The Sun
Television Data Sheets

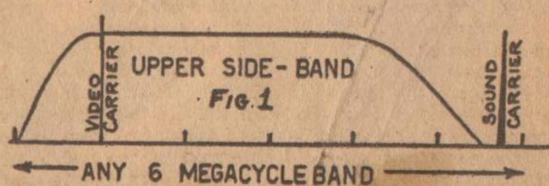
Compiled by RALPH R. BATCHER.

SINGLE SIDE-BAND RECEPTION

A

Television will emerge from an experimental status when all the system standards are definitely established, so that purchasers of receivers will not be required to make frequent changes in the apparatus as improvements are inaugurated, or would not be permanently tied down to a lower quality system because of the difficulties in making major changes. Heretofore all tests have been made with a 3.25 megacycle separation between the video and sound carriers located within the 6 megacycle band allotted for each transmitter (see sheet 200.4—Fig. 1). If full use is made of the quality afforded by a 441 line picture, or a greater number of lines, it has become evident that a video frequency range greater than the 2.5 to 3 megacycle limits afforded by this standard, must be arranged for. In the above mentioned figure, it is seen that if a band width greater than 2.75 megacycles is attained, interference might be caused in the sound channel of a station using the adjacent 6 megacycle carrier range (or in whatever service that channel happened to be used). Then if a 3.25 megacycle video frequency were reached the signal would also interfere with its own sound channel.

While it is doubtful if those individual pulses in the video carrier that happened to fall within the rather narrow range of the sound I. F., would cause much audible interference, nevertheless the sound signals would affect the picture, if the video stages were broadened to receive the wider limits.



The logical solution is to use single side-band reception, and to move the video carrier away from the associated sound carrier, as shown in Fig. 1. This separation is to be set tentatively at 4.5 to 4.75 megacycles in a series of tests to be conducted later, so that the advantages and disadvantages of transmitting and receiving only one of the sidebands of the video signal can be studied. The changes in the receivers necessary to do this involve a slight shift of the superheterodyne circuit oscillator, and a shift of the sound I. F., to a new value in the single operation tuning (for both sight and sound) type of circuit.

Sheet 350.1.
(To be continued.)

The Sun

Television Data Sheets

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SINGLE SIDE-BAND OPERATION

The cathode ray tube in a television receiver is a voltage operated device, and the brilliance of the spot is controlled in accordance with the rectified output of the video i—f amplifier. In the usual double side-band system two frequencies are always present to represent any given picture element. The rectifier does not discriminate between frequencies, so that the output potential represents the sum of both the individual amplitudes.

But it happens that the two pulses representing the picture element do not travel through the amplifier at equal speeds, due to a phase delay in each stage, even though they might start out together. In fact, they can separate enough to cause two distinct spots on the scanning line. For example, consider a 1.2 megacycle pulse in the video signal representing a particular change in light intensity on a scanning line. Assuming a 12 megacycle i—f carrier, two frequencies would result VIZ., 10.8 and 13.2 megacycles, both of which would be applied to the detector, but in an amplifier of a typical design with a time difference of around 1.5 microseconds. The cathode ray spot might have traveled 0.2″ along the scanning line during this interval so that the original shade effect that originated the pulse would appear twice in the picture, and a certain amount of confusion results. In single side-band operation a given picture element is represented by only one modulation frequency, so that any delay will not cause a double registration.

The adjustment of a video receiver to take care of a change to single side-band operation is very simple if the i—f stages are coupled by the usual broadly tuned double winding transformers, the type of coupling most popular in receivers built by experimenters. As shown in sheet 350.1 the video carrier would be shifted in the band, but a slight change in the oscillator tuning would place the video carrier on one side of the i—f transformer resonance curve (which is so flat that the peak is scarcely noticeable anyway), so that the increased range in the video band can be handled. It is quite possible that each stage can be made more selective by increasing the value of the shunting resistance. This would result in a greater gain per stage.

Sheet 350.2.

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Television Data Sheets

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RANGE OF TELEVISION SIGNALS

The idea prevails in many places that radio waves shorter than about ten meters, cannot be transmitted beyond the horizon as viewed at the height of the transmitting antenna. While there is some basis for this generalized statement, actual conditions are not so hopeless for those who reside beyond this magic circle around a transmitter, according to data which is being accumulated by many investigators.

Some of the most important checks of the short wave propagation are being made by radio amateurs working on the 60 and 120 megacycle bands. While this data is still too incomplete for a full knowledge of the problem, the following facts are acceptable:

Reception of ultra-short wave signals in the area within the horizon is mainly by the direct ray, or by a reflected ground ray, and the received signal energy follows the usual square law of attenuation. Actually, however, energy is picked up and re-radiated by many metallic objects which accidentally have lengths which relate to the wave length of the wave received, so that in metropolitan areas the radiation pattern can never be determined accurately. The attenuation caused by absorption of miscellaneous conductive masses such as buildings, &c., also cause abnormal losses, so that less signal intensity levels are always found where measurements have been made.

The horizon, for an antenna on a building as high as the Empire State Building (980 feet above sea level) is around forty miles in any direction, but this distance is increased somewhat by the height of the receiving antenna.

In view of the relatively greater difficulties of amplifying signals at frequencies of the order of 50 megacycles, it is desirable to take full advantage of all possible improvements that can be obtained by antenna design and installation. Such factors include the height from the ground, the length of the conductors (a dipole of some type is usually used), spacing of the leadins, whether the conductors of the dipole are stretched perpendicular or horizontal with regards to the earth (or at some intermediate angle) and various factors that affect directivity. All will be considered in later sheets.

The Sun

Television Data Sheets

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RANGE OF TELEVISION SIGNALS

In the reception of television signals it is desirable to be able to pick up sufficient energy to operate the television receiver without utilization of reflected sky waves. While these waves frequently account for extremely long transmission distances the effect is very haphazard and therefore undependable for television reception at the frequencies set aside for this purpose. The erratic nature of this reception medium also causes multiple reflections which have the effect of adding ghost images to the received pictures. Here the true picture appears on the television screen accompanied by a duplicate offset from the original by a certain amount. If the time difference between the signals received over the multiple paths is less than about 75 micro-seconds the ghost image will appear displaced horizontally only, but if a greater time difference occurs a diagonal displacement may be noticed.

A one micro-second difference between the arrival times of signals over the two paths represent a path length difference of some one-thousand feet or about 20 wave lengths. A delay of one micro-second would cause the image displacement of about one-tenth of an inch, enough to cause annoyance.

With longer wave lengths than those used in television, rapid fading, skip distances, multiple echoes, are important items in communication problems, but by restricting television reception to distances that can be covered by the direct rays—the line of sight rays—and to the ground waves that extend several times as far before they are attenuated so much as to be usable, such factors will not have to be considered. unusable

For best results, one factor that must also be considered is the eliminating of local interference, mainly from the ignition systems of automobiles. Installation instructions given purchasers of television sets in Great Britain, mention that the dipole should be erected as far as possible from any well traveled road. Where a concentric feeder was used, it had to be run several hundred feet in some cases.

Sheet 360.2.

The Sun
Television Data Sheets

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TELEVISION ANTENNAS

The ultra-high frequency signal bands allotted to television have many peculiar characteristics not possessed by the usual broadcast waves and the practices that are found most desirable with broadcast reception cannot always be followed when receiving television programs. In particular, the antenna problem differs considerably. In former times it was quite difficult to amplify signals with the tubes that were available at that time, and it was found that a good antenna provided a very satisfactory solution for the reception problem. At present, however, tubes and circuits have been improved so much that excellent broadcast reception can be obtained, in spite of a poor antenna. At present, however, the amplification of a television signal is much more difficult and expensive, and it is probable that a special television antenna will always be necessary. However, a good television antenna will not necessarily be a good broadcast antenna, or vice versa. This does not mean, however, that an antenna, particularly suitable for television, is difficult or expensive.

The typical arrangement is a "dipole" (See sheet 010.4.), which consists of a metal rod with a gap at the center, with a pair of wires leading off from the inner ends to the receiver. The important items to consider in erecting such an antenna are:

1. The dimensions of the rods and the center spacing. The length of the rods depends upon the wavelength of the television signal to be near by.
2. The location of the dipole with respect to ground and other objects near by.
3. The lead-in cable construction.

In the U. S. A. where programs will be transmitted on seven or more different frequencies, it will be impossible ultimately to design an antenna with a fixed conductor length that will efficiently respond to all waves equally. However, at present, the television broadcast facilities are arranged to utilize the two lowest frequency bands only, so that an antenna length can be easily arranged to cover these frequencies. The important dimensions to use on dipoles are:

TELEVISION BAND range megacycles	VIDEO CARRIER mc	VIDEO CARRIER meters	DIPOLE LENGTH (each rod)
44 – 50	46.50	6.45	6′ 2″
50 – 56	52.50	5.72	5′ 5.6″
66 – 72	68.50	4.38	4′ 2.2″
78 – 84	80.50	3.73	3′ 6.7″
84 – 90	86.50	3.47	3′ 3.8″
96 – 102	98.50	3.04	2′ 10.8″
102 – 108	104.50	2.87	2′ 6.2″

(To be continued.)

The Sun

Television Data Sheets

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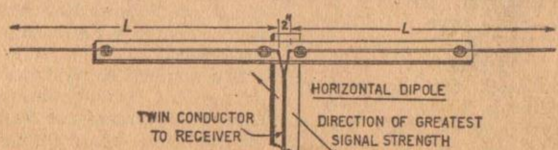
TELEVISION ANTENNAS

The dipole dimensions on the chart (Sheet 370.1) are correct when each rod has a diameter of ¼ inch to ⅜ inch, and when the inner ends are separated by 2 inches.

At this date, however, experimental data is lacking in the matter of optimum mounting positions. In Great Britain it seems that the majority of antennas are of the type shown in the figure below and are mounted with the rods vertical. This rule may not necessarily hold in this country however. Whatever may be best for receiving one station may not be best for another as their angle of polarization may differ, so this matter will be left open, with the suggestion that comparative tests, wherein the dipole is swung from vertical to horizontal positions, will give the answer, at least for the particular receiver location. At some future date it is probable that all transmitters will be arranged to send waves with the same polarization so that definite rules can be worked out in the matter of antenna mounting. Generally speaking, however, good results are obtained, at least from the Empire State tower transmitter, with the dipole rods mounted horizontally, at right angles to the signal path, as shown.



In most cases some kind of framework can be arranged to hold the dipoles. A wooden strip 1x4 inches, on which stand-off insulators are mounted, provides an easy way for keeping the dipole in shape while erecting.

It will be noted that a double antenna connection is necessary—such as a twisted pair of wires connecting to the inner ends of the dipole rods, at the 2-inch gap. This pair of wires ordinarily will have to run for considerable distances to reach the receiver. While it seems that no special precautions need be taken in most locations to secure a proper impedance match at the junction with the antenna, in certain cases where the field strength seems rather low, that a change in the position where the lead wires are connected, will improve the transfer of energy.

Sheet 370.2.

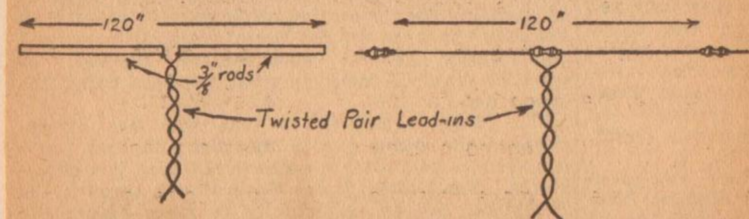
(To be continued.)

The Sun
Television Data Sheets

Compiled by RALPH R. BATCHER.

TELEVISION ANTENNAS

The erection of a television antenna is a problem that has no single sure-fire solution that can be applied to all locations. For example, the space available for its location, the distance and direction of the transmitter, the surrounding objects (mainly other antennas, metallic structures and nearby towering buildings), all contribute to the operation. Another important factor is the noise level and the location of the antenna so as to avoid as much direct pick-up as possible. Even when an antenna has been erected according to the best rules, it may happen that it has to be shifted or rotated to avoid multiple signal disturbances, where a second set of signals are received by reflection from some re-radiator. The distance from the point where the antenna can be located and the receiver position also influences the design. Finally, it is necessary to guess (for a while) how many television bands are likely to be used during the next year; two are already in use and one or two more are being investigated. Many television receivers that are becoming available have arrangements for tuning at least five different bands.



Luckily, it is easier to change the location and length of an antenna than it is to redesign the tuning constants in a receiver for the reception of additional wave lengths, especially when the dipole type of antenna is used. For a quick installation that will cover the present bands (44 to 56 megacycles) the dipole arrangement, Fig. 1, may be used. It consists of two rods mounted end to end with a 2" gap at the center, or two wires of equivalent length stretched between supports, either type having a total length of ten feet between the tips. It is connected to the receiver by means of a well insulated twisted pair lead, preferably of the low-loss type. It is especially necessary that this lead-in pair have a type of insulation that does not fall down in wet weather. Later on, when the 66-72 megacycle band is opened up the total length of the dipole can be reduced to around 107".

Sheet 370.3.

(To Be Continued.)

The Sun
Television Data Sheets

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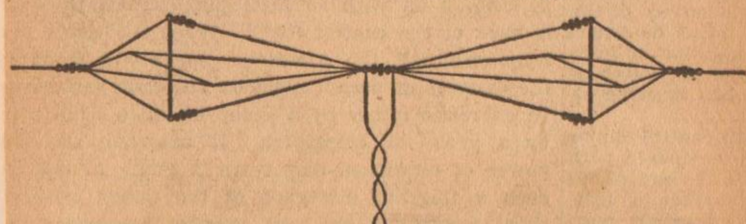
TELEVISION ANTENNAS

When the dipole length is decreased, in the manner outlined on sheet 370.3, for the purpose of increasing the number of stations that can be received on a single antenna, the signal strength on all bands drops off somewhat. Many arrangements have been suggested and many more are being tried, to improve this condition. In some of the RCA receivers it has been found advantageous to tune the antenna by shifting the impedance of the coupling coil connected at the lower end of the down lead; one set of coils being switched in by means of extra sections on the band change switch that controls all tuning.

It is common practice, however, to attempt to make the antenna itself responsive to as many television bands as possible. To secure the required broadness several principles are in use. In one the turnstile antenna, as it has been termed by RCA-NBC engineers on account of its shape, is constructed with two dipoles that are crossed at the center points. In view of the lack of actual data concerning the reception characteristics of this antenna at more than one wavelength full details cannot be listed as yet on this or other designs, although such data can be quickly secured as soon as more stations are on the air. It would seem that five bands can be covered fairly efficiently if one of the dipoles has a length of about 80″ tip to tip, and the other 120″ as suggested on Data Sheet 370.3.



Another arrangement is best adapted to be stretched between two elevated supports with rope or insulated guy wires. See the sketch. Here each end of the dipole is composed of four strands of wire, separated by "kite" spreaders at a point from two-thirds to three-fourths of the way out from the center. The total length is ten feet from tip to tip as before, but two of the wires in each section are made shorter than this by the insertion of an insulator at a point 40″ from the ~~outer~~ ends.

Inner

Sheet 370.4.

(To Be Continued.)

The Sun
Television Data Sheets

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WAVE POLARIZATION AND ANTENNAS

There is one problem around which some practical research still remains to be done, viz., that of the determination of the best direction of polarization of television carrier waves. Actually signals can be efficiently transmitted no matter whether the waves are polarized vertically or horizontally but there may be considerable difference in the amount of absorption caused by buildings and other obstacles that may intervene between the transmitter and receiver, and in the amount of interference picked up with the received signals.

Polarized waves are designated by the direction of the electrostatic component of the field, that is, a horizontal dipole will give horizontally polarized waves and a vertical antenna vertically polarized waves. At present horizontal polarization is used in the New York area. The sharpness of polarization, however, is never great at distant points and a vertically positioned dipole will pick up a certain amount of signal anyway.

The whole matter of polarization can be considered from an analysis of the magnetic component of the field radiated from an antenna, since magnetic fields are generally better understood. A horizontally polarized wave with vertical magnetic lines of force can be picked up best when the loop is turned so that it is at right angles to that field: i. e., horizontal. Such a horizontal loop might have one or more turns of wire in a horizontal plane. It is extremely difficult to prevent some electrostatic field pickup in such a loop, unless it is located quite close to (and on the same level with) the receiver. In any case the loop must be balanced electrostatically to ground.

There are many possible ways to design loops for television reception. The signal voltage obtainable depends on the combined area of the turns, so that a multi-turn arrangement can be considered. In any case the dimensions are important since the direction of the magnetic lines of force reverse at points one-half wavelength apart. A loop having a dimension in the direction of wave travel greater than one-half wavelength would therefore have less output than a loop with a dimension less than a half wave. An arrangement of this kind sometimes proves more effective than a half wave dipole when used inside of a room or elsewhere, when an elevated outside dipole would be difficult to install. Any kind of antenna will have poor pickup qualities in buildings that embody considerable grounded or ungrounded metallic materials in their construction.

SHEET 370.5.

The Sun
Television Data Sheets

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IMPEDANCE MATCHING

In locations where signal strength is low, as when at a distance from the transmitter, or where an unusually long lead-in is necessary, correct matching of the line and the antenna is especially important. In the first case this is so because some signal is lost, thereby making it more difficult to get sufficient signal strength to operate a receiver. An improvement equivalent to an additional stage of amplification can often be obtained by correctly matching these impedances. In the second case, signal reflections are likely to occur which cause "ghost images" widely displaced from the true position.

Ghost images can be caused by any one of four things. (1) They may be introduced into the transmitter signal when the video program is picked up from a remote point and relayed back to the main transmitter by ultra-short waves. (2) Reflection currents in the transmitting antenna and its feeder lines may occur. This possibility is remote as the trouble is usually located and corrected before any antenna is placed in regular service. (3) Multiple signals caused by the signal being received over two or more paths through the ether by reflections from neighboring buildings, &c. (4) Reflection waves in the receiving antenna system itself.

To avoid these reflections the transmission line that is used to interconnect the antenna and the receiver must "match" the impedance of the antenna at all frequencies in the television band or else the displaced images may appear. The input impedance of the receiver must also match the characteristic impedance of the lead-in. This is commonly done by loading the input circuit of the receiver with resistors of the correct value. Generally this value is equivalent to the characteristic impedance of the line. A transmission line of 200 feet may introduce a second image displaced one-tenth of an inch horizontally on the screen. In extreme cases several of these displaced images may be noted.

An antenna system made up of perfectly matched components will not only avoid the introduction of these spurious images, but at the same time will give maximum signal strength. It is not always easy either to measure with simple equipment, or to compute the impedance of a half-wave dipole, which varies quite rapidly as the received frequency is changed. In television it is essential that a single antenna be capable of covering a wide range of frequencies and as additional stations get started the band width will become still more important.

SHEET 370.6.

(*To be continued.*)

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IMPEDANCE MATCHING

To bring about impedance matching in the antenna system, it may be necessary to alter the impedance of the balanced line or the dipole (or both) or, in case these methods prove inadequate, it may be necessary to provide impedance converting devices in the lead-in circuit.

It is quite possible to alter the impedance of a concentric transmission line by as much as 3:1, but in most installations a coaxial line presents difficulties since the system is unbalanced to ground and more interference is likely to be delivered to the receiver—not that the coaxial line picks up the interference, but because the whole dipole acts as a simple antenna with respect to ground. In the concentric, or coaxial system, the impedance can be increased by using a small conductor inside a large diameter outer tube.

The impedance of a twisted pair lead-in may vary from 70 up to a couple of hundred ohms, depending upon the size of wires and the spacing between them. While it might be desirable to increase the characteristic impedance of a lead-in so as to be able to affect matching to some of the higher impedance types of antenna, such a procedure generally increases the losses.

The losses in a twisted pair keep within bounds solely because of the low operating impedance. The lead-in pair will handle only a low voltage under these conditions, so that dielectric losses are not high. Twisted and stranded lamp cord of the usual type is of little value for long lengths, both on account of the losses in the insulation, and the effect of the stranding. In fact, it is well to avoid using any kind of twisted wire whose characteristics at television frequencies are not known. The losses will generally increase with aging after a few months, and will always increase in wet weather to a marked degree.

Losses in such lines increase in proportion to the length, so that, in some cases, better results can be obtained when the antenna is mounted close to the receiver instead of at a greater distance but higher, thereby requiring an unusually long lead-in.

In cases where field strength seems low the most effective antenna structure is one that is elevated and isolated from other antennas, and one that is equipped with a transmission line of a more efficient type. Here a spaced-wire transmission line can be used to advantage, or where cost is not a factor—a double concentric tube line. These will be described in a later Data Sheet.

(to be continued)

The Sun
Television Data Sheets

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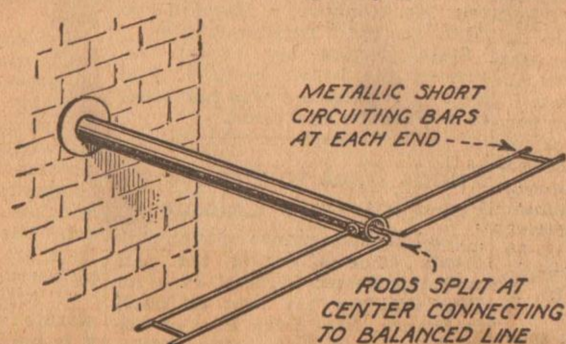
THE FOLDED DIPOLE

A great deal of the entertainment value of a television program is often lost when an excessive amount of interference is picked up, when the signal strength is too low, or when double images due to reflections are obtained. In many cases the antenna can be relocated or redesigned to improve these conditions, however.

In many cases where a stretched-wire type of dipole is used, improved operation is found when rods or pipes of large diameter (even one or one and one-half inches) are substituted, carrying rods self-supported from their inner ends. The advantage is mainly in a wider frequency range over which signals are received efficiently.

A relatively new type of antenna has come into use for television reception, consisting of two parallel half-wave dipoles mounted very close together. This style has been called the Folded Dipole. In this type the open ends of both dipoles are connected together by two short circuiting bars as shown in Fig. 1. A balanced line connects to the center gap in one of the rods. Actually this type might be considered as a special form of a single turn loop but it operates in an entirely different manner, since on account of the length and spacing, the current flows in the same direction in the two ends in much the same manner as a single dipole.



In one particularly interesting adaptation of this principle a series of four folded dipoles, each curved so as to lie in its own 90° arc of the circle, are used to transmit the sound program of the NBC system located in the Empire State Building.

One of the advantages of this arrangement is that it can be made quite strong physically, so as to permit its installation as a self-supporting unit, rigidly held by a hollow pipe which incloses the transmission line. The length of this combination of dipoles must be the same as with the ordinary dipole.

The antenna is particularly adapted for mounting outward from a wall, in locations where it would be difficult to extend upward from a roof.

(To be continued.)

SHEET 370.8.

The Sun
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TEST CHARTS

In order to make accurate checks on television apparatus design a special test picture is frequently transmitted during the test periods. At first it was customary to send out a trade mark of some kind or else a cartoon, but now special charts are used because they permit more accurate analysis of the results. One of these is the Tapered Wedge Chart, Fig. 1, used in the RCA-NBC field television tests.

For testing vertical and horizontal definition, two sets of lines are included within two large circle borders, which are used to gauge the size of the picture on the screen. Each set of lines are spaced at a definite distance at the left and top edges, but gradually converge at points near the right and bottom edges.

The resolution is indicated by numerals near each of these wedges, so that if the individual lines in the horizontal wedge are separately distinguishable at the point marked 500 it would indicate that the vertical definition was equivalent to 500 lines per picture. Similarly, horizontal definition is gauged by reference to the vertical wedge in the same way.

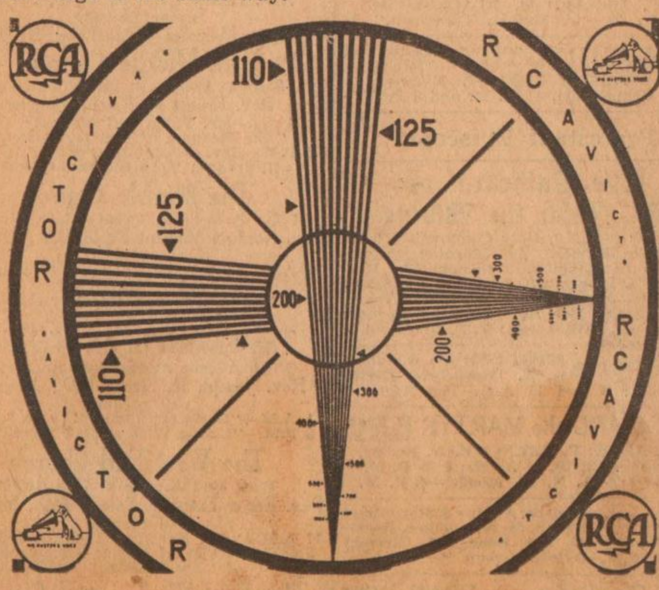

Fig. 1

Charts reproduced through the courtesy of the R. M. A. Engineer and A. V. Bedford of the RCA Mfg. Co.

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Television Data Sheets

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While the Tapered Wedge diagram shown on Sheet 390.1 is of great value in the determination of relative definition along both axes, it does not indicate the quality of half-tone values and the intermediate values of shading that occur in the usual televised scene. For this reason this test diagram is frequently replaced by the accompanying chart, Fig. 2. This chart shows up any distortion due to poor focusing at any part of the screen, since it contains twelve identical diagrams, which cover the useful portion of the television screen.

It also shows poor interlacing, non-perpendicular axes due to misaligned deflection elements, non-linear scanning oscillators, and wrong adjustments in the modulation circuit of the cathode ray tube, if any of these troubles are present. Any one of the twelve diagrams may be used in the same way as the wedge diagram, Fig. 1, since the sets of converging lines shown in the opposite corners of each major square represent the useful portion of the wedge diagram previously shown. In addition several typical background shading values are also shown in certain portions of each square.

These charts will be referred to later, when certain receiver tests are described.

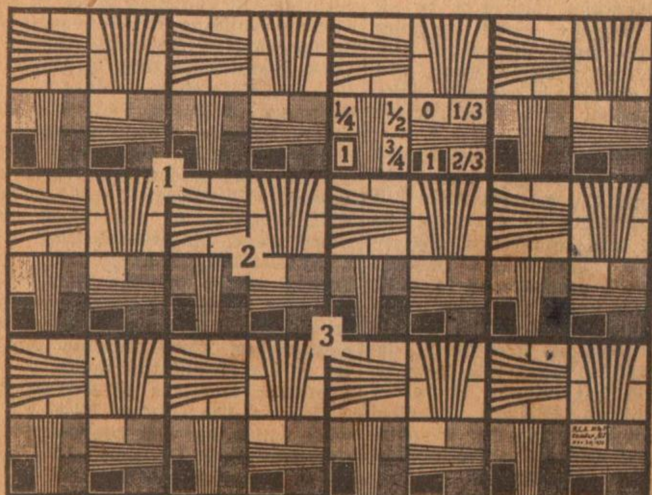

Fig. 2

Sheet 390.2.

The Sun
Television Data Sheets

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ANALYZING THE TEST CHART

A number of queries have been received as to why the television test-signal pattern has received so much prominence during the transmission periods and to what use it can be put in checking television receivers. This signal results from the transmission of one of the wedge charts, previously described (sheets 390.1 and 390.2).

One form of these charts consists of a pair of concentric circles, across which two groups of wedge-shaped lines are placed. A lot of test information is crowded into one of these diagrams, but it is not necessary to take note of all parts of the chart at once.

For example, in Fig. 1, below, a few of the essential lines in the diagram are shown, disregarding the other parts entirely. It is to be noted that this chart is symmetric and composed of true circles. On a television screen, however, the appearance might be somewhat as shown in Fig. 2, with egg-shaped circles and with the squares which appear inside these circles at the corners of different sizes.

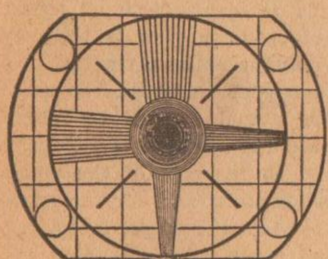

Fig. 1.

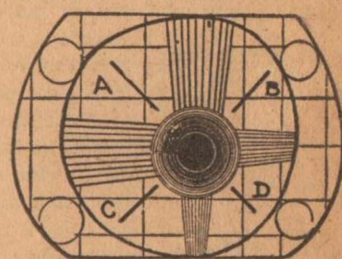

Fig. 2.

These distortions in the shape of the various parts of the diagram are due to non-linearity of the scanning-wave oscillator. While a lack of sharpness of the individual lines is generally due to distortion somewhere in the video stages, this diagram, Fig. 2, has been drawn to point out scanning-wave defects only.

Poor linearity is generally caused by a defective tube functioning as a scanning-wave oscillator or its associated scanning-wave amplifier. If, in Fig. 2, the rectangles A and C appear the same size, the low frequency scanning oscillator is probably not at fault, or if rectangles A and B appear to be the same size the line-scanning oscillator is not at fault. In Fig. 2 distortion appears in both scanning circuits.

Sheet 390.3.

(To Be Continued.)

CORRECTION:—The last line in Sheet 370.4 (May 6, 1939) should have read "20" from the outer ends."

MAY 20 39

The Sun

Television Data Sheets

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ANALYZING THE TEST CHART

Having discovered that distortion exists in one or both of the scanning oscillators by means of the test chart pattern analysis the matter can be checked by an examination of the scanning lines themselves. With the incoming signal tuned low the focus control may be readjusted until the horizontal lines that make up the picture are separately distinguishable. These lines should have the same separation at the top of the picture that they have at the bottom. In direct-viewing tubes the top lines are separated more than at the bottom edge whenever non-linearity occurs in the vertical scanning oscillator. When the picture is viewed in a mirror, however, the top lines may be the closest when the same circuit conditions prevail.

Close examination of the lines may also disclose that they are in pairs, with alternate close and wide spacing between the lines. A reading glass may be found useful in this examination.

The non-linear saw-tooth wave may be due to a defective discharge tube in the scanning oscillator, and a simple check is to interchange the tubes between vertical and horizontal scanning circuit and to see if the diagram shape remains unchanged. If the distortion appears to move to another corner it is an indication that one tube is at fault. A new tube should be substituted and the test repeated wherein the tubes from both scanning circuits are interchanged.

It may be difficult at the start to pick out just which of the tubes in the circuit is a part of the scanning oscillator. Here the chart which appeared on data sheet 020.5 may be used.

It will be noticed that most of the receiving sets listed therein use a "twin triode" for this purpose, such as a 6N7 or a 6F8G, except in the DuMont receiver, which contains a gas-filled triode, the 6AD5G. In all cases, however, the same type of tube is used in both the vertical and the horizontal scanning circuit. Also it is almost universal practice, as indicated on the above chart, to amplify the scanning-wave potentials, so that the amplifier tube in itself is a possible source of non-linear scanning. It should not be construed, however, that a non-linear scanning oscillator will produce crooked scanning lines, or that it will produce curved vertical lines in the picture. The latter condition is due to other effects to be described later. Non-linear scanning may cause curvature in any diagonal lines appearing in the test chart.

Sheet 390.4.

The Sun
Television Data Sheets

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ANALYZING THE TEST CHART

In addition to ~~the~~ these effects ~~listed on the previous data sheet~~ there are several other effects that may be introduced by troubles in the scanning wave oscillators.

1. Picture has wrong proportions. To take care of this condition most receivers have horizontal and vertical dimension controls (located in an inconspicuous space) which set the limits of the scanning wave amplitudes.

2. Picture not centered. Controls are also provided in most receivers which place an adjustable voltage in series with the deflection plate leakage resistors, or in series with the deflection coils, whichever are used.

3. Edges of picture waved and not clear cut. This condition occurs when the scanning oscillators are not sufficiently synchronized, as for example when caused by:

(a) Insufficient signal strength.

(b) Frequency adjustments in scanning wave oscillator circuits not correctly set.

(c) Too much noise and radio interference received which cause false synchronizing signals.

(d) Trouble in the synchronizing pulse filter circuit or in the pulse amplifier.

(e) Erratic operation of the tube in the discharge circuits in scanning oscillators. To remedy this trouble first make changes in the scanning frequency adjustments as in (b) above, trying to set the operating frequencies to values as near the standard as possible (60 cycles and 13,230 cycles).

4. Back trace visible zig-zag streaks appearing back and forth across picture. These always appear when the picture carrier is not being received, but should disappear when the carrier is on. If the lines persist an increase in the video signal output is required, although in some cases an adjustment of the "contrast" and "brilliance" controls on the panel will help.

5. Framing control frequently lost. The effect is as if the picture were projected on a page of a calendar, and the page turned down at irregular intervals, the same scene being continued on the next sheet. These momentary interruptions are due to the vertical synchronization being too weak. It is generally remedied by readjusting the vertical scanning frequency control, provided the tubes in this circuit are operating correctly.

The Sun

Television Data Sheets

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ANALYZING THE TEST CHART

Omit

An important application of the test-chart patterns received at frequent intervals in present day television programs is to permit the viewer to check the capabilities of the video amplifiers in his television receiver. The particular feature which will now be discussed has to do with the picture resolution.

For highest satisfaction in the received pictures it is essential that the vertical resolution and horizontal resolution be equal. The gradually converging lines forming the wedges that cross the central portions of the chart appear distinct and separately distinguishable whenever all of the circuits have an adequate range of frequencies and possess but little distortion. Since the transmitting station amplifiers have been highly developed and engineered (Cost is not the factor that it is in receiver amplifier design) they will not cause much distortion relative to that introduced in the receiver.

Omit

"Resolution" denotes the clarity and freedom from blurring of the originally sharply defined images, when viewed on the receiver screen. The eyesight differences among individuals and such factors as viewing distance and illumination intensity also are important factors to consider when making comparisons.

Vertical definition depends on the number of lines in the picture, 441 at present, about which nothing can be done at the receiver, although factors such as spot size, spot shape and the accuracy of interlacing also affect the results.

The main improvements come about from changes in the Horizontal Resolution, which depends upon the frequency-handling capabilities of the system and the size and shape of the spot on the cathode ray tube screen.

Omit

Other factors to be determined from the test-chart diagram, of interest to the engineer and service man, are the upper frequency limit passed by the receiver, false shading due to phase delays in the circuits, and "paired" scanning lines.

To the non-technical user of a television receiver the chart may be used to permit the adjustment of the vertical and horizontal amplitude controls so that the full picture area is received. The inside circle of the chart corresponds to the correct picture height and the outer circle (which is cut away at the top and bottom) corresponds to the true picture length. Simultaneous adjustment of the "brilliance" and "contrast" knobs should be made until as many separate shades as possible are evident in the central circular areas. The lines of the wedges should be separately distinguishable for the greater part of their length, before they run together.