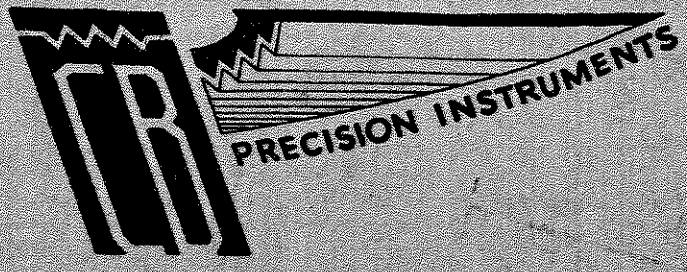

ENGINEERS AND
MANUFACTURERS OF
ELECTRICAL EQUIPMENT

The CLOUGH-BRENGLE CO.

CHICAGO, U. S. A.

W A R R A N T Y

We warrant each new instrument manufactured and/or sold by us to be free from defects in material and workmanship; our obligation under this warranty being limited to repairing or replacing any instrument or part thereof (except tubes) which shall within ninety days after delivery to the customer, prove by our examination to be thus defective.

In the execution of this guarantee we demand that the instrument claimed to be defective under this guarantee, shall be returned only by our written permission, transportation prepaid, for examination in our plant. Adjustment shall be made in accordance with dates set forth in guarantee card in our files.

Vacuum tubes are specifically excluded from the terms of the guarantee due to their nature as well as the fact that they are separately and specifically guaranteed by the manufacturer. All claims for tube adjustment must be made against the tube manufacturer.

The C L O U G H - B R E N G L E COMPANY

2815 W. Nineteenth Street

CHICAGO, U.S.A.

IMPORTANT NOTICE

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 either by ourselves or the manufacturer 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. Somewhat higher intensity may be necessary when observing a complex pattern but in such cases the intensity should be retarded before either of the deflecting voltages is removed.

One of the most common causes of damage due to excessive intensity is the use of the instrument in an external light which is too great. Choose a location where the instrument is facing away from windows and out of the glare area of an overhead light. In this way a clear, well defined, pattern may be formed at intensities which are within the safe operating values of the screen material.

Attention is also called to the fact that the deflecting plates inside the tube are delicately mounted and if the tube is dropped or otherwise suddenly jarred they will bend out of place, often before the glass envelope breaks, thus making it impossible to properly center the spot.

O P E R A T I N G I N S T R U C T I O N S

The CLOUGH-BRENGLE
Type 105 Oscillograph.

1. SETTING UP

The type 105 Oscillograph is shipped complete with all tubes in place and ready for operation. Reference should be made to the nameplate on the side of the case to determine the proper line operating voltage and frequency.

2. THE CONTROLS

The 105 Oscillograph is equipped with complete control for the adjustment of the tube and spot. The controls for placing the tube in operation initially are placed along the lower front of the instrument and are designed in their order (from left to right) INTENSITY, FOCUS, LEFT-RIGHT and DOWN-UP. The control marked INTENSITY also carries the ON-OFF switch for line power and is OFF in the extreme counter clockwise position as indicated.

At the upper left of the panel under HORIZONTAL is the control for the AMPLITUDE in the horizontal direction. The switch for choice of sweep is designated LINEAR SWEEP and BINDING POSTS. The amplitude control is effective when the switch is in both positions.

At the upper right, under VERTICAL, is the control for the vertical delecting plate marked AMPLITUDE. For the study of R.F. voltages at frequencies above 100,000 cycles per second, provision is made for direct connection to the vertical plates by means of a port hole near the top on the righthand side of the case. The opening is normally closed by means of a button, which may be disengaged by inserting a screwdriver under theedge and prying outward. Opening this port will disclose two terminal screws connected together by a link. For study of R.F. potentials, this link should be removed and the pulse applied to the vertical plates by making connection to the bottom terminal screw and to the ground binding post on the front panel.

The amplitude control is effective when the amplifier is in use, but is eliminated when the amplifier is out of use in order to avoid phase shift of the voltage being observed due to the capacity of the deflecting plates of the Cathode-Ray tube in conjunction with the high resistance of the volume control.

In the center of the panel is the main control for the LINEAR SWEEP FREQUENCY with steps numbered in the frequency range of each position. To the left of the main control is the VERNIER control which allows interpolation between the frequency ranges.

At the right center is a two position switch which permits the linear sweep circuit to be controlled from INTERNAL or EXTERNAL circuits, while just below is the control governing the amount of voltage introduced into the linear sweep circuit for control purposes. This knob is designated SYNCHRONIZING VOLTAGE CONTROL.

3. THE CONNECTIONS TO THE INSTRUMENT

Binding posts are provided for connections to the VERTICAL and HORIZONTAL circuits and are mounted on either side of the panel. The posts for connection to the vertical deflecting plates are mounted vertically one above the other, as are the pair of binding posts for connection to horizontal deflecting plates.

Attention is directed to the fact that one post of each pair is marked GND. indicating the grounded side of the circuit.

At the lower right of the front panel is a post for connection to the control circuit of the linear sweep, (EXTERNAL CONTROL VOLTAGE). The other connection of the circuit should be made to one of the binding posts marked GND. These posts are for connection to the source of voltage under test when the switch designated SYNCHRONIZING is turned to the EXTERNAL position.

4. PLACING THE TUBE IN OPERATION

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

N o t e:- DO NOT ALLOW THIS CONCENTRATED SPOT TO REMAIN ON THE SCREEN FOR MORE THAN A MINUTE AT A TIME or the material on the screen will be deteriorated. The life of the 913 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, etc., 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.

The 105 Oscillograph is designed so that it may be operated in ordinary daylight, without the necessity of increasing the screen intensity beyond the safe limit. This may be accomplished by catching the edge of the nickel-plated bezel around the 913 tube and pulling forward, thus bringing the tube hood out from the front panel a sufficient distance to place the tube screen in a comparatively shaded position. Operation by this manner in a subdued light allows a lowered screen intensity which will prolong the life of the tube.

Turn the horizontal control switch to LINEAR SWEEP and turn up the horizontal amplitude sufficiently so that a trace is formed practically completely across the screen of the tube.

The initial setting of the spot or trace will vary with the type of measurement to be made, and can be controlled with the two knobs designated LEFT-RIGHT and UP-DOWN, the first mentioned moving spot from side to side and second in the up and down direction. For the general run of applications, these adjustments will be made so that the spot is centered on the screen. For others, such as frequency alignment of radio receivers, it will be desirable to move the spot pretty well up or down on the screen initially, depending on the type of detector used in the output of the receiver. This matter is treated more fully in the instructions for the CLOUGH-BRENGLE Frequency Modulated Oscillator.

5. APPLICATION OF VERTICAL VOLTAGES

With the above adjustments made, the instrument is ready for the study of voltages applied to the vertical plates. Binding posts for these connections appear on the right side of the panel (mounted vertically). 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 will be necessary to actually ground this post to prevent spurious deflections showing on the tube screen.

When the amplifier is used the knob at the right (AMPLITUDE) controls the amount of voltage applied on the input to the amplifier, and hence the excursion of the spot in the vertical direction.

With the vertical amplifier in use and adjusted to high gain, the vertical posts will be found very sensitive to stray AC fields. For this reason it is suggested that the high lead to the vertical posts be shielded, whenever the capacity of such shielding will not disturb the circuit under test. In this way it is assured that the pattern will not be distorted by stray fields picked up by the leads and transmitted to the vertical deflecting plates.

With the vertical amplifier in operation, the input resistance of the instrument is 1 megohm and DC currents are blocked out by means of a condenser. With the amplifier out of operation, however, no control of the vertical amplitude is provided. This is done to eliminate any possible alteration of the phase of the applied voltage due to the combined action of the resistance of the volume control (if used) and the internal capacity of the Cathode-Ray tube, this being a matter of great importance in some measurements.

6. APPLICATION OF LINEAR SWEEP TO THE HORIZONTAL PLATES

The designations of the horizontal deflecting plate controls have already been discussed.

The Linear Sweep is used in the determination of wave form of the output of audio amplifiers and modulation measurements, as described in the CLOUGH-BRENGLE Application Bulletin on "Cathode-Ray Testing and Analysis", and is incorporated in the 105 Oscillograph.

The Linear Sweep consists of an 885 tube functioning as a sawtooth wave generator, together with an amplifier tube type 6F6, connected as a triode and so biased as to straighten out the inherent nonlinearity of the condenser charging cycle and bring the output to a condition of perfect linearity.

6a. FREQUENCY ADJUSTMENT SWEEP RATE

The principal frequency adjustment is the knob in the center of the panel which permits approximate adjustment. Actual frequency range on each step will be found to be somewhat wider than indicated on the panel, these figures indicating the ranges possible on each range despite the individual variations in instruments, tubes, etc. After the proper range is selected, accurate adjustment of the frequency can be made with the knob to the left, designated VERNIER.

6b. SELECTING THE PROPER FREQUENCY

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, two waves will be seen, etc. (See Patterns 5 & 6 of the C-B Application Bulletin).

6c. DOUBLE TRACES

There are adjustments of the sweep frequency in relationship to the observed frequency which will permit of stationary patterns, but which will be multiple traces. Multiple traces obscure the true nature of the wave being studied and are due to misadjustment of the instrument. The most common cause of these traces is due to setting the sweep rate to a higher frequency than the frequency of the wave being studied, although setting to some of the harmonic ratios,

such as 2/3, 3/4, 4/5, etc., will also cause multiple traces. The usual solution is to readjust the sweep to a lower frequency until a single trace of the desired number of cycles is seen. (See Pattern No.7).

6d. CONTROL OF THE PATTERN

After the pattern has been adjusted, it is necessary to introduce a small amount of energy from the circuit under examination (or one of related frequency) to the control circuit of the 885 sweep circuit tube in order to synchronize the sweeping action of the circuit to the frequency of the circuit under observation, and thus hold the pattern stationary on the screen of the Cathode-Rady tube. The choice of voltage for control is made with the switch on the right center, marked INTERNAL-EXTERNAL, while the degree or amount of voltage introduced into the sweep circuit for control purposes is governed by the knob designated VOLTAGE CONTROL just below.

On the INTERNAL position, the control is connected internally in the circuit so that the timing wave is controlled by the voltage under observation. The input characteristics of the vertical plates are not appreciably altered by the introduction of the control circuit in this manner. This connection is useful in the general run of audio frequency measurements.

In some measurements, such as the observation of modulated R.F. currents, it is necessary to control from the source of A.F. modulation rather than from the modulated R.F. current. This and similar measurements are made with the switch set to the EXTERNAL position. This connects the input of the control circuit to the binding post at the lower right of the front panel and ground, making it available for connection to the proper point of the circuit under examination.

In applying these connections to the circuit under test, the impedance and power requirements of the circuit should be regarded. The impedance is approximately 75,000 ohms and it will be necessary to apply about 1 volt minimum across this circuit in order to exercise proper control over the 885 tube. In no case should the applied voltage exceed 200 volts, voltages in excess of this amount to be reduced by insertion of a resistor or external transformer.

In observing such voltages as ripple hum in the output of amplifiers and other similar phenomena which are definitely related to the frequency of the supply line, it will be desirable to use an external 60-cycle sweep on the horizontal plates.

With either of the two positions of the switch, the amount of voltage actually introduced to control the discharge of the 885 tube is governed by the knob marked CONTROL VOLTAGE. This should in all cases be used at the minimum setting which will satisfactorily lock the pattern. Sometimes a pattern may become distorted due to adjusting the FREQUENCY control too far off the actually desired sweep rate and then attempting to lock it into synchronism by the application of excessive control voltages. A better plan is to retard the CONTROL knob completely and adjust the FREQUENCY VERNIER until a practically stationary pattern is formed, and then introduce just sufficient control voltage to lock the pattern.

7. LIMITATION OF VOLTAGES APPLIED

In order to avoid damage to any of the internal parts of the instruments, it is important that the peak voltage applied to the horizontal or vertical binding posts be limited to 400 volts.

This will involve the use of an external transformer or dropping resistor for excessive A.C. potentials and a guard circuit consisting of a condenser and resistor for circuits that have excessive D.C. potentials.

In applying external protective circuits, care should be exercised to see that the circuit reactances are such as not to distort the wave to be observed.

The EXTERNAL CONTROL VOLTAGE binding posts of the linear sweep circuit in the MODEL 105 are not conductive to direct current when other side of circuit is connected to ground, as there is an isolating condenser in the circuit.

8. AMPLIFICATION ON THE HORIZONTAL PLATES

A few applications call for the application of an amplifier on the horizontal plates of the Oscillograph. When this is required the circuit under test may be connected to the horizontal binding posts and the frequency selector switch turned in the extreme clockwise position marked TO HOR. THRU AMP. At the same time the horizontal control switch is turned to LINEAR SWEEP.

In this way the 6F6 tube is used as an amplifier on the horizontal deflection with a gain of about 6.2 which is controllable with the horizontal AMPLITUDE control. In order to avoid overloading, the input voltage should be limited to 20 volts, or a high resistance voltage divider may be used on higher voltages to keep the input below the overload point.

9. TUBE REPLACEMENT

All tubes are accessible by removal of the front panel and chassis which are one unit.

A P P L I C A T I O N S

GENERAL

The purpose of the following outline is to set forth as specifically as possible the external circuit connections and control settings of the MODEL 105 Oscillograph for carrying out the applications treated in a more general way in the CLOUGH-BRENGLE Application Bulletin covering Cathode-Ray testing and analysis. It will be found very useful to consult this bulletin in connection with the operation of this instrument.

In cases where no mention is made of certain of the binding posts and controls on the instrument, it may be taken that such connection or adjustment is of no significance for the particular application.

It is assumed, of course, that the spot has been properly focused on the screen before proceeding.

(A) PEAK VOLTMETER

No sweep of any kind is necessary for this measurement and the application divides into two sections.

(a) For peak voltages of the order of 5 to 55 volts and of frequencies from 15 cycles to extremely high radio frequencies.

Connect the unknown voltage to the vertical input (located behind the port hole on the right side of the case) and ground. THE PATTERN. A vertical trace will result. See Pattern No. 1. RESULTS. Scale the distances "A" and "B". The peak voltage will then be equivalent to the distance "A" or "B". For approximate results the peak voltages in the two directions can be taken to be 55 volts per inch. Where closer data is required the sensitivity may be compared with the height of measured sine voltages from the power line or from a source of similar frequency. POLARITY. With the tube operated under these conditions, the distance "A" in the upward direction will represent negative voltages, the distance "B" downward positive voltages.

(b) Peak voltages of the order of .2 to 10 volts and frequencies between 15 cycles and 100 kilocycles.

Connection in this instance should be made to the vertical binding posts on the front panel.

Advance the Vertical Amplitude control until a trace of convenient length is obtained.

RESULTS. The same type of trace as above which can be scaled. The amplitude will depend on the degree of gain introduced in the internal amplifier by means of the vertical amplifier control, so that this will have to be taken into account in computing the voltage. The two peak amplitudes can be calculated, approximately, taking the sensitivity of the oscillograph to be .95 volts (peak) per inch for the deflection each side of zero, with the amplifier at full gain. The amplifier amplitude control is substantially linear so a proportional factor for this control must be introduced with the above sensitivity figure when used at other than full amplification. A better plan is to introduce a measured value of sinusoidal current preferably of the same frequency to the vertical posts, and calibrate in this manner when an exact measure of the peak amplitude is needed. It should be noted that the introduction of the amplifier reverses the phase of the deflection so that amplitude in the upward direction is now positive, while the downward direction is caused by negative peaks.

(B) FREQUENCY CALIBRATION (Lissajou's Figures)

It is customary to connect the known frequency to the horizontal plates and the unknown to the vertical plates.

If the known frequency is to be the 60 cycle line, or if the known frequency is other than 60 cycles, throw the frequency selector switch to HORIZONTAL AMPLIFIER position connecting the known frequency to the horizontal binding posts through the amplifier. Throw the horizontal plates switch to LINEAR SWEEP.

PATTERN. Examples are given in Patterns No. 8 to 12 and 12A to 12N in the Bulletin, as well as in any standard physics text.

RESULT. If a stationary pattern can be produced, imagine a rectangle circumscribed about the pattern. Count the number of contacts along the horizontal side of the rectangle and along the vertical. The ratio of the two frequencies being compared is the ratio of the number of contacts along the two axes.

Where the two frequencies are not in exact harmonic relationship, a pattern may be formed which will turn at such speed that the number of turnings can be counted and timed with a watch. If one frequency can be slightly varied in order to determine whether it is above or below synchronism, then the true frequency can be determined by taking into account the frequency ratio for the pattern nearest in frequency and the rate of turn - as determined with a watch.

(C) PHASE DETERMINATION

Connect the horizontal and vertical binding posts to the two points in the circuit in which the phase is to be determined.

It will be preferable not to use the vertical amplifier, particularly if the frequency is in excess of 5000 cycles, to eliminate phase distortion in the volume control circuit. For the same reason, it will be desirable to work with the horizontal amplitude control at maximum amplitude. The amplitude of the pattern should be controlled by adjusting the amount of current in the circuit under test. PATTERN. Where the two currents are of the same frequency, the pattern will be of the nature of Patterns 8 to 12 in the Bulletin. RESULTS. The actual phase of the two voltages will be given by circumscribing a rectangle and evaluating the phase from the intercepts, as described in the Bulletin.

(D) AUDIO DISTORTION (Using Linear Sweep)

Connect the voltage to be observed to the vertical binding posts, using the vertical amplifier or not, according to the voltage available for the test. Turn the horizontal control switch to LINEAR SWEEP and the control switch to INTERNAL. Adjust the frequency dial and the vernier in accordance with the instructions detailed in Par. (6) and lock the pattern with the knob marked VOLTAGE CONTROL.

PATTERN. Sample Patterns are given in the Bulletin. See Pat. 5, 6, and 13 to 15.

RESULTS. It must be remembered that a voltage of current cannot have more than one value at any instant. Since the sweeping of the horizontal axis represents time, it is apparent that double valued traces along the vertical axis of the screen must be due to misadjustment of the equipment as discussed in Par. (6c) rather than to any phenomena in the circuit being examined. For this reason be certain that the trace is single valued before attempting to draw any conclusions.

Make use of the amplitude controls for both the horizontal sweep and the vertical excursion, in order to get the best relationship between length and width of the pattern. If a short "time" axis is used together with a tall trace, even a sinusoidal voltage may appear to be "peaked".

The Sense of The Trace. Using the internal sweep of the 105, the sweep action is in such direction that "time" appears to start on the left and progress to the right. If the vertical amplifier is in use, positive peaks appear above the axis and negative below. Without the vertical amplifier in use, the reverse is true.

Where necessary, the tube can be scaled and calibrated in the same manner described for use in measuring peak voltages. Detailed analysis of the trace can be accomplished by photographing the trace and removing same to the drafting board, where the usual analytical methods can be applied, and where such detailed information is necessary. Much can be determined by observation, however, using the illustrative material presented in the Bulletin and the simple rules below.

(a) Waves containing only the fundamental, or fundamental and odd order harmonics (third, fifth, etc.) are symmetrical; that is, each half wave is exactly like the previous or following half wave, reflected to the other side of the axis.

(b) By the same token, any dissymmetry is accountable for only by the presence of direct current or harmonics of even order (second, fourth, etc.). The effect of direct current, when present, is removed from the trace by the condenser in series with the leads to the "vertical" deflecting plates of the oscilloscope.

(c) Very high harmonics of small amplitude cause a ripple along the general wave shape, which is easily recognizable.

(d) Small faint traces, which dart out from the main trace at irregular intervals, are due to inharmonic transients. Sometimes these are of such high frequency, compared to the fundamental, that their traces are faint and not seen. Evidence of them still remains in many instances in a thinning out of the main trace at that point of the fundamental where they occur.

REFERENCE: A splendid treatment for the analysis of traces is contained in Steinmetz's "Engineering Mathematics", (McGraw-Hill). In addition this work is extensively illustrated with traces showing the effect of harmonics of various orders, amplitudes, and phases. Inspection of these figures will allow the mental analysis of many traces without recourse to specific analytical methods. As a treatise especially valuable for the general technician "Ridor's" - "Cathode-Ray Tube at Work" is suggested.

(E) AUDIO DISTORTION (Using Harmonic Sweep)

Connect the voltage to be observed to the vertical binding posts.

Connect the horizontal binding posts to the source of A.F. testing voltage, (beat frequency oscillator or such) and turn the horizontal switch to "LINEAR SWEEP" so that the horizontal amplifier may be brought into play.

PATTERN. Illustrative Patterns are given in Patts. 16 to 20 in the Bulletin.

RESULTS. The interpretation of patterns formed in this manner is necessarily more complicated than where the linear sweep is used to obtain a definite time axis. The patterns in the Bulletin show the relationship between the patterns obtained by this method and the simpler patterns obtained by means of the linear sweep.

(F) HUM DETECTION AND OBSERVATION

Connect a 60-cycle voltage to the horizontal binding posts.

Check different parts of the circuit under test for hum, by connecting to the vertical plates.

PATTERN. Illustrative patterns are given in the Bulletin, Pats. 21 and 23. Hum patterns are almost invariably complex, the important thing being to recognize whether the principal component is 60 or 120 cycles. This is fully explained in the Bulletin and will not be gone into further here.

(G) MODULATION ANALYSIS (Using Linear Sweep)

Do not use the vertical amplifier. Connect the ground binding post and the vertical binding post, located behind the port hole inside the righthand side of the case, to a search coil consisting of a few turns of wire. This coil should be placed in proximity to the antenna coil of the transmitter. On powerful transmitters, sufficient vertical amplitude may be obtained by simply placing the search coil near the ground or feeder leads.

Turn the horizontal switch to LINEAR SWEEP and the control switch to EXTERNAL. Connect the CONTROL binding post and ground to a convenient point in the A.F. modulation system of the transmitter, where a few milliwatts of energy may be obtained without upsetting the circuit characteristics. See Par. 6D Above. Set the sweep rate to that of the A.F. modulating frequency or a submultiple. PATTERN. Illustrations and the manner of interpreting same are given in the Bulletin. See particularly Pats. 25, 26, 27, 31, 32, 35 and 36.

(H) MODULATION ANALYSIS (using Harmonic Sweep) TRAPEZOIDAL METHOD.

The vertical connections and adjustments are the same as for the preceding topid. The horizontal switch should be turned to "BINDING POSTS", and the horizontal binding posts connected to the output of the speech amplifier thru a high resistance divider so that the potential may be dropped to a satisfactory level. PATTERNS. See Pats. 28, 29, 30, 33, 34, 37, and 38 of the Bulletin, together with the text regarding them.

(J) I.F. and R.F. FREQUENCY ALIGNMENT

(a) When used with the CLOUGH-BRENGLE Frequency Modulated Oscillator, connect the vertical binding posts to the detector output as indicated in the instructions accompanying the Modulated Oscillator, and use the vertical amplifier. Turn the horizontal switch to BINDING POSTS or LINEAR SWEEP as indicated and plug the cord from the Modulator into the socket located behind the port hole on the left side of the case of the 105 Oscillograph. PATTERNS and RESULTS. These are gone into fully in the Frequency Modulator instruction sheet.

(b) When used with other frequency modulated oscillators, connect the vertical binding posts to the detector output, and use the vertical amplifier. Turn the horizontal switch to LINEAR SWEEP. Turn the control switch to EXTERNAL, and connect the CONTROL binding post and ground to the proper posts on the frequency modulated oscillator.

faults in the audio frequency amplifier. If the 400 cycle output of the test oscillator is examined in accordance with the conditions set up for transmitter analysis in (G) above so that the wave form of the modulation is known, then the output of the oscillator can be impressed on the input of the receiver (Ant and GND posts), and the A.F. output of the wave across the voice coil of the speaker observed to see that there is no distortion in any portion of the receiver circuits.

Connect the vertical posts across the voice coil of the speaker.

Make all other adjustments in accordance with Par. (D) above.
RESULTS. If there is no distortion in the receiver circuits, the output wave as observed should have the same shape as the modulation voltage of the test oscillator.

(L) EXAMINATION OF PUSH-PULL AMPLIFIER FOR MODULATION HUM

This type of distortion is fully discussed in the Bulletin (Sec. V-D)

(a) With Linear Sweep.

Connect the vertical posts across the output load of the amplifier and use the oscilloscope, vertical amplifier or not, as required to get proper amplitude.

Turn the horizontal switch to LINEAR SWEEP.

Turn the control switch to EXTERNAL. Connect the synchronizing voltage binding post and ground to a source of 60-cycle voltage. Adjust the sweep rate to 60 cycles or a submultiple.
The amplifier should preferably be excited with a frequency of 1000 cycles or higher.

PATTERN. The character of the pattern is given in No. 22 in the Bulletin.

(b) With Harmonic Sweep.

Vertical connections the same as in (a) above.

Connect the horizontal plates to a source of 60-cycle voltage. If the amplifier is used it is necessary to keep the 60 cycle input to less than 20 volts, to avoid overload.

PATTERN. See Patt. No. 24 in the Bulletin.