
LESSON

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# THE OSCILLOGRAPH AND VISUAL ALIGNMENT

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It has been common practice to align the successive tuned stages of a radio receiver with the aid of an amplitude modulated signal until maximum response is obtained as indicated by an output meter. This procedure, however, is no longer adequate for modern receivers of the improved fidelity that are designed to operate over a wider band of frequencies. With these sets consideration must be given not only to the peak response, but also to their ability of amplifying these outer bands and converting them into the corresponding audible frequencies.

The response curves of the I.F. stages in such sets are inherently of the flat-top type, and to obtain optimum setting of the various trimmer condensers it is necessary to observe the response curve of each individual stage. If a stage is tuned too sharp, it will cut off the high audio frequencies that are intended to be audible; and if it is tuned too broad, it will permit side band chatter because it will also accept the high-frequency bands of the adjacent channels.

Although it is possible to measure the response of a tuned stage with a suitable output indicator at a number of frequencies below and above the resonant frequency and then draw a curve manually from the data obtained, this would be a very tedious process and too slow for rapid and efficient alignment work.

The oscillograph, however, offers a ready means for viewing such a response curve of a tuned stage, but a special type of signal is needed. Previously it was stated that for peaking a stage for maximum response a constant frequency signal is used modulated at an audio frequency (usually at 400 cycles). On the other hand, for outlining the response curve of the same tuned stage on the screen of the oscillograph, a constant amplitude but variable frequency signal is needed; that is, the frequency of the signal must be modulated over a range corresponding to the number of kilocycles above and below the resonant frequency that it is desired to check the response of the stage under observation.

With such an arrangement the shape of the curve is then visible at every instant, so that the necessary adjustments can be made and proper alignment established. This constitutes visual alignment. In small receiving sets that are less expensive the response curves are relatively narrow and sharply peaked, visual alignment can add but little to the general procedure of peaking for maximum response. But in sets that employ improved I.F. transformers and that have wider response curves with nearly flat tops extending over seven or eight kilocycles, visual alignment is not only important but actually necessary, for although the successive stages can readily be peaked for maximum response, tuning cannot be spread out over the proper band width by using merely an ordinary output meter.

Visual alignment is not, however, a "cure all", nor can it make a set with a simple intermediate frequency design operate like a high fidelity receiver. But it does make it possible to adjust a receiver to deliver maximum possible performance.

## FREQUENCY MODULATION

Frequency modulation is the process of periodically varying the frequency of a signal through a certain number of kilocycles above and below the resonant frequency. For example, if on a signal generator tuned to 460 Kc, the dial were turned back to 450 Kc. and up to 470 and then back to 450 again, and the action repeated at regular short intervals, it would be said that the frequency of the signal is modulated through a range of 20 kilocycles, 10 kilocycles above and 10 kilocycles below the resonant frequency of 460 kilocycles. If this occurred 120 times a second, the rate of modulation would be 120 cycles per second. This establishes two definitions. The range of modulation is the number of kilocycles through which the frequency is varied or modulated, and the rate of modulation is the number of times per second that it is modulated through this range.

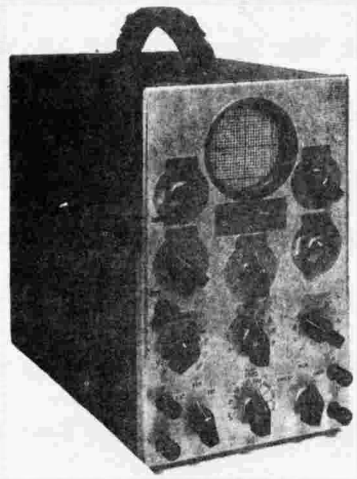
With a frequency modulated signal generator the signal frequency is varied through a suitably wide range; and the output of the amplifier under test is impressed on the vertical plates of an oscillograph so that the electron beam, and also the spot on the screen, are deflected vertically a distance corresponding to the amplifier response at every instant. At the same time the beam and spot of light are also swept across the screen horizontally; and if the two motions are synchronized properly, the vertical deflection plus the horizontal sweep will trace out the response curve of the amplifier over the range through which the frequency is modulated.

In one of the early methods of frequency modulation the main tuning condenser of the signal generator was shunted by a vernier or trimmer condenser that was rotated by a small synchronous motor. As the rotor plates of this trimmer were turned, the capacity of the main condenser was periodically varied, with the result that the generator frequency was increased and decreased (modulated) through a complete cycle of changes. Since the motor speed usually was 60 revolutions per second, the rate of modulation also was sixty per second. In another system the inductance of the oscillator coil was periodically varied and the signal frequency modulated accordingly.

Although these were effective means of frequency modulation, the methods in themselves were not so satisfactory; for besides involving the use of mechanically rotating devices, the range of modulation varied from the high to the low frequencies. Present day methods are purely electronic in nature, a common scheme being to employ a special control tube the operating characteristics of which are changed so that it periodically varies the effective tuning capacity of the generator and in this manner brings about the frequency modulation desired. In another system the generator inductance is varied in a manner similar to the automatic frequency control system employed in radio receivers, in which a variable lagging current is caused to flow through the generator inductance.

While separate modulator units are available that can be used in conjunction with any standard service oscillator for visual alignment, modern signal generators intended for this service have a modulating arrangement built in as part of the oscillator system. Such generators, however, are usually of the beat-frequency type, that is, they consist of two individual oscillators the outputs of which can be superimposed on each other so that a single frequency is produced which is either the sum or difference of the two component frequencies.

One of these oscillators is a typical variable frequency oscillator that can be tuned over the range of frequencies needed for general alignment work. It can be set to deliver a pure R.F. signal or a signal with the amplitude modulated at an audio frequency, generally 400 cycles at 30%. The dial on the generator is calibrated in terms of this variable frequency output. When frequency modulation is cut in, however, the second oscillator is brought inte action, but this oscillator operates at only one fixed frequency and is frequency modulated by an additional modulating system. The generator output frequency is then the sum or difference of the variable frequency oscillator and is also modulated over the same range as the fixed frequency oscillator is.



The type 164-E Cathode-Ray Oscillograph has been designed as a small, convenient instrument for laboratory and shop use. This oscillograph operates a three-inch cathode-ray tube at an accelerating potential of 1100 volts. It also has a single-stage vertical amplifier, which has a voltage-gain of approximately 43, which is provided for amplification of the vertical deflection signals. A horizontal amplifier, with a gain of approximately 55, serves to amplify the sweep signals from the gas-discharge sawtooth oscillator. This amplifier may also be employed for amplification of externally applied signals. The deflection-plate terminals of the cathode-ray tube are accessible at the rear of the instrument without removing the case.

CONTROLS

All controls of the Type 164-E Oscillograph are on the front panel and are plainly marked. The following description gives the location and use of the various controls. Because all the controls are on the front panel, it was deemed advisable to distinguish in some manner the controls frequently adjusted from those more permanently set. Therefore, the synchronising rough and fine frequency, and the horizontal and vertical amplifier controls have red-bar knobs. In the upper left corner is the intensity control. It controls the intensity of the trace and also carries with it the power switch, the "OFF" position being at the extreme counter-clockwise position. At the upper right is the focus control. Just below the intensity control is the vertical-positioning knob which controls the up and down movement of the spot or trace, while directly below the focus control is the horizontal-positioning knob which controls the left and right movement of the pattern. The synchronizing control is in the center of the panel just below the cathode-ray tube. Directly below the positioning controls are the amplifier gain controls, the vertical being on the left and the horizontal on the right. In the center of the panel under synchronizing is the vernier or fine frequency control of the linear sweep while directly below it is a rotary switch which controls the frequency in rough steps. The approximate range of these steps is as follows:

1 - Sweep off
2 - 15 to 60 cycles
3 - 60 to 220 cycles
4 - 220 to 900 cycles
5 - 900 to 3,000 cycles
6 - 3,000 to 10,000 cycles
7 - 10,000 to 30,000 cycles

At the bottom of the panel on the left side is a switch which permits either internal or external synchronizing while on the right, a switch places the horizontal amplifier in operation with the sweep, or connects it to the horizontal terminal post for external use.

The controls are arranged so that the minimum setting is obtained when the knobs are turned counter-clockwise and maximum when turned clockwise.

## TERMINALS

The vertical input is to the terminal posts on the left side of the panel, the lower post of the pair being the ground. The horizontal input is to the right and as in the previous pair the bottom post is the ground.

On the back of the instrument is a plate with five screw-type terminals. These permit disconnecting of either or both amplifier circuits, allowing a direct connection to the deflection plates. This feature will be found a great convenience in workind with d.c. or high frequency applications.

## FEATURES

Separate power supplies are provided for operation of the cathode-ray tube and the amplifier and oscillator circuits of this instrument. The use of an amplified-type sweep circuit of unusually wide range prevents any interaction between the various controls. Elimination of the return-trace of the sweep circuit is provided in this cathode-ray oscillograph by modulation of the grid of the cathode-ray tube by means of a frequency discriminating circuit in the plate of the gas-discharge oscillator.

The steel cabinet of the Type 164-E Cathode-Ray Oscillograph serves as an effective shield against stray electrostatic fields which may be present in the vicinity of the instrument.

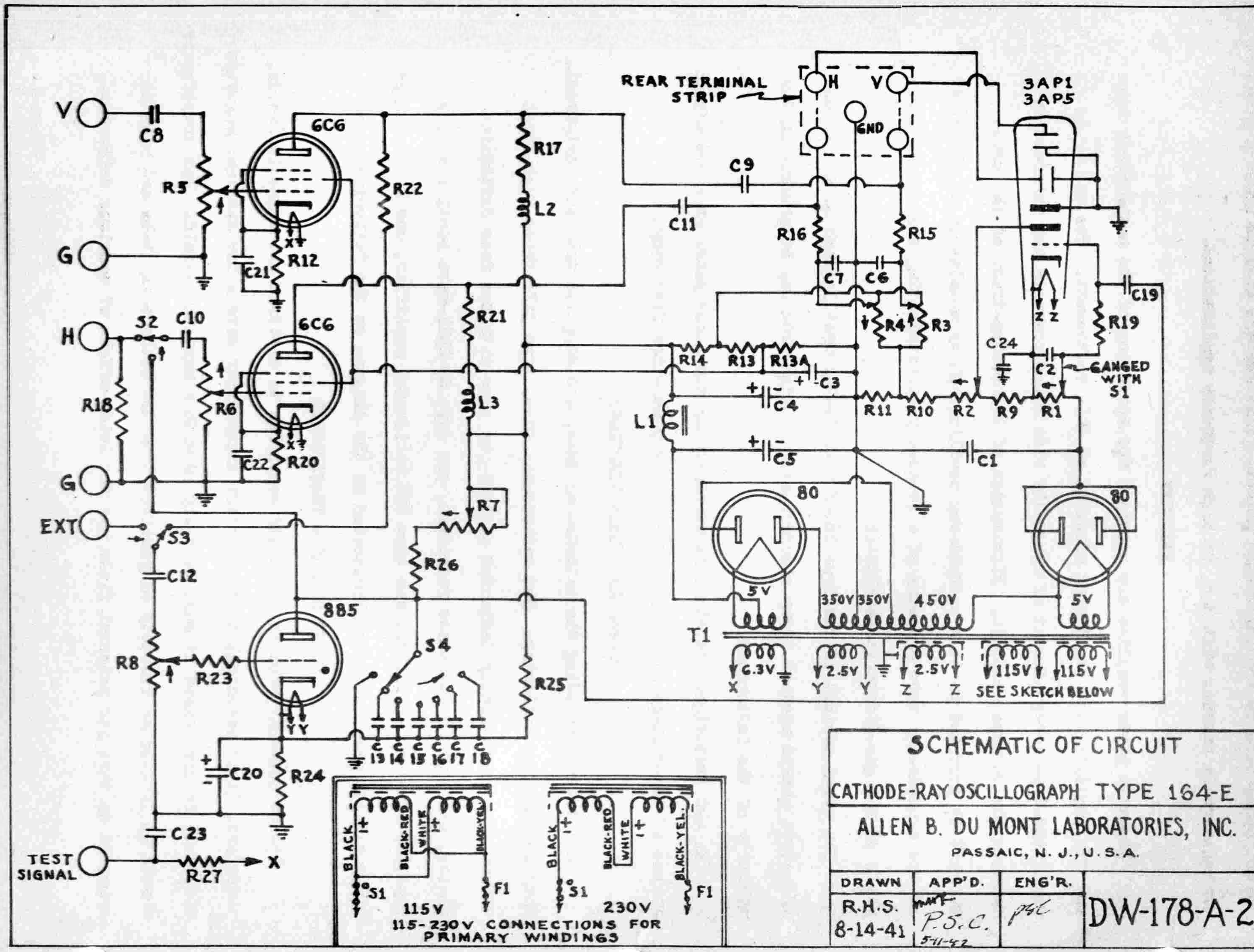
An A-C test-signal terminal is available on the front panel as a convenient source of low-voltage alternating current at power-line frequency.

## TUBES AND THEIR FUNCTIONS

All tubes, including the cathode-ray tube, are supplied with the instrument. They include the following: The cathode-ray tube, type 3AP1 three-inch, high vacuum electrostatically deflected cathode-ray tube with two free deflection plates, one type 80 half-wave rectifier, one type 80 full-wave rectifier, one type 6C6 vertical amplifier, one type 6C6 horizontal amplifier, one Du Mont type 885 Saw-tooth oscillator as illustrated in the diagram on the following page.

## POWER SUPPLY - TRANSFORMER

The cathode-ray tube is extremely sensitive to electric and magnetic fields, therefore, it is essential that the power transformer have a low external magnetic field and in some cases it must be equipped with a magnetic shield. The transformer should be located as remotely as possible from the cathode-ray tube and must be oriented so that its external field has the least effect of spurious deflection.



REAR TERMINAL STRIP
H
V
GND
3AP1
3AP5
V
G
H
G
EXT
TEST SIGNAL
6C6
6C6
885
80
80
C8
R5
R12
C21
S2
C10
R18
R6
R20
C22
S3
C12
R8
R23
C20
R24
C23
R27
X
R22
R17
L2
R21
L3
R7
R26
S4
R25
C 13
C 14
C 15
C 16
C 17
C 18
C9
C11
R16
R15
C7
C6
R4
R3
R14
R13
R13A
C3
C4
L1
C5
R11
R10
R2
R9
R1
C1
C24
C2
GANGED WITH S1
C19
R19
Z Z
X Y
X Y
Y Y
T1
5V
350V
350V
450V
5V
6.3V
2.5V
2.5V
115V
115V
X
Y
Y
Z
Z
SEE SKETCH BELOW
BLACK
BLACK-RED
WHITE
BLACK-YEL.
S1
F1
115V
BLACK
BLACK-RED
WHITE
BLACK-YEL.
S1
F1
230V
115-230V CONNECTIONS FOR PRIMARY WINDINGS
SCHEMATIC OF CIRCUIT
CATHODE-RAY OSCILLOGRAPH TYPE 164-E
ALLEN B. DU MONT LABORATORIES, INC.
PASSAIC, N. J., U. S. A.
DRAWN
R.H.S.
8-14-41
APP'D.
P.S.C.
5-11-42
ENG'R.
DW-178-A-2

Furthermore, the transformer, being the heaviest single component, should be located in a position such that the oscillograph will have an even weight distribution to facilitate its handling. Usually, a compromise must be made between these two factors. In general, the power transformer (and power supply) should be located near the rear of the instrument.

Since the majority of cathode-ray oscillographs are portable, it is essential to keep the size and weight of the transformer at a minimum consistent with good design practice. In no case, however, should a sacrifice be made in transformer ratings in order to obtain small size and weight. The insulation must be acceptable for at least the sum of the maximum positive and negative voltages.

The power supply transformer should have a lamination stack designed for at least the minimum operating frequency and preferably for a lower frequency in order to keep external magnetic fields at a minimum. A high turns-per-volt ratio is desirable even though it tends to increase the physical size of the transformer.

## PRIMARY

The primary windings should be completely surrounded by a grounded electrostatic shield to prevent capacitive coupling to the high voltage winding.

A safety switch of the momentary close type, connected in series with one side of the primary to the power line, is usually mounted on the rear of the chassis. Such a mounting is used so that the switch is closed only when the chassis is completely within its cabinet. This protection is important since dangerously high voltages are employed.

## SECONDARY

The exact voltages and currents required of the secondary windings of the power transformer will, of course, depend upon the subsequent oscillograph circuit. In all cases, the cathode-ray tube filament winding must be a separate winding and must be insulated from ground for at least the full accelerating potential.

**It is customary to insulate the windings from the core for at least twice the rated operating voltage plus 1000 volts. The cathode-ray tube heater winding also must be surrounded by a grounded electrostatic shield to eliminate capacitive coupling of this winding to other windings, which would cause distortion of the pattern by intensity modulation of the beam at power-line frequency. It is, likewise, desirable to shield the heater windings for the power supply regulator tubes, and these windings should be separate from the amplifier windings.**

**Amplifier voltages are usually obtained from a center-tapped secondary winding, such as those found in conventional radio receiver transformers. Secondary voltages in the order of 400 r.m.s. volts on either side of the center tap, and current values from 20 to 200 milliamperes, depending upon the d-c load requirements, are common.**

**High voltage for the cathode-ray tube is usually obtained from an extension of one side of the secondary winding. Voltages from 800 to 1500 volts r.m.s. either side of center tap are the usual supply voltages for 3 and 5 inch oscillographs. Current requirements are small, being in the order of 2 or 3 milliamperes.**

**Figure 3 shows the schematic diagram of a typical oscillograph transformer.**

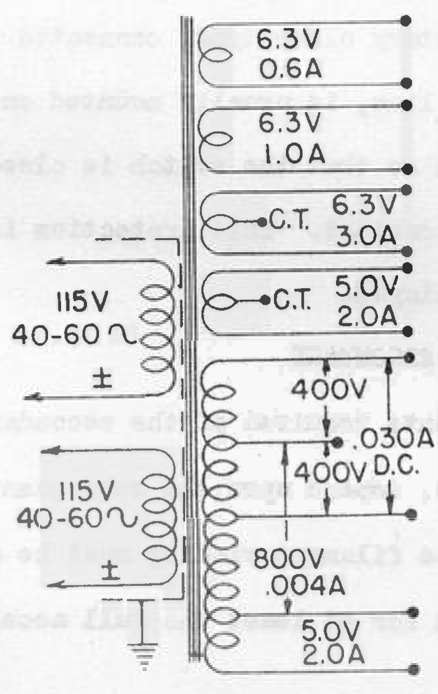



Figure 3
Typical power transformer for use in a cathode-ray oscillograph

## LOW VOLTAGE SUPPLIES

The oscillograph may have several low-voltage supplies for the amplifier and other circuits. All of them may often be derived from the same transformer winding. The supply will usually have positive and negative sections, either or both of which may be regulated or unregulated.

The voltage and current requirements for the deflection amplifier circuits are determined by the deflection factor of the cathode-ray for the accelerating potential at which the tube will be operated, the type of amplifier circuits, the frequency response range, and other factors whichmay depend upon particular operating conditions.

When balanced deflection circuits are used, as is true in the more recent designs, the spurious deflections resulting from line-voltage changes and from residual hum tend to be cancelled out. A further advantage in the use of balanced deflection circuits is that the deflection-amplifier supply voltage need be only half that for an unbalanced amplifier having the same signal-voltage output.

## HIGH VOLTAGE SUPPLIES

The high voltage power supply furnishes 1100 volts and can be connected directly into 115 or 230 volt A.C. line at a frequency of 40 to 60 cycles, and must have a fuse rated at 1 ampere for protection. This 1100 volts is the accelerating potential for the cathode-ray tube. The amplifier and sweep-oscillator operate on a 400 volt supply line. The total power consumption of this particular oscillograph is 50 watts.

## CAUTIONS AND WARNINGS

1. Do not operate this unit with the case removed, since high voltages are employed.

2. Do not experiment with magnets around or near the case of the oscillograph. You may impair or render your oscillograph useless.

3. Do not place the unit over, under or near a power transformer or reactance carrying AC as the field setup will cause distortion of the patterns to an extent that will make conclusions impossible.

4. Do not allow a small line or spot of high brilliancy to remain stationary on the screen for any length of time as the screen may become burned or discolored.

EXAMINATION QUESTIONS ON FOLLOWING PAGE