BENDIX

MODEL 160

CATHODE-RAY OSCILLOGRAPH

INSTRUCTION BOOK

BENDIX RADIO CORPORATION
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I N S T R U C T I O N S

For Use of

BENDIX MODEL No. 160

CATHODE-RAY OSCILLOGRAPH

SETTING UP OSCILLOGRAPH

Each instrument is shipped complete with the following items:

1 Cathode-Ray Oscillograph

1 Lens Attachment

1 Red Test Lead

1 Black Test Lead

1 Shielded Test Lead with Phone Plug

1 Instruction Book

1 Two Section Warranty Card

Check this list immediately after unpacking.

The Bendix Model 160 Cathode-Ray Oscillograph is shipped with all tubes in place and ready for operation.

To secure the lens attachment over the end of the Cathode-Ray tube housing, orientate it so that the female fittings inside the lens holder line up with the male fittings on the Cathode-Ray tube housing, then snap it into place by pushing the attachment fully against the end of the tubular housing. The attachment is now automatically locked into position. To remove it again, simply pull it away from the tubular housing.

Power requirements for the instrument will be found on the metal name plate attached to the rear of the instrument. Do not use the instrument on any other power supply than that there designated. The nameplate also carries the instrument serial number.

The warranty Card must be filled out IMMEDIATELY and the designated section mailed to the factory. This registers the instrument for warranty.

GENERAL INFORMATION

The instrument may be considered as an assemblage of several units with the necessary arrangements for conveniently connecting them to each other as required. They are:

1. The cathode-ray tube, with its associated beam controls and power supply.

2. Amplifier for voltages applied to the horizontal deflecting plates of the cathode-ray tube, together with its associated switches.

3. Amplifier for voltages applied to the vertical deflecting plates of the cathode-ray tube, together with its associated switches.

4. Variable frequency linear sweep circuit.

5. 1000 kilocycle base frequency modulated oscillator.

INSTRUMENT CONTROLS

The name of each control may be found on the front panel directly beneath the control in question. Arranged along the lower edge of the front panel are the four beam controls for the cathode-ray tube. They are, in the order of operation:

"INTENSITY" – This control carries the instrument on-off switch and controls the intensity or brightness of the cathode-ray beam. As the controlis turned clockwise a click is felt or heard indicating that the instrument power circuit has been completed. Further rotation in this direction serves to control the beam intensity. Always keep this control at the minimum setting consistent with satisfactory trace visibility. The life of a cathode-ray tube is determined almost solely by the intensity at which the screen is worked. Tubes with burned screens from excessive intensities can not be replaced. A much finer trace and consequent better resolving power is obtained when working at moderate to low intensities.

"FOCUS" – By rotating this control to the left or right, as required, the desired degree of fineness in the trace is secured.

"HOR.CENTER"

"VERT.CENTER" – As indicated by their respective titles, these controls serve to center the cathode-ray image on the tube screen. The direction of motion secured by manipulation of these controls is noted on the panel.

At the top of the panel are the amplifier controls. To the left of the panel center are those controlling the horizontal amplifier.

"HOR.AMP.SW."

"HOR.AMP.GAIN" – These controls select various functions for the horizontal deflecting circuits of the cathode-ray tube. In the "OFF" position of the "HOR.AMP.SW." the horizontal deflecting plates of the cathode-ray tube are connected to the "HOR.INPUT" terminals at the left edge of the panel through a 1 mfd. 400 volt blocking condenser. The blue terminal is connected to the instrument case while the yellow terminal is the ungrounded side of the signal input circuit. With this connection the deflection of the beam is dependent only on the magnitude of the input voltages and cannot be otherwise controlled.

In the "ON" position of the "HOR.AMP.SW." the "HOR.INPUT" terminals are connected to the internal amplifier through the "HOR.AMP.GAIN" control. In this and the remainder of the "HOR.AMP.SW." positions the amplitude of horizontal deflection may be controlled with the "HOR.AMP.GAIN" control. The sensitivity of the instrument is now increased by a factor equal to the amplifier gain, which is a maximum of forty.

With the "HOR.AMP.SW." in the "LINEAR" position the internal linear sweep circuit is connected to the horizontal amplifier through the gain control. In this and all subsequent positions of the "HOR.AMP.SW." the "HOR.INPUT" terminals are free from any internal connection to the instrument circuits. Control of the sweep will be covered in a following section.

With the "HOR.AMP.SW." in the "LINE" position the line voltage wave is applied to the horizontal deflecting circuits through the gain control and the amplifier. This is of particular help in determining phase relationship, also the presence and frequency of hum.

With the "HOR.AMP.SW." in the "CURVE TRACE" position the internal, frequency modulated, R. F. oscillator is set into operation and the horizontal deflecting circuits are connected to a linear sweep circuit preset to the line frequency.

To the right of the panel center are the vertical amplifier controls.

"VERT.AMP.SW."

"VERT.AMP.GAIN" – With the "VERT.AMP.SW" in the "OFF" position the vertical deflecting plates of the cathode-ray tube are connected to the "VERT.INPUT" terminals at the right edge of the panel through a 0.25 mfd., 400 volt blocking condenser. The blue terminal is connected to the instrument case while the yellow terminal is the ungrounded side of the signal input circuit. With this connection the deflection of the beam is dependent only on the magnitude of the input voltages and cannot be otherwise controlled.

In the "ON" position of the "VERT.AMP.SW." the "VERT.INPUT" terminals are connected to the internal vertical amplifier through the "VERT.AMP.GAIN" control. In this position the amplitude of vertical deflection may be controlled by the gain control. The sensitivity of the instrument is now increased by a factor equal to the amplifier gain, which is a maximum of forty.

Near the center of the panel are located the four sweep circuit controls.
These are, in the order of use:

"SWEEP SELECTOR" – This control varies the frequency of the internal linear sweep in large steps. It is used for approximating the necessary sweep frequency for an observation.

"SWEEP VERNIER" – This control also varies the frequency of the internal linear sweep but does so very gradually. It is used for setting exactly to the necessary sweep frequency for an observation.

"SYN. SELECTOR" – To obtain patterns sufficiently stable for easy observation it is necessary to positively lock the sweep frequency to some integral sub-multiple of the frequency of the observed wave-form. This is done by introducing a part of the observed wave-form into the proper place in the linear sweep generator. The "SYN.SELECTOR" selects the source of this locking or synchronizing voltage. In the "INT." position a part of the signal appearing on the vertical deflecting plates is selected. In the "EXT." position the synchronizing circuit is connected to the "SYN.INPUT" jack on the front panel so that synchronizing impulses may be used from any external source.

In the "LINE" position the power supply line is used as the source of synchronizing voltage.

"SYN.LOCK" – This control is used to set the magnitude of the locking voltage applied to the sweep circuit after the source has been selected by the "SYN.SELECTOR." The "SYN.LOCK" control should never be advanced farther than just necessary to obtain a stable image as too much locking or synchronizing voltage may tend to distort the observed image.

"ATTENUATOR" – This is the only control now remaining to be described. The "ATTENUATOR OUTPUT" jack appearing on the front panel is connected, through the "ATTENUATOR" to the output of the mixer, which is internally connected to the frequency modulated oscillator and also to the "R.F.INPUT" terminals which are at the lower edge of the panel. With the "HOR.AMP.SW." in the "CURVE TRACE" position and nothing connected to the "R.F.INPUT" terminals, there will appear at the "ATTENUATOR OUTPUT" a 1000 kc. base frequency signal which is frequency modulated between 985 kc. and 1015 kc. This signal is used in aligning receivers for best response. If any other frequency should be desired, it may be obtained by connecting a signal generator to the "R.F.INPUT" terminals. For a desired base frequency of less than 1000 kc. , set the signal generator to the frequency obtained by subtracting the desired frequency from 1000 kc. For a desired base frequency higher than 1000 kcs., set the signal generator to the frequency obtained by subtracting 1000 kcs. from the desired frequency.

USE OF THE INSTRUMENT

Do not use this instrument in bright sunlight or direct skylight. Far better results will be obtained when the surrounding lighting is somewhat subdued. Never allow the beam to appear on the screen as a spot for any length of time. Sufficient voltage should be supplied to the deflecting plates so the beam appears as a line so long as it is visible.

PREPARING FOR AN OBSERVATION

Turn the "HOR.AMP.SW." to the "LINEAR" position and advance the "HOR.AMP.GAIN" to about three on the graduated scale. The instrument is turned on by turning the "INTENSITY" control to the right until a click is felt or heard. The red pilot lamp on the front of the Oscillograph should now glow, indicating that power is being supplied to the instrument.

Set the controls, "INTENSITY" and "FOCUS," so that the arrows are approximately three-quarters on. After the tube has had about two or three minutes to warm up, a line or green haze should be seen on the screen. Adjust "INTENSITY" and "FOCUS" simultaneously until the line has been focused down to about 1/64 inch in width.

NOTE – DO NOT ALLOW A SPOT TO REMAIN STATIONARY ON THE SCREEN FOR MORE THAN A FEW SECONDS AT A TIME, or the material on the screen will be deteriorated. The life of the 906 tube is practically that of the screen, so it will prove economical to place the tube out of operation at any time when the circuit adjustments are being made by retarding the "INTENSITY" control slightly. This will avoid the necessity of waiting for the warm-up each time an observation is to be made.

Adjust the "HOR.AMP.GAIN" control so that a line appears across the removable over-lay chart from -15 to +15.

The initial position of the line trace will vary with the type of measurement to be made, and can be controlled with the two knobs marked, "HOR.CENTER" and "VERT.CENTER". The knob at the left moves the line from side to side and the one on the right in the up and down direction. For the general run of application, these adjustments will be made so that the line is centered within the boundary of the over-lay calibrated chart. For others, such as frequency alignment of radio receivers, it will be desirable to move the bottom of the pattern down along the lower edge to easily observe the frequency band pass of the selectivity curve.

APPLICATION OF VERTICAL VOLTAGES

With the above adjustments made, the instrument is ready for the study of voltage applied to the vertical plates. Binding posts for these connections appear on the right side of the panel. It should be noted that the lower post of the pair is marked "GND" (ground), which should always be connected to the earth or low-potential side of the circuit under test. If the instrument is used in a room containing equipment or wiring that causes stray fields about the room, it may be necessary to actually ground this post to prevent pickup from external sources from altering the observed waveform.

ADJUSTMENT OF LINEAR SWEEP

The sweep rate selected should always be equal to or less than the frequency of the voltage under observation. If the sweep rate is equal to the frequency of the observed voltage, one complete wave will be seen. If half the frequency, two complete waves will be seen, etc.

There are other adjustments of the sweep frequency which will permit stationary patterns which will be multiple waves or traces. Multiple traces obscure the true nature of the wave being studied and are due to mis-adjustment of the linear sweep frequency. The most common causes of these traces is due to setting the sweep rate to a higher frequency than the frequency of the wave being studied. The usual solution is to readjust the sweep to a lower frequency until a single trace of the desired number of cycles is seen.

CONTROL OF THE PATTERN

After the pattern has been adjusted, by means of the sweep controls, it can be locked in a stationary position by adjusting the "SYN.LOCK" when "SYN.SELECTOR" is turned to the "INT" position.

Sometimes a pattern may become distorted due to adjusting the SWEEP controls too far off the actually desired sweep rate and then attempting to lock it into synchronism by the application of excessive locking control voltages. A better plan is to retard the "SYN.LOCK" knob and adjust the "SWEEP VERNIER" until a practically stationary pattern is formed, and then introduce just sufficient "SYN.LOCK" to stop the movement of the pattern.

CHECKING RECEIVERS
POWER SUPPLY AND FILTER

The power supply may be checked by observing the voltage wave-form at several points in the filter system. As the voltage probe is connected successively to points further removed from the filter input the AC component should rapidly become negligible; i.e., 2% of the DC output voltage or less, at the filter output.

AUDIO AMPLIFIERS

The audio amplifier is tested by connecting the Oscillograph across the amplifier output and feeding a sine wave signal successively into each stage of the amplifier to show stage by stage gain, distortion or loss of power. Any point of trouble in the amplifiers will be immediately detected by a change in the wave form. A complete check of the signal at any point in the circuit is visually available, thereby, eliminating all guess work. Better than a vacuum tube voltmeter because it shows distortion, in addition to voltage, and superior to any type of output indicator because it shows actual wave form

RF—IF CIRCUITS

The RF—IF circuits are tested by connecting the Oscillograph across the diode load resistor and feeding a test signal successively into each stage of the RF and IF circuits. To render the AVC inoperative, disconnect the AVC filter resistor and connect to low potential end of AVC diode load resistor. Stage by stage gain is checked by obtaining the same vertical deflection on the Oscillograph for each successive stage. Ratio of the Oscillograph vertical amplitude graduation is proportional to the gain. Trouble from faulty resistors, condensers, and cold soldered connections is detected by the Oscillograph. Shows the operation of all component parts, thereby eliminating any doubts as to their operation. Actually shows the stage cutting out in intermittently operating receivers.

AVC CIRCUITS

The Oscillograph affords the most convenient and positive method of testing all types of AVC circuits, With the Oscillograph connected across the diode load resistor and feeding a sine wave modulated RF signal to the antenna and ground of the receiver, the signal input power is changed from low to high input. The wave is noted for flattening of the peaks which indicate faulty or no AVC action. Good AVC gives a perfect sine wave regardless of signal input.

ALIGNMENT

In aligning a receiver, it is important to align in the conventional manner with an output meter and signal generator in accordance with the manufacturers specifications. Then, after the receiver has been aligned in the conventional manner, use the Oscillograph to view the selectivity curve and readjust the trimmers on the IF coils of the receiver for proper band pass.

This is accomplished as follows:

1. Turn "ON" the Oscillograph and set "HOR.AMP.SW" to "CURVE TRACE".

2. Set SYN.SELECTOR" to "LINE". Advance "SYN.LOCK" to about three-quarters of full rotation.

3. With "VERT.AMP.GAIN" control turned to "O", adjust line across the screen by means of the "HOR.AMP.GAIN" and "HOR.CENTER" controls so that the line across the screen runs from –15 to +15. This will center the image so that the selectivity curve of the receiver may be read directly on the "SELECTIVITY CURVE CHART". Then turn the "VERT.AMP.GAIN" approximately halfway on or to "5" on the scale.

4. Insert plug end of shielded connector lead into the jack on the Oscillograph marked "ATTENUATOR OUTPUT". Connect other end of the cable to the antenna and ground of the receiver under test.

5. Connect the "VERT.INPUT" posts of the Oscillograph across the diode load resistor of the receiver.

6. Tune the receiver to resonance with the Oscillograph frequency of 1000 K.C. and observe the selectivity curve on the screen of the cathode-ray tube.

7. Adjust the receiver tuning dial or control until the peak of the selectivity curve appears in the exact center of the calibrated screen. Do not disturb this adjustment after the selectivity curve has once been centered on the screen, as this would affect the proper alignment of the receiver.

8. Advance or retard the "VER.AMP.GAIN" control so that the image is equal in height to that of the cross-hatched area of the graduated scale, but do not advance control beyond "9" on the graduated scale. The "ATTENUATOR" must be kept as low as possible. It will be found that the selectivity curve changes with intensity of the R.F. input signal, which is a normal indication.

9. The overall selectivity of any superheterodyne radio is largely controlled by the selectivity of the I.F. stages. Therefore, all adjustments for band pass or audio fidelity should be made to the trimmers controlling the alignment of the I.F. stages. Do not disturb the trimmers on the receiver condenser gang or any trimmers affecting circuits other than the I.F. stages after they have once been set with the conventional signal generator and output meter. Connect the R.F. output to the antenna and ground of the receiver. Connect the vertical input to the diode load resistor. Tune the receiver to resonance and note the curve. When trimmers are properly set, the curve should be symmetrical on each side of center. Any bumps or irregularities in the curve indicate faulty alignment. The calibrated chart shows the receiver selectivity directly in kilocycles.

FREQUENCY MODULATED OSCILLATOR

As previously stated, the Oscillograph contains a built-in 1000 K.C. frequency modulated Oscillator, the output of which is used directly for checking the overall selectivity of any receiver or may be connected by means of the "R.F. INPUT" and "GND. TERM" to any good Signal Generator for obtaining a frequency modulated signal of 15 K.C., above and below any desired base frequency over the entire range of frequencies covered by the Signal Generator. With the "HOR.AMP.SW." set at the "CURVE TRACE" position and the Signal Generator output connected to the "R.F. INPUT" posts at the bottom of the Oscillograph panel, a frequency modulated signal at the sum and difference frequencies of the Signal Generator and the built-in 1000 K.C. frequency modulated oscillator will be available at the "ATTENUATOR OUTPUT".

For a desired base frequency of less than 1000 K.C., set the signal generator to the frequency obtained by subtracting the desired frequency from 1000 K.C. For a desired base frequency higher than 1000 K.C. set the signal generator to the frequency obtained by subtracting 1000 K.C. from the desired frequency.

IMPORTANT INFORMATION

CAUTION --- About 1000 volts are present within the Oscillograph when operating. Therefore, it is important that the operator does not take the case from the Oscillograph when it is operating, as it would be possible to come in contact with the high voltage which is present internally in the Oscillograph.

Cathode-Ray tubes are subject to damage through burning of the screen by the employment of beam intensities which are too great per unit area. In view of the fact that Cathode-Ray tubes are not guaranteed against misuse of this character, the user should take every precaution in protecting the tube against burning of the screen.

The spot should never be focused on the screen without some voltage applied to either the horizontal or vertical plates. The intensity should then be turned up only sufficient to form a well-defined trace of moderate intensity. Somewhathigher intensity may be necessary when observing a complex pattern but in such cases the intensity should be retarded before the deflecting voltages are removed.

IMPORTANT NOTE:

ADDITIONAL INSTRUCTIONS COVERING ALL USES OF THE BENDIX CATHODE-RAY OSCILLOGRAPH WILL BE PUBLISHED SOON. REGISTER YOUR NAME AND THE INSTRUMENT SERIAL NUMBER BY FILLING OUT AND MAILING THE ENCLOSED GUARANTEE CARD, AND A COPY OF THE BOOK WILL MAILED GRATIS. YOU WILL ALSO RECEIVE ALL BENDIX TECHNICAL BULLETINS GIVING ADDITIONAL INFORMATION AND SUGGESTIONS, AS WELL AS ANNOUNCEMENTS OF NEW EQUIPMENT. PLEASE READ THE ENCLOSED GUARANTEE CARD AND MAIL IMMEDIATELY AS THIS REGISTERS YOUR INSTRUMENT FOR WARRANTY.

SPECIFICATIONS

AMPLIFIERS

Two separate 6C6 amplifiers are provided, one for horizontal input amplification, one for vertical input amplification. The maximum gain is approximately 40 over a frequency range of 20 to 100,000 cps. The gain controls are marked to show the degree of amplification.

SWEEP CIRCUIT

The sweep frequency range is 15 to 38000 cycles per second. An 884 thyratron is employed as the sweep generator. The sweep circuit has provision for minimizing return trace. The frequency may be synchronized with:

(1) Voltage under observation
(2) Any external voltage frequency
(3) Power line.

The sweep frequency range is divided into 11 steps of the selector switch as follows:

Position	0	15	to	45
	1	25	to	80
	2	55	to	160
	3	130	to	400
	4	340	to	1000
	5	850	to	2600
	6	1750	to	5500
	7	3300	to	10500
	8	6000	to	18500
	9	9700	to	27000
	10	16700	to	38000

BEAM ADJUSTMENTS

All four beam controls are on the front panel:

(1) Horizontal centering
(2) Vertical centering
(3) Focus control
(4) Intensity control

FREQUENCY MODULATED OSCILLATOR

The base frequency of the oscillator is 1000 K.C. with a fixed band width of 30 K.C. A transparent graduated scale is provided for placing across the screen of the cathode ray tube. A specially shielded attenuator circuit is employed whose output is connected thru a jack in the front panel. Input posts provide for connection to an external signal generator to beat with 1000 K.C. oscillator and produce frequency modulated signals over a range determined by frequency coverage of external generator. The maximum voltage output at 1000 K.C. is 1 volt.

SENSITIVITY

Vertical:	No amp:	24.6 volts RMS per inch
	Amp on:	0.615 volts RMS per inch
Horizontal:	No amp:	23.0 volts RMS per inch
	Amp on:	0.575 volts RMS per inch

POWER REQUIREMENTS

Operating power requirements are specified on nameplate at rear of instrument. Power consumption 80 watts.

TUBE REQUIREMENTS

1 type 906 cathode ray tube
2 type 6C6 amplifier tubes
1 type 6C5 frequency modulator tube
1 type 6J7 oscillator tube
1 type 6L7 mixer tube
1 type 884 sweep oscillator tube
1 type 5V4G low voltage rectifier tube
1 type 81 high voltage rectifier tube

PHYSICAL DETAILS

Height 20”
Width 13”
Length 20”
Weight 41 lb.

MECHANICAL FEATURES

Inclined panel with all controls readily visible and adjustable.

Swivel mounting for cathode ray tubes giving wide angle utility.

Snap on lens assembly and light shied.

ACCESSORIES

Snap on lens assembly produces the equivalent of a 5" cathode ray tube.

Two test leads with banana plug on one end and insulated clip on the other.

One shielded test lead with phone plug on one end and two insulated clips on the other end.

The graduated transparent scale supplied with the instrument will be found of great value in making exact measurements.

MAINTENANCE NOTES ON MODEL 160 CATHODE-RAY OSCILLOGRAPH

WARNING--- THERE ARE VOLTAGES IN EXCESS OF 1000 VOLTS USED IN THIS INSTRUMENT. EXERCISE EXTREME CAUTION WHEN WORKING PARTS ARE EXPOSED.

If the instrument is subjected to any severe shock or vibration, the cathode ray tube may rotate slightly so the trace on the screen is not properly orientated in the horizontal and vertical directions. To place the tube in the proper position, remove the rear end cap by pushing forward slightly, turning to the left, and pulling out. Rotate the cathode ray tube until the linear or line sweep is horizontal and then carefully replace the cap. The spring between the end cap and socket plate will hold the tube in the set position.

The instrument is equipped with a pilot lamp to show when it is operating. If the lamp does not light when the switch is on and the instrument is connected to the proper power supply, remove the bottom plate and check the fuse mounted on the lower side of the power supply assembly.

The various tubes may be removed from the instrument for testing or replacement either through the bottom of the case or the rear of the case. The rectifier and amplifier tubes are readily accessible through the rear of the case while the RF oscillator, frequency modulator, mixer and sweep oscillator tubes are readily accessible through the bottom of the case.

The oscillator frequency and its modulated band width are set at the factory and must not be re-adjusted without the proper equipment. The warranty on this portion of the instrument is void if these controls are reset by unauthorized personnel.

If the instrument does not operate properly after a reasonable warm-up period, and there is assurance that none of the tubes is defective, remove the case bottom and check to see that all the power supply terminal board connections are tight. DO NOT TOUCH THESE CONNECTIONS UNLESS THE POWER IS OFF AND ALL CONDENSERS HAVE BEEN DISCHARGED.

If the trouble still persists, write the factory giving full details.

In shipping the Oscillograph from one point to another, it is recommended that the original carton be used, but if this is not available, pack the instrument in a sturdy box with the cathode ray tube housing WELL SUPPORTED.