117-TYPE TELEGRAPH STABILITY TEST SETS
DESCRIPTION, OPERATION AND MAINTENANCE

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1. GENERAL

1.01 This section describes and gives the operating principles and methods of use of the 117A1 (portable) and 117B1 (rack-mounted) telegraph stability test sets.

1.02 The section is reissued to incorporate in one section both the descriptive information and the operating and testing methods.

1.03 The following additional information is also included:

Recommended speed of reversals for stability testing.

A method of calibrating the sets to permit the measurement of the percentage of distortion for "hits" which are recorded.

Use of the sets at No. 2 or No. 9B Service Boards.

1.04 All figures and tables are at the end of the section in the form of "fanfold" attachments.

2. PRINCIPLES

(A) General

2.01 Telegraph transmission stability testing provides a means of determining the stability of telegraph circuits in connection with telegraph transmission problems in the field.

2.02 The use of 117-type telegraph stability test sets permits a continuous graphic record on a chart over as long a period as is desired, showing the following information:

Variations in signal bias in terms of magnitude and type together with the time at which the variations occurred.

The number, magnitude and time of occurrence of fortuitous effects.

The number, type and duration of interruptions during the test, and at what time the interruptions occurred.

2.03 To check transmission stability, a source of reversals is connected to the sending end of the circuit to be tested and a 117A1 or 117B1 telegraph stability test set, plus a recording meter with auxiliary apparatus, is connected to the receiving end of the circuit to be tested.

2.04 Assuming that the received reversals are unbiased, a straight line will be recorded on the chart following the line of zero bias.

2.05 Factors which cause bias changes will affect the recorded pen trace. The change in the recorded trace will be gradual if the change is gradual and will be sudden if the change is sudden.

2.06 Interruptions which cause the circuit to be opened or closed for an appreciable length of time (200-300 milliseconds or longer) will be indicated by the trace suddenly changing to one or the other extremes of the chart.

2.07 Fortuitous distortion, if of sufficient magnitude to affect telegraph service seriously, will be indicated by sharp momentary changes in the record.

2.08 All of the effects described above are indicated on the sample chart in Fig. 4. The analysis of test results as recorded on the chart will be discussed in detail later in this section.

2.09 Continuously occurring fortuitous distortion, such as may be caused by crossfire or power interference, is not indicated on the sample chart shown in Fig. 4. This effect is indicated by a widening of the trace, the extent of the distortion being indicated directly by the width of the trace.

2.10 The record will not show the characteristic component of distortion as this is not evident where the pulses are of equal length such as in reversals. The inclusion of the effect of characteristic distortion in the measurement would add little to the results since that component is largely the result of circuit characteristics which remain fixed for any given circuit. Furthermore, the presence of excessive amounts of characteristic distortion may be determined easily by means of other telegraph transmission measurements, and corrective measures should be applied before a stability measurement is made.

2.11 The continuous record made during a stability measurement showing bias variations and the occurrence of fortuitous effects affords a good measure of transmission stability. It has been found that bias changes, large fortuitous distortions usually referred to as "hits," and smaller but more frequent fortuitous distortions are the principal causes of transmission impairment.

2.12 In addition to the recording meter, a bias alarm feature is included in the testing equipment. This feature provides an audible alarm whenever and only as long as the bias in the received signals exceeds a given amount determined by the setting of the alarm circuit. The alarm action is delayed slightly to avoid alarms for very short interruptions.

2.13 Fig. 1 shows schematically the circuit of the 117-type stability testing arrangement. Briefly, a polar loop relay A, having a bias winding, transmits the received reversals to a bridge type of circuit containing a recording meter M, and galvanometer relay G associated with an alarm circuit. The alarm circuit contains a calibrated shunt R_2 which may be adjusted so that

a buzzer alarm is operated whenever the distortion exceeds a predetermined amount over a range from 10 to 40 per cent.

(B) Recording Meter Circuit (Refer to Fig. 1)

2.14 Assume the armature (1) of loop relay A to be resting on the marking contact (4). The recording meter M is affected by the voltage drop across resistors R_3 and R_4 and the deflection will be a certain amount in the marking direction. If the relay armature is now operated to the spacing contact (5), the meter deflection will be the same amount as before but in the opposite direction, because resistors R_6 and R_7 are equal in value to resistors R_3 and R_4 but the current flow direction through the meter will be reversed. If the relay is repeating unbiased reversals, the relay armature will rest on the marking contact for the same length of time that it will rest on the spacing contact and the average current through the meter will be zero.

2.15 The recording meter, which is a separate unit, is equipped with a galvanometer-type element which is somewhat slow in its response and, in addition, electrical damping is provided so that the needle does not follow appreciably the individual marks and spaces of the reversals.

2.16 The amount of electrical damping is adjustable by means of capacitor C. Three values of capacitance are provided, one for each of three signaling speeds, namely, 15, 23, and 33 dps corresponding to 40-, 60-, and 75-speed operation respectively.

2.17 Stability measurements using 100-speed reversals are not satisfactory because the recording meter needle deflections from zero are too small to obtain accurate results. Experience has indicated also that the use of 75-speed reversals is somewhat questionable for obtaining the best accuracy. For these reasons it is recommended that measurements on a circuit be made with 60-speed reversals. Since bias variations recorded on the chart are the results of the relative lengths of the marking and spacing impulses at any given signaling speed, the per cent bias recorded with 60-speed reversals may be translated into the bias effect of the circuit at any signaling speed. A method of calibrating the 117-type sets to indicate the per cent distortion in received "hits" with 60-speed reversals is described later in this section, and a method for determining the relative per cent of such "hits" at higher speeds is also described.

2.18 The indication of the meter is dependent upon two factors. These are the potentials applied and the length of time for which they are applied. Assuming that the battery voltage is substantially constant, the indication of the meter will depend only upon the duration of the marks and spaces of the reversals and will be proportional to the average difference in duration, which is the bias. Therefore, if the loop relay is repeating unbiased reversals, the meter needle will assume a position midway between the maximum marking and the maximum spacing deflections, thus indicating unbiased reversals. With biased reversals the average indication is proportional to the bias.

2.19 The circuit is designed so that when the battery voltage is 130 volts the meter needle will indicate 100 to the right for a steady marking condition and 100 to the left for a steady spacing condition. With this arrangement the meter indicates directly the per cent of bias in the received reversals.

(C) Bias Alarm Circuit (Refer to Fig. 1)

2.20 It will be apparent that the galvanometer relay G, being connected to shunt resistors R_4 and R_7 of the bridge circuit, will be affected by the received reversals in the same manner as described for the recording meter. The amount of deflection of the relay armature is determined by the sensitivity of the relay which is in turn controlled by the variable shunt resistor R_2. Since the relay is adjusted at the factory to have a definite sensitivity, suitable resistance values for resistor R_2 may be selected which will permit the relay armature to touch one of its contacts for any desired amount of bias. Five resistance values are provided, corresponding to both marking and spacing bias of 10, 15, 20, 30 and 40 per cent. The buzzer in the alarm circuit will be operated whenever and as long as the bias in the received reversals exceeds the amount for which resistor R_2 is set.

(D) Source of Signals

2.21 The signals for use in connection with this method of measuring stability should be obtained from a good quality source of reversals

which has reasonably good speed regulation. → The 110C1 multiple sender is the recommended source.

(E) Recording Voltmeter

2.22 In addition to its use for making telegraph stability measurements, the 117-type set may be used as a recording voltmeter for such purposes as recording battery voltage variations or earth potentials between two points over any desired period of time.

3. DESCRIPTION

(A) Recording Meter

3.01 The recording meter generally used with the 117-type stability test set is an Esterline-Angus Portable Graphic Milliammeter. It has a zero center and gives full-scale deflection in either direction on 5 milliamperes.

3.02 The meter consists essentially of a large permanent magnet supplying the field flux and an armature wound with comparatively fine wire. The moving system, comprising the armature and the pen together with its supporting stirrup and retaining spring, is mounted on jeweled bearings to reduce friction and increase life. Current variation through the armature winding causes its movement and therefore the pen movement across the chart. Means for obtaining a zero adjustment are provided in the meter. The ink is fed from a well through the pen to a pen point in contact with the chart, thereby tracing a continuous record.

3.03 In the portable 117A1 set meter (KS-7255) a clock mechanism furnishes the driving force for the chart. The speed of the mechanism may be regulated as described later in the parts of this section covering the adjustments and use of the set.

3.04 In the bay-mounted 117B1 sets, the recording meter may be arranged with one of the various types of driving mechanisms as follows:

8-day clock	KS-8003
60-cycle synchronous motor	KS-8004
50-cycle synchronous motor	KS-8005
25-cycle synchronous motor	KS-8006

3.05 With any of these driving arrangements, two or more meters may be coupled together mechanically when it is desired to obtain simultaneous records at the same chart speed.

3.06 The recommended chart speed is 3 inches per hour. This speed permits a 15-day use for a 90-foot chart, based on 24 hours per day operation. For this speed a 4333-C chart is suitable. Other chart speeds may be obtained by changing gears. The extra gears are supplied with the meter and are located on studs at the bottom of the clock mounting plate. In order to have the time scale correct at other speeds, different charts may be obtained or corrected times may be written in the chart margin. A control lever provides a speed change by a factor of 60 for any combination of gears to change from recording in inches per hour to inches per minute. If a speed different from that normally used is to be employed for a considerable period, the chart with the time markings for the particular speed may be obtained in accordance with the following table. This table also contains data regarding the various gears.

CHART FEED INCHES PER HR. OR MIN.	NO. OF TEETH DRIVING GEAR	NO. OF TEETH DRIVEN GEAR	CHART
3/4	18	72	#4333-A
1-1/2	30	60	" -B
3	45	45	" -C
6	60	30	" -D
12	72	18	" -E

3.07 The chart ordinarily used with the meter has five major divisions each side of zero. Each major division contains five subdivisions. For measuring bias, therefore, each subdivision represents an indication of 4 per cent. The meter is equipped with a 100-0-100 scale and an arrow attached to the pen moving across the face of the scale may be used to indicate approximate bias. The more accurate bias readings should be made from the trace on the chart.

3.08 As a voltmeter, the 117-type stability test set meter normally is arranged to provide indications on the basis of three scales, namely, 100-0-100, 250-0-250 and 500-0-500 volts. The chart ordinarily used with the meter is marked so that voltages are indicated directly for the 100-0-100 scale. For the 250-0-250 scale the indi-

cations are multiplied by 2.5 and for the 500-0-500 scale the indications are multiplied by 5. The number of volts per division for the three scales is 4, 10, and 20 respectively, each division being about 3/32 inch. The arrangement of key and resistances for providing the three scales is shown schematically in Fig. 2.

3.09 A schematic of the circuit arrangements of 117-type test sets is shown in Fig. 3. The figure relates specifically to the 117A1 set and covers the arrangements in the portable test set box. The detailed circuit of the 117A1 set is shown on Drawing SD-63932-01, and of the 117B1 set on Drawing SD-70155-011. The portion of either type set covered generally by Fig. 3 contains apparatus required for obtaining certain operating characteristics of the meter. This apparatus consists of a group of flat-type resistors connected in the armature and relay contact circuits for obtaining an equal full-scale deflection for both marking and spacing conditions. In order to damp the pen sufficiently to produce a trace of reasonable width, a capacitor is shunted across the meter with a resistor between the meter and this capacitor. A three-position switching key (DPS) is provided for changing capacitor values in order to produce a trace of approximately the same characteristics for any of three testing frequencies, namely 15, 23 and 33 dps. As discussed in Paragraph 2.17, 60-speed reversals are recommended for all tests. Therefore, the 23 dps position of the DPS key will be the appropriate position. A turn-button key (60 MIL, LOOP) (20 MIL, POL) is provided for changing from the 60 milliampere neutral loop condition to the 20 milliampere neutral or polar receiving conditions in order to accommodate the various types of loop circuits. A 209-FC or a 255A relay is required for polar operation, or for use with a 60-milliampere neutral loop. A 209-FB or a 255A relay is required for a 20-milliampere neutral loop. A 255A relay is required for inverse neutral operation.

(B) Auxiliary Alarm Arrangement

3.10 The galvanometer relay used in connection with the bias alarm arrangement has keys which control the amount of current flowing through the galvanometer. These are so designated as to indicate the approximate amount of bias at which an alarm is given. For example, if the bias alarm key designated 20 is operated, the alarm functions whenever the circuit bias, either marking or spacing, exceeds 20 per cent for at least 200 to 300 milliseconds.

(C) Voltmeter Circuit

3.11 The voltmeter circuit with means for controlling the three scales is shown in the lower left-hand portion of Fig. 3. In the 117A1 set, connection to this circuit and to the meter is made with patch cords. In the 117B1 set the change of the meter connections from the stability test to the recording voltmeter condition is by means of a lever-type key.

(D) Inverse Neutral Arrangement

3.12 For use with inverse neutral loops in No. 1 telegraph service board offices an additional key in the 117A1 set, when operated to the correct position, arranges the set for connection to inverse neutral circuits. A battery jack designated —48V is also provided for connecting a suitable battery supply to the windings of the polar relay, and a grounding jack designated SG is provided for connecting the test circuit to signal ground. (This arrangement is not shown in Fig. 3 and reference should be made to the SD drawing.)

3.13 In the case of the 117B1 set in a No. 1 service board office, two nonmultiple appearances are provided. One is at the line board where connections may be made for measuring ground potentials or making stability measurements in 60-milliampere, 130-volt loops. The other appearance is in a miscellaneous or spare answer jack in the first service board position adjacent to the loop test position. From this appearance connections can be made to leg multiples of inverse neutral circuits. By means of a special patch cord, connection can be made to the equipment (EQ) jack of 48-volt, 20- and 60-milliampere loops terminated in the loop test position.

(E) Equipment — 117A1 Set

3.14 The meter generally used with the 117-type set is portable and is furnished with a handle for carrying. It is approximately 12 inches high, 9-1/2 inches wide and 8-3/4 inches deep. The weight is about 28 pounds. Binding posts for connection to the windings are provided on the

rear of the meter. Although this meter is of a rugged construction for this type of instrument, a certain amount of care should be exercised to prevent damage in case it is moved about or shipped to another location. Care should also be taken to prevent the ink from spilling from the inkwell. The meter should always be kept upright if there is ink in the inkwell. The inkwell →should be emptied and cleaned, and the needle →removed and packed separately before the meter is shipped.

(F) Equipment — 117B1 Set

3.15 The 117B1 equipment, including the recording meter, is arranged for mounting on 19-inch racks in a single unit, 29-3/4 inches high. The recording meter extends about 4-1/2 inches from the front of the relay rack and 6 inches from the rear. Its height is 18 inches and its width is 12 inches. The chart and scale are illuminated by a 15-watt lamp. If a clock drive is used in the set, the lamp derives its power from the 130-volt telegraph battery.

4. PRELIMINARY OPERATIONS

(A) Preliminary Adjustments

4.01 Certain preliminary adjustments of the recording meter and circuit of the 117-type telegraph stability test set are necessary in order to insure that the recording meter will indicate properly. When making stability tests the source of signals should also be checked.

(B) Chart Speeds

4.02 The chart speed, type of chart and gear selection can be determined from the information contained in Paragraph 3.06.

(C) Inserting the Chart

4.03 Hold the chart in the left hand so that the time figures are on the left-hand side. Release the chart supply bracket with the right hand. Place the chart core over the stud on the clock plate, and allow the supply bracket to return, thus holding the chart in position.

4.04 Cut or tear the end of the chart to a "V" shape, pull it forward and insert the end between the drive roll and the rod beneath the drive roll. Pull the chart up over the curved back of the writing table and forward under the paper guides until the chart perforations engage the pins in the drive roll. By turning the knurled set wheel on right end of drive roll, feed the chart through until there is enough to reach the reroll roller. Be certain that the paper is outside the stripper pins at both edges of the chart where it runs off the drive roll.

4.05 Open the spring reroll bracket by pushing it to the right. Remove the reroll roller and wrap two or three turns of the chart around it, taking care to have the axis of the roller at right angles to the edge of the paper. This will result in an even pull on the paper by the rerolling mechanism. Open the reroll bracket again and replace the roller, taking care that the paper is under the clip on the drive disk and that the clip is over the flat place on the reroll roller. Allow reroll bracket to return. Release reroll by backing it slightly and then it will move forward and take up the slack in the chart. See that reroll roller turns freely as too much paper under the clip will cause it to bind. There should be about 1/32-inch end play in the reroll roller.

4.06 Set the chart to the correct time by turning the knurled set wheel at right end of drive roll until the correct time marking appears at the tip of the writing pen. (If the time markings on the chart used do not correspond with the chart speed, or if the chart is used on other than a continuous basis, for example, eight hours per day, the time may be indicated by marking on the border.)

(D) Filling with Ink

4.07 Raise the scale plate and take out the pen element.

4.08 Remove the inkwell by lifting the two handles and pulling it forward. Using the inkwell filler furnished with the meter, fill the inkwell to a little below the cover (approximately one fluid ounce) with Esterline-Angus graphic meter ink. Replace the inkwell, with the cover on, being careful that it is under the spring clip at the back.

4.09 Replace the pen element in the stirrup and fill pen as follows: Compress bulb of pen filler, lay flat side on the chart, push pen point

into rubber pen filler, release bulb for about 5 seconds and remove pen from the pen filler.

4.10 See that the pen writes properly by blowing on it with the mouth in a manner to move it across the chart. If it does not, repeat the above operation in Paragraph 4.09. After the pen is filled, the scale plate should be lowered into position.

4.11 Be sure there are no air bubbles in the pen because a pen containing air bubbles will cease to write when a bubble reaches the pen point. The small vent hole in one corner of the inkwell cover should be kept open.

Caution: Pen elements should be handled carefully because a bent pen element will cause errors in the reading of the meter.

(E) Care of the Inking System

4.12 Only Esterline-Angus graphic meter ink should be used in this meter. Always keep the cap of the ink bottle screwed on tightly to protect the supply from the air, otherwise the ink may become contaminated and will not make a good record.

4.13 If the ink in the meter becomes thick the inkwell and pen element should be cleaned and refilled with fresh ink. To clean the inkwell, carefully pry off the inkwell cover and wash with water. The pen element and inkwell should be washed out with water and refilled frequently in order to insure good records.

4.14 It is necessary to have the pen inserted in the pen tube the correct distance, which is 4-3/8 inches from the pen pivot to the tip of the pen. An arc line on the pen table makes it easy to check the pen element length without removing it. The pen tube should be straight and at right angles to the pen pivot. The pen tip must set squarely on the paper for a good record.

4.15 Adjustments of the balance of the pen element are seldom necessary, but can be made with the counterweights which are locked by screwing them against each other. If the pen pressure on the chart is too heavy the meter will read low when going up scale and high when coming down, due to excesive pen friction. When properly set this drag is negligible at hourly feeds and at the minute feeds it is less than 1 per cent of the scale width. The adjustment of the weights on the meter is as follows:

4.16 Set the weights on the meter at a point which just balances the pen with the pen filled.

4.17 Advance them about ten turns, which should cause the pen to bear on the chart with the correct pressure.

(F) Starting the Chart Drive

4.18 The 117A1 test set meter is furnished with a clock drive. The 117B1 meter may be equipped with a clock drive or may be electrically driven by a synchronous motor. To start the latter, operate the toggle switch beside the meter to ON. To start a clock drive meter, proceed as outlined in the following paragraphs.

4.19 Wind the clock by inserting the crank in the winding arbor and turning it in a clockwise direction. (When not in use the crank is held in a spring clip on the side of the drive roll bracket.) If the winding crank does not turn smoothly this is caused by a friction clutch on the reroll spring, and does not indicate trouble in the clock. Spring clocks will run eight days (for hourly drive) with one winding but are usually wound each week.

Caution: The clock should be wound fully until the winding crank refuses to turn but should not be wound too tightly since overwinding may break the springs or damage the escapement. Overwinding is indicated by violent movement of the balance wheel and a double ticking noise.

4.20 Start the clock by moving the control lever to the position indicated on the nameplate on the left side. If the clock fails to start, the control lever should be moved back and forth until it does start. A small white target mounted on the pallet and lever staff is visible through the clock window, and indicates whether or not the clock is running.

4.21 If the clock is operated at rapid feed it should be rewound approximately every three hours.

Note: On some electric motor chart drives, the take-up reel is spring driven and must be wound.

(G) Zero Adjustment

4.22 A lever located at the bottom of the meter and over the nameplate is used for adjusting the zero. This adjustment should be made with the instrument disconnected. Adjust until the pen point is on the zero line on the chart, tapping the pen table lightly with the finger to eliminate the possibility of false reading due to sticking of the pen.

(H) Inspecting the Chart

4.23 The chart can be pulled from the reroll to look at the record made, after which the chart should be slowly fed back on the reroll again. Any amount of chart can be pulled from the reroll without damaging the mechanism.

(I) Feeding the Chart Out of the Bottom of the Case

4.24 If desired the meter can be used without rerolling the chart to make more of the record visible and permit tearing it off as recorded for immediate use. To change the meter to feed the chart through the bottom of the case proceed as indicated in the folowing paragraphs.

4.25 Remove the sheet metal strip at the lower edge of the case cover by taking out the five screws.

4.26 Weight the end of the chart with a paper clamp to pull it through the slot. Do not jerk on the end of the chart or it may slip the chart out of its correct timing.

(J) Removing the Chart

4.27 To remove the completely rerolled chart from the meter, open the reroll bracket, remove the chart and reroll roller from the clock and press the reroll roller from the chart. The chart is then ready for inspection or filing.

(K) Adjustment of Stability Measuring Circuit

4.28 Check adjustment of the loop relay in the relay test circuit. (Use 209FC or 255A relay for 60-milliampere loop or polar operation, 209FB or 255A relay for 20-milliampere loop, and a 255A relay for inverse neutral operation.)

4.29 Insert the relay in its mounting in the test set.

4.30 Make connections to a dummy loop circuit having suitable loop current and operate keys as indicated for "Stability Test" in Table A or B attached to this section.

4.31 Start the chart driving mechanism.

4.32 Have the dummy loop circuit in the spacing condition, so that the armature of the relay is held against its spacing (No. 5) contact. Note the reading. The meter should indicate approximately 100 per cent to the left which is the last division line on the chart. Normal battery variations will cause as much as ±4 per cent (±1 division) variation in the position of the pen for this condition. (This item need not be checked each time the set is used, but only at appropriate intervals as required.)

4.33 Reverse the connections to the binding posts of the meter. The deflection should now be the same amount but in the opposite direction to that noted in Paragraph 4.32.

Requirement: The difference between the deflections in the two directions should not be greater than 2 per cent (1/2 division) as read on the chart. If the difference is greater than this amount the meter should be repaired by manufacturer's representatives or returned to the factory for service.

Leave the connections to the meter in the way which deflects the pen to the left for spacing condition of the loop.

4.34 See that the alarm circuit buzzer operates if any of the BIAS ALM keys are operated.

4.35 Put the dummy loop circuit in the marking condition. The recorder should indicate to the right of the chart.

4.36 Check the indication of the recorder. It should indicate approximately 100 per cent marking, which is the last division line to the right on the chart. Normal battery variations will

cause as much as ±4 per cent (±1 division) variation in the position of the pen for this condition.

(L) Checking the Source of Telegraph Reversals

Note: This should be done at both ends of the circuit under test.

4.37 The source of reversals should be checked for speed regulation before each test and at suitable intervals during a test. This can be done with a standard means for checking the speed of the source being used. It is recommended that 60-speed (23 dps) reversals be used generally as discussed in Paragraph 2.17.

4.38 Check the quality of the dots (reversals) using a standard means such as a 118-type telegraph transmission measuring set, a 161-type telegraph station test set, a 164-type telegraph transmission measuring set, a testboard meter arranged for measuring bias in reversals or a dummy loop circuit and testboard meter in series. The bias should not be more than 2 per cent and the total distortion not more than 4 per cent.

(M) Checking the Complete Testing Arrangement

4.39 Connect the source of reversals to the 117-type test set through a dummy loop having no added inductance. Set the three-position key (DPS) to the 23 dps position (see Paragraph 4.37).

Requirement: The recording meter should indicate the same bias as found in Paragraph 4.38 to within ±1 per cent. Also the width of the recorded line on the chart should not exceed ±1 per cent bias. If this requirement is not met the A relay of the set should be replaced.

4.40 Interrupt the reversals for a sufficient length of time to permit the pen to move beyond the percentage bias for which the alarm is set. The alarm circuit should function and operate the buzzer during the interruption.

5. CONNECTIONS

5.01 The connections and key settings for the 117A1 and 117B1 sets differ somewhat, and are different for various types of test. They are listed in Tables A and B.

5.02 The information in the table columns headed "Inverse Neutral Circuits" pertains to use of 117-type sets in No. 1 telegraph service board offices.

5.03 When 117-type sets are used at No. 2 or No. 9B service boards, they can be connected to circuits at the facility or service positions by means of the standard loop monitoring arangements described in the BSP sections covering these service boards. Reference should be made to table columns headed "Loop Circuits" for the operating information.

6. TELEGRAPH STABILITY TESTING PROCEDURE

(A) General

6.01 During a telegraph stability test any interruption to the signals will be recorded so that ***it is important to organize the test in such a way as to reduce to a minimum the accidental interruptions not necessarily chargeable to the circuit.*** Particularly the terminal telegraph offices concerned should be warned not to interrupt the signals or the circuit. The connections to the circuit from the source of reversals and from the recording apparatus should be made in such a way as to avoid the possibility of interruptions from these sources. To obtain satisfactory results in some cases it will probably be desirable to make semipermanent connections through the frame. Also, it is desirable to observe the operation of the recording apparatus at frequent intervals during the test and to keep a log record of any pertinent items which arise during the test.

6.02 The question as to whether the circuit under test should be adjusted to its best operating condition, or whether the test should be made with the circuit as found depends upon the purpose of the test. If the test is to be made on a proposed circuit layout, it is usually desirable to go over this circuit thoroughly and line it up section by section before making the test. In case the object of the test is to determine the stability of a circuit under its usual operating condition, the circuit should not, of course, have special attention previous to the test.

6.03 The length of time during which a given test should be run will also depend on the purpose. For example, it may be desirable to have

a test of a proposed circuit layout run for a period of a day or even longer. On the other hand, in cases where a sample of the stability of a circuit that has been in regular operation is desired, a test of a few hours' duration may prove sufficient. In cases where a circuit has been taken out of service because of recurring trouble and a stability test is desired as an aid to locating the trouble, it will, of course, be necessary for the test to be run until the trouble appears.

6.04 Although the method as described makes use of one recorder, it may be found of advantage to employ a recorder at each repeater point in some cases. With this arrangement it is much easier to determine the cause of instability since the variation in each section of the circuit is recorded. Also by means of such a test it is easy to show bias canceling effects in the several sections which are not clearly indicated by an over-all test but which nevertheless reduce the operating margins and cause instability. In such cases it is usually necessary to provide an arrangement at the sending end for putting a periodic time synchronizing mark on all of the charts.

(B) Initial Adjustment

6.05 Adjust the 117-type set as described in Part 4.

6.06 Make connections and operate keys as in Table A or B (attached) for the particular type of circuit.

6.07 Measure loop current and, if necessary, adjust to the correct value.

6.08 Start the recording meter chart, using the speed desired for the test.

6.09 Open the loop circuit and check to insure that the meter indicates approximately 100 per cent spacing. The buzzer should also be operating if any of the bias alarm keys are operated. Close the loop circuit and check to insure that the meter indicates about 100 per cent marking. (If the meter of a 117A1 set indicates spacing with the loop closed, move the plug from the N loop jack to the REV loop jack.)

6.10 Operate the BIAS ALM key corresponding to the amount of bias at which it is desired to have the bias alarm operate.

6.11 The apparatus is now in condition to proceed with a test.

(C) Measurement

6.12 Patch source of telegraph reversals of good quality and proper speed in series in the same loop with the 117-type set. Make a short run, perhaps 15 minutes long, to obtain a record of these reversals, then remove these local signals.

6.13 Request telegraph reversals in the loop at the distant end of the circuit. The recording meter needle will assume a position indicative of the amount of bias in the circuit. Leave this setup in operation until the desired length of record has been obtained.

Note: When making stability measurements where the occurrence of "hits" is of primary interest, it is generally desirable to connect a 117-type set in the loop at the distant end. This permits a continuous record of the quality of the reversals at the source. A comparison of the chart at the measuring end of the circuit with the chart at the reversal source will make it possible to identify irregularities caused at the source rather than by the circuit being tested.

(D) Restoring Circuit to Service

6.14 At the conclusion of the test stop the recorder and remove the connections.

(E) Analysis of Results (Refer to Fig. 4)

6.15 The chart obtained from the recording meter at the conclusion of a test will contain two records, namely, a short record showing any bias or irregularities in the signals from a local source and a generally longer record showing the same effects for signals from a distant source received over the circuit which was tested. The short record of local signals is of interest in affording a final check that the measuring equipment is in satisfactory operating condition. The trace of the signals received over the circuit is, of course, the record of principal interest.

6.16 The record of the received signals will show the variation in bias, the variation in frequently occurring fortuitous effects, the

number and kind of interruptions during the test, and the time at which the variations and interruptions occurred. Reading from the bottom to the top of the sample chart shown in Fig. 4, it will be noted that first there is a trace along the center line indicating zero bias. Following there are records of two momentary failures, one spacing (to the left) and one marking (to the right). These failures were of sufficient duration to permit the pen to move to the scale limit before returning to zero. These failures might have been caused by the circuit "opening up" or "closing down" for several dot lengths. Dropping out of one mark or one space results in a sharp change on the record, as indicated for 23 dps signaling speed, shown next above the momentary failures. Next on the record several "hits" are shown which would cause distortion of 25 to 40 per cent of a dot length. Above that is shown the bias variation of the circuit which was tested.

6.17 The record provides an indication of the general condition of a telegraph circuit. From this standpoint it may be used to compare the performance of proposed circuit layouts, or of spare telegraph circuits, with that of similar facilities which are known to be in satisfactory condition. It may be determined from such a comparison the relative frequency of occurrence, duration, and severity of effects such as lost circuit time, bias, and momentary distortion which may cause transmission impairment in the two cases.

6.18 The chart record of the 117-type telegraph stability test set is also helpful in determining the causes of recurring troubles. For example, a general increase in bias of received signals may indicate a gradual departure from correct adjustment of some part of the circuit. Excessive width of the trace indicates rapidly occuring fortuitous effects such as may be caused by crossfire or power interference. Intermittent deflections might indicate such troubles as brief circuit interruptions due to line work, interference, a loose connection, a sticking relay or others of a momentary nature. Since the times of occurrence of these troubles are recorded on the chart, it is often possible to coordinate them with known conditions on the circuit, such as simultaneous telephone troubles, plant operations, weather conditions, etc, and thereby determine trouble causes.

6.19 As a further aid in localizing circuit troubles, records may be obtained simultaneously by means of several 117-type sets located at various repeater or carrier terminal points along the circuit. A comparison of these charts from the recorders will indicate the sections in which specific trouble effects originate, and will also indicate the amount and kind of bias and fortuitous distortion contributed by the various sections between the recorders. Time synchronizing signals are usually required with the use of multiple recordings as discussed in Paragraph 6.04.

6.20 It may be advantageous in recording results to summarize the number of interruptions, and the number of times and length of the intervals during which certain amounts of bias were exceeded. This summary should also show the time at which marked changes were recorded, as these changes may be traced to definite known causes which can be coordinated with these times.

(F) Calibration (Refer to Fig. 5)

6.21 In some uses of the 117-type set it is useful or necessary to know the percentage of distortion for "hits" which are recorded. The procedure given below gives a calibration for any particular set. This calibration will vary between sets and may change if a different Esterline-Angus recording meter is used. Theoretically the calibration curve, when plotted on graph paper should go through the 0-0 point, but usually it will not do so. The actual meter deflection for any given per cent distortion will vary, but for 100 per cent should be 1/4 inch to 1/2 inch with lesser distortions proportionally smaller. A sample curve is shown in Fig. 5.

6.22 For this calibration procedure, it is assumed that the adjustments and checks of the test set and reversal source have been made in accordance with Part 4 (K), (L) and (M).

6.23 Connect the 117-type set and the source of 60-speed reversals to the same TLT. The resultant trace is zero distortion and the zero adjustment lever of the Esterline-Angus recording meter should be moved to bring this trace to the center of the chart. Use a chart speed of 3 inches per minute for the succeeding steps.

6.24 Leaving the connections up as made in Paragraph 6.23 above, add a 60-speed teletypewriter (keyboard send) to the same TLT and send the "LETTERS" character by hand at least 100 times, at the rate of about one character in 2 seconds. The ***maximum*** meter deflection obtained is the 100 per cent calibration point.

6.25 Disconnect the 60-speed teletypewriter and substitute a 75-speed printer. Send the "LETTERS" character 100 times as described in Paragraph 6.24. The ***maximum*** meter deflection obtained is the 80 per cent calibration.

6.26 Repeat procedure above using a 100-speed teletypewriter. The maximum meter deflection obtained is the 60 per cent calibration.

6.27 Repeat procedures in Paragraphs 6.24, 6.25 and 6.26 above, but in each case put the teletypewriter signal through a 119-type telegraph signal biasing set adjusted for 50 per cent marking bias, at the speed used. The results under this condition with a 60-speed machine give the 50 per cent calibration, with a 75-speed machine the 40 per cent calibration and with a 100-speed machine the 30 per cent calibration.

Note: In recording the maximum meter deflections for the sample calibration curve (Fig. 5), the smallest division on the chart was called 10. The first heavy line then becomes 50. This is a convenient scale to use in such applications of the set since most of the deflections will be quite short. The scales printed on different chart papers differ. Actually ,any convenient scale may be used. The important fact is that when actual test readings are converted to distortion values, the ***same*** scale must be used that was used to prepare the calibration curve. An alternative would be to assign several horizontal scales to the calibration curve, corresponding to all the types of chart paper available. Readings could then be converted from whatever scale appeared on the paper, using the corresponding scale on the curve.

6.28 If teletypewriters of all these speeds are not available, as many of the calibration points as possible should be obtained. They should be plotted as shown in Fig. 5 and a smooth curve drawn through the plotted points. From this curve the distortion value of any recorded "hit" of 100 per cent distortion or less may be determined. It should be noted that "hits" causing more than 100 per cent distortion will be observed when the 117-type set is used on actual circuits. It is not practicable, however, to extrapolate the curve very far beyond the 100 per cent point.

6.29 The calibration procedure given above uses the start pulse of the "LETTERS" character to interrupt the reversals. The five selecting pulses of this character are all marking, so when the "LETTERS" character is sent at 60 speed the only result is a 22 millisecond space. It is necessary to repeat the character a large number of times to make sure that at least one of these spaces will coincide exactly with a marking pulse of the reversals. This will of course blank out that marking pulse completely and result in a 100 per cent spacing "hit." The characters are sent slowly to permit the meter needle to return to zero between deflections. At 75 speed the space is 60/75 of 22 milliseconds or 80 per cent distortion. At 100 speed the space is 60/100 of 22 milliseconds or 60 per cent distortion. Applying these spacing pulses through a 119-type biasing set, adjusted for 50 per cent marking bias, shortens the spaces by 50 per cent thereby resulting in 50, 40, and 30 per cent for 60-, 75-, and 100-speed signals respectively.

6.30 From the measurements resulting from the calibration procedure described in Paragraphs 6.23 through 6.29 it is possible to plot a calibration curve similar to the one shown in Fig. 5. This curve can be used with reasonable accuracy to translate meter needle deflections resulting from "hits" into the per cent distortion of these "hits." It will be noted that this calibration procedure was based on 60-speed reversals and therefore indicates the per cent distortion of "hits" only when using 60-speed reversals for stability measurements. As recommended in Paragraph 2.17, it is desirable to use 60-speed reversals for stability tests in all cases. If it is proposed to use the circuit for higher speeds the relative per cent distortion at these higher speeds can be calculated from the per cent distortion recorded with the 60-speed reversals. For example a 40 per cent distortion "hit" at 60 speed would at 75 speed be 75/60 or 1.25 times greater, or a 50 per cent distortion "hit."

7. RECORDING VOLTMETER TESTING PROCEDURE

(A) Methods

7.01 As a recording voltmeter the 117-type set has three scales, 500-0-500, 250-0-250, and 100-0-100. Its resistance for these three scales is 100,000, 50,000 and 20,000 ohms respectively.

7.02 Uses for the 117-type set as a recording voltmeter may be quite varied. A few which it is thought may be of more frequent occurrence are discussed below.

(1) Obtaining a continuous record of earth potential difference between two points. For this purpose the recording voltmeter with keys set for the appropriate scale is connected in series in a ground return circuit between the two points. When used in this manner the accuracy of the indication will be affected by the characteristics of the line conductor. Where possible, the latter should be of low resistance compared with the voltmeter resistance, and the insulation resistance should be good. To meet these requirements simplexed or simplexed phantom cable circuits should be used wherever possible. If the line resistance is less than 1000 ohms, its effect can usually be neglected. If it is necessary to use a line of higher resistance, the reading may be corrected by multiplying by

$$\left(1+\frac{\text{line resistance}}{\text{meter resistance}}\right)$$

provided the line has good insulation resistance. If open wire lines must be used the indication in wet weather may be lower by 15 per cent or more in extreme cases. It is not practicable to make correction for leakage, but if it is known that the source of earth potential is principally at one end of the line the error due to leakage will be least with the meter located at that end.

(2) Recording variations in battery voltage. For this purpose the voltmeter with suitable scale is connected from battery to ground, or across the battery at some convenient point as required by the circumstances of the test.

(3) As a "hit" recorder. For this purpose the 500-volt scale should generally be used, thereby making the meter resistance 100,000 ohms. In this condition it may be connected to the receiving relay armature of a telegraph repeater as a leak circuit to ground in the same manner as the 162A1 hit indicator and will indicate whenever the receiving relay armature leaves its marking contact.

(4) To determine the proportion of time that a circuit is in actual operation. For this purpose the meter, set for 500-volt scale, may be bridged to ground at some point where the voltage of the circuit will change in response to signals. To obtain response to signals sent in either direction the connection might be made at the point where the loop conductor joins the telegraph repeater, or if an impedance correcting network is used, at the loop side of that network. If it is desired to record operating time in the receiving direction only, the connection may be as described above for "hit" indication.

(5) In addition, other uses will undoubtedly arise. The general rule to be observed is that the meter may be connected to any circuit in the same manner as an indicating voltmeter of similar scale and resistance.

7.03 To use the 117-type stability test set as a recording voltmeter, make connections and operate keys as indicated in Table A or B attached to this section.

7.04 The patch to the split loop jack is specified in order to permit the voltmeter circuit to be inserted in series with the line to indicate the potential difference between two points. This will require patches to both the tip and ring jacks of the split loop jack circuit.

7.05 To measure the potential difference between the local ground and any distant ground, a ground and positive battery tap should be patched to the tip and ring jacks of the split loop jack circuit so that the recording meter will deflect to the right and the magnitude of the deflection will indicate roughly the calibration of the meter and the scale in use. The battery tap should then be replaced by the line to the remote ground. Before proceeding to obtain the voltage record, continuity to the remote ground should be checked.

7.06 To measure the potential difference between two remote grounds, at an intermediate point, proceed as above, except that local ground should be replaced by a line to the second remote ground and the chart should be marked to indicate the positive voltage from the first remote ground which will cause the meter to deflect to the right. Continuity should be checked to both remote grounds before starting the voltage run.

7.07 Start chart mechanism, having speed of chart set as desired.

7.08 Leave in operation during the period for which a record is required.

(B) Interpretation of Readings

7.09 The readings of voltage on the 117-type set chart are direct for the 100-0-100 scale. For the 250-0-250 scale the indications must be multiplied by 2.5 and for the 500-0-500 scale they must be multiplied by 5.

8. REFERENCES

Circuit Drawings	
117A1 Telegraph Stability Test Set	SD-63932-01
117B1 Telegraph Stability Test Set	SD-70155-01
Equipment Drawings	
117A1 Telegraph Stability Test Set	J64713B
117B1 Telegraph Stability Test Set	J70030B
Bell System Practices	
117A1 Telegraph Stability Test Set — Equipment Design Requirements	AA282.804
117B1 Telegraph Stability Test Set — Equipment Design Requirements	AA282.808

Attached:

Figs. 1, 2, 3, 4 and 5

Tables A and B

TABLE A

OPERATING INFORMATION FOR 117A1 TELEGRAPH STABILITY TEST SET

	VOLTMETER TEST	STABILITY TEST	
		LOOP CIRCUITS	INVERSE NEUTRAL CIRCUITS
METER CONNECTION	Patch to VM meter jack	Patch to METER jack	Patch to METER jack
VM SCALE key	500, 250 or 100 as required (See Par. 7.09)		
VM LINE key	Patch to telegraph line through split loop jack circuit (See Pars. 7.04, 7.05 and 7.06)		
LOOP or INV NEUT key		LOOP	INV NEUT
LOOP key		20 MIL, 60 MIL or POL as required	
DPS key		23 (See Note 1)	23 (See Note 1)
TG jack		Patch to telegraph ground	
+130V jack		Patch to positive 130-volt telegraph battery (See Note 2)	
LOOP or NOR jack		Patch to LPG jack in TLT of circuit to be tested	Patch to LEG MULT jack
−48V jack			Patch to negative 48-volt battery
SG jack			Patch to signal ground

Notes:

1. It is assumed that stability tests will be made generally with 60-speed reversals and the DPS key set at position 23. Refer to Paragraphs 2.16 and 2.17.

2. The positive 130-volt telegraph battery tap must be equipped with a 120-ohm resistor. Any higher value of resistance will result in erroneous meter deflections.

TABLE B

OPERATING INFORMATION FOR 117B1 TELEGRAPH STABILITY TEST SET

		STABILITY TEST					
		LOOPS					
			48V 20 MIL				
	VOLTMETER TEST	130V 60 MIL	NO. 1 SVC. BD. OFC.	NON-SVC. BD. OFC.	48V 60 MIL	POLAR	INVERSE NEUTRAL CIRCUITS
METER KEY	VM	STAB	STAB	STAB	STAB	STAB	STAB
LINE BD, SVC BD LOOP, SVC BD INV NEUT key (No. 1 Service board office only)		LINE BD	SVC BD LOOP		SVC BD LOOP	LINE BD	SVC BD INV NEUT
VM SCALE key	100, 250 or 500 as req'd (See Par. 7.09)						
DPS key		23 (See Note)	23 (See Note)	23 (See Note)	23 (See Note)	23 (See Note)	23 (See Note)
LOOP key		60	20	20	60	POL	
BAT key		ON	ON	ON	ON	ON	ON
Connections	Patch from STAB TST appearance jack to line to be tested through split jacks	Patch from STAB TST appearance jack to LPG jack of TLT	Use patch cord (Fig. 9 SD-70279-01) to connect from svc. board appearance to EQ jack of circuit under test	Patch from STAB TST appearance jack to LPG jack of TLT	Use patch cord (Fig. 9 SD-70279-01) to connect from svc. board appearance to EQ jack of circuit under test	Patch from STAB TST appearance jack to LPG jack of TLT	Patch from misc. or spare ans. jack in svc. board to leg mult. of circuit to be tested

NOTE: It is assumed that stability tests will be made generally with 60-speed reversals and the DPS key set at position 23. Refer to Paragraphs 2.16 and 2.17.

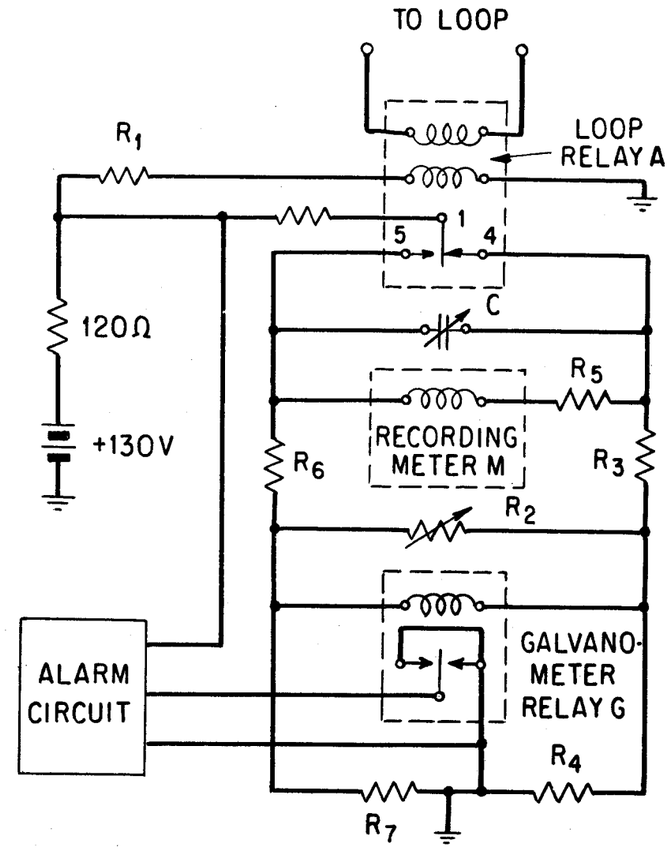

Fig. 1 – Stability Testing Arrangement

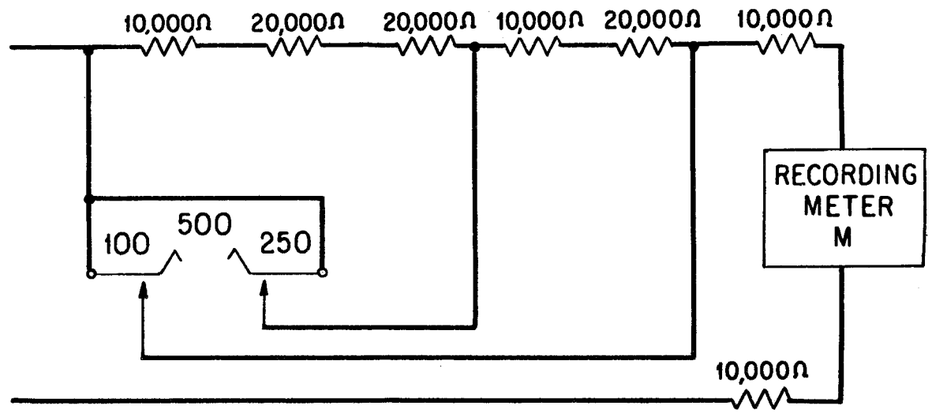

Fig. 2 – Schematic of Voltage Measuring Circuit

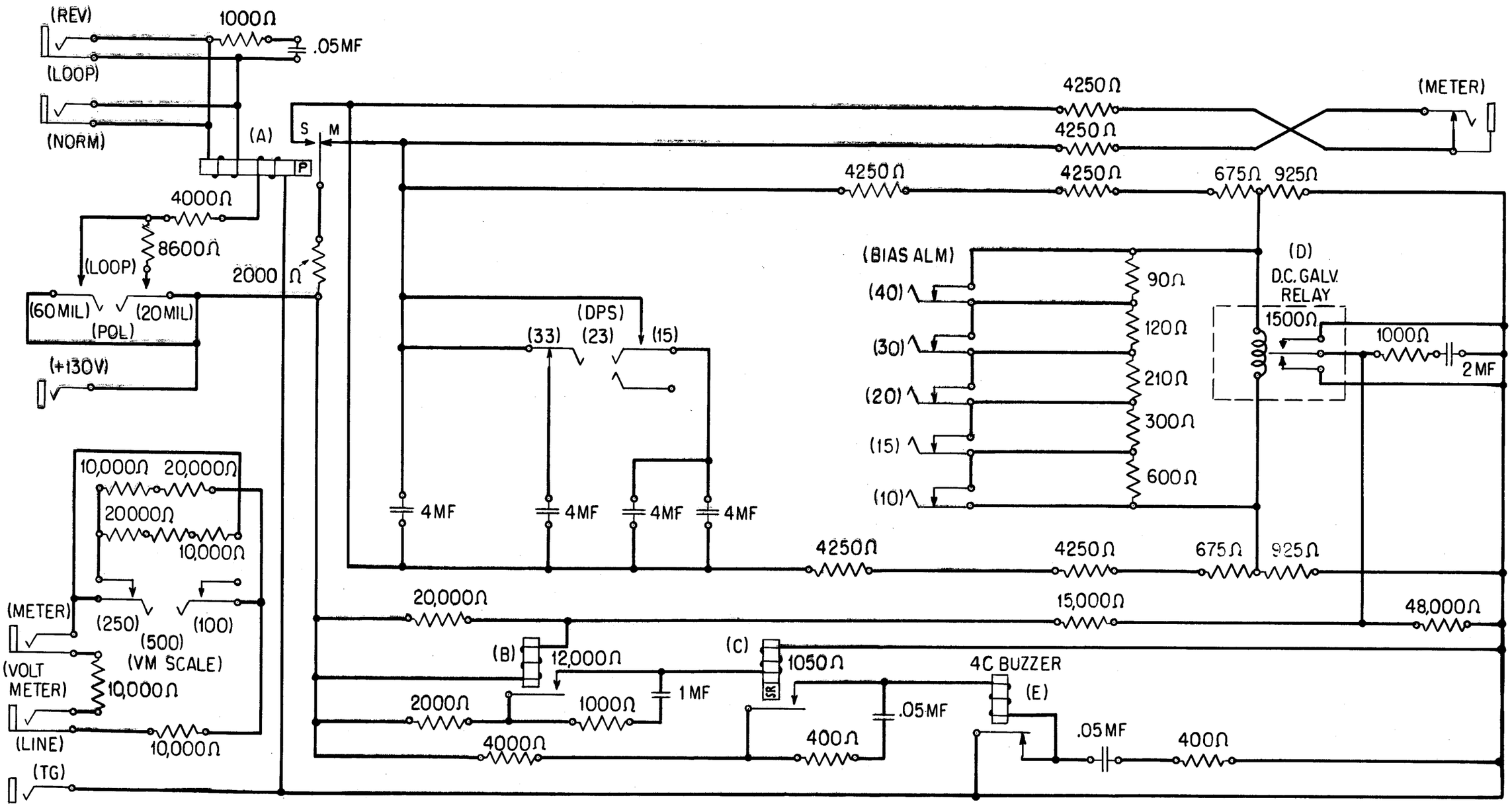

Fig. 3 – Schematic of Circuit in 117A1 Test Set Box

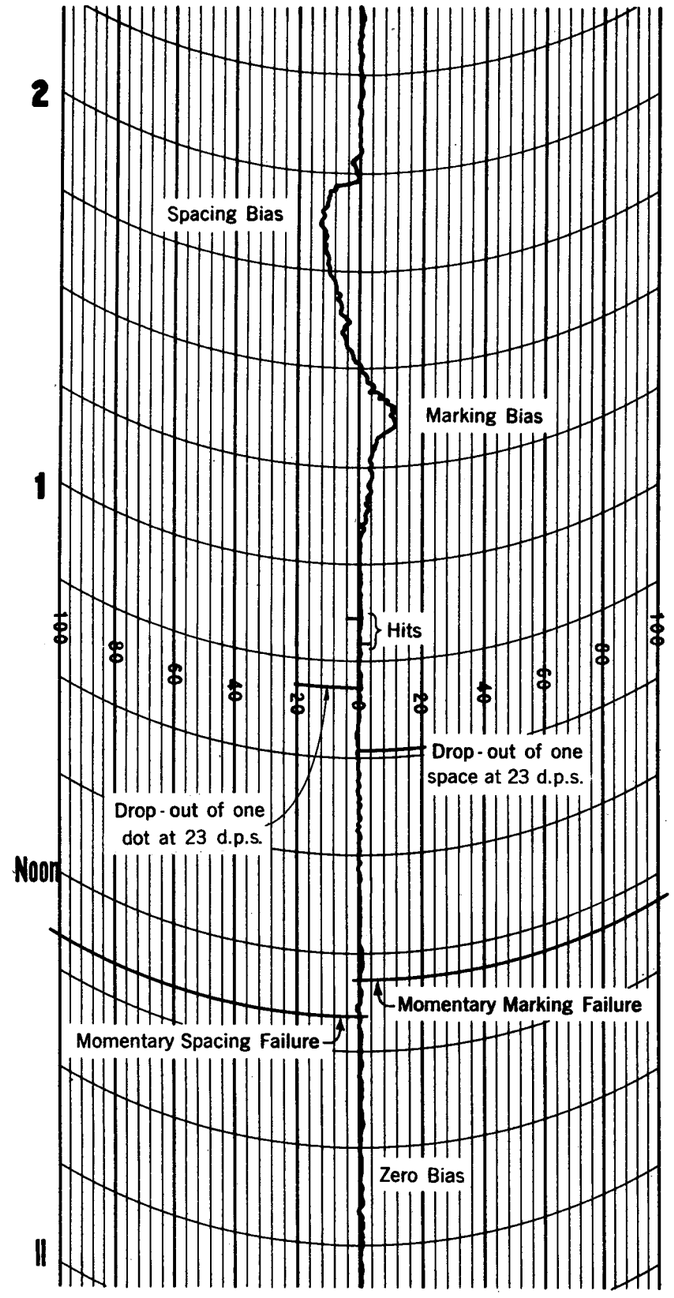

Fig. 4 — Sample Chart

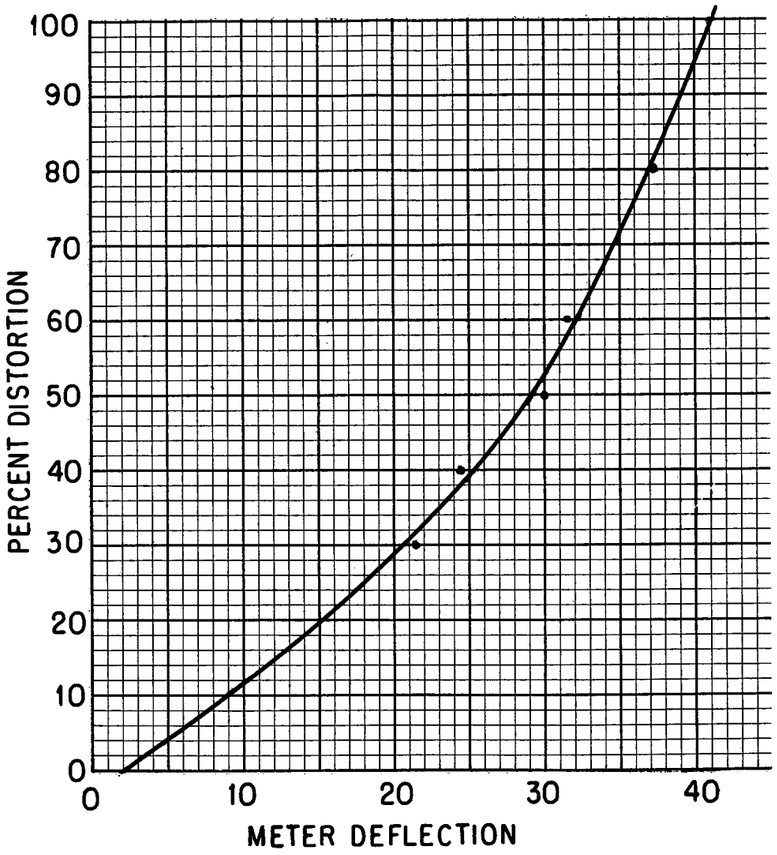

Fig. 5 – Sample Calibration Curve for 117-type Sets