The Sun

Television Data Sheets

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THE TELEVISION RECEIVER

In the early days of broadcast reception receivers were characterized by the large number of controls which were then considered to be necessary. As the circuits became standardized and simplified certain operations were dispensed with and several controls were eliminated. In television receivers even more controls may be necessary at the start until some of the variable effects can be studied and automatic compensation provided. Just which controls will be utilized ultimately cannot be predicted at this time. The following factors may require adjustment:

(1) Off-and-on switch. It is desirable that the sound channel be kept on the air at times when the visual program is not required. This is due to the fact that a television program requires strict attention on the part of the audience, unlike the conditions encountered in sound programs. Viewers cannot read or otherwise engage themselves and at the same time benefit by the visual part of the program. To keep the expense down, therefore it may be necessary to leave only the sound channel connected at times, until it seems from the program heard that the visual part is interesting. The off-and-on switch may have to control several circuits.

(2) Tuning control, whereby various programs can be intercepted.

(3) The focus and brilliance control associated with the cathode ray tube.

(4) Amplitude adjustments associated with the deflection circuits controlling the height and width of the picture.

(5) Position controls, for centering the picture on the screen.

(6) Amplitude of the sound channel reception.

(7) Tone or pitch controls on the sound receiver.

(8) Amplitude of the visual reception, which controls the "contrast" of the picture. In some circuits the background level may require adjustment also.

It is quite possible that items 3, 4 and 5 can be placed in an inconspicuous place as they may require adjustments only rarely in practice.

Item 2, that of tuning, will be taken up in detail first.

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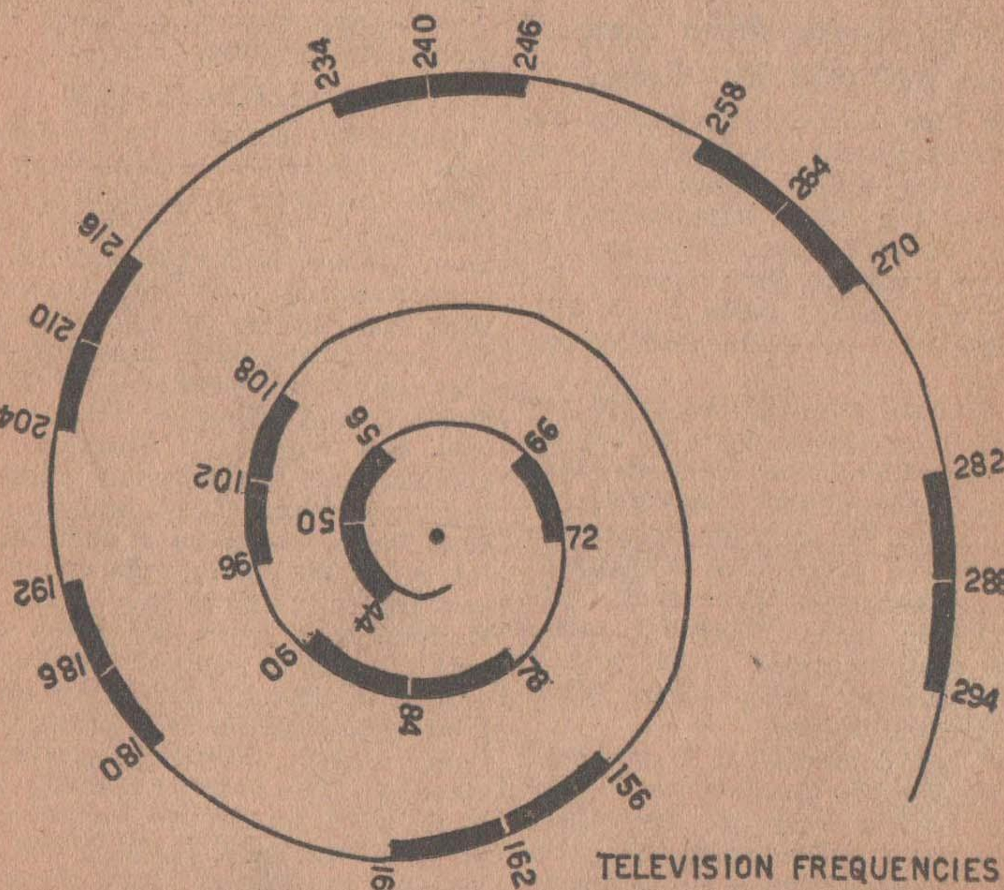
RECEIVER DESIGN

In receiver design the first consideration is to determine the required tuning range. This matter has not been permanently settled, although a new frequency allocation, announced by the F. C. C. will go in effect on October 13, 1938, according to present plans. This change assigns the various channels between 30 megacycles and 300 megacycles to television service, amateur operation, governmental and aviation applications. The nineteen bands assigned to television are not in a continuous range but have numerous gaps. The television frequencies have been shown by the heavy sections on the spiral line in Fig. 1. At the center, the two bands nearest the frequencies used in present television experimentation, are shown. The other allocated frequencies are also shown, with their megacycle limits. One complete revolution of the spiral line represents a 2:1 range of frequencies.



TELEVISION FREQUENCIES
IN MEGACYCLES

The range of 44 to 108 megacycles will be particularly useful in television broadcasting, and with careful design can doubtless be covered by a single dial range. The frequencies lying between 156 and 294 megacycles will prove useful for fixed service applications such as with mobile units for transmitting video signals from an outside location back to the main transmitter, or for linking up the studios with the transmitter (when at separated locations) when coaxial cable facilities are not available. Twelve bands are shown, each six megacycles wide.

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THE I. F. AMPLIFIER

The band spread capabilities of an i-f amplifier suitable for television signals has been analyzed in other sheets of this series. The theory and circuits for such an amplifier are not essentially different from ordinary sound reception apparatus, but it is necessary to use special i-f transformers and (if they become available) special tubes having high values of mutual-conductance. In order to pass modulation frequencies of ~~one~~ or more ~~or two~~ megacycles it is necessary to use a relatively high i-f value, since a two megacycle pass band with a ten megacycle i-f carrier represents a relative "broadness" of tuning about nine times as great as that found in ordinary broadcasting receivers.

Part of this broadness is accomplished by the use of a higher C/L ratio in the i-f transformer, since it is a well known fact that circuits with small inductances and large capacitances tune less sharply than those with the reverse set of conditions.

For example, the Aladdin type U-100 coils can be cited for their capabilities along this line, having been designed for this type of service in television receivers. Tuned to a carrier of approximately 13 megacycles, they provide a relative broadness of around 6.5 times that used in broadcast receiver practice. However, the C/L ratio is around 100 times as great as that used in normal i-f transformers, so that the selectivity is greatly reduced. In addition the coupling between primary and secondary is rather large, which provides flat topped characteristic curve of selectivity. When additional broadness is required the plate and grid circuits are both shunted with loading resistances, selected by experimental data made on the complete receiver. The lack of selectivity in these circuits makes it difficult to tune all these coils to the same i-f carrier frequency, a condition in itself that tends to broaden the whole amplifier, by the introduction of "staggering" of the tuned circuits.

In the Aladdin television coils, the plate circuit is tuned by a small mica trimmer, but the grid circuit is left untuned. The inductances are extremely small, being wound on a form about 5/16" in diameter. Practical circuit details of the use of these and other types of broad-band i-f coils will be given in following sheets, in conjunction with a complete receiver.

As a result of the "low Q" broad band characteristics of these circuits, not much gain can be obtained per stage in the i-f amplifier so that four or more stages are usually required. The ordinary pentode type of tube of the 6J7 class requires a high impedance load, while the circuit load with a high C/L ratio is inherently an exceedingly low impedance, and in addition it is often shunted by resistances of the order of a few thousand ohms. It is found that tubes with exceedingly high mutual conductances operate best into this type of load. Television receivers in other countries are developed around the use of special tubes.

The Sun

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Add to sheet 330.3 at A

one or more stages of

BRILLIANCE CONTROL

~~Reviewing the principles of cathode ray tube operation~~ I it will be remembered that the brilliance of the spot depends upon the bias applied to its modulation grid. ~~In many tubes this control is effected by a variation of some twenty or thirty volts.~~ In common with other types of vacuum tubes the more negative the bias the lower the anode current; consequently the spot intensity decreases. While the high frequency (i-f carrier) potentials can be applied directly to the control grid of the cathode ray tube (since a certain degree of rectification occurs in the grid-cathode circuit itself) this method is rather inefficient. The usual method is to rectify the output of the video stages first with a specially designed detector tube, and in ~~some~~ cases to add video amplification thereafter, ahead of the cathode tube. One or two stages of this type of amplification reduces the required gain in the i-f stages. However, the design of this type of amplifier is a special problem if the wide range from thirty cycles to some two megacycles is to be covered.

The value of carrier level that must be available to modulate the spot brilliance depends upon the transmission system used, i. e., whether positive or negative modulation is adopted.

In positive transmission a "white" area, that is, a spot with maximum brilliance, corresponds to an increase in carrier level. If the carrier level decreases, either by intention or through fading the brilliance of the spot decreases and thereby the whole picture darkens. However, in some systems no attempt is made to transmit the background intensity level by the control of the carrier level, and the video signal controls the successive changes in light intensity only.

In negative transmission, "white" corresponds to a decrease in the carrier level, so that a black spot, which calls for the most negative bias to the cathode ray tube, is transmitted with the maximum carrier level.

It happens that with the equipment in use in television transmitters, the slowly varying or steady values are lost in the usual camera pickup amplifiers in the studio and must be reinserted later in the system. These average levels are important in the true reproduction of the scenes, since the video signal itself controls only the variations in the light values.

Sheet 200.7.

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A

THE PEDESTAL

The "pedestal" is the name given to a certain condition of the video carrier during that interval of time which is allotted for the spot to jump back to the starting point, that is, between scanning lines. During this interval the radio carrier, by prearrangement, has a level equal to that which gives a "black" spot. That is, the cathode ray tube is biased by the rectified carrier, so that the electron emission is below cutoff, and is completely extinguished. In the negative modulation system, the carrier level required to do this is greater than any value that is likely to occur in the transmission of the video signals of the picture proper. The oscillogram of the carrier therefore (shown in block B, sheet 220.1) shows a succession of high peaks, all having the same amplitude, and giving rise to the descriptive term "pedestal." The system is also arranged so that the synchronizing pulses are likewise transmitted during the same interval, so that they will appear superimposed on the pedestals.

In the transmission system which has been tested during the past few years by RCA-NBC from the Empire State Building transmitter, the pedestal intervals are also used for a third function: The energy transmitted during these intervals is utilized to control the background level at the receiver.

In any television receiver it is not only necessary to handle the variations in the light intensity for each scanning line but it is also necessary to maintain the correct average brilliance of each line. This is known as the background control, which operates (in the RCA-NBC system) in accordance with the relative height of the pedestals, so as to permit the receiver to use this method to re-establish the background level. Here the carrier level is maintained approximately constant irrespective of the illumination level in the studio. Thus instead of the cathode ray tube having a fixed value of bias to which the video signals, representing the rapid changes in light intensity, are applied, it is the plan to have an adjustable bias which is relocated with each scanned line so that the average ilumination is right for each line. This adjusted bias is, of course, also further modulated with the video signals.

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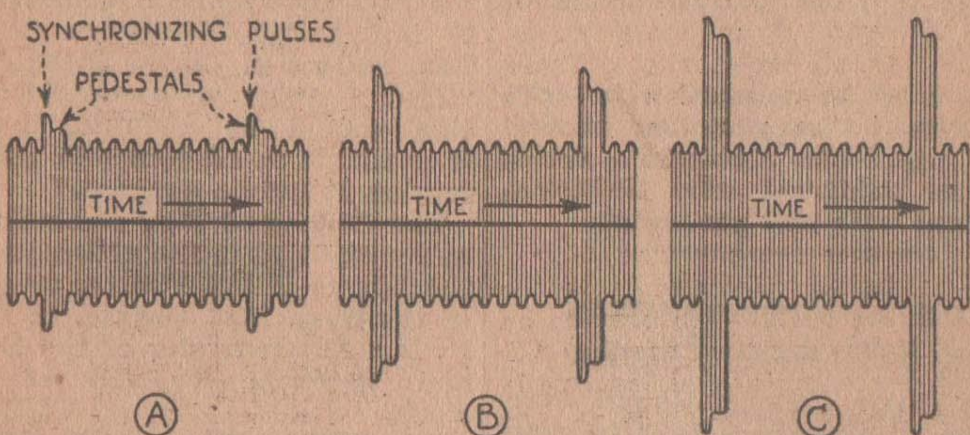
THE PEDESTAL (Continued)

In order to study further the pedestal level system of background control, which is being tested by the RCA-NBC engineers, it will be necessary to consider at least three conditions in picture reproduction: a scanning line where the background is dark, that is, one which appears in a shaded part of a picture, a line having an average background intensity, and one that appears very brightly illuminated. In the negative system of modulation these would be represented by oscillograms as follows:



(An oscillogram of this type shows pictorially the variations in the carrier level during a certain interval of time. The vertical distances in this sketch show the moment-to-moment values of carrier, while time is indicated by the horizontal deflections, about one hundred microseconds in each figure.)

Under the assumed conditions in these diagrams, the actual scene is a lightly mottled area with a dark background in (A), a medium background (B) and a very light background in (C). The main difference is the relative height of the pedestal with respect to the average carrier level.

It is evident that some sort of discriminating filter is necessary which takes note of the pedestal height with respect to the carrier, that is, an amplitude filter arranged to respond to signals that are greater than a certain assigned minimum. In other words, it is a "mower" that is adjusted to cut off and rake in the upper portions of all peaks greater than a certain level.

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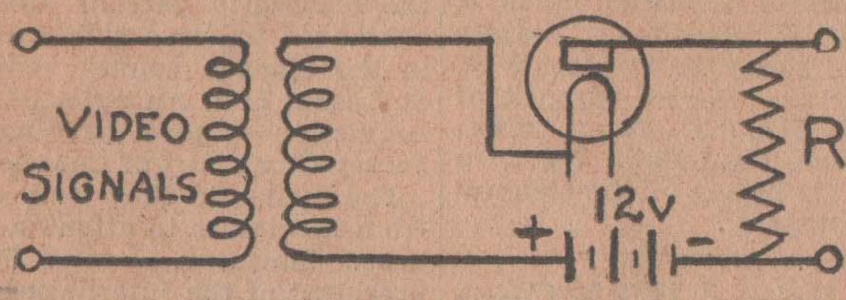
THE PULSE FILTER

Both vertical and horizontal synchronizing pulses have a polarity which places a high negative bias on the modulation grid of the cathode ray tube for the purpose of extinguishing the return trace of the spot between lines and frames, the so-called blanking pulses. It will be recalled that these pulses are always stronger than any variations which may appear in the video signals. While actually the synchronizing pulses are superimposed on the pedestals, for the purpose of this preliminary analysis it will be assumed that they are the same, viz: sharply peaked pulses that are transmitted between each line of the scanned picture and function to bring about the following effects:

1. Vertical synchronizing control. A positive pulse is required to trigger off most types of scanning oscillator circuits.
2. Horizontal synchronizing pulse, also requiring a positive pulse.
3. Blanking out the spot during the return interval, requiring a negative swing during this interval.
4. Setting up the average illumination for each line, i. e. background control.



Let us consider that a signal of the type shown in Fig. 1 sheet 220.2 is applied to the circuit herewith, showing a half wave rectifier biased with a negative potential of 12 volts applied to the anode. This rectifier is entirely ineffective and inoperative, therefore, unless the signal voltage exceeds this threshold value of twelve volts (peak voltage). It will be evident that if the video signals approach this value as a maximum but do not exceed it, the rectifier is ineffective. However, the synchronizing pulse and pedestal potential comes along and the applied potential is quickly raised to a value greater than 12 volts. Rectification then occurs, which causes a potential to appear across the rectifier load resistor R. This potential is used either directly or amplified, to produce all of the four control effects outlined above.

(To be continued.)

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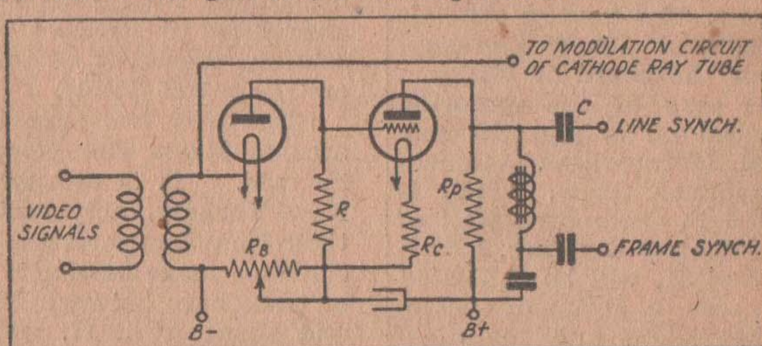
THE PULSE FILTER (continued)

In a television receiver, the deflection system (if electrostatic, and sometimes when a magnetic system is used) is always held at the same potential, with respect to ground, as the final anode. On the other hand, the modulation grid is always at the other end of the voltage supply, hence several kilovolts potential difference exists between them. The control pulses must be fed into both potential levels, therefore insulating condensers are necessary to keep these potentials separate, the condensers being inserted in the various pulse leads.

Let us consider the circuit below, which is a practical example of the basic arrangement shown on sheet 200.10. In order to avoid disturbing the constants of the rectifier load circuit, the potential that appears there is conducted to the input of an amplifier stage. The output of this stage therefore contains a frequency discriminating filter that separates out the line synchronizing pulses (at the rate of 13,230 per second) and the frame synchronizing pulses (at the rate of 60 per second). The former readily pass through a condenser C, connected to the anode of the triode, and are applied thereby to the interlock circuit of the line scanning oscillator, which may be the grid of the thyratron discharge tube, or its equivalent.

A



The low frequency pulses are taken from the terminals of a low-pass filter which passes the 60 cycle pulses but cuts off those of higher frequency, and

~~The framing pulses~~ are ~~also~~ connected to an equivalent point of the framing oscillator so that the discharge occurs at the exact interval required.

Both of the synchronizing pulses must have a sharp wavefront so that its effect is to initiate the discharges without any delay. ~~A delay of only a micro-second might prove to be the cause of noticeable distortion.~~ No capacitance is connected across the load resistor R since this would tend to smooth out the sharpness of the synchronizing pulse waveform.

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VIDEO FREQUENCY AMPLIFICATION

The foregoing analysis (340.1) has referred mainly to the video i. f. amplifier. In the usual broadcast receiver it is universal practice to use one or more stages of audio frequency amplification following the i . f. stages and detector. It happens that this is one of the easiest methods of securing adequate sound output since vacuum tube amplifiers are well adapted to audio frequency service. It also is true that a fairly high energy level must be maintained to operate a speaker, so that a "power" stage is required. This same practice is carried out in the sound receiver section of a television receiver.

However, the story is altered somewhat in the video frequency receiver, and the amplification of the wide picture frequency band after rectification of the video i. f. is by no means universal.

While some 20 or 30 volts are required to modulate the usual cathode ray stream, to produce the light intensity gradations of the picture, this voltage swing does not have to be backed up with much current, so that a power tube is not necessary. Then again, the amplification of a wide range of signal frequencies extending to several megacycles is by no means easy, for it will be shown that the phase shift through the system must be rigorously controlled.

It seems that the majority of television receiver models that have been made available to the public in Great Britain do not use video frequency amplification, and the others generally limit this amplification to a single stage.

Such a stage, however, cannot be switched in or out at will, because the signal polarity is always reversed in a tube (a phase shift of 180°), since a positive output potential swing is always produced by a negative swing on the grid. While this effect would introduce no trouble in a sound receiver it has the property of reversing the black and white areas in the received picture so that a "negative" scene results. The circuit alterations that will correct this reversal are not difficult to apply, however.

Summarizing the above effects in the following table:

	POSITIVE MODULATION (BRITISH SYSTEM)	NEGATIVE MODULATION (PRESENT AMER. SYSTEM)
MAXIMUM CARRIER LEVEL	GIVES WHITE SPOT	GIVES DARK SPOT
MINIMUM CARRIER LEVEL	GIVES DARK SPOT	GIVES WHITE SPOT
NORMAL BIAS ON C-R- TUBE	NEAR CUT OFF	TO GIVE BRILLIANT SPOT
BIAS CHANGE WITH SIGNAL	LESS NEGATIVE	MORE NEGATIVE

The Sun
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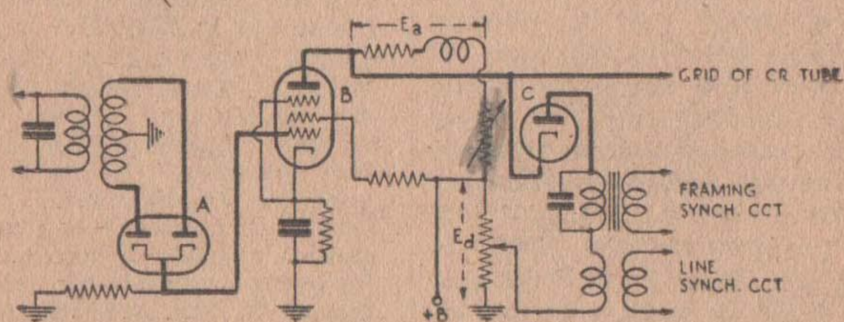
VIDEO FREQUENCY AMPLIFICATION

Several arrangements are possible whereby the cathode ray spot brilliance can be controlled by the incoming carrier variations. ~~The figure below~~ shows one method. Here T1 is the final i—f transformer which feeds a full wave signal rectifier A. The carrier envelope appearing across the load resistor R is impressed on the grid of the video amplifier tube B. ~~Referring to the table in 200.12, it will be seen that~~ it is necessary to fulfill several conditions in this circuit:

1. The bias on the modulation grid of the C. R. tube is established under the "no-signal" condition so as to give a spot of maximum desired brilliance.
2. The carrier must lower this bias toward cut off.
3. Synchronizing pulses must be filtered out and separated in their proper channels.



In this circuit the tube B is normally biased to a value near or at cut off, so that Ea is very small. The fixed bias is obtained by the adjustment of Eb. When a carrier is applied, a positive signal is applied to the grid of B, which increases the plate current, and increases Ea, and thereby reduces the spot brilliance as required. The half wave rectifier C is connected so that its cathode has a higher positive potential than its plate, by the adjustment of R3. However, as the carrier level increases a certain value is reached where the value of Ea is equal to the selected value of Ed. This point corresponds to approximately the 70 per cent modulation level of the carrier.

During the synchronizing pulse intervals the carrier level increases and the diode (C) passes current. The plate circuit of this tube contains a network or filter to separate the line and framing pulses or, as shown, two transformers which resonate at the frequencies necessary to accept these respective pulses.

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Second Detector and Pulse Separation

It has been shown that, in any television receiver, the video signal, which is made up of the picture wave and synchronizing pulses, is amplified to a level of at least several volts in the video i. f. It is subsequently handled in different ways in commercial receivers, but in all cases the same general plan is followed: the wave is rectified and in most cases amplified in its entirety and applied to modulate the cathode ray tube. The synchronizing pulses are also picked off at the detector or at one of the video amplifier stages. This must be done without affecting the video signal itself.

The complete signal is applied to two amplifier stages in parallel. One of them handles the video signal but leaves the synchronizing pulses in. The other handles the pulses, but is arranged to clip off the video signals at the same time. That this can be done, depends on the fact that the video signal has a lower amplitude, so an amplifier that is arranged to handle only signals that are stronger than a fixed value, will pass only the synchronizing pulses.

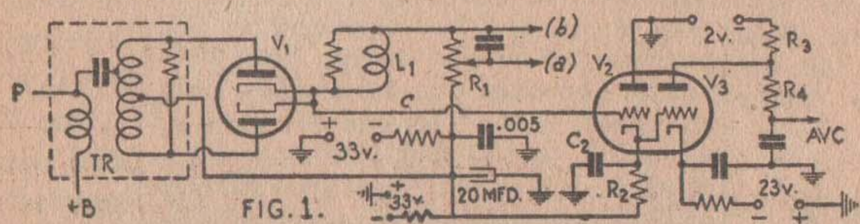

FIG. 1.

Take for example the circuit Fig. 1, which is used in the popular RCA model, TRK-12. Here the video signal from the final i. f. transformer (TR) is applied to the second detector V1—a 6H6 double diode. The load circuit of this tube is the inductance L1 and the "Contrast" control R1, the latter being variable. The rectified signal at point (a) is applied through a single stage video amplifier to the cathode ray tube.

Before continuing with the matter of this video signal amplification the matter of the synchronizing pulse separation will be taken up since the division takes place at this second detector. Incidentally, automatic volume control potentials are also produced at this point, and this item will also be described later.

In the circuit herewith, it will be noted that the signal which is applied to the pulse separator is taken off at the point (b) and the signal to the automatic volume control tube (V2) at point (c).

(To be continued.)

The Sun
Television Data Sheets

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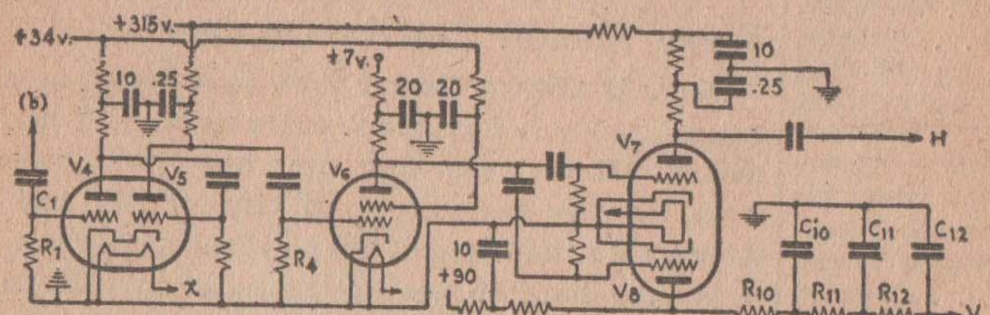
SYNCHRONIZING PULSES

The RCA Victor TRK-9 and TRK-12 television receivers taken up on sheet 200.15 have been found to have remarkably steady pictures due to the great care taken in providing synchronizing pulses that have sufficient amplitude and complete isolation from the video signals.

In Fig. 1 on the previous sheet, the connections to the synchronizing pulse separator were shown (tap b). How the pulses transferred by this lead are utilized will now be analyzed. It is recalled that both the video signals and the two series of synchronizing pulses are transferred along lead (b) to the separator circuit, Fig. 2. Thereupon the video signals are first eliminated.



The circuit for the first section (V4) of the 6N7 tube in Fig. 2, appears to be the usual amplifier circuit, but this is not the case. The tube has (1) a low plate voltage (34V); (2) no cathode resistor, and (3) a high grid leak R1 (1 megohm). Under this set of conditions distortion occurs, as a considerable amount of grid rectification takes place. It will be noted that the combined video-synch-signal is transferred to V4 through a condenser (C1). It is on this condenser that the rectified grid potential accumulates. If the load resistor were high enough very little energy would be drawn from this condenser and it would charge up to a voltage equal to the peak of the incoming signal. As it happens, however, the load (the grid resistor R1) is low enough so that the grid is biased to a value somewhat less than this peak.

As long as the average signal strength is constant, the only part of the signal that will break through and cause a registration in the plate current is that part of the signal that is stronger than the average potential that is across the grid.

This potential is then amplified by the second half of the 6N7 twin triode (V5). The resulting output consists of the heavy surges that represent the synchronizing pulses, with very little of the video signal left. This output is thereupon directed through a second "clipper" tube V6, which, like V4, is arranged to pass only the heavier pulses of the signal. Like V4, it has zero cathode resistance and a 1 megohm grid resistor (R4) and moreover operates on an extremely low anode voltage (7 volts).

(To be continued.)

The Sun
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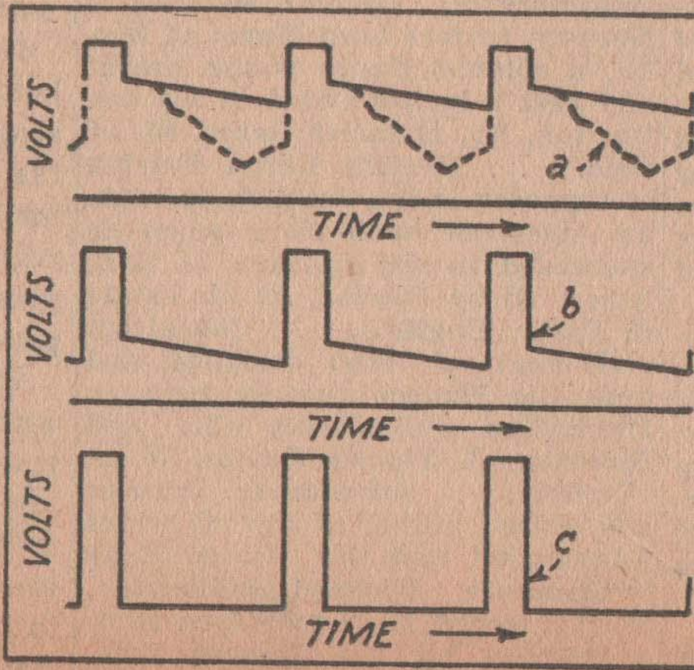
SYNCHRONIZING PULSES

(Continued from Sheet 200.16.)

Before progressing with the analysis of the system of synchronizing pulse separation used in the RCA-Victor TRK-9 and TRK-12 television receivers, started on sheets 200.15 and 200.16, it is necessary to analyze the shape of the signal that is present in this circuit. The incoming signal is represented by the dotted curve (a) in Fig. 3. It consists of a series of heavy horizontal sync pulses with a video signal component in between. This signal is rectified in the grid circuit of V_4, Fig. 2, and the resulting wave is somewhat as shown in the heavy lines in Fig. 3a.

The latter wave, mainly composed of the sync pulses as in Fig. 3b, is amplified in V_5 and V_6. The latter tube, as stated before, acts also as a "clipper" and effectively cuts off all remnants of the video signal that was passed by the first clipper V_4, giving a wave as in Fig. 3c.

The output voltage of V_6 consists of the double series of pulses, one set occurring every 1/13,230 second, of short duration of a few microseconds each, and at the less frequent intervals of 1/60 second, the longer pulses lasting about 1/4,000 second each. Both sets of pulses are transferred by condensers to the second 6N7 tube. A small condenser C_7 transfers the high frequency pulses quite effectively to the V_7 section, but does a poor job at transferring the lower frequency vertical control pulses. The latter are transferred by a larger condenser C_8 to the second section of the tube, V_8. The output circuit of V_7 also has a small transfer condenser C_9, which effectively shuts out the low frequency pulses from the horizontal wave oscillator connected at H. The slow build-up of the vertical pulses would do no harm anyway, as regards affecting the horizontal oscillators.



(To be continued.)

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AUTOMATIC VOLUME CONTROL

At this point we will refer back to the circuit Fig. 1 on sheet 200.15, which shows the second detector circuit used in the RCA Victor TRK-9 and TRK-12 receivers. It was mentioned that the tubes V2 and V3, (the separate parts of a twin triode, 6N7) provided the automatic volume control action for the video amplifier sections of the receiver. It is a function of this tube to take care of abnormal changes in signal level due to such items as swinging antennas, &c. ?

The principle of A. V. C. action in a television signal is a little different than in the usual broadcast receiver since the carrier level varies continually, on account of the continual changes in the average brilliance of the scene: a view taken of a brightly illuminated stage having a much lower carrier level than a scene taken at a dimmer place.

The question arises: what change takes place when carrier level fading occurs, that differs from the condition where the carrier level drops on account of changes in illumination? There would be no difference actually, if it were not for the fact that at the transmitter great care is exercised always to transmit the synchronizing pulses at a definite carrier level no matter how much or how little the video signal may vary between these pulse intervals. Therefore any system of A. V. C. must depend upon noting the amplitude of the synchronizing pulses only and not on the rest of the signal.

In Fig. 1, sheet 200.15, the input circuit of the tube V2 is connected across the load resistor R1 of the second detector.

The grid and cathode circuit of this tube acts as a half-wave series rectifier across the second detector output and the rectified output (which is the voltage drop across the cathode resistor R2) is allowed to accumulate in the condenser C2.

The voltage across C2 depends to a large extent upon the peak amplitude of the carrier, since the charge on C2 does not have time to drop much, on account of the rapidity with which the peaks of the signal come in (13,230 per second).

The second section of the A. V. C. tube (V3) receives this voltage (across C2) to its input, modified by a fixed bias from the power supply which is, in the circuit shown, 33 volts. In order to describe the method whereby the volume control voltage for the high gain i. f. amplifier tubes is obtained it will be necessary next to refer to the latter tubes themselves. In the TRK-9 and -12 receivers, the first detector (converter tube) and all tubes in the 5 stage video i. f. amplifier except the first stage are under A. V. C. action. The converter tube is an 1852 and the i. f. tubes are all of the 1853 type.

The Sun
Television Data Sheets

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AUTOMATIC VOLUME CONTROL

(continued)

The 1853 tube is a high transconductance tube of the remote cut-off type, requiring a bias of the order of two or three volts to give maximum amplification. The gain is gradually reduced when the bias to these tubes is reduced, reaching cutoff at a voltage of the order of minus 30 volts.

Referring back to Fig. 1 on sheet 200.15 which illustrates the a-v-c action in the RCA television receivers, it will be noted that the second section V3 of the (6F8G) twin triode (erroneously referred to on sheet 200.18 as a 6N7) has an unusual arrangement for anode voltage. The anode voltage is held at a value of minus 2 volts with respect to ground whereas the cathode is 23 volts negative, so that this tube has an operating voltage of plus 21 volts. Its grid voltage is 33 volts negative or 10 volts negative with respect to its own cathode but this voltage is altered by the a-v-c voltage across C2, as outlined on the last sheet.

In the above mentioned circuit the bias on the video i-f tubes is equal to 2 volts, plus the R. I. drop across R3 in the plate circuit of V3. This voltage drop is small unless the rectified signal voltage (which was described in the last sheet) exceeds a selected value, which is established by the adjustment of a manual volume control.

Each tube in the video amplifier except the first is under a-v-c action and therefore has three bias voltages in series: the two-volt fixed bias from the main power unit bleeder circuit, plus the drop in an individual cathode resistor of 82 ohms, and the a-v-c drop across the 680,000 ohm resistor R3.

The signal level at which a-v-c action starts depends upon the normal no-signal bias voltage on the grid of V3, which is minus 10 volts, somewhat greater than the cut-off voltage of V3. Until a certain signal strength is reached therefore no action occurs and maximum signal gain is maintained. Once this value is exceeded, however, the drop across the high resistance R3 increases rapidly and the bias of the video i-f tubes is proportionally increased, thereby reducing the gain.

In good receiver locations where adequate signal strength is available for good pictures, a-v-c action is not important since ordinary types of fading are not found at television carrier frequencies within the line of sight area. A certain amount of signal strength variation might be caused by a swinging antenna or lead in, or the variations in the position of swinging metallic objects in the vicinity of the antenna.

The Sun
Television Data Sheets

Compiled by RALPH R. BATCHER.

SCANNING OSCILLATOR CONTROL (DuMont)

Numerous types of scanning oscillators have been described in these sheets, most of which have been based on some type of relaxation oscillator circuit. In practice there are various degrees of scanning oscillator stability among the circuits used in the various commercial equipment receivers. The more stable the oscillator, the less synchronizing signal needed to keep it in step, "if" its original frequency setting is close to the value needed by the ~~system~~. However the "if" here is an important consideration since the original circuit values might shift from several causes.

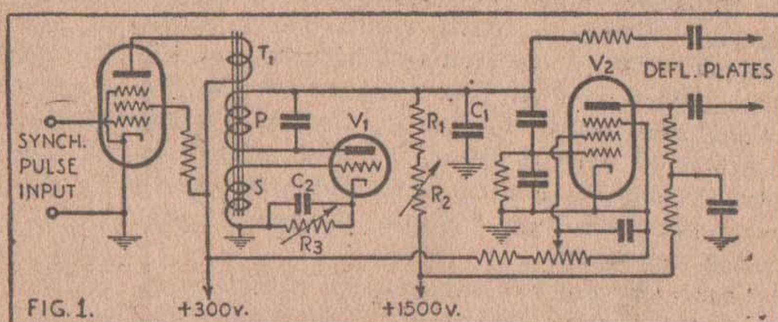


FIG. 1.

Therefore it has been deemed desirable by many designers to use less stable ~~scanning oscillators~~ and to place more attention on the synchronizing pulse ~~separator and amplifying~~ arrangement. Such oscillators in fact have some of the characteristics of a "driven" oscillator since the synchronizing pulse will be strong enough to pull it to the correct speed, no matter what the frequency is that it might want to assume of its own.

The RCA pulse amplifier system described on the preceding sheets is of this nature. In the DuMont television receiver the scanning deflection oscillators ~~follow a different theory of operation and~~ use a circuit basically as in Fig. 1. The condenser C_1 accumulates a charge slowly through the resistors R_1 and R_2 and gives a potential of the sawtooth variety. The charging voltage is quite high, 1,500 volts, although in normal sweep operation the charge on C_1 is not permitted to reach the maximum value of the charging source.

The tube V_1 has a cathode resistor R_3 and a large cathode bypass condenser (C_2). Normally this cathode bias voltage holds the tube V_1 at cutoff. The bias voltage drops slowly, due to the rather high values of R_3 and C_2, but a point is reached after a time where this tube becomes conductive, and current from the charged condenser C_1 flows through it.

(To be continued.)

The Sun
Television Data Sheets

Compiled by RALPH R. BATCHER.

SCANNING OSCILLATOR CONTROL (DuMont)

In the DuMont system of scanning oscillator design, sheet 200.20, the condenser C_1 was arranged to discharge at regular intervals through tube V_1. In order to discharge this condenser rapidly it is necessary to apply a positive pulse on the grid: when the normal bias on the tube V_1 drops low enough so that some current flows from the condenser this current flows through the primary of a transformer T_1. The secondary of this transformer thereupon has a voltage induced in it which is applied to the grid of V_1 in such a way as to apply a positive pulse to its grid.

This action is thereupon cumulative. The faster the current flows out of the condenser and into the tube through the transformer, the greater the surge induced on the grid of the tube, which in turn further reduces the plate impedance of the tube. It happens that the condenser's charge does not last long under these circumstances. Part of the charge that has left the condenser C_1 has been transferred to the cathode resistor C_2 which restores V_1 to the original non-conductive state, with its grid below cutoff.

In practice a single control operates both R_1 and R_3 at the same time so that both the amplitude and frequency are affected. Primarily it is used as an amplitude control since the voltage that accumulates across C_1 depends upon how soon the tube V_1 loses its cut-off bias and becomes conductive. The variable cathode resistor R_3 provides accurate control of this factor. Frequency control is obtained by the application of synchronizing pulses to the grid of V_1. This is done conveniently by injecting these pulses into the secondary winding of the transformer T by injecting the pulses into a third winding which is connected to the synchronizing pulse amplifier. In practice this pulse has a positive polarity at the grid and is strong enough to start the discharge at the correct intervals.

The condenser charges to such a high percentage of the full charging voltage that the charging curve is extremely non-linear. This makes the saw-tooth wave, so generated, not quite suitable for scanning purposes. In the DuMont receiver, however, this curvature is corrected in the scanning potential amplified tube V_2, which is arranged to have a distorted output but with a curvature opposite to that of the charging curvature of C_1.

The amplifier tube (which is used mainly as a phase reversing tube to obtain push-pull operation) is a 6R6G pentode.

An electrostatic deflection type of cathode ray tube of the larger sizes, especially when used for television, is always equipped with separate leads to each deflection plate, so that a push-pull deflection amplifier is provided, or some alternate system whereby the applied potentials are balanced with respect to the second anode potential. Except for difference in the values for the condensers and resistors the same circuit is used to provide both line and frame scanning.

The Sun
Television Data Sheets

Compiled by RALPH R. BATCHER.

Scanning Wave Amplifier Characteristics.

In the design of scanning wave pulse amplifiers there has been some question as to the required frequency characteristics. Some descriptions have started with an analysis of the frequency characteristics of a true saw-tooth wave, as derived by the Fourier formulas. The latter analysis is a method of deriving the frequency components of a wave form by a mathematical conversion. It happens that this system appears to prove that frequencies up to the twentieth harmonic of the fundamental are needed if a true linear saw-tooth is to be obtained.

However, it seems to the writer, that this whole matter is beside the point, and gives an erroneous idea as to actual requirements. No matter what kind of scanning oscillator is used the resulting wave will have either a linear or an exponential (curved) form. The following discussion pertains to electrostatic deflection systems only.

If a linear form is obtained from the oscillator it is necessary to use a linear amplifier; that is one that operates on the linear part of the tube's characteristic curve. Since scanning potentials of many hundred volts are needed in typical receivers this means that a tube must be used that is capable of operating on high anode potentials (one thousand volts or more) if linearity is to be attained in this stage.

It happens, however, that the output wave from the discharge circuit in the scanning oscillator is rarely linear. Several data sheets have shown this condition, where the exponential form of wave was illustrated. The problem in this case is to amplify this wave form without making it worse, or better still to compensate for the curvature in some way, so that a linear output is obtained even though a distorted input wave is applied. This is easier than it might seem and methods for full correction of the curvature will be outlined in the following sheet.

It is first necessary to check the discharge time (flyback time) of the scanning wave to see if it is short enough. In any case this discharge interval should not be greater than say 10 per cent of the whole saw-tooth interval. If it is necessary to reduce this interval the resistance in the discharge circuit can be altered, or the resistance of the discharge tube lowered by driving the grid more positive during the discharge interval.

There is no reason to hurry up the discharge interval too much, since a certain time is allotted for this function at the transmitter anyway.

The Sun
Television Data Sheets

Compiled by RALPH R. BATCHER.

CORRECTION OF SCANNING WAVE DISTORTION

In Sheet 200.23 it was shown that satisfactory correction of the distortion in a scanning wave amplifier could be obtained by the utilization of the curvature in amplifier tube characteristics. This type of distortion shows up in a television picture as uneven spacing of the scanning lines, resulting in the cramping of certain edges of the picture and spreading out of the opposite edges.

In applying the correction to a given amplifier, determine first the actual wave-shape of the pulse to be amplified, as shown at X in Fig. 1 in Data Sheet 200.23. Then draw a linear saw-toothed wave B, having the correct height for the particular voltage required. Curve X should then be drawn according to some voltage scale also. The required characteristic can be determined by the intersection of lines projected from the curves at equivalent time intervals (curves X and B both having a base proportional to "time"). An amplifier tube must then be selected that has this characteristic curve under particular operating conditions.

In the usual case, a push-pull deflection amplifier is used so that the same correction must be applied to each half of the output wave. This means that each tube in this stage must operate under the same conditions: those determined according to the above analysis.

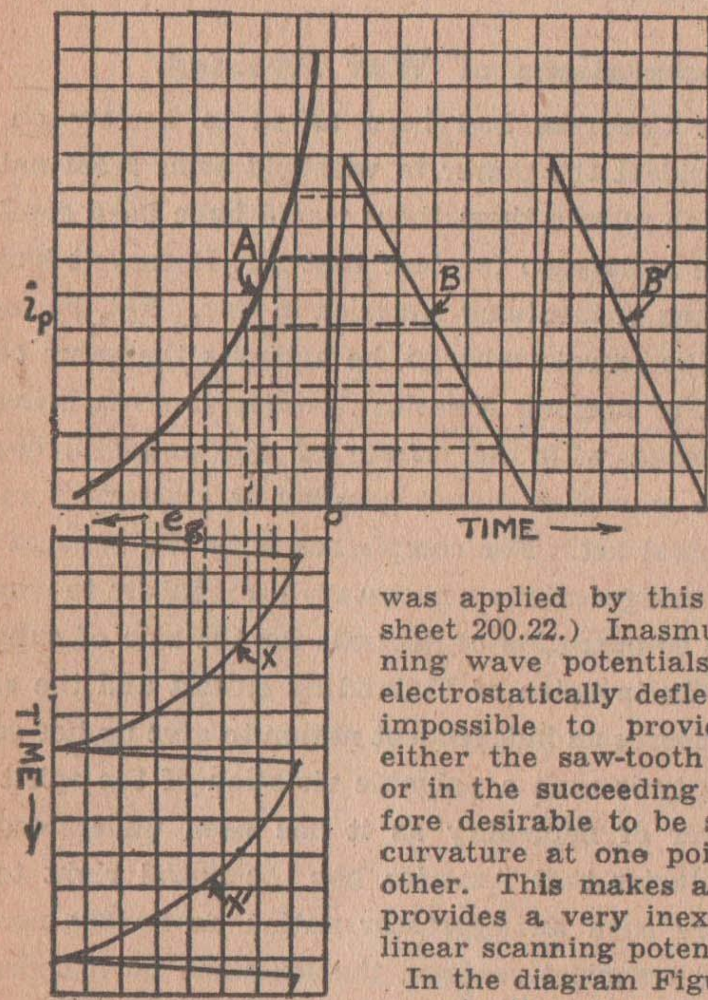
While the foregoing analysis is applicable directly to television receiver systems that employ electrostatically deflected cathode ray tubes, the problem is quite the same when deflection coils are used. The problem of linear deflection fields is complicated if high impedance (and consequently in practice—high resistance) deflection coils are used.

Since the advent of numerous types of output or power pentodes, the deflection system usually preferred uses low impedance coils, designed with relatively few turns but requiring a scanning wave amplifier to handle heavy currents of the saw-tooth waveform. The deflection is proportional to ampere turns so that the use of a coil of few turns and a large impressed current will give a satisfactory deflection. This system is particularly effective with short tubes designed for magnetic deflection coils. If the plate characteristics of the output tube is a family of horizontal curves (as is usual with a pentode) the impedance drop across the coil itself is of no consequence and the only problem is to get a linear saw-tooth current wave in the plate circuit of this tube. This linearity can be obtained, therefore, by the application of these same principles, as outlined on this and the preceding Data Sheet 200.23.

The Sun
Television Data Sheets

Compiled by RALPH R. BATCHER.

Curvature Correction in Scanning Amplifiers



On Data Sheet 200.20 the Du-Mont scanning circuit was shown in which a transformer - coupled discharge circuit formed the basis of operation. A 6R6G amplifier tube provided the inverse potential needed for push-pull deflection. In this amplifier a feature was mentioned wherein scanning curvature correction was applied by this amplifier tube. (See sheet 200.22.) Inasmuch as quite high scanning wave potentials are needed when an electrostatically deflected tube is used, it is impossible to provide strict linearity in either the saw-tooth wave forming circuit or in the succeeding amplifier. It is therefore desirable to be sure that the resulting curvature at one point is corrected in the other. This makes a virtue of a fault and provides a very inexpensive way to secure linear scanning potentials.

In the diagram Figure 1, the curve A represents the characteristic curve Eg-Ip for an amplifier tube, which shows considerable non-linearity. Below this there is shown two pulses of a non-linear saw-tooth wave which might be obtained from a non-compensated scanning wave oscillator. It is desired to correct the curvature of the sides of the saw teeth, at x and x′, so that a linear wave is produced. If this wave form x-x′ is applied to the grid of the tube having the characteristic curve A, the output wave is shown at B-B′. While this latter curve represents plate current, the usual amplifier stage has a fixed load resistance, so that the output voltage wave has a similar waveform, with substantially uniform rate of change.

Sheet 200.23.

(To be continued.)

The Sun
Television Data Sheets

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TELEVISION NETWORK OPERATION

Since television must compete with moving pictures in the entertainment field, all of its inherent advantages must be utilized to greatest advantage. The important factor in this regard is its ability to handle local news happenings and sports events without delay. One of the expensive propositions, however, has been the need for an elaborate set-up of ultra short short-wave transmitters or special transmission lines over which the program can be returned to the main transmitter.

However in spite of the enormous losses introduced by ordinary telephone cables when television video-frequencies are handled, the Bell Telephone Laboratories have shown that television program transmission over such lines is far from hopeless. A mile of ordinary 22 or 26 gauge cable such as is used in regular telephone conversations may have over five million times as great a power loss at 3 megacycles as at 3 kilocycles. This loss can be compensated for by a high-gain amplifier. The problem is complicated, however, by the selective frequency requirements of such an amplifier. The amplification of a 0.50 megacycle signal for a certain length of cable might be twenty to one, but for a 3 megacycle signal the gain required for the same cable would be around 3,700 times.

In tests conducted in transmitting actual television programs it was found that by greatly exaggerating the higher video frequencies before connecting the signal to the line it was possible to equalize the rest of the difference at the other end, with the result that the losses were constant at all frequencies in the normal video range. At the same time the travel speed of the signals was equalized so that "ghost" images were avoided. Before the telephone line is actually used it is subjected to special transmission loss tests that show whether abnormal characteristics are present. Special amplifiers having these characteristics have been subjected to tests by both NBC and CBS, with promising results over distances up to about one mile. Particularly severe checks were applied to see that interference was not introduced into the television signal, and, on the other hand, to see that additional disturbances were not caused by that signal in other pairs of wires in the same cable.

The pick-up cameras and associated microphones, with their regular amplifier, are taken to the point of interest and set up in the normal manner. The signal from the pick-up camera is transferred to the telephone line through high-frequency booster amplifiers that over-emphasize the high frequency end of the video range. At the receiving end (which is located at the transmitter) other high-pass amplifiers are used to bring about an equality in the signal strength at all frequencies. The resulting video signal closely corresponds to the output of the pickup camera. The sound program is handled in the usual manner.

The Sun
Television Data Sheets

Compiled by RALPH R. BATCHER.

COAXIAL CABLES FOR VISION FREQUENCIES

As reported in the previous Data Sheet, it has only been recently that distance as great as one mile could be covered using regular telephone cables for transmitting video signals from an outside pickup point, back to the transmitter. For several years great distances have been covered by using coaxial cables, consisting of a tubular conductor containing a wire centrally located and spaced with numerous inslating beads from the outer conductor. The actual amount of insulation, however, is kept at a minimum so that the losses are low. The cable is sealed to exclude all moisture.

By careful design and installation, the losses are easily compensated since the attenuation is linearly proportional to the frequency. With proper terminal amplifiers and other equipment installed at specified intervals, the upper limit of the frequency that can be economicaly handled is as great as is needed in television.

The coaxial cable between New York and Philadelphia has been used at frequencies of more than one megacycle, but this limit was set by the characteristics of the amplifiers used at the time of the tests.

Coaxial cables are not well adapted to the use of temporary pickup locations on account of installation difficulties, but will become important means for interconnecting studios and transmitters. It is generally inconvenient to locate studios, which must be large and easily accessible for the talent, near the transmitter. The latter must be near its antenna which is always on a high building or other elveated place that might be relatively remote from the best studio locations. In this case, coaxial cables can be installed with permanent terminal amplifiers having correct characteristics for equalizing the frequency range.

Another application for the coaxial cable is for the interconnection of studios in various cities in system networks so that a single program can provide entertainment to greater areas than that supplied by the limited horizon of a single transmitter. When network operation is started the cost of putting on elaborate stage presentations and special features is spread over a larger audience coverage, and an added entertainment value is assured. In a later Data Sheet other types of interstation connecting links will be described—using ultra-high frequency radio carriers as the connecting medium. These carrier frequencies are higher than used in television transmission for public participation. As was shown in Fig. 1 sheet 200.3, twelve of these special bands have already been set aside by the FCC for this use.