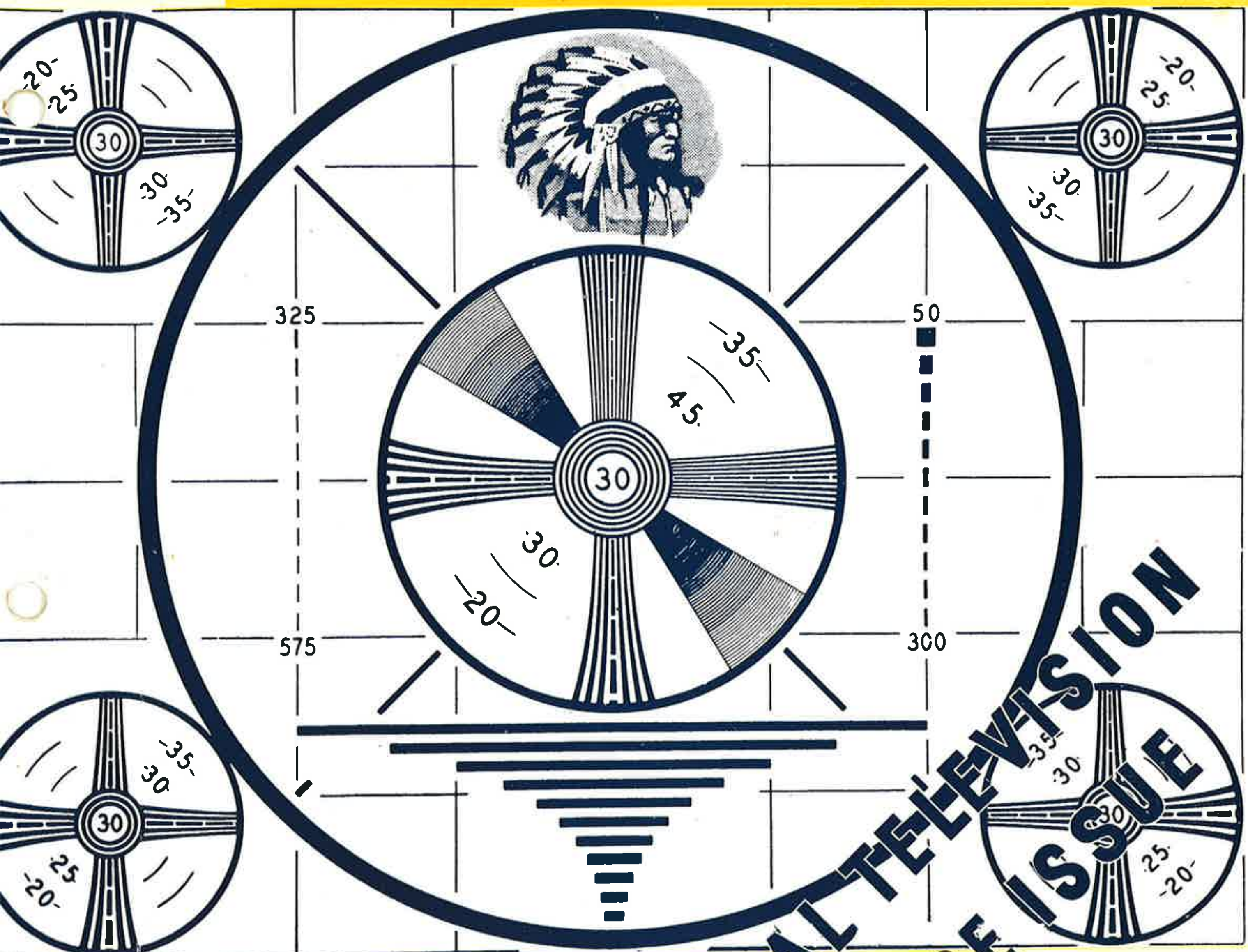
RADIOTRONICS

Vol.16 January 1951 No.1



SPECIAL TELEVISION SERVICE ISSUE

An AWV Publication

PRICE 1/-

RADIOTRONICS

Volume 16 **January, 1951** **Number 1**

By the way—

With this release of Radiotronics it will be noted that the issue numbering method has been changed from its previous consecutive form to the standard volume and number system. As Radiotronics has been published since 1935, this first issue for 1951 is referred to as Vol. 16, No. 1.

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We regret that in our December, 1950, issue, the author's by-line and credit were omitted from the feature article, "The Design of a Push-Pull Amplifier and Driver Stage". Therefore, we would extend our apologies to Mr. Albert Preisman, A.B.E.E., who is well-known for his book, "Graphical Constructions of Vacuum Tube Circuits", and also to the Capitol Radio Engineering Institute, from whose publication, "CREI News", the article was reprinted.

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Referring to the article, "Universal Coil Winding", by Mr. E. Watkinson, appearing in the same issue, we would like to point out an error on page 138, column 1, line 16, which should read: "spaces per layer is". Also on page 140, column 2, Example 1, the right-hand side of equation (d) should read 44/33.

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The following back numbers of Radiotronics are still available at 1/- per copy:—1948: 130, 131, 132, 133, 134; 1949: 135, 136, 137, 138, 139, 140; 1950: 141, 142, 144, 145, 146.

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CONTENTS

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EDITORIAL

The current issue of Radiotronics is noteworthy for several reasons which merit the close attention of our readers. This is the first issue of a new year of the second half of the twentieth century.

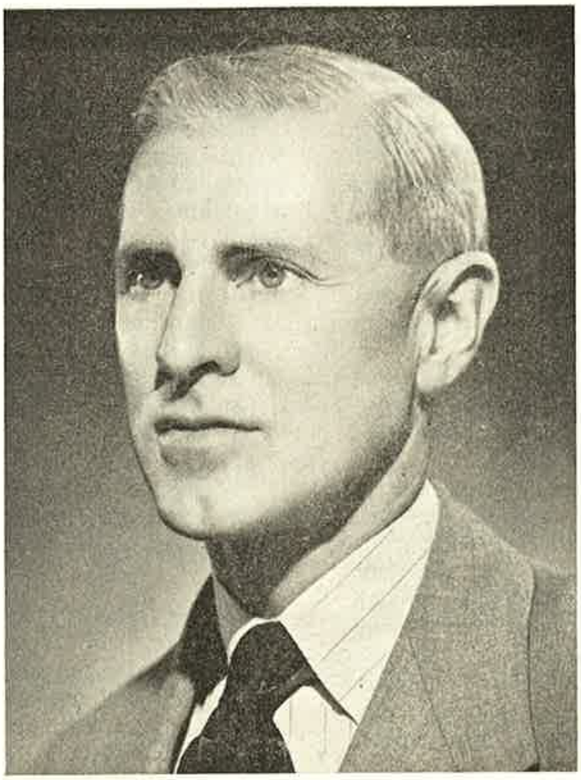
The years just past have witnessed the greatest growth in scientific achievement ever known, while the years to come promise to outdo those gone.

In retrospect, some eighteen years ago, Radiotronics made its bow in the modest form of stencilled sheets, which appeared at irregular intervals.

This presentation was soon superseded by an illustrated journal which has been printed from the year 1935 onwards by Mr. W. Short of Cloister Press, whose ever-helpful co-operation we are pleased to acknowledge here.

At this stage, the Company's Application Engineer, Mr. F. Langford-Smith, became editor, which post he has held to the present day.

To this position, Mr. Langford - Smith has brought a wealth of practical experience. In addition to his academic qualifications—B.Sc. and B.E. with first class Honours—he is an Associate Member of the Institution of Engineers, Australia; a Senior Member of the Institute of Radio Engineers, U.S.A.; and a Chartered Engineer.



F. LANGFORD-SMITH

During 1928-32 he was in England, initially with the Metropolitan-Vickers Electrical Co., and later employed as development engineer and as the valve factory engineer with the Cosmos Lamp Works. In the latter year he returned to Australia as engineer-in-charge of the Amalgamated Wireless Valve Company laboratory. Subsequently he also visited U.S.A. and Canada in 1934-35 to investigate the possibility of manufacturing transmitting valves in Australia.

During the war years, he served as a member of the Valve Production Advisory Panel, and was also appointed Acting Sales Manager of A.W.A. in 1941, during the period of Mr. Hosking's leave of absence with the Armed Forces.

In addition to his work on Radiotronics, Mr. Langford-Smith edited three successive editions of the Radiotron Designer's Handbook, the last selling several hundred thousand copies throughout the world.

At the present time he is completing the final editing of the monumental fourth edition, which will be a very considerable advance in every way on its forerunners. Enquiries pouring in from all quarters show the keenness with which this new work is awaited.

During the intervening years Radiotronics has grown in size and has kept pace with the times. The latest step is to revert to monthly publication to reduce the time lag in the presentation of data on new valves and their application.

While there have been changes in the appearance of Radiotronics, its editorial policy has remained unchanged. That this is wise, is borne out by the regularity with which thousands of readers renew their subscriptions annually.

The popularity of this technical journal is in no small measure due to the wise guidance of Mr. Langford-Smith, ably assisted by Valve Works' engineers.

Effective this issue, Mr. Ian Hansen succeeds Mr. F. Langford-Smith as Radiotronics editor, and it is the intention of the new editor to maintain the high standard of technical journalism set by his predecessor.

Television Trouble Shooting

Nomenclature

Different manufacturers use different names for the same sections of television receivers, as follows:

1st detector, or mixer, or converter
R-f oscillator, or local oscillator, or heterodyne oscillator
Picture i-f, or pix i-f, or video i-f
Picture 2nd detector, or pix 2nd detector, or video detector
Sound i-f or audio i-f
Sound 2nd detector, or audio detector, or discriminator.

The word *"raster"* means the horizontal white lines (about 500 of them) seen on the kinescope when the brightness is turned up, but with no picture. These lines are crossed by several diagonal lines which are formed when the electron beam in the kinescope is moving from the bottom to the top of the raster.

Test equipment for TV service in home

Experience indicates that it is not advisable to take a sweep generator, marker oscillator, and other bench-type test equipment into the home except in special cases.

A voltohmmeter is essential, and the electronic type, with high input resistance and an isolating probe (1.0 megohm or more in series with the probe tip) is definitely recommended.

With an electronic voltmeter, it is possible to check the operation of the r-f oscillator, the horizontal oscillator, and the vertical oscillator by measuring developed grid voltage. The electronic voltmeter can be used to trace sync pulses through the sync separator and amplifier stages by measuring the developed bias. It can be used to check the operating bias in picture i-f and video amplifiers. It reveals high-resistance leakage in coupling capacitors. It is essential in checking discriminator tuning adjustments.

A complete supply of replacement tubes, including kinescopes, is essential for home television service.

Figure 1. **Use TV set to monitor stations.**

Any shop that handles television service soon finds out that its most valuable and scarcest commodity is *time.*

One way to save time is to avoid unnecessary service calls. When Mrs. Jones calls to complain that her television set isn't working, don't dash right out to her house; maybe the trouble is at the transmitter; maybe little Johnny Jones has pulled out the plug; maybe Mrs. Jones doesn't know how to operate the set.

At least one TV receiver should be operating in the shop to "monitor" sound and picture on the local TV stations. Owing to "technical difficulties", TV stations can develop a variety of troubles that Mrs. Jones may blame on the receiver: The station's sound may be interrupted, weak, or noisy; the picture may be interrupted, washed out, jittery, or noisy; the vertical or horizontal sync may be erratic. Relay programmes are somewhat more prone to trouble than direct studio programmes, and ancient movie films may have inherently poor sound and picture quality.

Handle certain calls by phone

First check the station on the monitor receiver. If the picture and sound are OK, get back on the phone and ask Mrs. Jones some questions. The kind of questions will naturally depend on the complaint, but it is necessary to find out:—

(a) Is the set plugged in and turned on?
(b) If it is a combination TV and radio, is the function switch set for TV?
(c) Is the set tuned to the correct channel?
(d) Are the controls set correctly?
(e) Are other TV stations OK on Mrs. Jones' set?
(f) Has the set been moved recently? Maybe the antenna transmission line is shorting or disconnected.

Remember that most TV owners "don't talk our language". When Mrs. Jones says there is "no picture", she probably means that there is a picture, but that the horizontal or vertical sync is out.

Schedule calls for air time

If the trouble appears to be external interference, try to find out when it occurs. There is no sense making a service call on Thursday a.m., to find that the interference is evident only on Tuesdays between 8.00 and 9.00 p.m.

If the complaint involves only one station, and the other stations are OK, schedule the call for a time when the particular station is on the air.

If the complaint indicates need for antenna re-orientation, schedule the call for daytime, and for a day when all the TV stations are on the air.

Schedule calls to save unnecessary travel time.

Check antenna orientation

Before going into the home, check the antenna for correct orientation, preferably with the aid of a compass, particularly if the complaint indicates weak signal or interference. Of course, the antenna may have been intentionally set off the normal angle

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to minimize interference or to favour the weaker station if there are several stations in different directions.

Much time can be wasted working over a chassis in the home before discovering that the trouble is due to antenna orientation.

Have owner demonstrate trouble

In the home, ask Mrs. Jones to turn on the set and demonstrate the trouble. This will show whether Mrs. Jones has learned how to operate the set, and it may save time, because frequently the actual trouble is entirely different from the trouble as originally described over the phone.

If trouble is interference

If the trouble is due to external interference such as diathermy that is prevalent in the particular area and that cannot be improved by reorienting the antenna, or by using a coaxial transmission line, explain the situation to Mrs. Jones as simply as possible.

In this connection, some manufacturers include illustrations of typical interference in the owner's instruction book, with an explanation that there is no immediate remedy for some forms of interference. Such *printed* information may help in explaining the condition to Mrs. Jones.

TELEVISION SERVICE
IN
OWNERS HOME

1. USE TV SET TO MONITOR STATIONS.
2. HANDLE CERTAIN CALLS BY PHONE.
3. SCHEDULE CALLS FOR AIR TIME.
4. CHECK ANTENNA ORIENTATION.
5. HAVE OWNER SHOW YOU CONDITION.
6. IF TROUBLE IS INTERFERENCE, EXPLAIN TO OWNER; TRY REMEDIES.
7. IF TROUBLE IS INTERNAL, INSPECT FOR OBVIOUS DEFECTS.
8. LOCALIZE TROUBLE TO ONE SECTION.
9. TEST THIS SECTION.
10. BRING "TOUGH" SET BACK TO SHOP.

FIG. 1

In this same category, a particular TV station may have a noticeable reflection (echo or ghost) all through one area in one or more directions from the transmitter. This may be due to reflection from a tall building in the vicinity of the transmitter. Here again, orientation of the antenna won't help if the condition is prevalent in the area.

In both cases, the job of explaining to Mrs. Jones is made easier if she realizes that the same condition exists in neighbours' sets.

If the interference is from the r-f oscillator in a nearby TV set, it may be improved by repositioning and orienting the antenna and/or by using a shielded transmission line.

Some cases of diathermy have been cleared up by grounding the diathermy equipment.

The F.C.C. and some TV manufacturers have traced down and eliminated many sources of interference.

Interference due to radio transmitters can be minimized in some cases by the use of stubs, as explained later.

If trouble is internal

If there is any question of sensitivity, the following check may prove helpful:—

Disconnect the antenna and turn the picture contrast control full clockwise. There should be some evidence of thermal noise in the form of speckles on the raster. With experience, it is possible to tell whether the intensity of the speckles is normal for the particular model of set.

Reconnect the antenna: If the transmission line and the antenna are OK, there should be a very marked increase in noise.

If there is any doubt about the antenna, substitute a temporary indoor dipole, and compare the signal strength. The outside antenna should provide much stronger signals. (If the set has AGC, automatic gain control, it may be necessary to compare signal-noise ratios rather than signal ratios.)

TWO MAIN SECTIONS IN TV SET

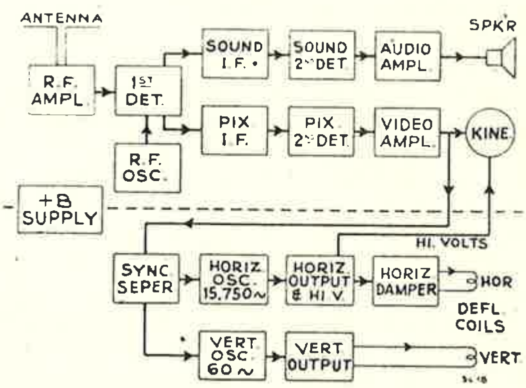

FIG. 2

If the trouble appears to be in the receiver, the next step is to localize it to one section and then check that section.

In many cases, it is possible to localize the source of trouble to a particular section of the receiver simply by observing and analyzing the sound, the raster, and the picture.

To show how this is done, we will briefly analyze various combinations of symptoms for the typical television receiver shown in Figure 2.

Figure 2. **Two main sections in TV set**

The following analysis does NOT apply to receivers that are basically different from Figure 2. For example, it does not apply to:—

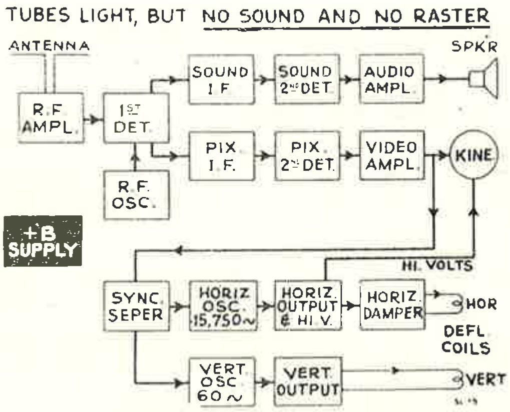

FIG. 3

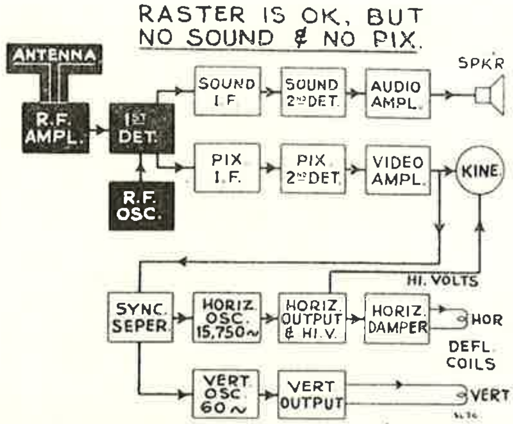

FIG. 4

(1) TV receivers that employ a separate high-voltage supply using either an r-f oscillator or a 60 cycle transformer to supply high voltage for the kinescope.

(2) TV receivers in which the sound and picture signals are handled in one common channel from the antenna to the kinescope, where the sound, as a 4.5 megacycle beat, is trapped out and passed into a discriminator and audio amplifier.

(3) TV receivers with series heater connections. If one heater opens, several sections of the receiver may be affected. The first job here is to find and replace the tube with open heater.

We assume that the set was installed and operating satisfactorily before the trouble developed. We assume also that only one trouble has developed, as is usually the case.

As mentioned later, when the trouble has been localized to one section, it is generally advisable first to try new tubes in this section. Much time can be wasted removing the chassis from the cabinet and checking around under the chassis when the trouble may be in a tube that could have been replaced in a few minutes.

In localizing trouble, it is helpful to think of a television set as being divided into two main sections:—

(1) The receiving circuits from the antenna to the kinescope and to the speaker
(2) The sync, deflection, and high-voltage circuits.

The heater and low-voltage plus B supply is common to both of the main sections.

In Figure 2, the high voltage for the kinescope is obtained from pulses in the horizontal output tube. Consequently, if the high voltage is OK, the low-voltage plus B feed to the horizontal circuits must be OK.

Figure 3. **Tubes light, but no sound and no raster**

The tubes light, so we know that the set is plugged in and turned on.

"No raster" might be either a kinescope failure, or no high-voltage. But if it were simply a case of kinescope failure, the sound would be OK. So the trouble is likely to be no high voltage.

With no high voltage and no sound, we expect trouble in something common to both main sections of the receiver; therefore first check the plus B supply.

In the succeeding illustrations, we will omit the B supply for simplicity.

Figure 4. **Raster is OK, but no sound and no picture**

The raster is OK, so we know that the high voltage and deflection circuits are OK. As the high voltage is OK, we know that the low-voltage plus B supply must be OK, or nearly so. However, we should check plus B in the sound and picture channels.

No sound and no picture, or
Weak sound and picture, or
Intermittent sound and picture,

generally point to trouble in the "head end" (antenna, r-f, converter, or oscillator) which is *common to both the sound and picture channels.*

A word of caution here: Some troubles in the head end show up only in the sound, and are not evident in the picture, because the sound channel is more responsive to slight changes in frequency of the r-f oscillator. For example:—

(1) Poor contacts, due to dirt or lack of tension in the channel-selector switch, or other type of tuning system, may produce noise in the sound, but not on the picture.

(2) A microphonic r-f oscillator tube, or microphonic parts in the r-f oscillator circuit, may be evident only in the sound, and not in the picture.

(3) The r-f oscillator can be off frequency far enough, in one direction, to kill sound, with little effect on the picture. If the oscillator is off far enough in the opposite direction, there will be sound in the picture, but no sound from the speaker.

Figure 5. **Picture is OK, but sound is missing, weak, or distorted**

The picture is OK, so we know that the entire picture channel from the antenna to the kinescope is OK, and that the sync, deflecting, and high-voltage circuits are OK.

If there is no sound on any channel, check the audio amplifier and speaker by touching a finger on the discriminator output with the volume control turned up. If this section is alive, the trouble may be in the sound - i-f amplifier or discriminator.

If the set has a switch-type channel selector, and there is no sound on one station, but the other stations are OK, it is probable that the r-f oscillator is off frequency and requires readjustment on this channel.

A safe method of adjusting the oscillator is to connect an electronic voltmeter to the output of the discriminator and adjust the oscillator frequency to the "centre zero" on the discriminator response curve, where a slight change of the oscillator frequency in one direction will cause the meter to swing positive, and a slight change in the other direction will cause the meter to swing negative.

If the TV set has a "fine-tuning" control, centre it while making this adjustment.

Figure 6. **Sound is OK, raster is OK, but no picture**

The sound is OK, so we know that the entire sound channel from the antenna to the speaker is OK, and that the frequency of the r-f oscillator is probably OK.

The raster is OK, so we know that the kinescope, deflecting circuits, and high voltage are OK.

The only thing left is the picture channel, from the 1st detector to the kinescope. The video amplifier in this channel can be checked by using the sound signal in the audio amplifier as a signal source in this way:—

Tune in a TV station's sound (preferably a constant 400-cycle tone) and connect a shielded jumper in series with an .01 mfd. capacitor from the plate of the audio output tube to the kinescope grid.

Turn up the volume control until there is some evidence of sound on the raster.

Move the jumper back to the 2nd video grid, to the 1st video grid, and finally to the 2nd Detector output, reducing the audio volume control as necessary. If the TV set has a contrast control in the video amplifier, turn it full up during this check.

By following this procedure, it is possible to find a dead video stage or an open video coupling capacitor, and to get a rough idea of the video gain.

If the video amplifier appears OK, concentrate on the picture - i-f amplifier and the picture 2nd detector.

Figure 7. **Sound is OK, but there is sound in the picture**

In sets with a fine-tuning control, and in sets with a continuous tuning system, if the sound tunes OK, it indicates that the frequency of the r-f oscillator, sound - i-f amplifier, and discriminator are probably OK.

This leaves several possibilities:—

(1) The sound traps may be detuned, due to change in value or failure of some component.

(2) The sound - i-f is being coupled, in some manner, into the picture - i-f amplifier, *after* the sound traps.

(3) A harmonic of the sound - i-f falls in an r-f channel and is being picked up in the input circuits of the set.

Possibilities (2) and (3) can be checked definitely by temporarily removing the 1st sound - i-f tube, which eliminates any strong sound - i-f signal in the set that might produce (2) or (3). Then if there is still sound in the picture, it may be due to item (1).

If the adjustments show evidence of tampering, bring the set to the shop for complete alignment check.

If it is necessary to adjust the traps, in the owner's home, first tune in the sound correctly, preferably by connecting an electronic voltmeter to the dis-

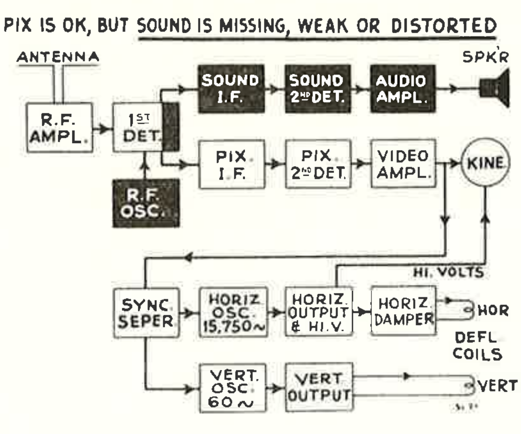

FIG. 5

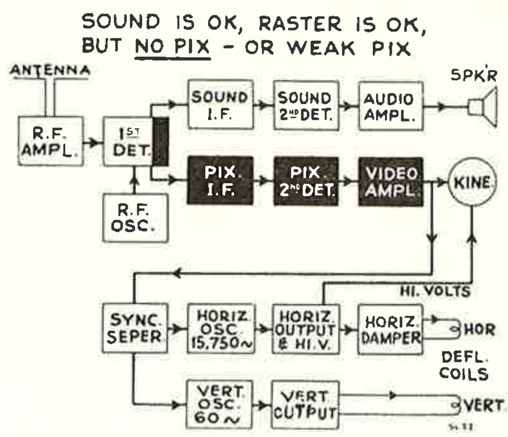

FIG. 6

SOUND IS OK, BUT SOUND IN PIX

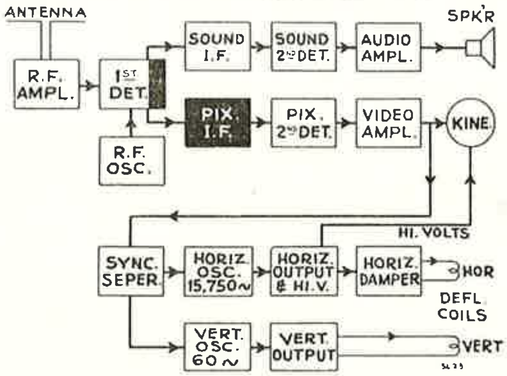

FIG. 7

criminator output to determine the correct tuning point. Then adjust the sound traps for minimum sound in the picture. If the traps cannot be tuned for a definite null, bring the set to the shop.

(In some TV sets, one or more of the sound traps is in the video amplifier.)

Do not adjust the wrong traps by mistake (the adjacent-channel sound trap, or the adjacent-channel picture trap) as there is no simple means, in the home, of getting them back on correct frequency.

Figure 8. **Sound is OK, picture is OK, but brightness is low**

This may be caused by kinescope failures, insufficient high voltage, or trouble in the associated circuits.

Figure 9. **Sound is OK, but no raster**

This may be caused by kinescope failure, or no high voltage.

In this type of receiver, if the horizontal oscillator fails, there is no drive to the horizontal output tube, and therefore no high voltage.

Figure 10. **Sound is OK, but picture definition is poor**

The "definition" of a television receiver can be judged by "how far in" toward the centre of the test pattern it is possible to distinguish the separate lines in the vertical and horizontal wedges.

SOUND IS OK, BUT NO RASTER

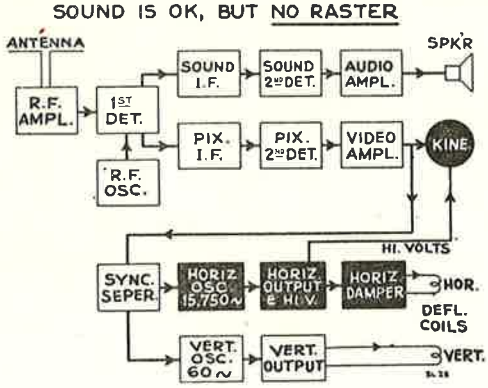

FIG. 9

SOUND IS OK, PIX IS OK, BUT BRIGHTNESS IS LOW

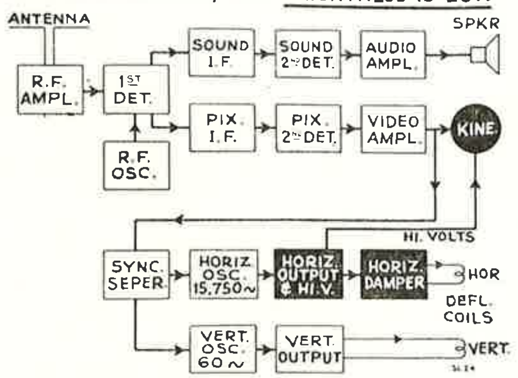

FIG. 8

The "farther in" the separate lines can be seen, the better the definition. The definition depends, among other things, on the bandwidth of the r-f - i-f - video response, and the focus of the electron beam in the kinescope.

The focus can be regarded as satisfactory if:

(1) The beam can be focussed to a *small* enough spot so that the separate lines in the raster can be discerned, and if

(2) The spot is *round*, as indicated when the best definition on *both* the horizontal and vertical wedges is obtained at the *same point on the focus control*. (If best definition on the horizontal wedge is obtained at one point on the focus control, and best definition on the vertical wedge is obtained at a slightly different point on the focus control, the spot is not round, but is elliptical.)

If the spot is good, as explained above, but if the vertical wedge cannot be "seen in as far" as is usual for the particular model of TV set, and for the particular test pattern, it may indicate that the set needs picture - i-f or r-f alignment.

This check cannot be used in locations where there are "close-in" reflections, or where the signal/noise ratio is bad, as these conditions obscure the normal definition.

SOUND IS OK, BUT PIX DEFINITION IS POOR

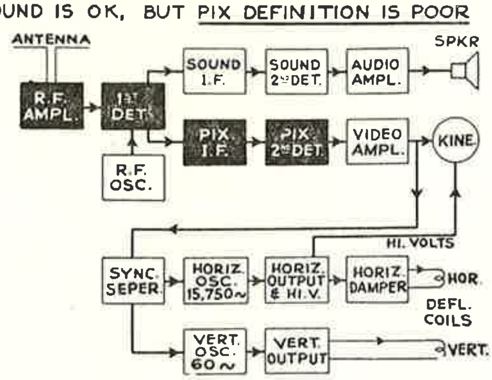

FIG. 10

An additional check on alignment is provided by the relative intensities of the vertical and horizontal wedges. The horizontal wedges represent low video frequencies; the vertical wedges represent high video frequencies. The wedges should be of equal intensities or blackness.

This is an elementary and incomplete treatment of a rather involved subject, but it is mentioned here because correct analysis of definition is a necessary and important part of television service in the owner's home.

Figure 11. **Sound is OK, but picture smeared**

One condition of smearing is seen occasionally in televised prize fights where the referee's white shirt is followed (on the right) by a dark smear, and where a fighter's black trunks are followed (on the right) by a light smear. This is termed "trailing reversal". The smears may extend only a fraction of an inch, or they may extend more than half-way across the TV receiver screen. Sometimes there is a similar reversal for a short distance on the left side of objects: This is termed "leading reversal".

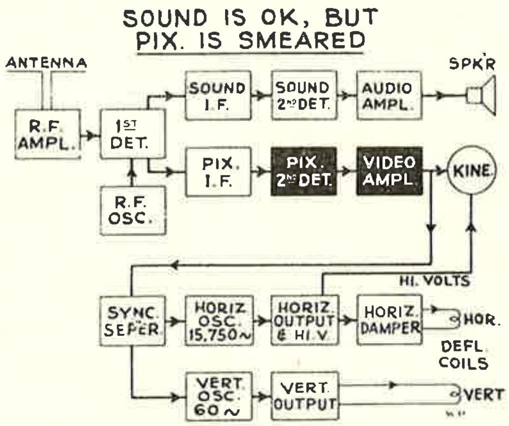

FIG. 11

This condition can originate at the transmitter, but a similar condition can originate at the receiver.

If one receiver has noticeable smear on all stations while another receiver is clear (call the shop to see if the picture on the monitor is clear), first check the video amplifier, looking for open peaking coils, coupling capacitors, wrong value plate load resistors, incorrect bias, etc. If the video amplifier appears OK, bring the set to the shop for alignment check.

Figure 12. **Sound is OK, but picture is out of sync.**

The block marked "sync separators" acts to remove the sync pulses from the picture, and to separate the vertical pulses from the horizontal pulses.

If both H and V sync are poor, check the common sync separators or amplifiers that handle both H and V pulses.

If only H sync is poor, check the H sync amplifiers, oscillator (and frequency-control circuits if the set has horizontal AFC).

If only V sync is poor, check the V sync amplifier and the V oscillator.

Poor sync can also be caused by incorrect r-f - i-f alignment, and by trouble in the video amplifier.

If the picture carrier is too far down on the slope of the over-all r-f and picture - i-f response curve, low-frequency modulation, which includes H and V sync and blanking, will be reduced in amplitude, and this can cause unstable sync.

Any defect that reduces low-frequency response in the video amplifier may result in unstable sync.

A quick check, to see if r-f - i-f alignment or video troubles are causing poor low-frequency response, can be made by inspecting the horizontal and vertical sync as they appear on the kinescope:—

Reduce the contrast and increase the brightness until the V and H sync pulses are a dark grey. The sync should be definitely blacker than the blanking, and no picture elements should be darker than the blanking. The leading edge (left-hand edge) of the horizontal sync should change abruptly from the grey level of the blanking to the darker grey level of the sync. There should be no changes of shading for the duration of each sync pulse.

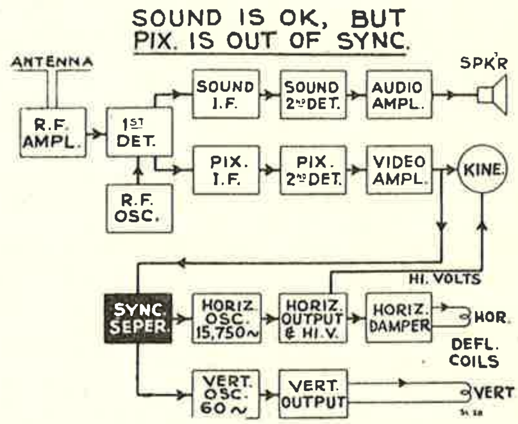

FIG. 12

If H and V sync appear OK on the kinescope to the critical eye of an experienced man, the trouble is probably not due to alignment or to video response.

In order to observe the vertical sync pulses, it is necessary to roll the picture out of vertical sync, so that the sync and blanking move slowly from top to bottom.

In order to observe the horizontal sync pulses, in receivers that use AFC on the horizontal oscillator, it is necessary to adjust the phasing circuit to move H sync and blanking to the left.

Figure 13. **No vertical deflection**

This is caused by trouble in the vertical oscillator or output circuits.

After localizing trouble

After the trouble has been localized to one section, the following procedure is suggested:

(1) Try new tubes in the suspected section.
(2) Look for over-heated parts, loose connections, shorts, and grounds.
(3) Measure voltages.
(4) Check the parts.

To find microphonic troubles

(1) Tap the tubes in the suspected circuits and try new tubes.
(2) If the r-f oscillator is microphonic, tap and flex the oscillator parts. Cement loose coils and adjustments.

To find intermittent troubles

(1) Wiggle the tubes in their sockets.
(2) Tap and flex the chassis.
(3) Tap and flex the parts, wiring, and joints.

Troubles due to open electrolytics

Some very odd symptoms can be produced by an open electrolytic capacitor in the plus B and other circuits. This is particularly true when the common lead opens in a multiple electrolytic, and affects several sections of the receiver.

Sets with AGC (automatic gain control)

In a strong signal area, when first checking a set that has AGC on the r-f and picture - i-f amplifier, the first reaction may be that the signal strength isn't up to par, because it may not be possible to over-load the set (produce a negative picture, or distort the picture) by turning up the contrast control. But this is normal with AGC.

Trouble in the AGC circuits can produce odd symptoms, so if in doubt, check the bias voltages on the r-f and picture - i-f amplifier tubes for strong and weak signal input to see if it is OK.

"Picture and sound don't track"

In sets with continuous tuning, and in sets with a fine-tuning control, a common complaint *on weak signals* is that "the sound and picture don't track". That is, if the owner tunes away in one direction from the point where sound is best, the picture will become brighter and stronger, possibly doubling in strength, but the sound will be lost.

Strange as it seems, this is a perfectly normal condition, and nothing should be done about it.

The reason for the apparent lack of tracking is that, due to single side-band transmission used in television, *the picture carrier must be parked about half-way down the slope of the r-f picture - i-f response curve in order to get equal response at low and high modulating frequencies.*

If, by detuning the r-f oscillator, the picture carrier is moved to the top of the slope, the gain at low modulating frequencies will be doubled, but the bandwidth will be reduced, high-frequency modulation will have only one half the amplitude of low-frequency modulation, and the definition will suffer.

This complaint is not encountered *on strong signals*, because the additional picture strength isn't needed, and because the loss of definition is obvious on a strong signal when the set is detuned.

Figure 14. **You can listen to interference on picture channel**

The principal sources of interference in television reception may be classified as follows:

(1) *Short-wave radio stations*, AM, FM, and code.
(2) *Industrial r-f equipment*, diathermy, r-f heating, r-f - excited sterilizing lamps, etc.
(3) *R-f oscillators* in short-wave, r-f, and television receivers.
(4) *Non-radio devices* that produce radio interference, such as ignition systems, smoke precipitators, some sterilizing lamps, some electrical and telephone equipment, etc.

In handling interference problems, it is always helpful to identify the source and the frequency.

If the interference is in class (1) above, it may be possible to identify the station by listening to the interference on the picture i-f channel as shown in Figure 14. (In some TV sets it is better to connect to the cathode of a video tube rather than to a grid, if there is a cathode resistor with no by-passing, or only a small by-pass capacitor across it.)

With this method, the interference will be obscured by the low-frequency picture signals

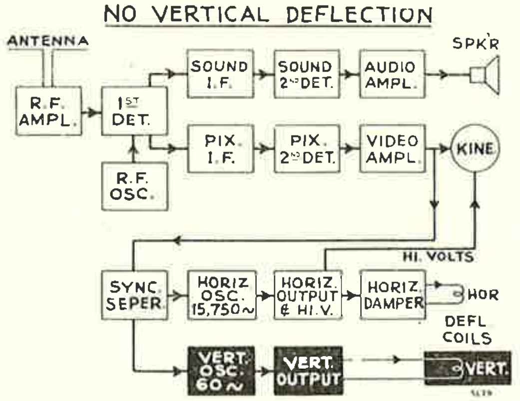

FIG. 13

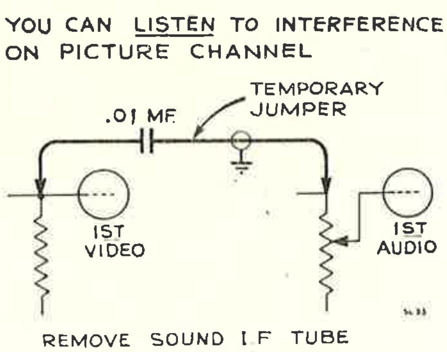

FIG. 14

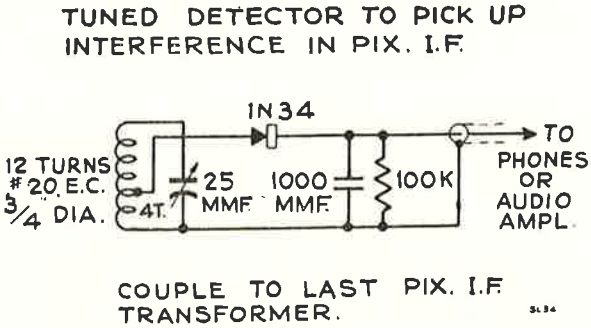

FIG. 15

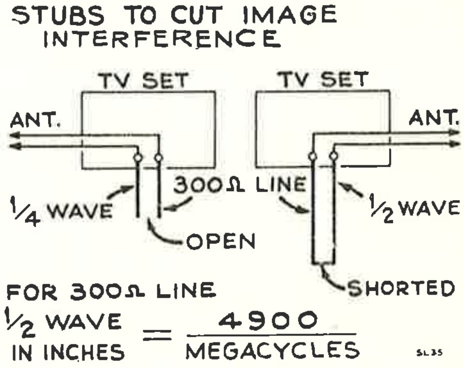

FIG. 16

(principally vertical blanking and sync), so that it may not be possible to identify the interfering station unless the TV station is off the air.

Figure 15. **Tuned detector to pick up interference in picture - i-f**

A better method to identify interference is by using a tuned pickup as shown in Figure 15. This is simply a tuned circuit covering the range of about 17 to 27 megacycles, with a crystal detector connected to a tap at the 4th turn. The dial of the variable condenser should be calibrated with the aid of a signal generator or test oscillator.

The tuned circuit should be held near the last picture - i-f transformer and tuned over the i-f range. At the frequency corresponding to the picture - i-f, the low-frequency picture elements and vertical blanking and sync will be heard. If the frequency of the interference is not too close to the picture - i-f, it can be tuned in without interference from the picture signal.

Having determined the frequency at which the interference appears in the picture - i-f amplifier, it is easy to compute the two probable r-f frequencies at which the interference originates:

(1) Determine the frequency at which the interference appears in the picture - i-f amplifier. Call this F1.

(2) Determine the frequency of the r-f oscillator in the particular set for the TV channel on which the interference occurs. Call this F2.

Then F2 minus F1, and F2 plus F1 will be the two probable r-f frequencies.

As an example, if—

(a) the interference is present on channel 3, and

(b) in the particular TV set, the r-f oscillator for channel 3 is at 87 megacycles, and

(c) the interference in the picture - i-f amplifier appears at 23 megacycles, then,

87 minus 23 = 64
87 plus 23 = 110

So the interference may originate at 64 or 110 megacycles.

It must be pointed out that there are other possible combinations in which r-f interference can beat with the r-f oscillator, or with a harmonic of the r-f oscillator, to produce interference in the picture. Also that strong i-f interference may get past the "head end" directly into the picture - i-f amplifier.

Figure 16. **Stubs to cut image interference**

In television receivers, the local oscillator is tuned higher than the r-f - picture carrier by an amount equal to the picture - i-f.

For example, on channel 3, the r-f picture carrier frequency is 61.25 mc. In one make of TV set, the picture - i-f is 25.75 mc. The r-f oscillator frequency for this channel is therefore 61.25 plus 25.75, or 87 mc. If a strong signal is present near the image frequency of 87 plus 25.75 or 112.75 mc, it can beat with the r-f oscillator, and the difference frequency of 25.75 will cause interference.

In television, the picture - i-f amplifier covers a wide band of frequencies, and therefore the image is also a band of frequencies.

For example on channel 3, 60 to 66 mc, the image band on this particular set is 108-114 mc. Strong signals in this band can cause interference on channel 3.

The appearance of interference on the kinescope depends on how far the interfering frequency is from the r-f picture carrier, or from the image of the carrier. If it is one mc different, it produces a one mc "beat" which may appear as approximately 50 slanting dark vertical bars on the kinescope. A two mc beat will produce about 100 bars, a four mc beat will produce about 200 bars. Conversely, the beat can be determined by counting the bars.

The most common form of image interference is from local FM stations in the range of 88-108 mc.

This interference can be reduced or eliminated by the use of stubs at the receiver antenna terminals. The stubs are cut to $\frac{1}{4}$ or $\frac{1}{2}$ wave at the interfering frequency as shown in Figure 16.

The length of the stub can be determined from the formula which is based on the use of 300 ohm ribbon line with a velocity constant of 0.83.

It is advisable to cut the stub somewhat longer than necessary and chop off short pieces to determine the exact length to obtain maximum attenuation of the interference.

Television Alignment Equipment

The following test equipment is required to align television receivers:

Sweep generator	or "sweep"
Marker oscillator	or "marker"
Cathode-ray oscilloscope . .	or "CRO"
Electronic voltmeter	or "VTVM"

Figure 17. **An elementary sweep**

Essentially, a sweep is a test oscillator in which the frequency is varied up and down, or "swept" over a band of frequencies at a rapid rate, usually 60 cycles or more per second.

To illustrate the basic principles and application of a sweep, we have devised the elementary arrangement shown here which is "swept" by hand, and therefore will not produce a continuous trace or response curve on the CRO.

(Actually, the voltage output of the 2nd detector is around two volts, so it would be necessary to use an amplifier, direct coupled, with a gain of 30 to obtain a vertical shift of about one inch.)

The upward deflection of the spot depends on the sensitivity or response of the TV set at different frequencies.

For example on channel 3, 60 to 66 mc, the picture channel of a conventional TV set has approximately the following response:—

Frequency	**% Response**
60 mc	0
61.25 (picture-carrier frequency)	50%
62 to 64.5 mc	100%
65.75 mc (sound carrier)	0

We will assume that the TV set is operating on channel 3, and that the test-oscillator dial covers a range several megacycles wider than channel 3, or from 58 to 68 mc.

AN ELEMENTARY SWEEP

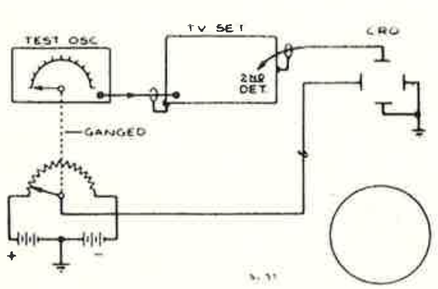

FIG. 17

TYPES OF SWEEPS

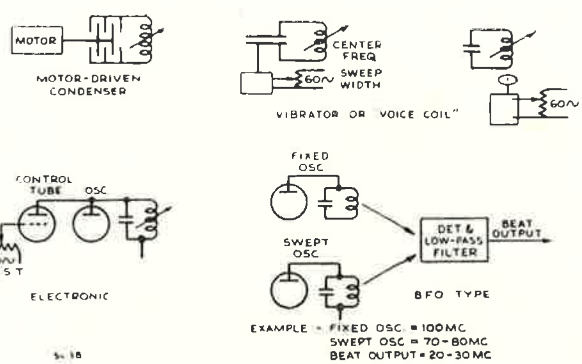

FIG. 18

A potentiometer and batteries are connected as shown to the horizontal deflection plates of a CRO. When the "pot." is turned to its left-hand position, the CRO spot is deflected to the left-hand side of the CRO screen. As the pot. is turned clockwise, the spot is moved to the right-hand side of the CRO screen.

If the pot. is turned rapidly and repeatedly from one end to the other, with the TV set turned off, the spot will trace a horizontal line across the CRO screen. (If the batteries are each 90 volts, the total deflection will be about 3 inches.)

In this illustration, a simple test oscillator is feeding an r-f signal into a TV set. The output of the picture 2nd detector is connected to the vertical-deflection plates of a CRO. If there is no output from the TV set, the CRO spot will not be deflected up or down. But if the test oscillator is tuned in the pass band of the TV set, there will be output, and if it is positive polarity, the spot will be deflected upward.

The tuning shaft of the test oscillator, and the shaft of the potentiometer are ganged so they turn together.

With the ganged shafts in the position shown, the oscillator is at 58 mc, and the spot is at the left-hand side of the CRO. There is no output from the TV set, so the spot is not deflected upward.

As the ganged shafts are moved slowly clockwise, the spot moves toward the right, and also upward as the response of the set increases. From approximately 62 to 64.5 mc, the output of the set is maximum and constant, so the spot is held at its highest upward position over this range. As the frequency of the test oscillator is increased, the output of the set and the spot begin to drop and become zero at the sound-carrier frequency of 65.75 mc. They will remain practically at zero as the test oscillator is turned full clockwise to 68 mc.

By manually sweeping a signal across this band of frequencies, we have traced on the CRO the response curve of the TV set for channel 3.

If we turn the shafts counter-clockwise, we will get the same response curve.

If we turn the shafts rapidly and repeatedly from one end to the other, and have a long-persistence CRO tube, we will get many identical curves which fall on top of each other and appear as a single curve.

Before leaving this illustration, it is worth while to note the following points:

(a) If the polarity of the voltage output from the picture 2nd detector is negative, the CRO spot will be deflected down instead of up, and the response curve will be up-side-down. In actual practice, the response may appear either way, depending on the polarity of the output voltage, the number of stages in the CRO vertical amplifier, and the connections to the CRO tube.

(b) If the polarity of the horizontal deflecting voltage is reversed, the low-frequency end of the response will be at the right instead of the left. Again in actual practice, this may be either way and is of no importance.

(c) Vertical (up and down) deflection represents change in output voltage or sensitivity of the TV set.

Horizontal (left-right) deflection represents frequency. In this particular example when the spot is at the left, the test oscillator is at 58 mc. When the spot is at the right, the test oscillator is at 68 mc. But the curve that we see on the CRO is not the r-f or i-f or video frequency; it is simply the rectified (DC) output of the picture 2nd detector changing in amplitude as the input signal is swept across the band.

If we sweep back and forth repeatedly, and each sweep requires one second, then the distance from left to right on the CRO represents one second. So the "frequency" of the response curve depends on how fast we sweep back and forth.

We have covered the basic principles of a sweep. If it is clearly understood, we can proceed to consider a few variations and requirements for television alignment.

Figure 18. **Types of sweep**

Of course the manual sweep that we have been discussing is not practical. Designers use either a mechanical or an electronic system to sweep the oscillator frequency.

The mechanical type may consist of a motor-driven variable condenser in the oscillator circuit, or it may be a specially designed vibrator mechanism similar to the voice coil and magnet structure in a permanent-magnet loudspeaker, which alters either the capacity or inductance or both in the oscillator tuned circuit. An adjustable voltage (60 cycles) is fed to the "voice coil" to control the amplitude of vibration. Small vibration gives narrow sweep width; large vibration gives wide sweep width.

The electronic type uses a reactance-tube frequency-control circuit similar to the type used in automatic-frequency control. In this type, the sweep width depends on the amount of change in gain of the control tube. The gain is controlled by the amplitude of a saw-tooth, sine-wave or other shape signal (usually 60 cycles) impressed on the grid of the control tube: Small amplitude gives narrow sweep width; larger amplitude gives wider sweep width.

Beat-frequency oscillator (BFO) sweep. Either the mechanical or the electronic type of swept oscillator may be used in conjunction with a fixed-frequency oscillator to produce a swept beat of lower frequency. The two oscillator signals are mixed in a detector, and the difference-frequency beat is used. The high-frequency signals are filtered out.

In the example shown, the fixed-frequency oscillator is operating at 100 mc. The swept oscillator is sweeping from 70 to 80 mc. When the swept oscillator is at 80 mc, the beat is 100 minus 80, or 20 mc. When the swept oscillator is at 70 mc, the beat is 100 minus 70 or 30 mc. So the beat sweeps from 20 mc to 30 mc.

If we want this sweep to cover from 10 mc to 20 mc, it is necessary only to tune the fixed-frequency oscillator to 90 mc. Then when the swept oscillator is at 80 mc, the beat is 90 minus 80 or 10 mc. And when the swept oscillator is at 70 mc, the beat is 90 minus 70, or 20 mc. So the beat sweeps from 10 mc to 20 mc.

If we want this sweep to cover the video range from 0 to 10 mc, we set the fixed-frequency oscillator at 80 mc. Then when the swept oscillator is at 80 mc, the beat is 80 minus 80, or zero. And when the swept oscillator is at 70, the beat is 80 minus 70, or 10 mc. So the beat sweeps from 0 to 10 mc.

In the latter case, there is a tendency for the two oscillators to lock together when they are both near the same frequency. So there may be no beat output below several hundred kilocycles. This is not a disadvantage in receiver servicing, but the lock-in range can be reduced in numerous ways, such as isolating the two oscillators from each other, operating one oscillator at half frequency, etc.

By using the BFO principle, it is possible to obtain the required sweep width at i-f and video frequencies. The r-f bands can be swept directly, without using BFO action, because the ratio of sweep-width to centre-frequency is low. This has the advantage that there are no spurious signals and beats to cause confusion.

Figure 19. **A sweep must be flat and should be linear**

The output voltage of the sweep must be flat or constant (within plus and minus 5%) over each band of frequencies.

This is probably the most important requirement in a television sweep.

A little thought will show that if the sweep output has peaks and dips, the response curve of a TV set will show the same peaks and dips, leading

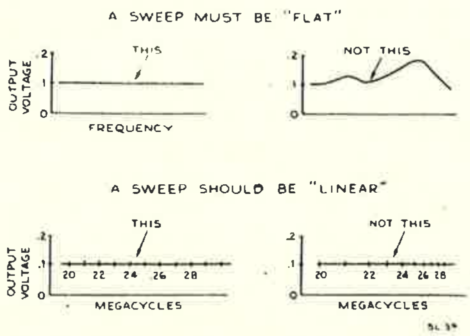

FIG. 19

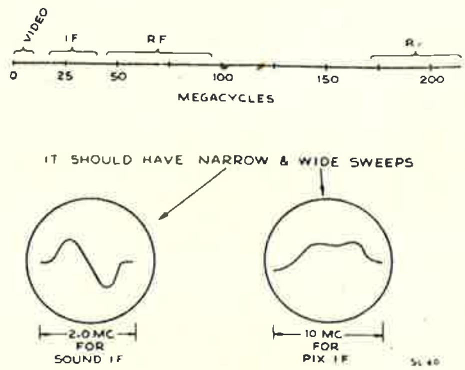

FIG. 20

to the erroneous impression that the alignment is off. If the set is re-aligned to make the response look good, then the alignment will really be wrong. Flatness of output voltage must be maintained at all settings of the output attenuator.

The sweep should be *reasonably linear* in frequency distribution as checked on the CRO, using the horizontal deflection voltage furnished by the sweep, or if this is not furnished, by using the sync from the sweep and the internal sawtooth deflection in the CRO. The illustration conveys this requirement better than words can do.

Figure 20. **A sweep should cover the television frequencies, and should have narrow and wide sweep widths**

A television sweep should cover the following ranges:

Video from a few hundred kilocycles to 6 or 10 megacycles.

I-f from about 18 to 28 mc. (Pre-war TV sets require i-f from about 7.5 to 15 mc.)

R-f for each of the 13 television channels, which extend from 44 to 88 mc, and from 174 to 216 mc.

The sweep should provide *narrow* sweep width of about 2.0 mc for sound - i-f alignment, and *wide* sweep width of about 10 mc for r-f and picture - i-f alignment.

Figure 21. **The sweep output voltage should be adjustable**

When aligning the last picture - i-f stage, which may have a normal gain of 5, using a small CRO that requires about .3 volt peak for one inch vertical deflection, the sweep output should be at least 0.1 volt to give a usable response on the CRO.

The sweep output voltage should be adjustable so it can be decreased as the sweep is moved back stage-by-stage during alignment.

To check stage gain in the same manner, the TV set must be operated at maximum gain, which again requires adjustable output voltage from the sweep.

When checking the over-all r-f and picture - i-f response, it is convenient if the sweep output can be reduced to 500 microvolts or less.

Figure 22. **A sweep should provide sync or horizontal deflection voltage**

The sweep and the CRO must stay in step with each other, so all television sweeps provide sync voltage to trigger the sawtooth horizontal oscillator in the CRO, or deflection voltage to move the CRO beam back and forth horizontally.

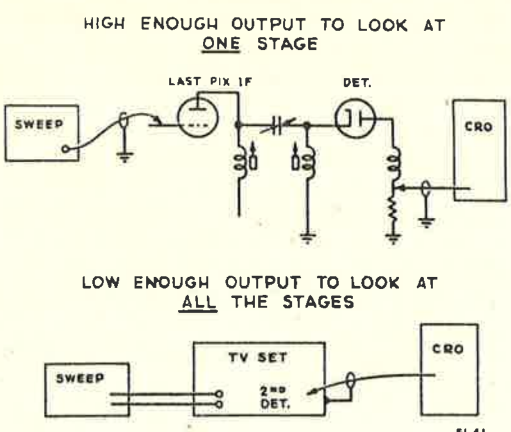

FIG. 21

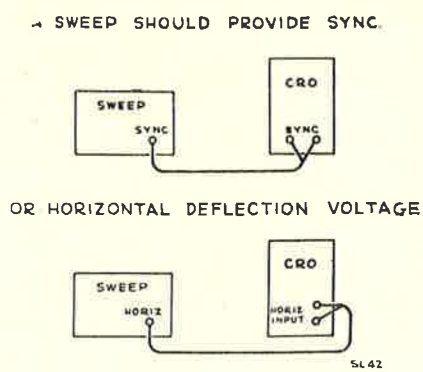

FIG. 22

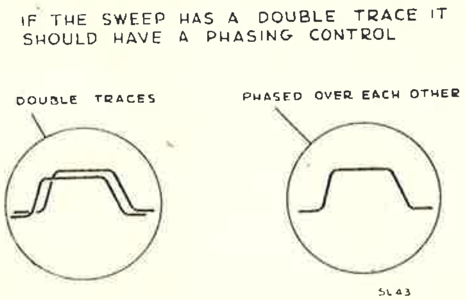

FIG 23

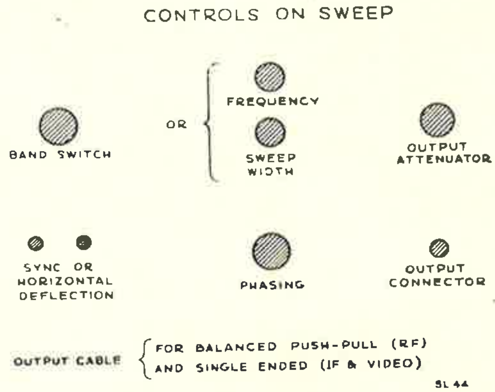

FIG 24

In some sweeps, a specially-shaped horizontal deflection voltage is furnished to compensate for non-linear change of frequency, so that the final distribution across the CRO is reasonably linear in frequency.

If deflection voltage is furnished, it is fed into the CRO horizontal amplifier, and in this case the CRO internal sawtooth oscillator is not used.

Figure 23. **Phasing control**

If the sweep has a "double trace", it will also usually have a phasing control so that the two traces can be moved horizontally to lay over each other and appear as a single trace.

(For clarity in this illustration, the draftsman has shown a slight vertical displacement also.)

Figure 24. **Controls on sweep**

Some sweeps have a band switch which automatically gives the correct centre frequency and the correct sweep width for aligning sound - i-f, picture-i-f, and each of the 13 r-f channels.

Other sweeps have one control for centre frequency, and another control for sweep width.

The output attenuator, phasing control, and sync output have been covered previously.

One requirement that must not be overlooked is provision for balanced push-pull output for r-f alignment, and single-ended output for i-f alignment.

Figure 25. **It looks nice, but—**

If we connect a sweep and a CRO to a TV set, we may get a response curve like the one in this illustration. It looks nice, but it doesn't tell us a thing about frequency. The alignment may be completely wrong. We can't tell from this curve where the picture carrier will fall, whether the traps are tuned to the correct frequencies, etc.

Figure 26. **You can find out—**

To tell whether the response is correct, we need a frequency marker. We can get this by loosely coupling an accurate test oscillator or signal generator into the TV set along with the sweep.

Figure 27. **Now you have a marker**

The sweep and marker signals beat together. This beat appears on the response curve at the marker frequency. If we tune the marker oscillator over the sweep range, the beat or mark moves from one end of the response curve to the other. To find the frequency at any point on the response curve, we tune the marker so the beat falls on this point, and by looking at the marker dial we can find the corresponding frequency.

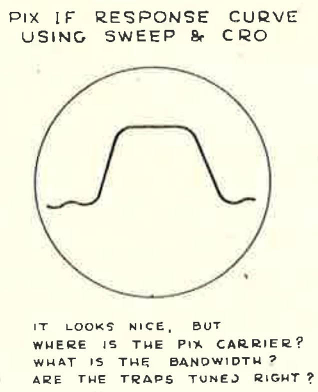

FIG 25

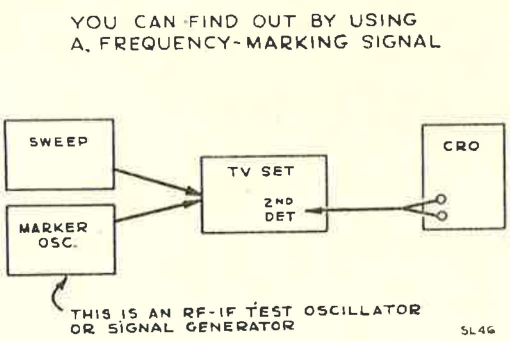

FIG 26

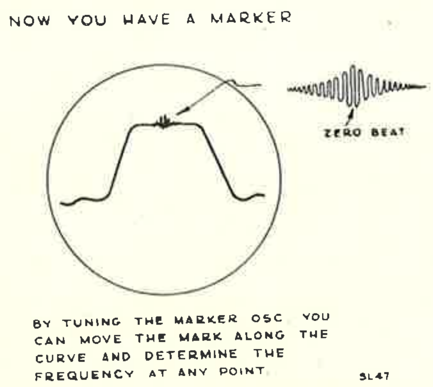

FIG. 27

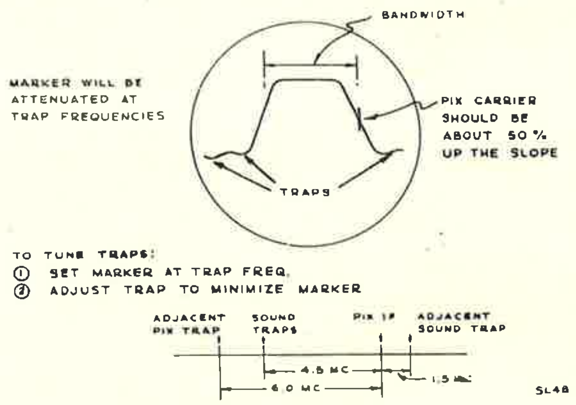

FIG. 28

(The beat frequency is produced when the sweep oscillator passes through the same frequency as the marker oscillator. When the two are identical, the beat is zero. Actually the beat extends out in each direction to the limits of the response curve, but the higher beat frequencies are limited by the video response of the 2nd detector with CRO cable and input loading, and the response of the CRO. If the CRO has response to several megacycles and an isolating probe, the marker will be much wider than shown here, and it will be necessary to add capacity across the 2nd detector load resistor, or place a resistor in series with the CRO lead, to reduce the high-frequency response.)

Figure 28. **Using marker —**

This illustration shows how the marker can be used to tell whether the frequency corresponding to the picture carrier is at the correct point on the response curve, the frequency that each trap is tuned to, and the bandwidth of the response.

For convenience, we have shown the spacing in megacycles between the picture - i-f carrier and the various traps.

Figure 29. **Using marker on discriminator**

This illustration shows how to use 400 cycle amplitude modulation on the marker to find the centre frequency of the discriminator response.

Figure 30. **How about the CRO?**

As mentioned previously, the response curve on the CRO shows how the rectified (DC) output of the 2nd detector varies as the frequency of the input signal is swept back and forth. The sweep rate is usually 60, 120, or 240 cycles per second. Therefore an ordinary CRO that has reasonably good low-frequency response is OK for alignment.

Naturally, to look at the picture signals, or to trace television sync pulses, or to observe waveform in deflecting circuits, it is necessary to use a CRO that has good low and high frequency response, good phase characteristics, and low loading on the circuits. An ordinary CRO is NOT OK for these applications in television servicing.

The marker oscillator

In studying television alignment procedures, it will become evident that the marker oscillator must have extremely good accuracy, particularly in setting the r-f oscillator frequency for each channel. An accuracy of plus and minus 0.1 mc is not good, yet

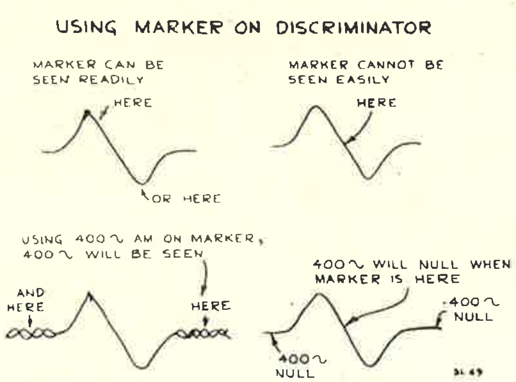

FIG. 29

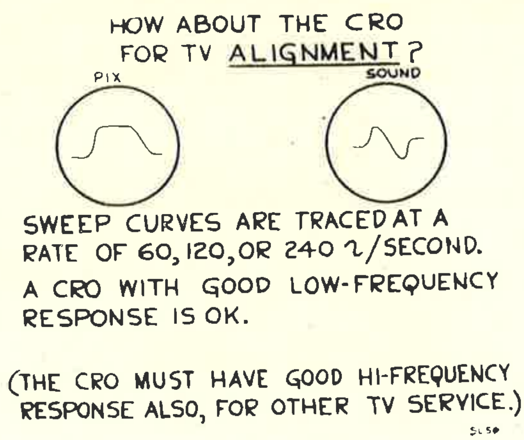

FIG 30

this represents 0.1 of 1% at 100 mc, or .05 of 1% at 200 mc. Even an expensive laboratory signal generator couldn't be expected to have this accuracy.

Therefore, it is necessary to use crystal calibrators and a heterodyne detector to set the marker oscillator exactly on the specified frequencies. But even the crystal calibrator must be special:

All TV sound and picture carrier frequencies end in $\frac{1}{4}$ mc. For example 77.25, 87.75, 175.25, 215.75, etc. If we use a $\frac{1}{4}$ mc fundamental crystal, its harmonics will be entirely too weak above 50 mc which is the 200th harmonic, and out of the question at 200 mc, which is the 800th harmonic.

To get around this difficulty, it is possible to use one crystal at 2.5 mc. This can be made to provide good harmonics up to 250 mc or more. Then a $\frac{1}{4}$ mc crystal oscillator can be used to modulate the 2.5 mc oscillator. This produces numerous $\frac{1}{4}$ mc sidebands at each 2.5 mc harmonic, and thus provides strong $\frac{1}{4}$ mc calibration points all the way up through the television bands.

The two crystals must be adjusted for zero beat, and the 2.5 mc crystal must have very good accuracy and stability.

The marker oscillator must be "spread-band" so that it can be set at the $\frac{1}{4}$ mc points accurately and easily, even at 200 mc.

Television Alignment Procedures

It is always advisable to follow the manufacturer's alignment instructions. However, the following sequence of alignment is satisfactory in some TV sets:

1. Traps.
2. Picture - i-f amplifier.
3. Sound - i-f and discriminator.
4. R-f and converter.
5. R-f oscillator frequencies.
6. Over-all r-f and picture - i-f check on each channel.

Naturally it isn't necessary to go through the complete alignment procedure on every set that comes in for service.

For instance, if the picture is OK, but the sound is weak on all stations, we should check the sound-i-f amplifier and discriminator, and align these if necessary.

When in doubt, the safest procedure is first to check the over-all r-f and picture - i-f response on the various channels. If this check shows definite need for realignment then do so. The same thing applies to the sound channel.

Figure 31. **These systems can be peaked**

One question always comes up, "when must we use a sweep, and when can we align for peak output with an ordinary test oscillator?"

In general, any r-f or i-f amplifier that has single-tuned circuits between the tubes, or that has undercoupled (single-peak response) transformers, can be peak aligned with a test oscillator.

Figure 32. **These systems should be swept**

In general, if the amplifier has overcoupled transformers, or overcoupled networks of any kind, it is necessary to use sweep alignment.

Sweep alignment can be applied to any type of tuned amplifier, overcoupled or undercoupled.

Figure 33. **One exception —**

By temporarily reducing the coupling, it is possible to peak align a normally overcoupled transformer, as shown in this illustration.

The resistor is used to reduce the "Q" of one circuit so the transformer becomes undercoupled, while the other circuit is peak aligned.

(In FM sound - i-f amplifiers, the resistor may be 1,000 ohms or less.)

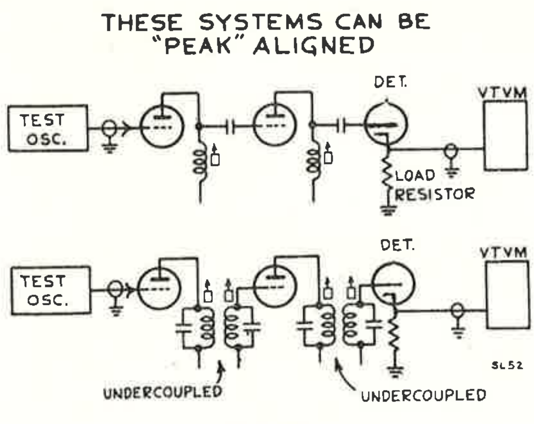

FIG 31

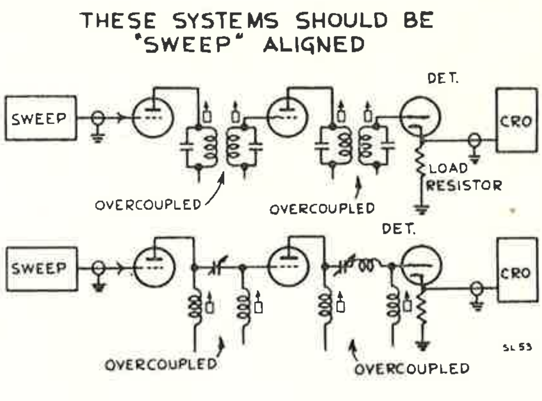

FIG 32

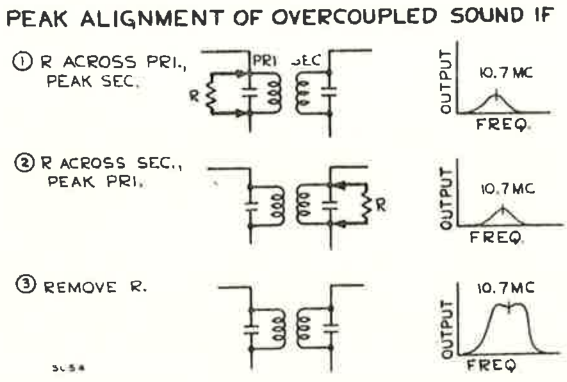

FIG. 33

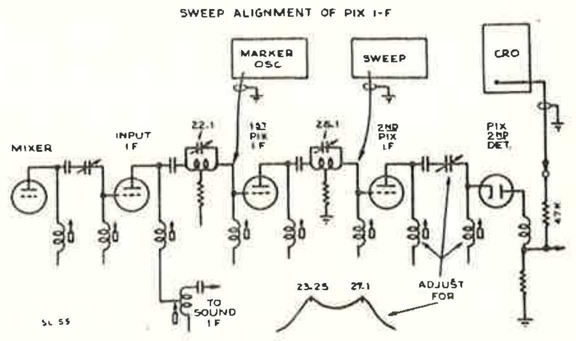

FIG 34

TWO TYPICAL EXAMPLES OF TELEVISION ALIGNMENT PROCEDURES

To show the practical application of television alignment equipment, we will go through the step-by-step alignment procedure for two TV sets of different make: The Philco 48-1000, and the RCA 630 TS. These are good examples because opposite alignment methods are required:

	Alignment Method	
	RCA	**Philco**
Picture - i-f amplifier	Peak	Sweep
Sound - i-f amplifier	Sweep	Peak
Discriminator	Peak	Sweep

In addition, the head-ends (r-f, converter, osc.) are different in their circuits and adjustments.

In the following procedures we have NOT repeated the information given in "Alignment Precautions", which MUST be observed in all television alignment.

Alignment procedure, Philco model 48-1000

In Philco Model 48-1000, two test jacks are provided for convenience in connecting a CRO or VTVM during alignment and other tests:

Jack J200 is connected to the output of the sound discriminator.

Jack J401 is connected to the output of the picture 2nd detector.

A 47,000 ohm resistor (R419) is connected between the 2nd detector load (R420) and the test jack J401. This isolation prevents the CRO or VTVM connection from affecting the picture quality, and it keeps i-f off these cables, thus reducing the possibility of feedback to the input (regeneration).

Figure 34. **Alignment of picture 2nd detector and adjacent-channel sound trap (28.1 MC)**

(1) Adjust the indicated coils and trimmer for the response shown. Philco suggests:
   (a) Set the coupling trimmer at minimum capacity (full out).
   (b) Adjust the two coils for a peak at 27.1 mc.
   (c) Adjust the trimmer to produce response shown, with second peak at 23.25 mc.

(2) Disconnect the sweep cable from the grid of the 2nd picture - i-f tube.

(3) Tune the marker to 28.1 mc, with 400 cycle amplitude modulation.

(4) Adjust the 28.1 mc trap for *minimum* 400 cycle output on the CRO.

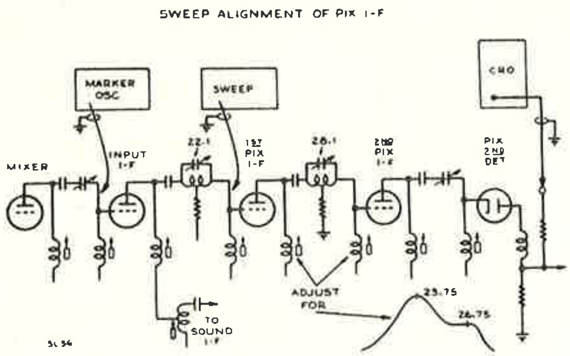

FIG 35

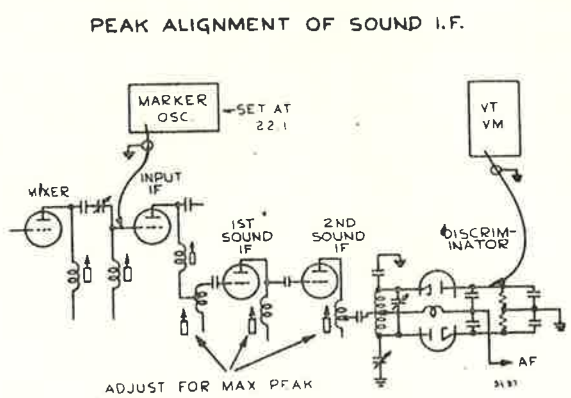

FIG 36

Figure 35. **Alignment of 2nd picture - i-f, and sound trap (22.1 MC)**

(1) Adjust the indicated coils for the response shown.
(2) Disconnect the sweep cable from the grid of the 1st picture - i-f tube.
(3) Tune the marker to 22.1 mc with 400 cycle amplitude modulation.
(4) Adjust the 22.1 mc trap for *minimum* 400 cycle output on the CRO.

Before aligning the 1st picture - i-f, it is necessary to align the sound - i-f amplifier, because the 1st sound - i-f transformer has some effect on the 1st picture - i-f response.

Figure 36. **Alignment of sound - i-f amplifier**

(1) Tune marker to 22.1 mc.
(2) Adjust the three sound - i-f coils for maximum peak output on the VTVM.

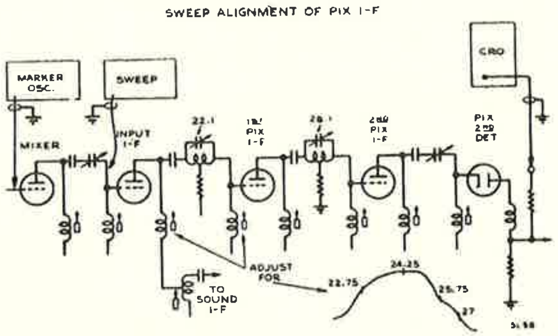

FIG. 37

Figure 37. **Alignment of 1st picture - i-f**

Adjust the indicated coils for the response shown.

Figure 38. **Alignment of input - i-f**

Adjust the indicated coils and trimmer for the response shown.

This is the over-all picture - i-f amplifier response. The position of the carrier, 26.6 mc, is important and should be approximately 40% up the slope.

Figure 39. **Alignment of sound discriminator**

(1) Tune the marker to 22.1 mc, with 400-cycle amplitude modulation.
(2) Adjust the indicated trimmers for the response shown. Note that:
 (a) The "cross-over", where output voltage is zero, should be at 22.1 mc.
 (b) The positive and negative peaks should be equal in amplitude.
 (c) The frequency difference should be approximately 500 kc between the positive and negative peaks.

Refer to section in "TV Alignment Procedure", describing the use of 400 cycle amplitude modulation on the marker to determine when the marker frequency is at the centre zero of the discriminator response curve.

Figure 40. **Alignment of r-f oscillator**

In this Philco receiver, the r-f amplifier and the mixer each have one trimmer to compensate for differences in tube and wiring capacities. It is preferable to adjust these trimmers on a high-frequency channel, where the circuit capacities are more critical. Philco specifies channel 10.

However, before the r-f trimmers are adjusted, the r-f oscillator for channel 10 must be set at its correct frequency, so that when a marker signal is inserted at the r-f picture carrier frequency, the frequency difference between it and the r-f oscillator will produce the i-f marker of 26.6 mc.

If the r-f oscillator is off-frequency during this check, the i-f carrier marker will fall on a different part of the response curve, leading to erroneous indications.

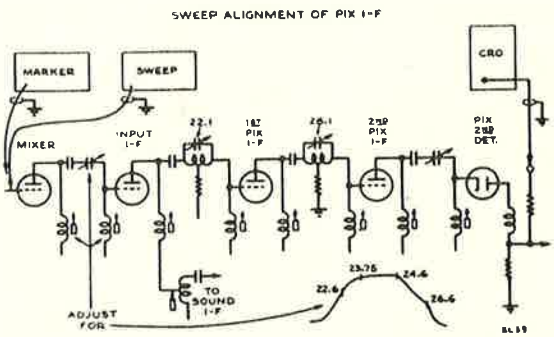

FIG 38

The procedure for setting the r-f oscillator is as follows:—

(1) Set the TV station selector on channel 10.
(2) Connect the marker oscillator to the antenna input terminals, and set the marker accurately at 197.75 mc, which is the sound carrier frequency for channel 10.
(3) Connect a VTVM to the output jack, J200, of the sound discriminator.
(4) Adjust channel 10 oscillator frequency to the point where the VTVM reads zero. This must be the "centre zero" of the discriminator.

The r-f oscillator frequency is now OK for channel 10.

The procedure may be understood better if we re-state what has been done:

(a) The sound - i-f amplifier and the discriminator were previously aligned so the centre zero of the discriminator was exactly at 22.1 mc.
(b) A signal at the r-f sound carrier frequency of 197.75 mc was fed into the antenna input of the set.
(c) The r-f oscillator frequency on channel 10 was adjusted until the beat between it and

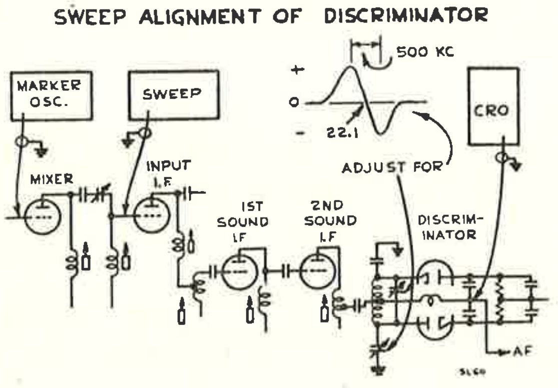

FIG. 39

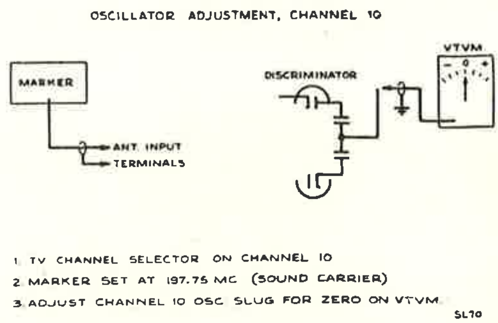

FIG. 40

the r-f sound carrier was exactly 22.1 mc, as indicated by centre zero on the VTVM connected to the discriminator output.

Therefore, the r-f oscillator is operating at 197.75 plus 22.1, or 219.85 mc, which is correct for channel 10 on this Philco set.

Figure 41. **Alignment of r-f and mixer**

(1) Set the marker to 193.25 mc, which is the picture carrier frequency for channel 10.

(2) Set the sweep to cover channel 10.

(3) Short the discriminator output (J200) to the chassis to prevent AFC action.

(4) Adjust the two r-f trimmers for the response shown, which is the same as the over-all picture - i-f amplifier response.

The r-f picture carrier of 193.25 mc will be "beat down" to the correct picture - i-f of 26.6 mc which should be about 40% up the slope, as shown.

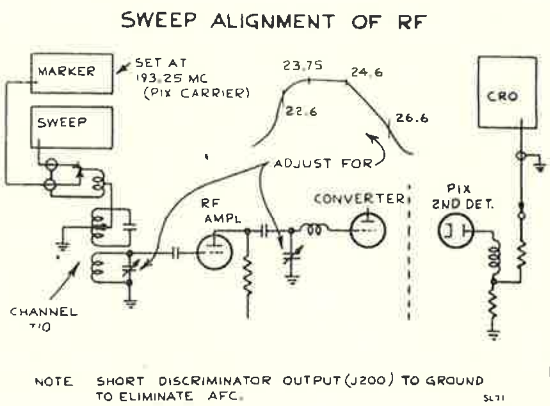

FIG. 41

As we previously set the r-f oscillator to the correct frequency for this channel, it is entirely satisfactory, and a lot easier, to use an accurate i-f marker instead of an r-f marker. In this case, tune the marker to 26.6 mc and couple it *loosely* to the front end of the picture - i-f amplifier.

If the frequency of the r-f oscillator has been checked or adjusted on some or all of the other channels, we can tune the sweep to each of these channels and look at the over-all r-f - picture - i-f response on these channels. In this case, leave the marker tuned to the picture - i-f of 26.6 mc, coupled loosely to the front end of the picture - i-f amplifier. *This is easier, simpler, and quicker than having to set the marker accurately to the r-f picture carrier frequency for each channel.*

Remember that whether the marker is set at the r-f or the i-f carrier frequency, the r-f oscillator frequency must first be set accurately for each channel that is to be checked.

Remove the short on the discriminator output jack.

Sound trap in video amplifier

In this Philco TV set, there is only one sound - i-f trap in the picture - i-f amplifier, and some of the sound - i-f signal at 22.1 mc gets through the picture-i-f amplifier. This signal at 22.1 mc beats with the picture - i-f carrier of 26.6 mc and produces a beat of 26.6 minus 22.1 or 4.5 mc in the picture 2nd detector output.

This beat is eliminated by a trap tuned to 4.5 mc in the plate circuit of the 1st video amplifier.

This trap is adjusted as follows:

(1) Connect the marker to the grid of the 1st video amplifier. Tune the marker accurately to 4.5 mc, with 400 cycle AM. Turn the video contrast control to maximum gain.

(2) Connect the CRO to the grid of the kinescope and adjust the trap for *minimum* 400 cycle output on the CRO.

This completes the alignment procedure for the Philco set. We will now go through the alignment of an RCA television receiver.

ALIGNMENT PROCEDURE RCA MODEL 630TS.

Figure 42. **Peak alignment of traps and picture - i-f amplifier**

(1) Connect the marker to the grid circuit of the mixer tube.

(2) Connect a CRO or VTVM, or both, to the picture 2nd detector load resistor with an

isolating resistor of approximately 22,000 ohms as shown. If a CRO is used, set the marker for 400 cycle AM. The CRO shows evidence of overloading somewhat better than the VTVM.

(3) Adjust in sequence shown by circled numbers. The traps come first. Adjust each for *minimum* output at the specified frequencies.

(4) The peaking adjustments come next, but first set the i-f bias at about 3 volts by adjusting the contrast control. Tune each coil for *maximum* output at the specified frequencies, in the sequence indicated.

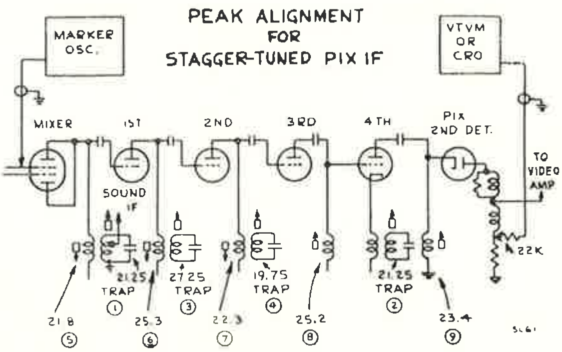

FIG. 42

There is some interlocking between the peaking coils and the traps that are coupled to them. If any peaking coil requires appreciable adjustment, recheck the associated trap.

Figure 43. **Alignment of sound - i-f amplifier**

(1) Connect test equipment, using an isolating resistor of about 33,000 ohms in series with the CRO lead as shown.

(2) Set the marker at 21.25 mc.

(3) Using two "neut" sticks, one for the primary and one for the secondary, adjust the transformer that feeds the 3rd sound - i-f tube, for maximum gain and symmetry around 21.25 mc as shown.

(4) Move the sweep and the marker to the grid of the 1st sound - i-f tube, and adjust the transformer ahead of the 2nd sound - i-f tube for maximum gain and symmetry around 21.25 mc.

The bandwidth should be about 200 kilocycles, measured between points 70% up the slope on each side.

Figure 44. **Alignment of discriminator**

(1) Connect the marker to the 3rd sound - i-f grid and tune it to 21.25 mc.

(2) Connect the VTVM in series with a 1.0 megohm resistor to the centre point of the two diode load resistors.

(3) Tune the primary of discriminator transformer for *maximum* voltage output on the VTVM.

(4) Connect the VTVM to the top of the two diode load resistors and tune the secondary for *zero* output voltage (centre zero of discriminator).

(5) Check the discriminator by tuning the marker to obtain a peak positive voltage, and then tune the marker in the opposite direction to obtain a peak negative voltage. The two peaks should have approximately equal amplitude; if not, readjust the primary slightly and re-check. Repeat if necessary until the peaks are of equal amplitude, with zero output at 21.25 mc.

In this particular discriminator circuit, the 1.0 megohm isolating resistor is essential when the VTVM is connected to the centre tap of the two diode load resistors, because this point is coupled through a capacitor to the plate of the 3rd sound-i-f tube: Even one micro-microfarad capacity added at this point will detune the primary. The 1.0 megohm resistor isolates the small capacity of the VTVM probe tip.

Figure 45. **Alignment of r-f and converter**

(1) Connect the test equipment, using an isolating resistor of approximately 22,000 ohms, as shown in series with the CRO lead.

The converter tube functions as a diode in this

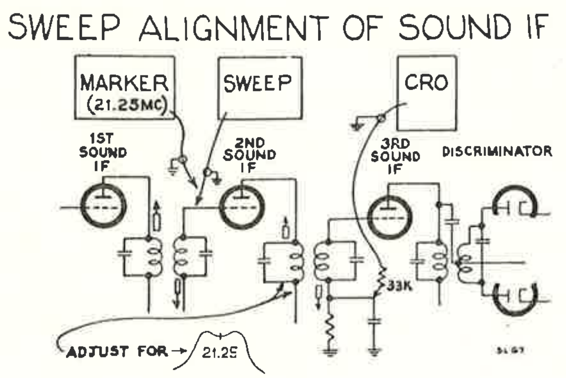

FIG. 43

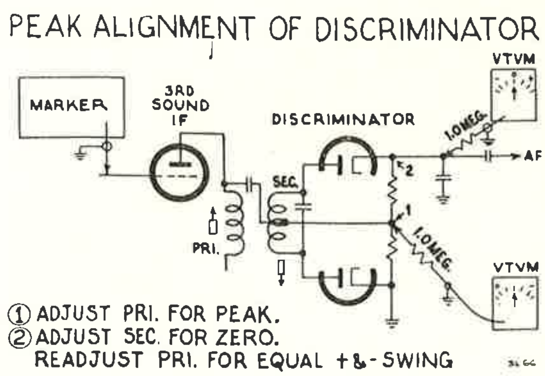

FIG 44

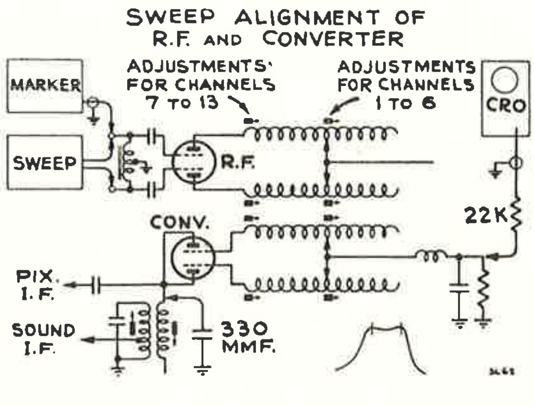

FIG. 45

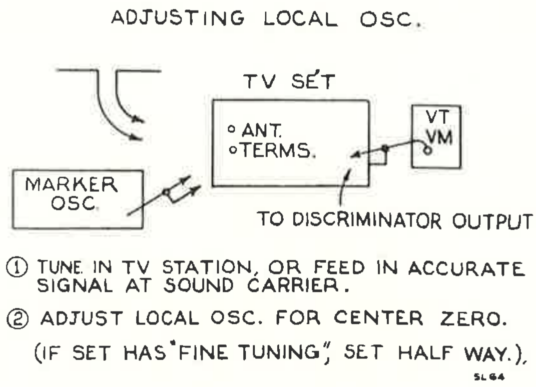

FIG 46

step, and the CRO therefore shows the rectified envelope of the r-f response.

(2) Temporarily connect a 330 mmf capacitor from the grid of the 1st picture-i-f tube to the chassis, using only one or two inches of lead. This capacitor is shown connected to the converter plate, but the i-f grid is easier to reach.

(3) Set the r-f bias at 1.0 volt with the contrast control. Increase the CRO vertical gain until hum is just becoming evident.

(4) Set the station selector and the sweep for channel 13. With most sweeps, it will be necessary to use maximum output to get sufficient amplitude on the CRO.

(5) Tune the marker to the r-f picture carrier frequency for channel 13, and then to the r-f sound carrier. Note where these marks fall on the response curve. Check channels 13 to 7 in this way. *Both carriers should be at least 70% up the slopes, or on top of the response curves.* Normally, the response appears overcoupled and reasonably symmetrical.

(6) The "tuned line" in the r-f plate circuit has only one pair of adjustments for channels 13-7, and one pair for channels 6-1. The same applies to the tuned line in the converter grid circuit. *In order to keep the line balanced, the two adjustments in each pair are moved in or out equally during alignment.*

(7) If necessary, tune the r-f and converter adjustments to produce the correct response on channels 7-13.

(8) Check channels 6 to 1 inclusive in the same manner, and tune the corresponding adjustments if necessary.

In this simplified diagram, the means for coupling the r-f and converter tuned lines are omitted. Normally channels 13 and 6 are definitely overcoupled, and channels 7 and 1 are only slightly overcoupled.

The purpose of the 330 mmfd. capacitor is to avoid i-f regeneration during alignment. If the capacitor is disconnected, the shape of the r-f response curve will alter slightly, and the amplitude will increase. Also there will be notches in the curve corresponding to the 21.25 and the 27.25 mc traps. Each notch can be identified by placing a finger on the corresponding trap; the notch will shift in frequency and decrease in amplitude.

Remove the 330 mmfd. capacitor when the r-f alignment is completed.

Figure 46. **Adjusting r-f oscillator, using TV stations or marker oscillator**

Before looking at the over-all r-f-i-f picture response curves, it is necessary to check the r-f oscillator frequencies.

Three methods of doing this will be described. The first method uses the available TV stations, and is therefore limited to a relatively few channels:

(1) Connect a VTVM to the discriminator output.

(2) Tune in the highest frequency available TV station.

(3) Adjust the fine-tuning knob to obtain best sound, and then set it exactly to produce zero output voltage. This is the discriminator centre zero, where the output will swing positive or negative when the fine-tuning knob is turned slightly in either direction from this point.

(4) Check the position of the fine-tuning knob. It should be in the centre third of its range. If not, set it at its mid position and tune the oscillator adjustment for this particular channel for zero output voltage on VTVM (centre zero of discriminator).

(5) Do this on each of the TV stations, starting at the highest frequency and working down to the lowest.

Adjusting r-f oscillator using marker oscillator

(1) Connect a VTVM to the discriminator output.

(2) Set the station selector on channel 13.

(3) Connect the marker to the antenna input terminals. Tune the marker to the sound carrier frequency, 215.75 mc, for channel 13. It must be accurate.

(4) Adjust the fine-tuning control for zero output voltage on the VTVM (centre zero of discriminator).

(5) Check the position of the fine-tuning control. It should be in the centre third of its range. If not, set it at its mid-position and tune No. 13 channel oscillator adjustment for zero output voltage on the VTVM (centre zero of discriminator).

(6) Do this on each channel, starting at the highest frequency and working down to the lowest. This sequence is necessary because 13 effects 12, 12 effects 11, and so on.

Figure 47. **Adjusting r-f oscillator, using marker osc., xtal calibrator, and heterodyne detector**

(1) Couple the input of the heterodyne detector loosely to the r-f oscillator in the TV set.

(2) Tune the marker to 237 mc, which is the r-f oscillator frequency for channel 13 in this RCA set. Use the crystal calibrator to set the marker accurately and then turn off the crystals.

(3) Set the TV station selector on channel 13.

(4) Turn the fine-tuning knob until a beat is heard in the heterodyne detector.

(5) Check the position of the fine-tuning knob. It should be in the centre third of its range. If not, set it at its mid-position and tune the No. 13 channel oscillator adjustment until a beat is heard in the heterodyne detector.

(6) Do this on each channel from 13 to 1 in that order.

Figure 48. **Check of overall r-f - i-f picture response**

(1) Connect test equipment as shown. Set the marker at 25.75 mc, which is the picture - i-f.

(2) Check the response on each channel. It will change slightly from channel 1 to 6 and from 7 to 13.

(3) Touch up the picture - i-f adjustments slightly if necessary to get a good compromise response on all channels. The "ideal" curve is shown in this diagram. The 25.75 mc marker should be at about 40-50% up the slope.

Figure 49. **Checking TV tuning: How a discriminator operates**

Television sound is FM, and therefore almost all TV sets use a discriminator as 2nd detector in the sound - i-f channel.

A discriminator discriminates. At its centre frequency, it minimizes amplitude modulation but responds to frequency modulation.

There are many things about a discriminator that must be understood for good television service.

A discriminator operates rather simply:—

If an i-f signal of constant frequency and amplitude is fed into the discriminator at its centre frequency, the output is zero, regardless of the strength of the input signal.

If the signal is shifted slightly higher or lower in frequency, the discriminator produces a positive or negative D.C. output voltage. With a *larger* shift in frequency, up to a certain limit, the discriminator produces a higher negative or positive D.C. output voltage.

If the *frequency* of the input signal is increased and decreased repeatedly and rapidly, the discriminator produces a rapid change from zero to plus, from plus to zero, from zero to minus, from minus to zero, etc. In other words, the output is low-frequency A.C.

If the *frequency* of the signal is varied at an audio rate, the discriminator produces an audio (A.C.) output voltage.

If the frequency of the input signal is varied by plus and minus one kilocycle, the audio output is weak. If the frequency of the input signal is varied by plus and minus 25 kilocycles, the audio output is 25 times higher in amplitude.

The rate at which the frequency of the input signal is varied determines the audio output frequency.

The amount by which the signal is varied, or "deviated" in frequency, determines the percentage modulation.

In television sound a deviation of plus or minus 25 kilocycles is 100% modulation.

In regular FM sound, a deviation of plus and minus 75 kilocycles is 100% modulation.

The centre slope of the discriminator response must be straight or linear for a frequency range as wide as the maximum deviation. In TV, the slope must be linear for at least plus and minus 25 kc. In

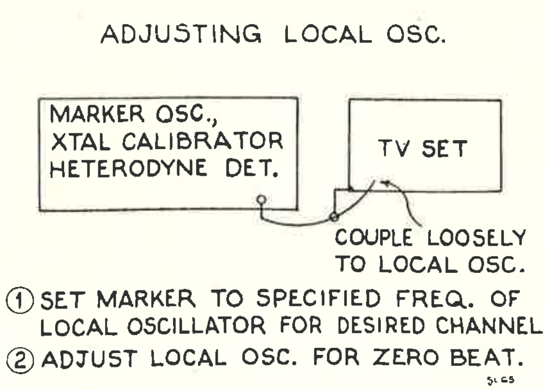

FIG. 47

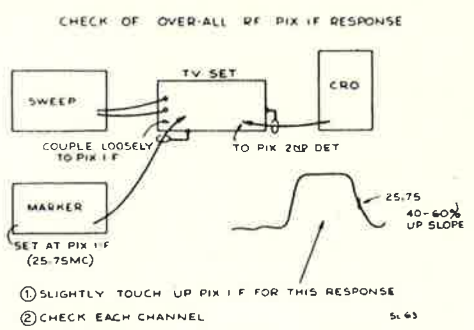

FIG. 48

FM, the slope must be linear for at least plus and minus 75 kc.

If the centre slope is not linear over this frequency range, if it bends or has jogs, the audio output may be distorted.

In actual practice, the slope is made considerably wider in frequency range than required, in order to allow for frequency drift in the r-f oscillator, which causes an equal drift in the sound - i-f carrier.

As mentioned previously, if an i-f signal of constant frequency and amplitude is fed into a discriminator at its centre frequency, the output voltage will be zero. If the signal is amplitude modulated, the discriminator output will still be zero.

But if the frequency of the amplitude-modulated signal is shifted slightly away from the centre frequency of the discriminator, the amplitude modulation will appear in the output, and will become maximum when the frequency of the input signal is the same as either of the two peaks of the discriminator.

It may not be possible to get a complete null of the amplitude modulation when the AM input signal is set at the centre frequency of the discriminator. This is generally due to one or two things.

(a) The discriminator response is not symmetrical the centre frequency,

(b) The test oscillator that is used to provide the signal has some frequency modulation when it is set for amplitude modulation; the discriminator responds to the frequency modulation.

After this brief review of discriminator action, we can consider the effect of tuning or adjusting the r-f oscillator frequency in a TV set. In many receivers, this is accomplished by a vernier trimmer or fine-tuning control in the oscillator circuit.

The r-f oscillator in the TV set beats with the TV station's sound carrier to produce a beat that is equal to the frequency difference between these two signals. This beat is the sound - i-f carrier.

If we turn the fine-tuning control from one end to the other, the frequency of the r-f oscillator is changed by about one mc, and consequently the frequency of the sound - i-f carrier is also changed by about one mc, or from approximately 21.75 to 20.75 mc.

21.25 mc is the correct frequency in this set.

Let's see what happens when we change the sound i-f by turning the fine-tuning control. First, connect an electronic voltmeter to the discriminator output, which is the point where the audio is taken out. For convenience, we will use a voltmeter that has a centre zero, so that it can deflect either positive or negative.

Let's look at the voltmeter. With the fine-tuning control full counter-clockwise, the meter reads zero. As we turn the knob slowly clockwise, the meter goes to a negative voltage peak, then to zero, then to a positive voltage peak, and then back to zero. Notice that there are three positions of zero voltage. The centre one is critical, and it is the correct tuning point. The i-f at this point is 21.25 mc.

Let's look at the picture. With the fine-tuning knob full counter-clockwise, we see that there is a lot of sound in the picture. Why? Because the sound i-f is now 21.75 mc and it falls on the low-frequency slope of the picture - i-f amplifier response. This FM sound - i-f signal is amplified and rectified in the picture channel, and appears as interference on the kinescope.

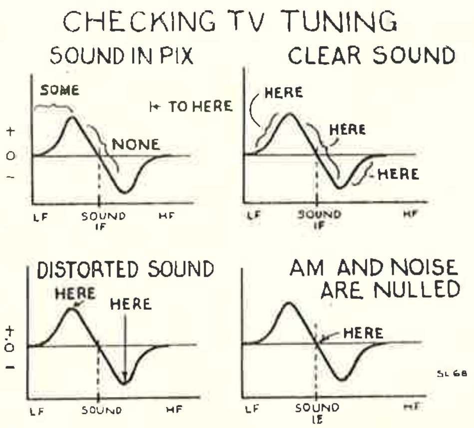

FIG. 49

As we keep turning the fine-tuning knob slowly clockwise, the sound begins to drop out of the picture, and we find a section where there is no sound in the picture. The sound - i-f is now near 21.25 mc, and is no longer getting into the picture - i-f amplifier because the sound traps chop the picture - i-f response at 21.25 mc.

Turning the fine-tuning knob clockwise slightly past this section, we may notice a fine beat in the picture because the picture - i-f amplifier has some response on the low-frequency side of the sound traps, allowing some of the sound - i-f signal to get into the picture channel. This beat is always 4.5 mc, the difference between the sound - i-f and the picture - i-f carriers. This beat appears as approximately 240 faint thin slanting vertical lines. Also note that the picture becomes brighter or stronger when the fine-tuning knob is turned clockwise, because the picture - i-f carrier is moved up the slope of the picture - i-f response.

Let's listen to the sound. With the fine-tuning knob full counter-clockwise, the sound - i-f is about 21.75 mc, and it does not fall in the discriminator response band, so there is no sound. As we turn the knob slowly clockwise,

(a) We begin to get clear sound when the sound i-f falls on the high-frequency slope of the discriminator.

(b) When the sound - i-f falls on the high-frequency peak, the sound becomes distorted.

(c) When the sound - i-f falls on the centre slope, the sound is clear and strong.

(d) When it falls on the low-frequency peak, the sound again is distorted.

(e) When it falls on the low-frequency slope, the sound is clear.

(f) When we get the knob full clockwise, there is no sound, because the sound - i-f is now 20.75 mc and this is outside the discriminator response.

Why is the sound distorted when the sound - i-f falls on either of the two peaks? On the peak, when the sound - i-f deviates up in frequency, the output goes toward zero, and also when it deviates down in frequency, the output goes toward zero. This produces frequency doubling: When the fine-tuning knob is turned so the sound - i-f signal falls on either peak, a 400 cycle FM tone changes to 800 cycles.

How about noise reduction? To show this, we need a weak signal or a lot of noise, which we may be able to simulate by removing one or both of the antenna leads to decrease the signal strength. Let's turn the fine-tuning knob for best sound and listen carefully to the background noise. At one critical point, which the voltmeter shows in centre zero, the noise nulls out. The noise increases if we tune slightly away from this point in either direction.

By making these checks, we have seen that we should always tune the TV receiver so the sound - i-f falls at the centre zero of the discriminator response in order to obtain:

(1) The best sound

(2) Minimum sound in the picture

(3) Additional noise reduction on sound.

With experience, it is possible to tell many things about the alignment of the sound and picture channels and traps by simply observing these results while turning the fine-tuning knob.

This same information can be applied to TV sets that use a continuous-tuning system, and to TV sets that use AFC on the r-f oscillator if the AFC is temporarily shorted out.

With some *ratio detectors,* the effects of changing the sound - i-f are somewhat different because the response drops sharply to zero from the peak at each end of the response curve.

TELEVISION ALIGNMENT PRECAUTIONS

(1) *Don't overload the picture - i-f amplifier.* In many TV sets, the last picture - i-f tube has a small *fixed* bias. If the input signal to this tube has a peak voltage in excess of this bias, the tube will draw grid current and act as a limiter, or "overload".

When the input signal is increased beyond the overload point, the response curve, as seen on the CRO, will flatten out on top, and while it may look very good, it is not the true response. If the input signal is increased still more, the response curve will develop several big dips, and this is not the true response.

When overload exists, the adjustment (r-f, picture-i-f, and traps) will not peak properly, or if they seem to peak OK, it will be at the wrong points.

The amount of input signal to the last picture - i-f tube depends on two things:—

(1) The votage output from the sweep (or from the marker in peak alignment).

(2) The gain of the r-f and picture - i-f amplifiers.

The gain of these amplifiers depends on the bias voltage applied to these tubes. Maximum gain is obtained with 1 volt or less. Minimum gain is obtained with 6 volts or more.

In some sets the bias voltage is adjusted by the picture contrast control. In sets with AGC, the bias voltage comes from the AGC circuit, and during alignment it should be set by an external supply, as described later.

During alignment, the r-f and picture - i-f bias should be kept at a value representing average TV signal conditions, or roughly 2 to 3 volts. The response alters somewhat with change in bias or gain; also if the gain is run too high, there is increased tendency toward regeneration during alignment.

As the r-f and picture -i-f bias should be kept within these rather narrow limits during alignment, *it is necessary to adjust the output voltage from the sweep (or from the marker in peak alignment) so that the last picture - i-f tube is always safely under the overload point.*

In *sweep* alignment, a CRO is connected across the picture 2nd detector load resistor to observe the response.

In *peak* alignment, a VTVM is connected across the picture 2nd detector load resistor to observe the response, but a CRO may be used, in conjunction with 400 cycle amplitude modulation on the marker.

As a safeguard, to minimize the chance of overloading, KEEP the vertical gain of the CRO near maximum, and KEEP the VTVM on its lowest scale (3 or 5 volts).

During alignment, when the response becomes too high on the CRO, or when the needle deflects off scale on the VTVM, DON'T reduce the gain of the CRO, and DON'T switch the meter to a higher scale, but instead reduce the voltage output from the sweep (or from the marker in sweep alignment).

If the sweep does not have a continuous control of output, but has tapped output (high, medium, low), it will be necessary to select a suitable tap and adjust the bias on r-f and picture - i-f amplifiers to obtain a satisfactory amplitude on the CRO.

In stage-by-stage sweep alignment of the picture-i-f amplifier, the sweep is first connected to the grid of the last i-f tube, where high output is required from the sweep because there is only one amplifying tube between the sweep and the CRO. When the sweep cable is moved to the grid of the next-to-last i-f tube, the sweep output must be reduced to compensate for the increased gain. On the final step, when the sweep is connected to the grid circuit of the 1st detector, only a small output is required from the sweep.

In every step of alignment, it is always a safe procedure to reduce the signal input to zero, and then slowly increase it until there is sufficient output on the CRO or VTVM, at the same time carefully observing to see that the output increases as the input is increased. If the output stops increasing, or starts to decrease, it indicates overload.

During peak alignment of a stagger-tuned picture-i-f amplifier, remember that a relatively strong input signal is required to adjust the traps, because they reject the signal. Only a relatively weak signal is required to peak the plate and grid coils.

Peak alignment can be made stage-by-stage (as in sweep alignment). This may be necessary in a set where the picture - i-f amplifier is oscillating, or badly out of alignment. It is also a good method to isolate trouble in a particular stage.

As mentioned previously, in peak alignment of the picture -i-f amplifier, a VTVM is generally used as the output indicator. But it is a good idea to connect a CRO also across the picture 2nd detector load resistor and use 400 cycle AM on the marker. Change in shape of the 400-cycle modulation is a good indication of overloading. If desired, the CRO may be used instead of the VTVM during peak alignment.

In TV sets that have AGC, it is generally advisable during alignment, to over-ride the AGC voltage by supplying an external adjustable bias to the r-f and picture - i-f bias bus: Connect a 5,000-ohm potentiometer across a 4½ volt battery. Connect the positive side to the chassis. Connect the slider to the r-f and picture—i-f bias bus. Instead of using a battery a potentiometer may be connected to a low-voltage negative bias point in the power-supply circuit if it is well by-passed to chassis. Adjust the potentiometer to secure the desired bias.

(2) *Couple the marker so it does not disturb the response.*

In *sweep* alignment, the marker should be coupled to the set in such a way that:

(a) It does not alter the output of the sweep.

(b) It does not alter the response of the amplifier.

Also, the marker output must be kept low enough so it does not overload and distort the response.

One of the following connections will meet requirement (a):

(c) Connect the marker to the grid of a tube ahead of the sweep, either one tube or several tubes ahead.

(d) Connect the marker in series with approximately 100 ohms (carbon resistor) to the same grid as the sweep.

(e) Place the marker output lead near the amplifier. The stray coupling may provide sufficient input.

Here is a safe procedure:—

(a) Set up the equipment and get the response on the CRO *before* connecting the marker.

(b) Connect the marker, with output turned off. See if the connection alters the response. If it does, use a different connection point.

(c) Tune the marker, and increase its output until the marker is seen on the response curve.

(3) *Don't short out the grid bias.*

Be certain that there is a built-in or external capacitor in series with the sweep i-f - cable, and the marker output cable, otherwise the bias may be shorted out. The sweep r-f - cable does not require blocking capacitors.

(4) *Use shielded cables.*

The following cables should be shielded to within an inch or so of the connecting clip or probe:—

The CRO vertical input cable.

The electronic voltmeter D.C. cable.

The sweep i-f - output cable.

The marker output cable.

Long unshielded leads invite trouble from regeneration in the picture - i-f and sound - i-f amplifiers.

(5) *Use two "neut" sticks when aligning over-coupled circuits.*

When sweep aligning any over-coupled circuit, it is almost essential to use two neut sticks, one on the primary and one on the secondary, to obtain the specified response quickly and easily.

The neut sticks should be of fibre, with hardened steel screwdriver tips, and with one end recessed. The tips must be thin to fit the narrow slots in adjustment screws of modern r-f and i-f transformers.

TELEVISION FREQUENCIES
RCA and Philco

Channel No.	Channel Freq. MC.	Picture Carrier MC.	Sound Carrier MC.	Local Oscillator Freq. RCA	Local Oscillator Freq. Philco
1	44-50	45.25	49.75	71	71.85
2	54-60	55.25	59.75	81	81.85
3	60-66	61.25	65.75	87	87.85
4	66-72	67.25	71.75	93	93.85
5	76-82	77.25	81.75	103	103.85
6	82-88	83.25	87.75	109	109.85
7	174-180	175.25	179.75	201	201.85
8	180-186	181.25	185.75	207	207.85
9	186-192	187.25	191.75	213	213.85
10	192-198	193.25	197.75	219	219.85
11	198-204	199.25	203.75	225	225.85
12	204-210	205.25	209.75	231	231.85
13	210-216	211.25	215.75	237	237.85

	RCA	Philco
Sound - i-f	21.25 mc.	22.1 mc.
Picture - i-f	25.75 mc.	26.6 mc.
Adjacent-channel sound - i-f trap	27.25 mc.	28.1 mc.
Adjacent-channel picture - i-f trap	19.75 mc.	—
Same-channel sound - i-f trap . .	21.25 mc.	22.1 mc.
Sound trap in video amplifier .	—	4.5 mc.

Stroboscope Design

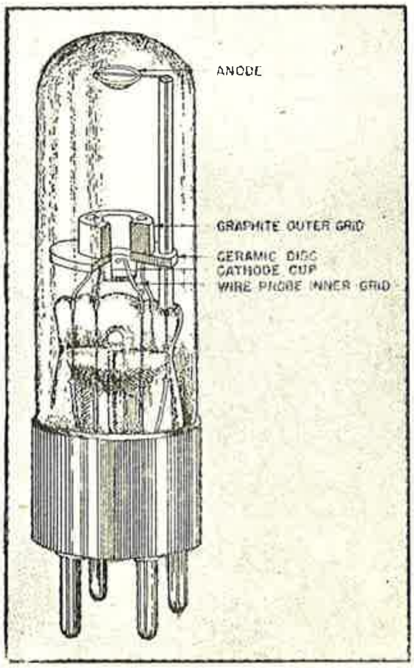

Fig. 1.

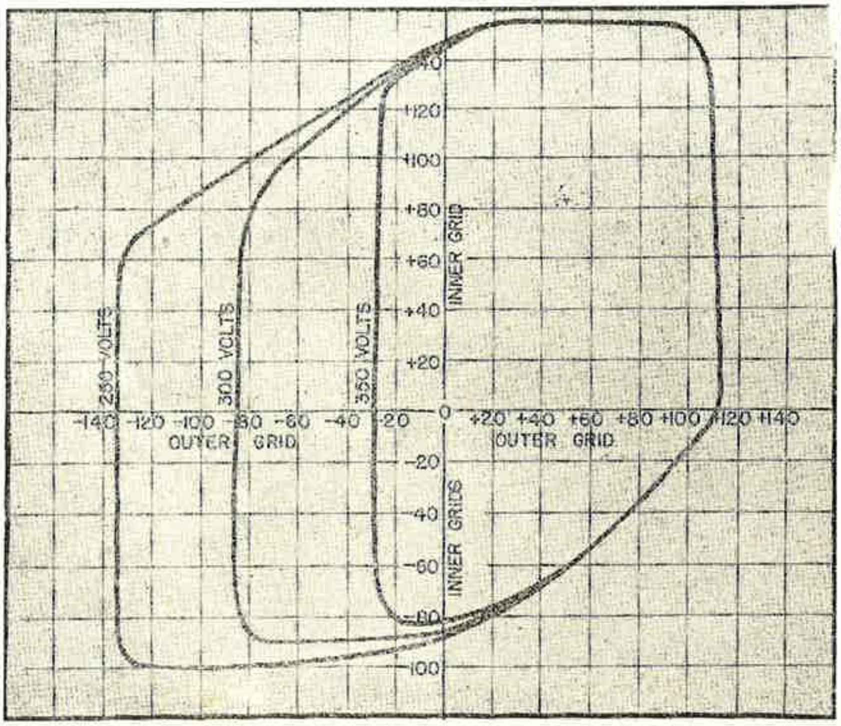

Fig. 2.

Strobotrons

Although the strobotron is not a tube in the strictest sense, the implications of its special properties merit a brief review of its characteristics. The type 1D21/631P1 neon-filled strobotron shown in Fig. 1 was designed principally as a medium-intensity light source for stroboscopic applications.[1, 2] This type of tube and the high-intensity strobotrons described later were developed by Edgerton, Germeshausen, and Grier at the Massachusetts Institute of Technology. The ability of the tube to pass extremely high peak anode currents of short duration led to its use as a control device in connection with many special electronic circuit applications.[3]

Figure 3 gives the basic circuit of a commercial stroboscopic test device developed by the General Radio Company, employing a strobotron light source driven by a multivibrator. The oscillation frequency is varied by changing the grid bias voltage of the 6N7 by means of potentiometer R. The output signal of the multivibrator at the grid of the strobotron is in the form of a sharp negative pulse. This insures that the time interval between strobotron flashes will be substantially independent of variations which may occur in circuit or tube constants.

The 1D21/631P1 is essentially a double-grid cold-cathode gaseous discharge tube capable of peak anode currents as high as 300 to 400 amperes under favorable duty cycle conditions.

The components are a cathode, an inner grid, an outer grid and an anode. All leads are brought out to the terminals of a standard 4-pin base. The cathode, which is composed of powdered metal and a compound of caesium, is shielded from the discharge by a ceramic disc.

The inner grid is a wire probe and the outer grid is a graphite ring to which a wire probe is also attached. Graphite is used because the breakdown voltage between the outer grid and the anode will be less affected should some of the caesium from the cathode be deposited on the outer grid. The use of caesium for the active cathode material is dictated by the necessity for a rapid breakdown of the cathode surface under bombardment to form a

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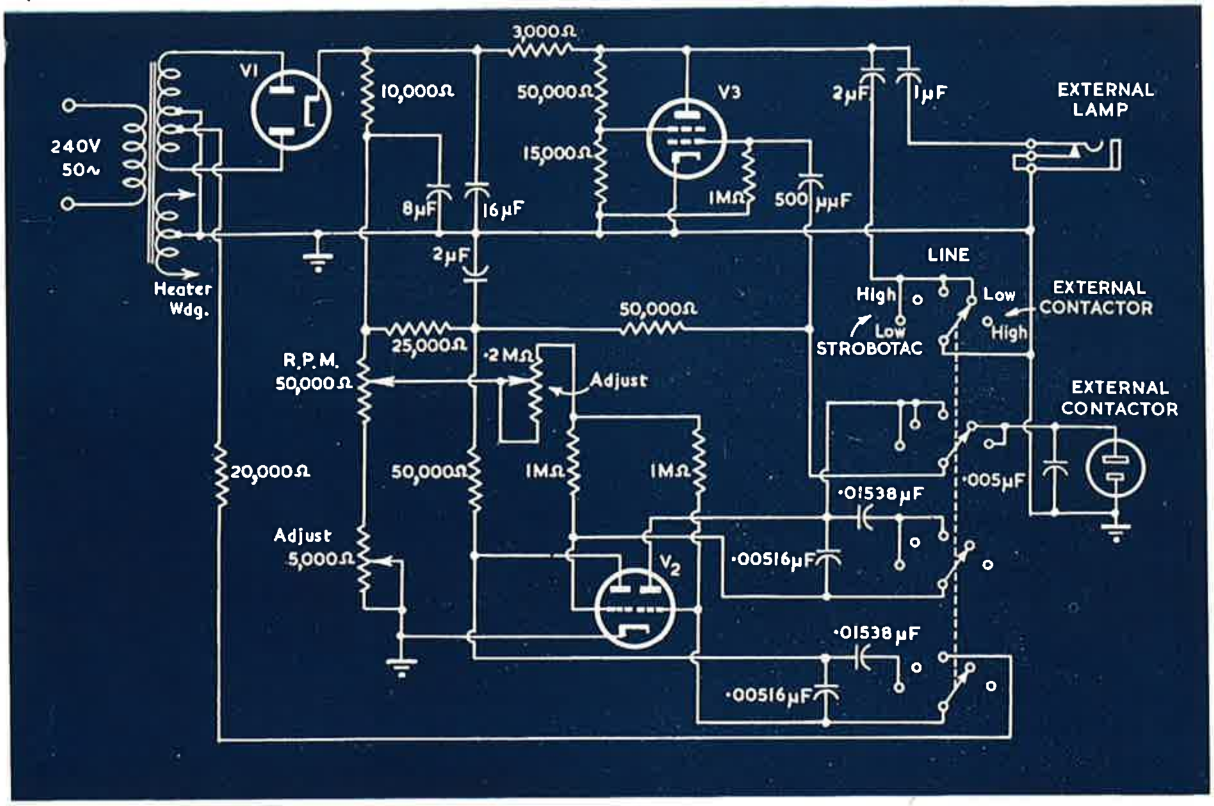

Fig. 3. Circuit diagram of complete stroboscope. V1 = 6 × 4, V2 = 6N7-GT, V3 = 1D21.

cathode spot facilitating the formation of an intense arc rather than a glow discharge.

Control characteristics

In Fig. 2, the control characteristics of the 1D21/631P1 are given for three values of anode voltage. For a given anode voltage, as long as the vector sum of the two grid voltages falls within the closed loop, the tube will not fire. Any increase or decrease in one or both of the grid voltages which causes their vector sum to fall outside the closed loop will result in breakdown of the tube. It has been found that such control curves vary during the life of the tube and hence are not included as characteristic curves. This is due to the fact that during discharge a portion of the cathode material may be evaporated and deposited on either or both of the control grids, thus altering the control characteristics for subsequent operation.

If extreme stability of operation is required, the tube may be fired by means of subsidiary apparatus which provides a steep pulse of sufficient amplitude (about 150 volts peak), as in the circuit of Fig. 3.

Effect of reverse current

The impedance and, in consequence, the voltage drop through the tube are low and care should be taken in design of operating circuits to avoid any tendency toward reverse current, causing the anode to assume the role of cathode during a part of the discharge cycle. This can result in anode sputtering with attendant blackening of the envelope and some cleanup of gas. The inductance of long leads from the discharge capacitor might be sufficiently high to result in voltage backswing and inversion. Shortening the leads and introducing sufficient resistance to provide critical damping of the circuit will usually avoid complications.

Cathode spot formation

A peak cathode of approximately five amperes is necessary for formation of the cathode spot and the resulting brilliant arc-type discharge. Best results for high-current operation are to be expected when the circuit constants are proportioned to give peak cathode currents of from 10 to 200 amperes, at an average anode current of 50 mA or less. The plate voltage should not exceed 350 volts d-c. Repetition rates up to 250 pulses per second may be reached with some deterioration in life at the higher values.

The tube can also be operated under conditions of glow discharge without the formation of the characteristic cathode spot. Under these conditions the tube can be used as a control device when high peak currents are not required.

The 1D21/631P1 strobotron has a light output sufficient only for visual observations close to the subject.

References

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