, VT-1 will have a maximum current limited only by the emission, while VT-2 will have such a high negative potential on its grid that it will be entirely blocked.

This action takes place during but a fraction of the total cycle and accounts for the sharp rise of the plate current. At this stage, when one tube is not passing any current and the other is passing the maximum current, the circuit is no longer symmetrical and the condenser begins to discharge. This discharge continues until the blocked tube begins to draw current and then the entire action repeats in the second tube.

These oscillations by the proper design may be made to appear at any frequency between 50 KC. and 1/50 of a cycle per second. The period is proportional to the product of the capacity and resistance.

The sharp corners of the plate current curve, of course, indicate the presence of a large number of harmonics. As high as the fiftieth harmonic is detected with ease. This presence of many harmonics and the fact that a multivibrator will lock in step with any frequency that is a multiple of its own approximate frequency, makes it adaptable to other applications besides the use as a special wave generator for television scanning circuits.

Negative Image

A negative image occurs when the voltage is applied nearly 180° out of phase. The light sections then appear dark and the dark parts appear white.

Negative Modulation

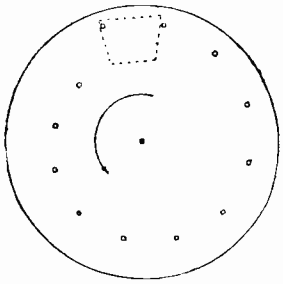
Negative modulation is used in America's present day television system. Black corresponds to greatest amplitude of the modulated carrier, and white reduces the carrier to nearly zero intensity.

Neon Bulb

Any glass tube filled with neon gas and having two insulated electrodes constitutes a neon bulb. This type of bulb was used for receiving television sets of the mechanical type since neon bulb illumination will follow without much lag the impressed signal.

Nipkow Disc

A Nipkow disc was named after its inventor and is any revolving disc having openings (apertures) so placed as to scan the image.



Optics

Optics is the study of light. It includes the origin, behavior, and effect of light at different frequencies. Electron optics deals with the behavior of an electron beam under the influence of varying electrostatic field. This action is similar to the behavior of light in a lens system.

Origin Distortion

Origin distortion may be experienced in a gas filled cathode ray tube with regular deflecting plates. Bright cross lines appear in the center of the screen. Since modern tubes are of the vacuum type and magnetic deflection is used this problem is not important.

Panchromatic

A panchromatic substance has an equal response to all colors of the spectrum. This term is used in studying cathode ray screens.

Partial Image

In modern television a partial image is almost impossible. If the synchronizing is off a jumble of streaks will result. A partial image may occur if fly back time is too large (much larger than 15% of the horizontal scanning time).

Persistence of Vision

Persistance of vision is the name of the phenomenon that permits the human eye to retain an image for a short time after the actual rays have disappeared. There is an actual sluggishness or time lag in the action of the retina and optical nerve. When a series of pictures, each showing a slightly different view, is moved in a rapid succession, the eye receives the illusion of life motion. These changes must occur at least sixteen times per second. A flicker, however, will be noticed at this speed and motion pictures use the rate of twenty-four pictures per second. In television thirty frames per second are used. Persistance of vision is very important in television for it permits us to see images with motion when actually the electron beam scans line after line of each frame.

Phasing

Phasing is taken to mean "to bring into phase" or synchronize. In the old mechanical television receivers phasing was performed manually. In the present day television sets, of course, the scanning is synchronized automatically with the transmitted signal.

Phosphorescence

This term is described under AFTERGLOW.

Photo Cell

A photo cell is a device for changing light intensity of color variations to corresponding electrical energy. The ordinary radio type vacuum tube emits electrons because the cathode element is heated. Photo active substances, on the other hand, depend on electron emission caused by the peculiar reaction of certain metals when in the presence of light rays. These metals include caesium, lithium, potassium, and sodium. Usually the hydrides and oxides of these metals are used. The sensitivity to different colors and the general reaction characteristic of any substance depends on the emitting material used as the cathode and whether the cell is of the vacuum type or contains a small amount of some special gas.

Under ordinary conditions when a piece of photoelectric active metal is exposed to light, the emission of the electrons is retarded by the large atoms of the gases forming the atmosphere. But if the metal is placed in a vacuum and a beam of light is allowed to strike the metal, the electrons will be thrown into the surrounding space. The number of electrons emitted will be proportional to the intensity of the light. Stronger light will cause a greater number of electrons to be emitted.

The mosaic of the Iconoscope tube consists of a great many tiny photo cells and makes the study of photo activity important to the student of television.

Picture Element

A picture element is that small portion of the image that is determined by the instantaneous value of the beam coming from the electron gun. Also see ELEMENT.

Picture Frequency

Picture frequency is the number of times the complete image is scanned each second. It corresponds to the number of frames.

Picture Ratio

The picture ratio is the English name for the aspect ratio. It is the ratio of the picture's width to the height. (This is 4/3 in the R.M.A. Standards.)

Picture Tube

This is a term used by Philco and others to describe the receiving television tube. Such tubes are listed under KINESCOPE.

Prism

A prism is a piece of glass having two of its faces not parallel. It is usually triangular in shape. If a beam of light is passed through, it will be split into several colors of the solar spectrum. This proves that white light is made up of several colors. The violet light is refracted more in passing through the glass than the other colors, since it has the shortest wave length. The red rays are bent least in passing through the prism. The separation of composite light into several colors is known as dispersion.

R.M.A. Standards

In order to have successful television reception, the receiver must be interlocked (be in phase) with the transmitter. This synchronization must be standardized, for a radical change in transmission practice may make all existing television receivers obsolete. Therefore, a set of standards have been worked out by the Radio Manufacturers' Association. These standards are sufficiently broad to permit improvements in the future, and yet assure the purchasers of television receivers of many years of service and the possibility to receive all television programs within range.

It was decided to use but a single side-band transmission and allow a 6 MC. channel for each station. This channel was to include also the small band needed for corresponding sound transmission. Seven of these channels are included between 44 to 108 megacycles. Between these frequencies there are also other ultra high frequency channels for communication purposes. There are also additional channels for television relay stations, remote pick-up rebroadcasts, and link stations.

The video (television) carrier and audio (sound) carrier are separated by 4.5 MC. At the upper end there is also a blank .25 MC. band used to assure proper separation between adjacent channels.

Negative modulation is used. (See the meaning of this term). The 441 line scanning aids to good definition of the picture. To eliminate flicker, 30 frames per second has been decided on. The vertical scanning frequency, field frequency, is 60 per sec., since double interlaced scanning is employed. The selection of 60 fields minimizes 60 cycle "hum" distortion.

Since negative modulation is used, black level corresponds to maximum video modulating signal. Very bright light reduces the carrier to zero amplitude. The line and frame synchronizing impulses must be transmitted as carrier values higher than the black level. These impulses are to be between 20 and 25% of the maximum carrier amplitude. The function of these, of course, is to synchronize the receiver and the transmitter.

At the end of each line we have a horizontal synchronizing impulse to retrace the electron beam and to blank out the view of this retrace. Since one line occupies a time element called H, this impulse will occur during a small fraction of H. R.M.A. Standards provide 15% of the time, i.e. .15 H for this purpose. The actual synchronizing impulse occupies about one-half the blanking time.

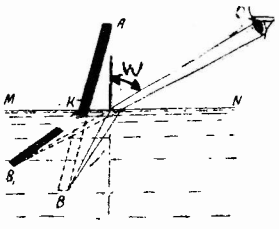
The vertical scanning impulse lasts during three lines, 3H, but is made up of six small pulses to maintain horizontal scanning at all times. These six impulses are needed to keep horizontal line synchronization active in the double scanning system used. Also six equalizing impulses precede and six follow the vertical impulse period. Since the circuit cannot be changed suddenly from one frequency of operation to another, these impulses serve to prepare the circuit for the vertical (subdivided) impulse after horizontal impulses, and vice versa.

Reflection

Reflection occurs when the light rays strike a body at an angle greater than the critical angle. If we view an object under water, looking at it from an angle close to the perpendicular, it will appear further from the perpendicular line than it really is. This is due to refraction. The critical angle for water is 48.5°, and light striking the water at a greater angle will be totally reflected.

Refraction

The bending of a ray of light out of its course as it passes obliquely from one medium into another of different optical density is called refraction. When light passes obliquely from a medium of lesser to one of greater optical density, it is bent towards the perpendicular. And conversely, when light passes from a denser to a rarer medium, it is bent away from the perpendicular to the surface.



In the illustration, AKB is a rod placed partially in water with a surface MKN. The angle W is called the angle of incidence. The rod under water will appear to occupy the place KB_1. Light rays coming from the water are bent away from the perpendicular, but the object appears to lie in the water in a straight line of vision.

Retentivity of Vision

The continuation of a view after it has in reality disappeared is the retentivity of vision. It is due to the time lag in the human eye. See the meaning of persistence of vision.

Retina

The back surface of the eye is called the retina. The structure of the retina is very complex and it is here that light impulses activate nerve centers.

Return Trace

The return trace is the movement of the electron beam back to its starting position. Usually the view is blocked out during the return trace. See the meaning of Fly Back.

Scanning

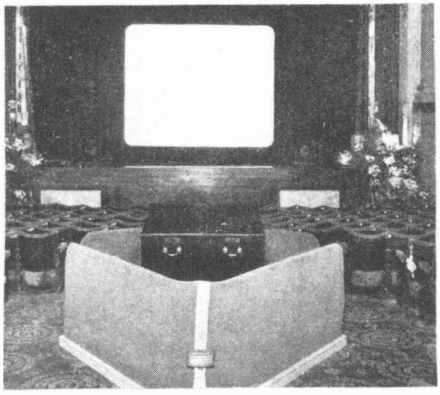
The process of subdividing the image into line elements is called scanning. This may be accomplished mechanically, but at the present time the superior electrical scanning method is used.

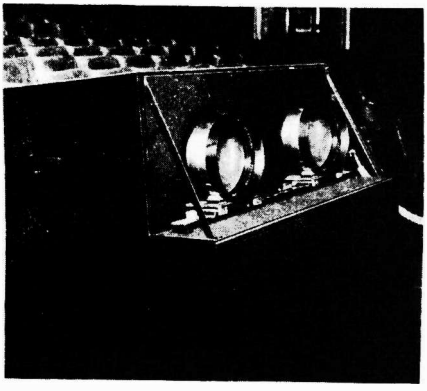
Scanning Spot

The spot formed by the beam of the electron gun is the scanning spot. It may be about 1/50 of an inch in diameter and covers a great many photo active globules at one time.

Screen

The screen of a cathode ray tube is made of phosphorescent material. Projection of television images on a large screen is also employed. See the illustration of an English system of this type.





Secondary Emission

The effect of electrons dislodging other electrons from the plate causes secondary emission. While sometimes this phenomenon is useful, as in the case of the dynatron oscillator, ordinarily secondary emission is not wanted. In pentode tubes the suppressor grid is used to limit secondary emission and in cathode ray tubes precaution for this purpose must be taken.

Shield (Cathode Ray Tube)

A shield is used in cathode ray tubes to concentrate the electron beam through the opening of the anode and prevent loss of electrons. The shield is placed around the cathode.

Shot Effect

Shot effect was analyzed by Schottky and is due to non-continuous emission of electrons. The number of electrons leaving a cathode during any very short interval will vary and produce noticeable distortion. As an example in one text-book, it is said that a tube having a load resistance of 100,000 ohms shunted by a capacity of the wiring equal to about 5 mmfd., at an average plate current of one milliampere, and having an amplification factor of 100, will have a

shot effect that will produce the same results as a disturbing input voltage of 8 microvolts. In practice the theoratical calculated values of shot effect are reduced because of space charge.

Side-Bands

The side-bands are the two channels on each side of the carrier and are created by the modulating frequency. In sound broadcasting each side band is five kilocycles wide. In television transmission a single side-band is used and is up to about 4.5 megacycles wide.

Sound Channel

The sound channel is the band used for audio transmission in connection with the television program. The sound carrier is 4.5 MC. above the video carrier.

Spot Size Distortion

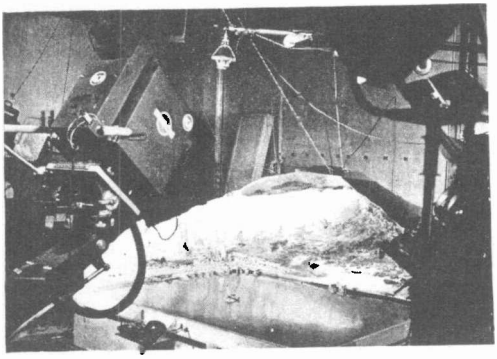
Since the scanning spot is round in shape and since a number of globules may lie on the border line, a limited distortion will be introduced. The ideal spot would be rectangular in shape having the ratio of 4/3 (the same as the aspect ratio), and be 1/441 of the mosaic in height.

At the receiving cathode ray tube the actual size of the spot may be influenced by the intensity control although for ideal results this control should only control the brilliancy.

Stroboscopic Effect

The eye can distinguish a single scanning line if blinked quickly. This stroboscopic effect makes the line scanned during the instant the eye is blinked to stand out above the rest. Horizontal scanning makes this effect less noticeable than vertical scanning.

Studio (Television)



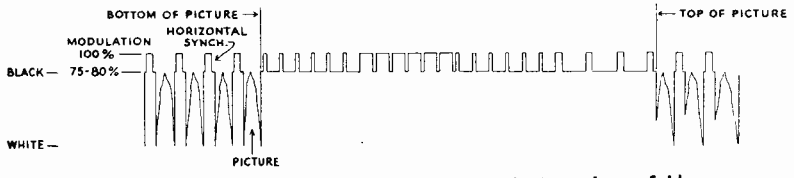
Special studios are required for television. Not only must these be suitable for sound, but they must also provide the needed light and background for television pick up. The motion picture practice is used and many tricks of the "older brother" are employed. Notice, for example, the miniture realistic set up.

Sweep Voltage

The voltage used to deflect the electron beam is called the sweep voltage. It may be applied to either magnetic deflecting coils or electrostatic plates.

Synchronization

An automatic method is used to synchronize the movement of the electron beam at the receiving Picture Tube with the movement of the beam at the transmitting Iconoscope. The synchronizing signals are superimposed on the carrier. See the illustration and the read the explanation under R.M.A. Standards.



Picture, synchronizing and blanking signals near bottom of one field.

Television

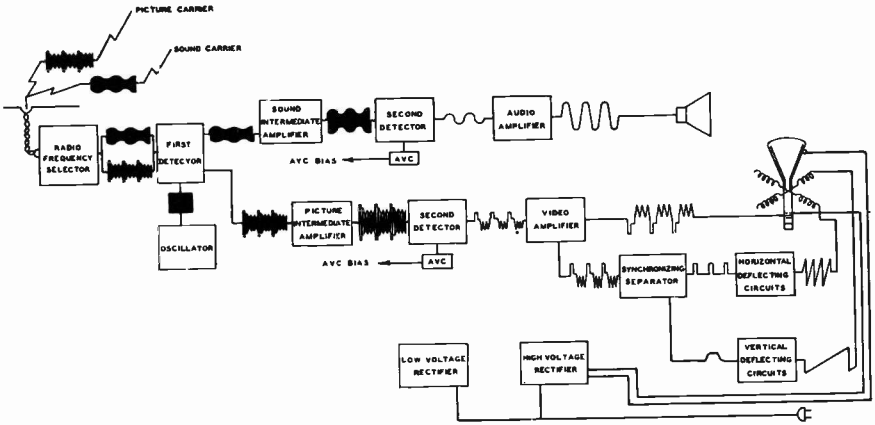
Television is the name for the method used to transmit views of changing scenes to a remote point using radio waves as the carrier. At present television is commercially possible and transmissions are being carried in many cities. The general theory of television is given in the appendix.

Television Receiver

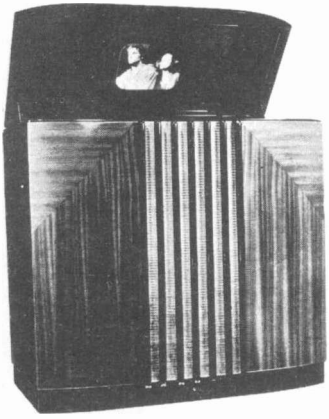
Several different types of television receivers have already been placed on the American market. First of all television sets should be classified as being able to receive both video and sound channels without any other equipment, or requiring the use of a regular radio set and including only the video receiver and sound channel converter. The sets may be described as using different size Picture Tubes and either of the direct viewing type or employing mirrors. Many types of both European and American makes are illustrated.

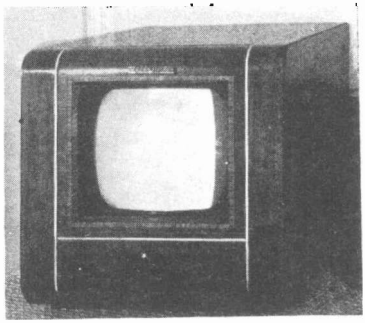
Time Constant

A value of time required for a fully charged condenser to discharge to about 37% of its peak voltage is the time constant. The actual value is proportional to capacity and resistance of the circuit.



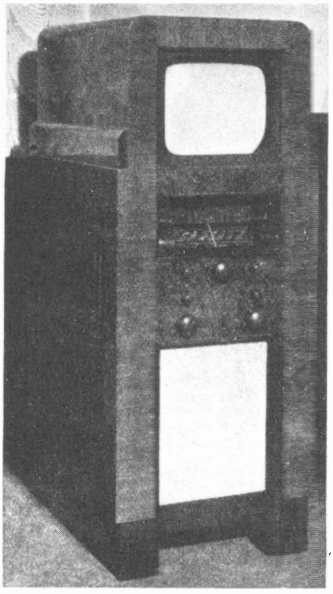
American Make



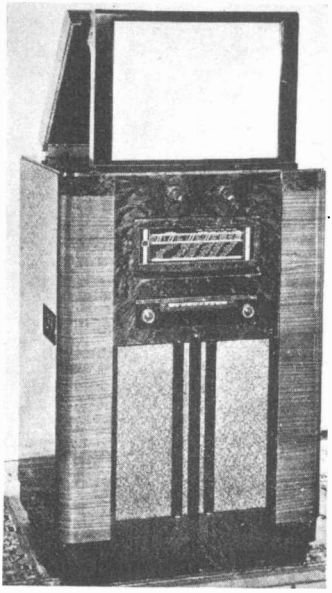


The Telefunken small home receiver

German Make

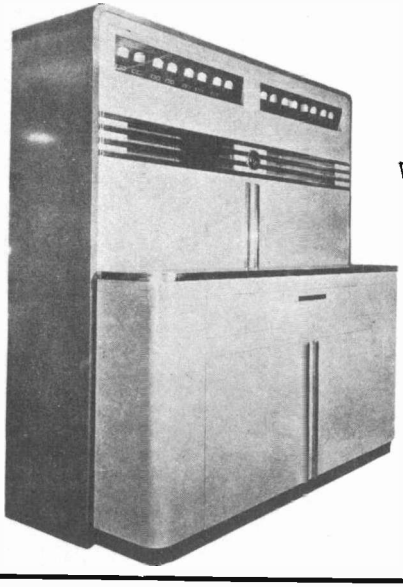


Ferranti Console T4.



Philips C.R. Projection.

English Make



R.C.A. 1000 watt
Video Transmitter

Trapezoid Distortion

Trapezoid distortion is formed because of interaction between the vertical and horizontal deflecting coils (or plates). With this distortion present the outline of the picture forms a trapezoid instead of a rectangle.

Ultra High Frequency

Transmission below 10 meters (30 MC.) is considered of the ultra high frequency type. Since the first television channel lies between 44 and 50 MC. the action of ultra high frequencies applies to television transmission.

Vacuum

A vacuum (lack of air) must be created in tubes to prevent the cathodes from burning out and causing the electron beam to behave erratically. Even the best obtainable vacuum has some gas present and, of course, the corresponding pressure. In a cathode ray tube the pressure is about 10^{-16} mm. of mercury. Since no single pump can create such a vacuum, several must be used together.

Vacuum Tubes

The understanding of vacuum tube operation is important to the student of television since these tubes form the back bone for all radio and television circuits. The basis of all vacuum tubes' operation, be they rectifiers or multi-purpose tubes, in glass or in metal envelopes, is electron emission. Electrons are emitted from an electrically heated filament or from a cathode placed over this filament and insulated from it. This later type of emission is called indirect. Some substances are far better emitters than others. Coating a poor emitter with an oxide of certain metals may raise the emission thousand times.

In 1883 Thomas Edison discovered that when an additional electrode was placed inside an incandescent lamp and this electrode connected to a positive potential with respect to the filament, a current passed through the circuit. This was actually a simple vacuum tube of the diode type. It contains but two elements, the cathode to emit and the plate (anode) to receive the electrons. Under the influence of a positive potential applied to the plate, electrons will flow from the cathode to the positive plate. An increase in the plate potential will increase the plate current. This complete action is easily analyzed.

From a heated cathode many electrons venture out, forming a cloud around it. If a negative potential is applied to the plate, the electrons around the cathode will be repelled back into the cathode and no current will pass between these elements. If, however, the plate becomes positive with respect to the cathode, the electrons around the cathode will be attracted to the plate, since unlike charges attract, and current will pass. In a rectifier an alternating current is applied, during the positive cycle current will flow, but not during the negative. In this manner the alternating current will be rectified into pulsating direct current.

Of the electrons leaving the cathode not all, of course, reach the plate. Many return to the cathode while others remain for short periods of time between the cathode and plate forming a space charge.

Since this charge consists of electrons it is electrically negative and has a repelling force exerted upon other electrons and, thereby, impedes the passage of current between cathode and plate. By increasing the plate voltage, more electrons will be attracted and the tendency to form a space charge will be reduced.

Once the plate voltage reaches a certain maximum, when all the electrons leaving the cathode are attracted to the plate, a further increase of the plate voltage will have no effect on the plate current.

Tubes having a third electrode for control purposes are known as triodes. This control electrode is the grid and is made of fine wire in a form of a mesh. The purpose of the grid is to control plate current. With a negative voltage applied, the grid exerts a force on electrons and drives the electrons back to the cathode. In this way, the negatively charged grid opposes the flow of electrons to the plate. When the voltage on the grid is made more negative even stronger repelling force will be present and less electrons will reach the plate. In this way the grid can control the plate current.

The grid, plate, and cathode of a triode form an electrostatic system, each electrode acting as one plate of a small condenser. The capacitance between grid and plate is of greatest importance and prevents proper operation at high frequencies.

A much smaller change in the grid voltage will produce the same change in the plate current as a much larger plate voltage change. The ratio of the small change in plate voltage to the smaller change in the grid voltage that will produce the same variation in the plate current is called the amplification factor of the tube.

The plate resistance of a tube is the resistance to the alternating current of the path between the plate and the cathode. It is the ratio of a small change in plate voltage to the corresponding change in the plate current.

The detrimental effect of the grid-plate capacitance mentioned may be reduced greatly by the introduction of a fourth electrode, called the screen grid, placed between the grid and the plate. This screen in ordinary application is connected to a positive potential somewhat lower than the plate potential.

Electrons striking the plate dislodge other electrons from it. This indirect emission is known as secondary emission. In the diode or triode this action does not cause any difficulties because of the absence of any positive bodies in the vicinity of the plate. In the screen grid type tetrode, however, the screen is positive, placed close to the plate, and does attract electrons emitted by the secondary emission action. This effect lowers the plate current and limits the permissible plate swing.

This limitation in turn may be removed by a further introduction of another electrode, known as the suppressor, between the screen and the plate. Since such tubes have five elements they are called pentodes. A beam power tube uses a different principle of secondary emission suppression and while it has but four electrodes, it acts as a pentode.

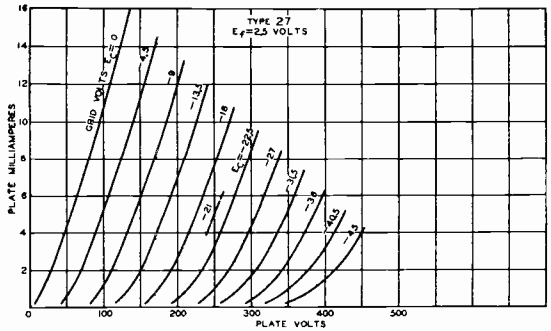
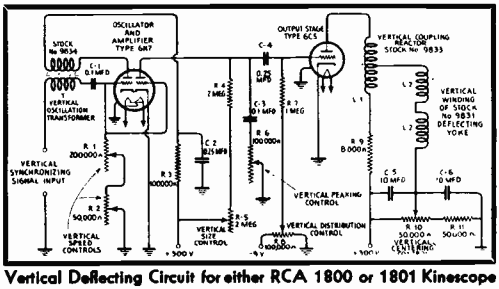


Plate characteristic curves are useful in determining the best operating conditions of a tube. The plate current is plotted as the ordinate, and the plate voltage as the abscissa. Keeping the grid potential fixed at some value, the variations in plate voltage are plotted against the corresponding variations of plate current. By repeating this process for a number of different grid potentials, a group of similar curves is obtained, as illustrated for a type 27 tube.

The functions of vacuum tubes are varied. In a receiving radio set vacuum tubes are used primarily as voltage and power amplifiers, and to a limited extend as detectors and oscillators. There are also special tubes and tubes combining several functions.

Vertical Scanning

The process of shifting the electron beam downwards after each line scan and then returning the beam to original position is vertical scanning. Vertical scanning is interlocked with the horizontal scanning and, of course, in the receiver depends on the incoming synchronizing impulses.



Vertical Deflecting Circuit for either RCA 1800 or 1801 Kinescope

Video Amplification

The amplification at video frequencies presents new problems not found in designing radio circuits. Frequencies up to four and one-half megacycles must be handled without noticeable distortion. This calls for special tubes and other component parts. These circuits are of the resistance coupled types with phase correction. A late article on this subject appeared in "R.C.A. Review" for January 1939.

Video Receiver

Several "television" receivers have been placed on the market capable of receiving the video signals only -- no associated audio. The audio carrier is received on a separate short wave converter which produces an I.F. frequency corresponding to a wave band not usually employed and receivable on the regular house radio. The house radio than serves as the I.F. and audio amplifier. Economy of price is made possible because of saving in parts.

Voltage Gain

Voltage gain of any part or circuit is the ratio of output voltage to the input voltage. In a tube it is equal to the amplification factor. But in any stage the gain is a fraction of the tube's amplification factor and depends on the circuit.

Work Function

An electron to leave a hot body must overcome a certain boundry force before it can pass through the surface of the body. The amount of work to be performed in overcoming this force varies for different substances and is called the work function of that material.

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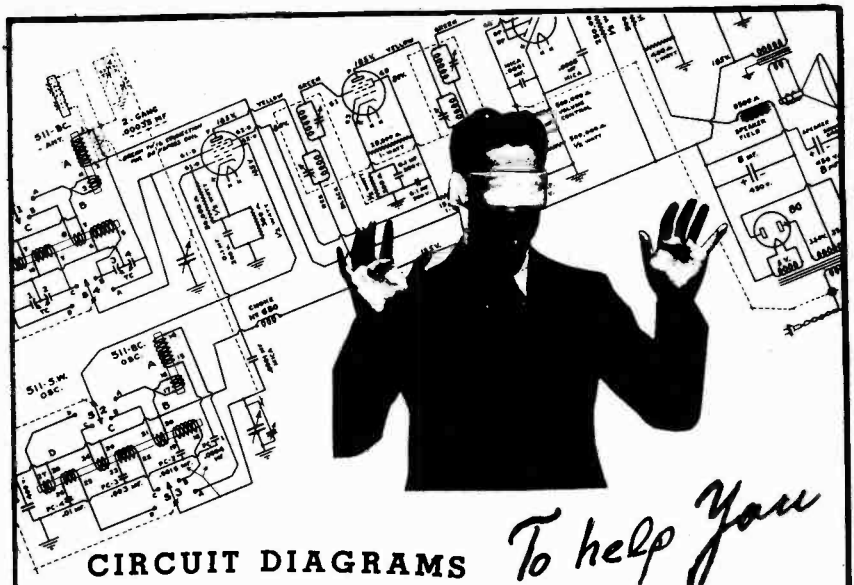

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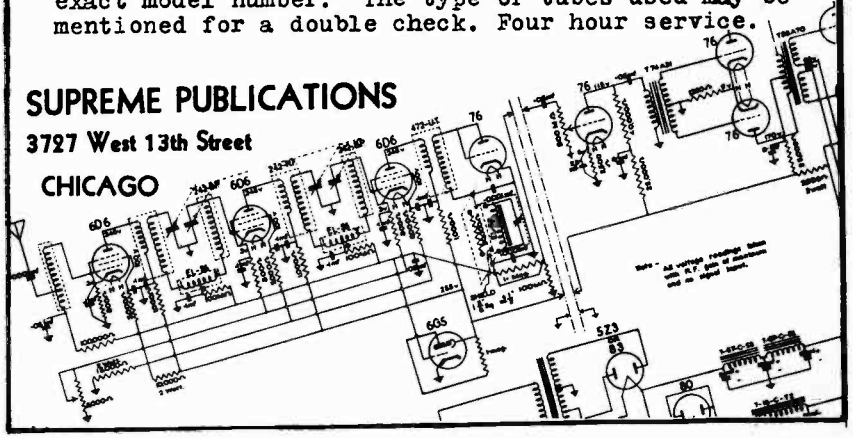

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