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In This Issue

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WESTON MODEL 1475 MULTI-RANGE INDUCTRONIC® D-C AMPLIFIER

THE new Model 1475 Inductronic Amplifier is a general purpose d-c amplifier primarily intended for laboratory measurements and special purpose set-ups requiring sensitive d-c amplification. The instrument is comprised of a Weston Model 1411 D-C Amplifier, a range network, and an indicating instrument mounted on a standard 19-inch relay rack panel, 5 units (8¾ inches) high, supplied in a rack cabinet.

Many Model 1411 Amplifiers have been combined with an indicating instrument and a large complement of range standards for general laboratory service. In response to the requirements of many users, the Model 1475 Amplifier now combines these components in a single unit, with switch selection of ranges for more convenient operation.

Figure 1 shows the standard Model 1475 Amplifier as supplied in a cabinet. Figure 2 shows the rear panel layout of the Model 1411 Amplifier proper, and a rectangular metal box enclosing the range network as a unit. The amplifier, range network unit, and the indicating instrument may be dismounted from the panel, as shown in Figure 3, for permanent bench mounting or installation within other equipment when desired; to facilitate remounting, all the panel controls are included within the

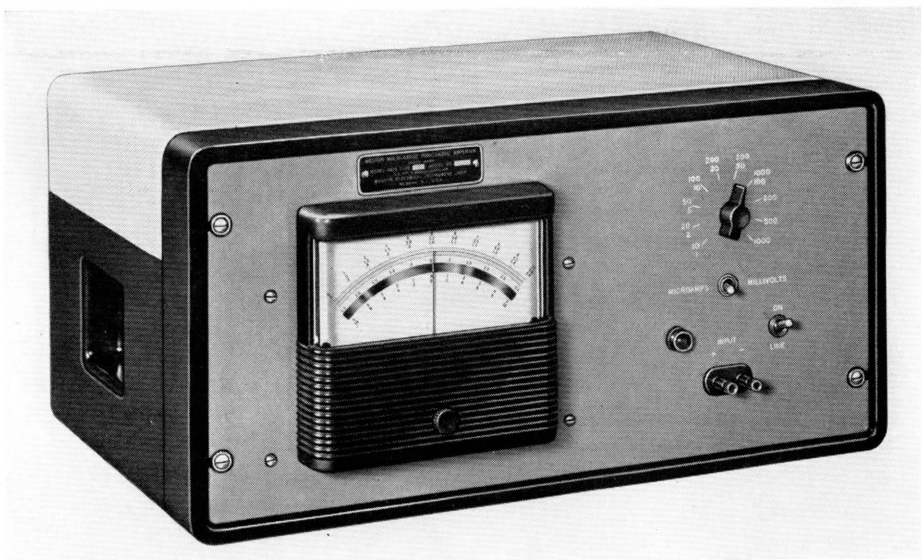


Figure 1—Standard Model 1475 Multi-Range Inductronic D-C Amplifier.

The major component, the Model 1411 Inductronic D-C Amplifier, is described elsewhere,[1] and its detailed operation need not be repeated here. But, briefly, it has a basic input resolution of 5 microvolts and 0.1 microampere, related by a match resistance of 50 ohms. In the Model 1411, the operating range, voltage or current is determined by plug-in range standards containing the feedback network.

range unit, which may be integrally dismounted from the panel.

The indicating instrument is a special milliammeter having a knife-edge pointer and a 5.5-inch scale with a parallax mirror. It is scaled for left-hand zero and center zero ranges; and the zero corrector is a knurled knob, rather than the usual screw driver slot, having sufficient throw for left to center zero adjustment. The instrument may thereby be set for either left-hand or center zero ranges. The output current of the amplifier is 1 milliampere on all ranges; 0-1 milliampere for left-hand zero ranges, and 0.5-0-0.5 milliampere for center zero ranges. Terminals are provided at the rear of the range unit for connection of the output current to accessory equipment when desired. The output circuit may be loaded with up to 5,000 ohms.

As with the Model 1411 Amplifier, the input circuit of the Model 1475 is maintained in potentiometric balance in operation. With voltage inputs the current burden is balanced out, and with current inputs the potential burden is balanced out, providing effectively infinite and zero input resistances respectively. This feature is particularly important when making measurements upon low-level devices such as thermocouples, photocells, transistors, and such, where the burden imposed even by sensitive conventional indicating instruments is prohibitive.

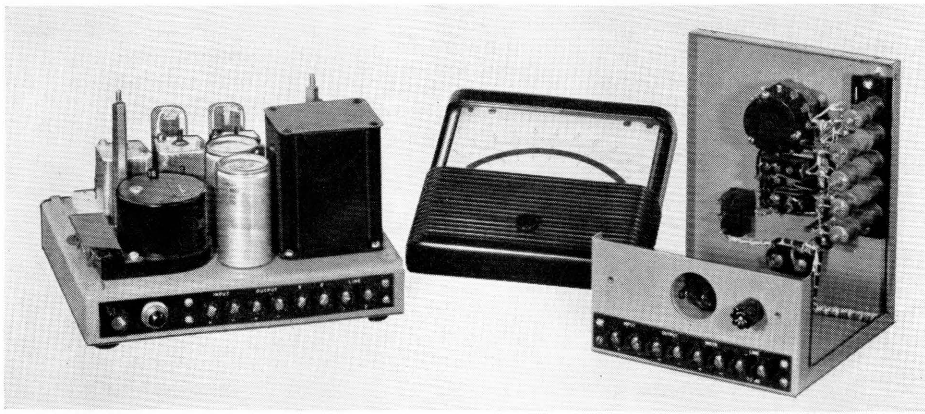


Figure 3—Model 1411 Amplifier, range network unit, and indicating instrument dismounted from the panel.

The basic accuracy of indication is 1 per cent of full scale, plus the resolution figure, 5 microvolts or 0.1 microampere, as applicable, when the input resistance is no greater than 50 ohms on potential ranges or no less than 50 ohms on current ranges. The resolution figure becomes trivial on all except the lowest ranges. Accuracy in terms of the output current is 0.5 per cent of full scale plus the same resolution figure. When accessory external devices are operated by the output current, the output current tolerance figure should be added to the tolerance stated for the connected equipment. The separate accuracy of the special indicating instrument is 0.5 per cent of full scale.

Ranges

The Model 1475 Amplifier is supplied with ranges of 1, 2, 5, 10, 20, 50, 100, 200, 500, and 1000 millivolts; and 10, 20, 50, 100, 200, 500 and 1000 microamperes, a total of 17 ranges. Ranges are selected by a single rotary range switch and a millivolt-microampere toggle switch. All ranges may be made either left-hand or center zero by adjustment of the instrument zero corrector.

The amplifier saturates at an output current of between 1.5 and 2 milliamperes regardless of the input overload, and equipment connected to operate from the output current need not have an overload capacity greater than the 2-milliampere figure. The input overload limit is 0.5 volt greater than the operating voltage range on all voltage ranges, and 10 milliamperes on all current ranges.

Transient Errors

The Weston Inductronic system is basically insensitive to input transients or a-c stray disturbances. It operates on a carrier frequency of 200 kilocycles per second, and in this respect is quite unlike low frequency carrier systems such as chopper-modulated amplifiers. No input filter is necessary. For this reason, it is not sensitive to grounding conditions except insofar as d-c leakage is concerned.

Furthermore, it will properly average inputs having rates of change greater than the amplifier can follow in balance. Thus, inputs having large ripple components, up to 100 per cent of the d-c level, can be measured without error due to partial ripple rectification. This avoids danger of the insidious aver-

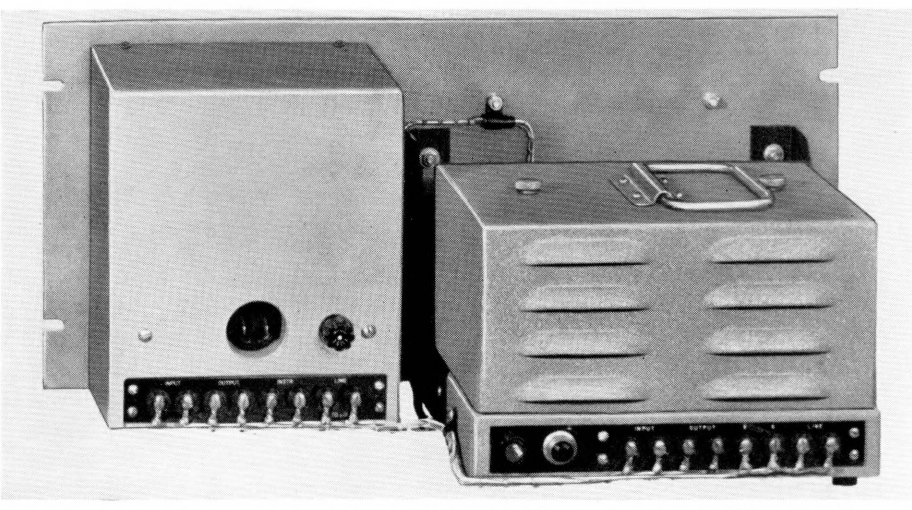


Figure 2—Rear panel layout of the Model 1411 Amplifier and rectangular metal box enclosing the range network as a unit.

aging errors commonly experienced with low-frequency carrier systems, which usually require input filters sufficiently large to limit the indicating response speed.

Specifications

Ranges:

1, 2, 5, 10, 20, 50, 100, 200, 500, and 1000 millivolts; 10, 20, 50, 100, 200, 500, and 1000 microamperes; left-hand and center zero.

Input:

Current or potential balanced; maximum burden 5 microvolts and 0.1 microampere, as applicable; 50 ohms match resistance.

Output:

0-1 or 0.5-0-0.5 milliampere, into a load not exceeding 5,000 ohms; maximum delivered overload 2 milliamperes.

Accuracy:

1 per cent on panel instrument; 0.5 per cent on output current; both plus 5 microvolts or 0.1 microampere, as applicable.

Response:

As amplifier, approximately 0.2 second on low ranges; less than 0.1 second on high ranges; indicating instrument adds about 0.3 second to the amplifier response.

Source Resistance:

Recommended 50 ohms maximum on voltage ranges and 50 ohms minimum on current ranges; other source resistances acceptable with some accuracy qualification.

Mounting:

Standard 19-inch rack panel, 5 units (8¾ inches) high, 11 inches clearance depth behind panel; may be dismounted from panel for assembly within other equipment; supplied in rack cabinet, 9¾″ x 20″ x 16″ overall.

Weight:

40 lbs., 7 ozs. (in cabinet).

Power:

100-130 volts, a-c; 50-1600 cps.; approximately 30 watts demand.

Reference:

[1] *"The Weston Model 1411 Inductronic D-C Amplifier,"* WESTON ENGINEERING NOTES, Vol. 6, No. 1, April, 1951.

E. N.—No. 108 —*R. W. Gilbert.*

NEW WESTON METHOD OF TV RECEIVER ALIGNMENT

A short description is given of the alignment requirements and current practice used in aligning monochrome TV receivers. Shortcomings of the present method are pointed out and details given of the new Weston Simplified Method.

Introduction

IN THE United States, television programs are transmitted with a vestigial side band amplitude modulated carrier for the video signal and a frequency modulated carrier for the sound signal. The center frequency of these two signals is required to be exactly 4.5 megacycles apart and the total band width occupied is limited to 6 megacycles under FCC regulations. In the VHF TV broadcasting band, air space is allocated to 12 channels as follows:

Channel	Video Carrier (Megacycles)	Sound Carrier (Megacycles)
2	55.25	59.75
3	61.25	65.75
4	67.25	71.75
5	77.25	81.75
6	83.25	87.75
7	175.25	179.75
8	181.25	185.75
9	187.25	191.75
10	193.25	197.75
11	199.25	203.75
12	205.25	209.75
13	211.25	215.75

This comprises the complete VHF TV broadcasting band permitted under FCC rules. Figure 1 shows the frequency allocation of Channel 3 together with its adjacent Channels 2 and 4.

From the alignment point of view, VHF TV receivers in the United States are either of the "Split Sound" or "Intercarrier" varieties. The difference between the two types may be seen from Figures 2 and 3 which show the sound signal going all the way through the IF amplifier and video detector in the Intercarrier system before being split off into its own simple sound IF and discriminator. In the Split Sound System, the sound signal is divorced from the vision signal at the rear end of the tuner. In both types of systems, the multiplicity of channels dictates the use of a heterodyne RF or tuner stage which, by adjusting the frequency of the local oscillator in the TV receiver at the same time as the

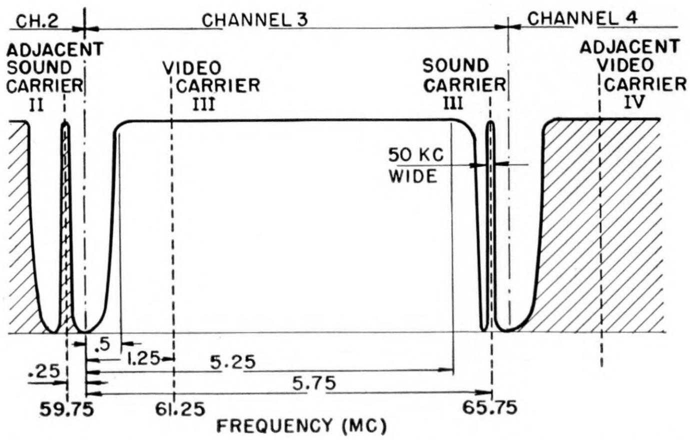


Figure 1—Frequency allocation of Channel 3, together with adjacent Channels 2 and 4.

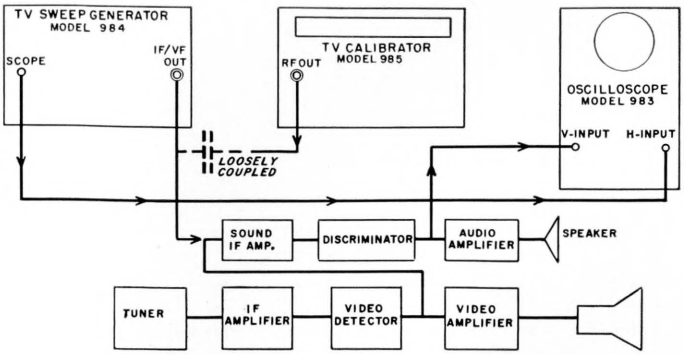


Figure 2—Conventional method of checking over-all sound IF response and discriminator characteristics of intercarrier systems.

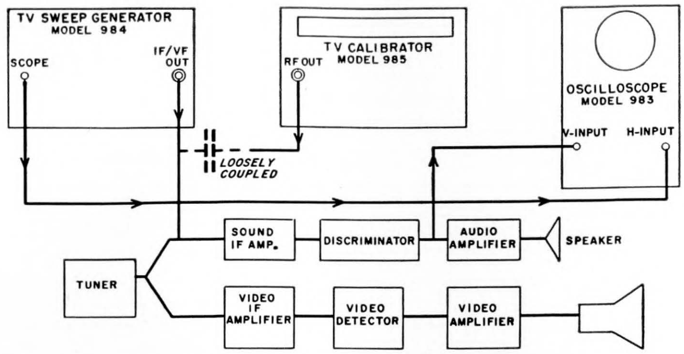


Figure 3—Conventional method of checking over-all sound IF response and discriminator characteristics of Split Sound System.

channel selector switch is changed, permits the use of a common intermediate frequency for all channels. Several different types of alignment problems are required to be considered.

Requirements for the Alignment Technique

In general, we wish to determine the shape of a response curve of a portion or portions of a TV receiver. To do this, we inject a unit voltage variable frequency or "wobbulator" signal and find the response of the receiver to this signal as in Figure 4.

RF or Tuner Response

It is the job of the RF stage to accept all the video and sound information for the desired channel. This dictates that the frequency of the local oscillator of the receiver be set for the particular channel used, so that the video and sound signals at their different frequencies will be accepted at full amplitude. While it is a desirable feature in an RF stage to reject as much other information on adjacent channels as possible, it is to be expected that a certain amount of extraneous information will pass through this stage. The limitation of frequency coverage of the RF stage is that it should not extend as far as the image frequency of the particular channel used. The response curve will be the same for both Intercarrier and Split Sound Systems, as shown in Figure 5.

The exact shape of the curve and all pertinent frequencies for this and indeed all other types of alignment throughout the set are given very completely in the TV set manufacturers' data sheets, which can be obtained by any serviceman. In general, the shape of the RF response curve varies from channel to channel, particularly since the frequencies involved vary from about 55 megacycles in Channel 2 to about 210 megacycles in Channel 13. The reasons for the double dots (marker pips) are explained later in discussing the Weston Simplified Method.

Intermediate Frequency Response for the Vision Signal

Intermediate frequency amplifiers are in general either of the stagger-tuned variety or the overcoupled type. That is, the over-all broad-band amplification desired from the amplifier is effected, either by having the separate stages as high-gain stages responding to different frequencies to give a broad-band, high-gain over-all effect, or alternatively as individual stages covering the whole frequency band each with low gain. In the case of Intercarrier receivers, the desirable object is to pass both video and sound information in the response curve, see Figure 6.

In the Split Sound System, Figure 7, only the video signal is required, with complete elimination of the sound carrier.

In both types, however, it is required to reject all other information from adjacent channels and particularly to reject any information occurring at the exact frequency of video and sound carriers on adjacent channels, since passage of signals from these particular frequencies would cause unwanted information to be included on the picture and in the sound of the receiver. The exclusion of this unwanted information is effected by the use of tuned, resonant traps that absorb all information at adjacent sound and vision frequencies. In the video IF response, unlike the tuner response, the shape *and* frequencies of the response curve will be exactly the same for all channels.

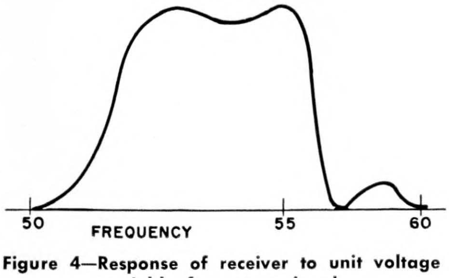


Figure 4—Response of receiver to unit voltage variable frequency signal.

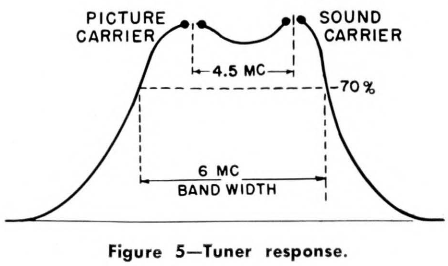


Figure 5—Tuner response.

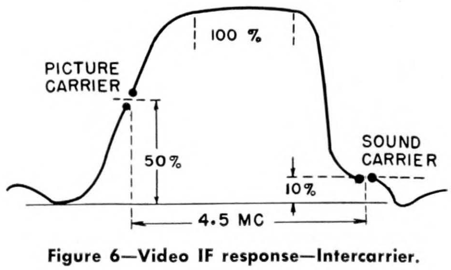


Figure 6—Video IF response—Intercarrier.

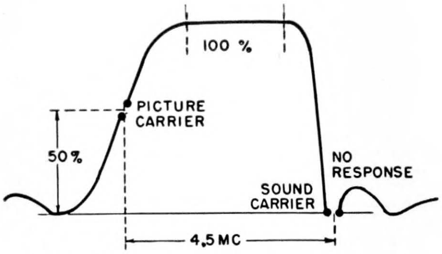


Figure 7—Video IF response—Split Sound.

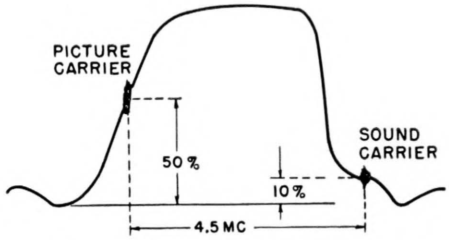


Figure 8—Over-all response—Intercarrier.

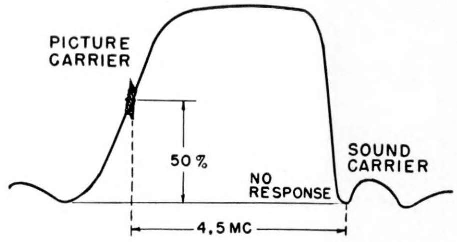


Figure 9—Over-all response—Split Sound.

Over-all Response

The over-all response covers the performance of the receiver including both tuner and video IF responses; that is, the signal is placed in the antenna terminals and removed at the video second detector giving responses as in Figures 8 and 9, for Intercarrier and Split Sound Systems.

As noted before, Intercarrier response will contain some sound information, and the Split Sound carries none whatsoever. It will be noted that the marker pips in Figures 8 and 9 are somewhat different to those found in Figures 6 and 7. The former figures show the Conventional Method of Alignment, whereas Figures 6 and 7 show the Z-axis method of the Weston Simplified Method.

Video Amplifier Response

The video section of a TV receiver consists of an amplifier that should give a fairly flat response up to approximately 4 megacycles and drop very quickly thereafter down to zero at 4.5 megacycles. This insures that no sound information is injected into the picture. Response curve is shown in Figure 10.

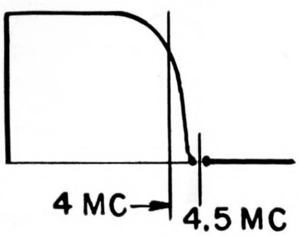


Figure 10—Video amplifier response.

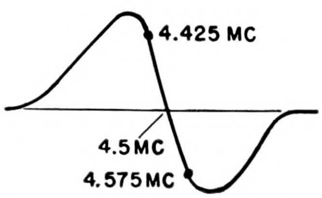


Figure 11—Properly adjusted sound IF and discriminator.

Sound IF and Discriminator Response

The sound signal is transmitted as a frequency modulated signal of narrow band width and, when the response is properly adjusted, should give the sound IF, as shown in Figure 11.

The sound IF response is an S-shaped curve with linear performance along a 150-kilocycle frequency band, ± 75 kilocycles from the center point and attenuated on each side of the center point to zero, so that only sound information may be transmitted to the sound amplifier.

Conventional Method of Alignment

Basically the Conventional Method of Alignment consists of injecting the output of a sweep generator into the TV receiver under test, taking the output of the TV receiver into the vertical amplifier deflection plates of an oscilloscope and at the same time loosely coupling the output of the calibrator into some position inside the TV set.

The function of these units is as follows:

The sweep generator injects into the TV set a constant amplitude signal whose frequency varies at a sinusoidal rate from a low to a high value; the normal rate of repetition of this sinusoid is power frequency, usually 60 cycles. The resulting picture on the oscilloscope screen is thus a graph of a response of the TV receiver to a unit voltage of differing frequency. However, the frequency of particular points on the screen cannot be closely identified unless an additional marking signal is used. This is normally obtained from the calibrator and the exact frequencies set on the calibrator can be identified on the oscilloscope screen by a small marker pip as shown in Figures 8 and 9. This

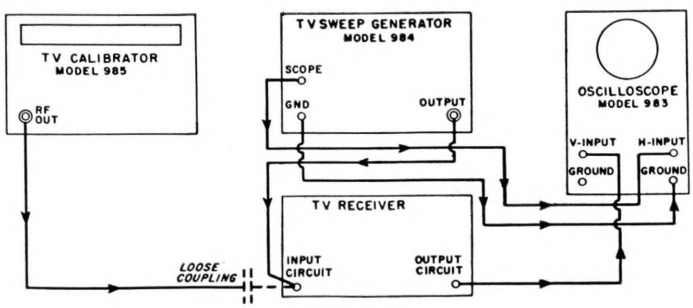


Figure 12—Television alignment procedure (Method 1).

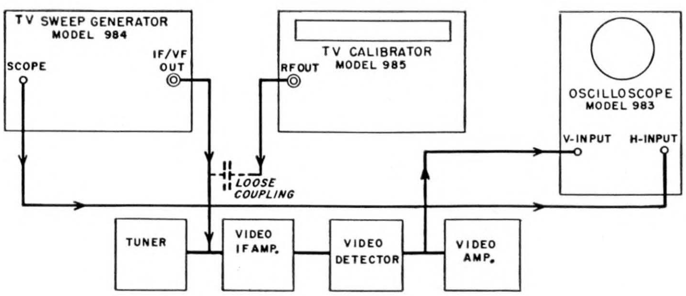


Figure 13—Conventional method of checking video IF response.

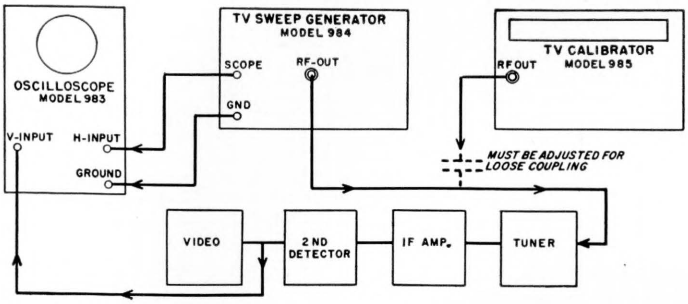


Figure 14—Conventional method of checking over-all response characteristics.

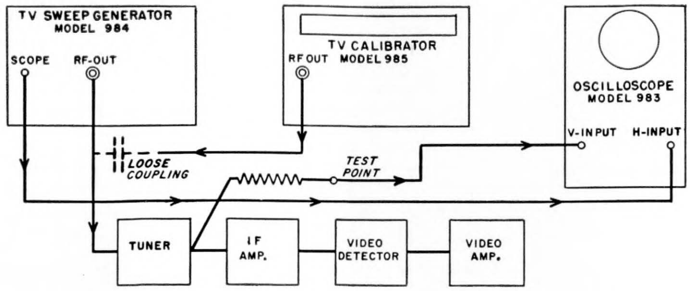


Figure 15—Conventional method of checking tuner response.

method is one of long standing and gives very good results when correctly applied. The detailed responses may be obtained as in the following figures:

Figure 2—Conventional method of checking over-all sound IF response and discriminator characteristics of intercarrier systems.

Figure 3—Conventional method of checking over-all sound IF response and discriminator characteristics of Split Sound System.

Figure 13—Conventional method of checking video IF response.

Figure 14—Conventional method of checking over-all response characteristics.

Figure 15—Conventional method of checking tuner response.

The conventional method of alignment has, however, several major disadvantages associated with it.

1. If the signal from the calibrator is too large or too tightly coupled into the TV set, the amplifiers in the TV set may be overloaded and a false or distorted response curve obtained on the oscilloscope, as shown in Figure 16A.

2. Spurious marker pips can be obtained from the mixing action of fundamentals and harmonics of the calibrator with fundamentals and harmonics of the local oscillator in the TV set.

3. When the output of the TV set is zero, such as at a resonant trap, there will be no marker pip. This occurs at a time when the marker pip is most needed, so that in tuning a resonant trap, the marker disappears just as the trap nears correct adjustment.

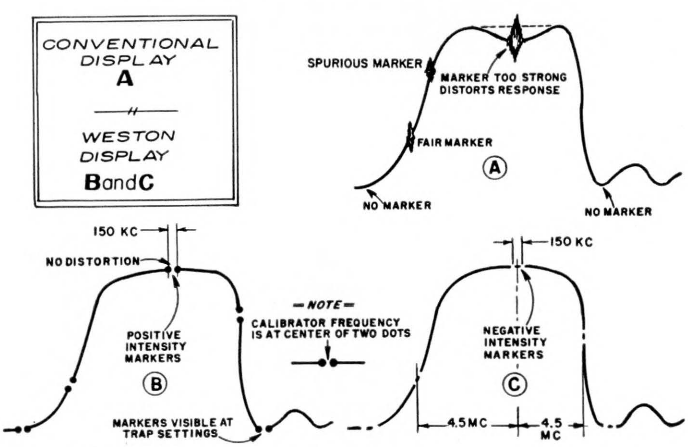


Figure 16—Weston intensity marker display vs conventional marker pip display.

4. The several leads connected to the TV set may cause it to break into oscillation.

Weston Simplified Method

To overcome these disadvantages of the conventional method, Weston has devised a simplified method of alignment which is shown in block form in Figure 17.

It will be seen that the sweep generator is connected to the TV receiver as before, but now a portion of the swept signal is injected into the calibrator where it is mixed with the calibrator frequency. The resulting beat signal at zero frequency is amplified and applied as a sharp pulse to the Z-axis of the oscilloscope. In this way, a bright or dark spot appears on the oscilloscope, dependent upon the polarity of the pulse and the oscilloscope Z-axis connection. The advantages of such a system include:

1. Coupling of the calibrator signal in the conventional method can cause distortion of the response curve. This simplified method eliminates trouble in finding how loose or tight to make the coupling, since a direct connection is made from the sweep generator to the calibrator.

2. The output of the calibrator no longer feeds into the TV receiver, so that intermodulation products and spurious marker signals due to the reaction of the calibrator and local oscillator signals will be eliminated.

3. Points of zero output on the TV receiver such as resonant traps may be identified by a clear marker pip.

4. Elimination of one pair of leads helps to reduce the problem of oscillation of the IF amplifiers.

Although this is the basic method, further improvements have been added to give greater simplicity and ease of operation for the user.

5. The bright or dark marker spot noted previously has been replaced by the double bright or dark marker

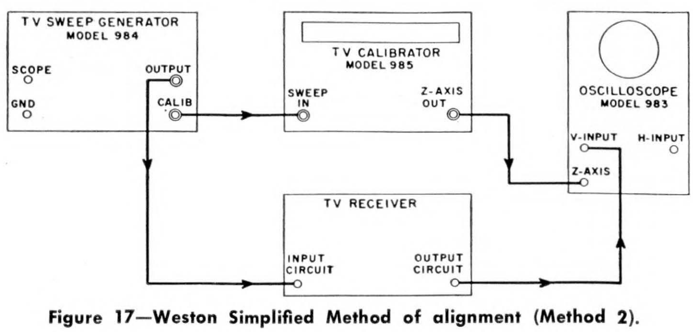


Figure 17—Weston Simplified Method of alignment (Method 2).

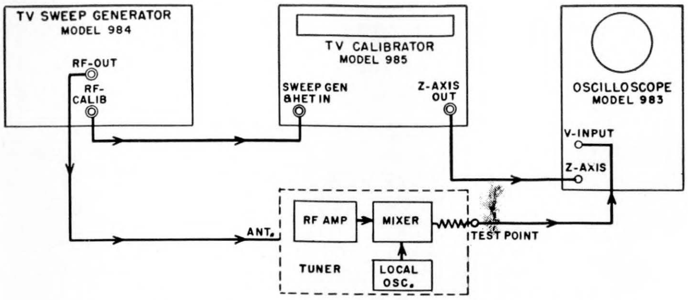


Figure 18—Weston Simplified Method of checking tuner response.

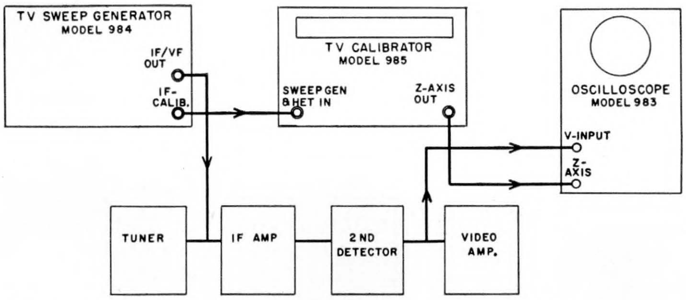


Figure 19—Weston Simplified Method of checking video IF response characteristics.

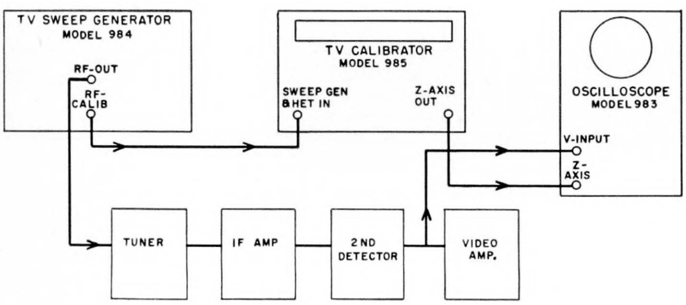


Figure 20—Weston Simplified Method of checking over-all response.

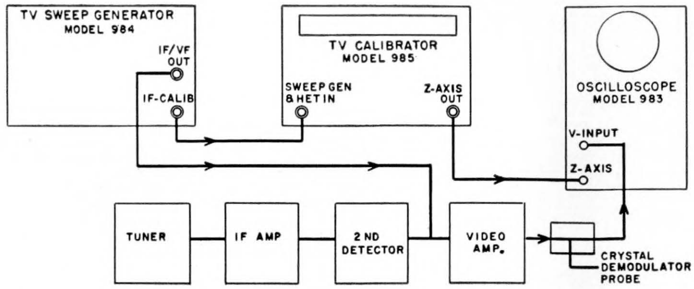


Figure 21—Weston Simplified Method of checking video amplifier response.

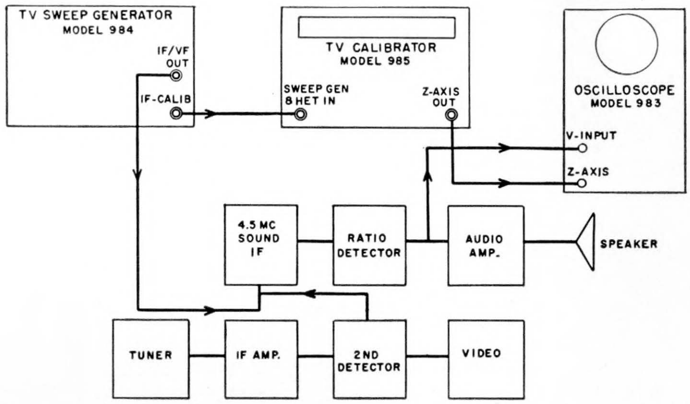


Figure 22—Weston Simplified Method of checking over-all sound IF response and discriminator characteristics of intercarrier systems.

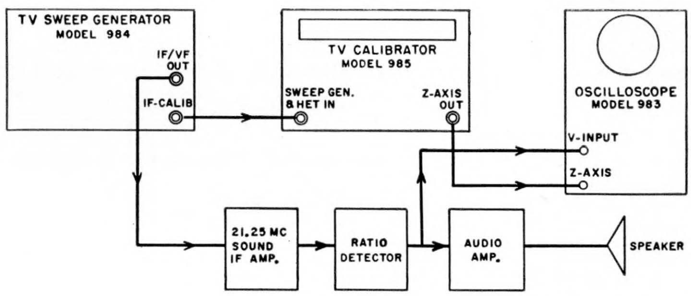


Figure 23—Weston Simplified Method of checking over-all sound IF response and discriminator characteristics of split carrier systems.

as shown in Figure 16. The spots are 150 KC apart and the exact frequency of the calibrator is midway between these spots. This offers a considerable increase in sensitivity in adjusting the frequency of resonant traps within very narrow limits and the 150 KC separation of the dots is particularly chosen to give clear marker points on the linear portion of the S-discriminator curve, ± 75 KC from the center point as seen in Figure 11.

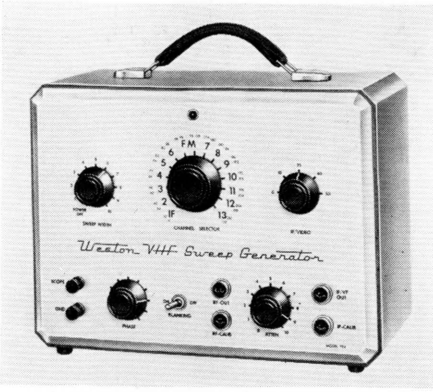
6. A further 4.5-megacycle signal is injected into the mixer and calibrator, as shown in Figure 5. (This signal is generated inside the calibrator and is used additionally to check the frequency calibration of the dial of the calibrator.) Injection of this signal will provide side band marks at ± 4.5 megacycles away from the set calibrator frequency, so that as the calibrator is set to the video frequency of the particular channel, another double marker pip will appear at 4.5 megacycles away; that is, at the exact frequency of the sound carrier of that particular channel, as shown in Figure 5. Thus, during alignment, the effect of the adjustment of some particular coil in the TV receiver on the performance of the receiver at both video and sound frequencies in that channel may be seen simultaneously, reducing considerably the amount of alteration and tuning of the dial of the calibrator required.

7. To further reduce the number of leads required in alignment, the oscilloscope is fitted with a 60-cycle sinusoidal time base capable of phase adjustment. This eliminates the leads connecting the sweep generator and oscilloscope.

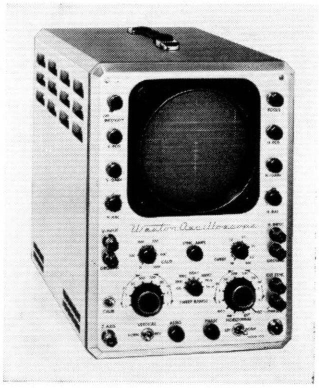
Using the Weston Simplified Method, complete alignment of a TV receiver may be very conveniently effected, and is shown in detail in the above figures.

E. N.—No. 109 —*R. C. Langford, Ph.D.*

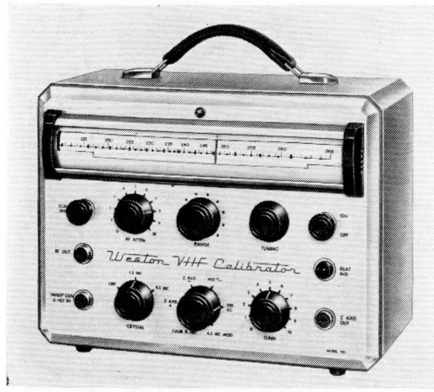
THE NEW WESTON "980" LINE TEST EQUIPMENT



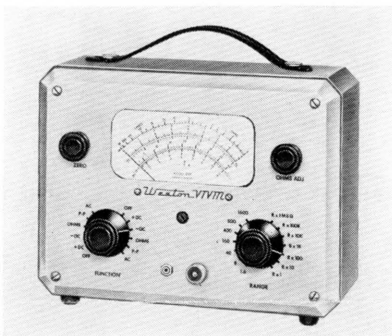
Model 984 Sweep Generator



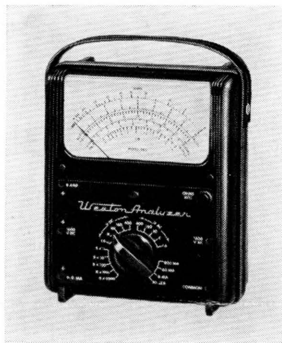
Model 983 Oscilloscope



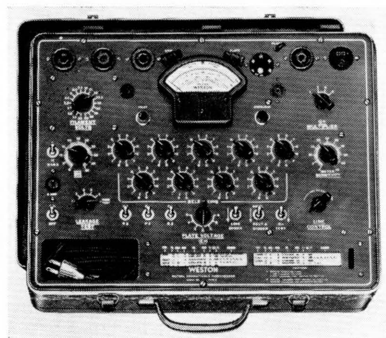
Model 985 Calibrator



Model 982 Vacuum Tube Voltmeter



Model 980 Analyzer



Model 981 Tubechecker

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