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**SELECTOR CIRCUITS**  
**UNGUARDED INTERVAL ANALYSIS**  
**PANEL OFFICES**

**1. GENERAL**

**1.001** This addendum supplements Section 215-171-301, Issue 1. The attached pages must be inserted in the section in accordance with the filing instructions above.

**1.002** This addendum is reissued to correct the name and address of the manufacturer of the 9761 clamp.

**2. APPARATUS**

The following change applies to Part 2 of the section.

Paragraph 2.02 — revised

**Attached:**

- Page 1 dated October 1963, revised
- Page 2 dated October 1963, revised
- Page 3 dated May 1966, revised
- Page 4 dated May 1966, reissued

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**1. GENERAL**

**1.01** This section describes methods and procedures to be followed in the analysis and correction of unguarded intervals which occur on the sleeve of a selected trunk during the trunk hunting process in district, office, or incoming selectors. With this information, faulty district or office selector circuits detected by the unguarded interval test set SD-21986-01, and incoming selector circuits suspected of unguarded interval troubles due to the frequent recurrence of unresolved failures, may be analyzed with the use of an oscilloscope and corrective action may be taken. A significant reduction in circuit failures due to double connection troubles should result.

**1.01.1** An unguarded interval is defined as a period of time during which a trunk picked by one selector is not made busy to other hunting selectors.

**1.02** In the trunk hunting process, a selector circuit hunts for an idle trunk by testing the sleeve leads of a group of trunks for the idle condition (no ground). When an idle trunk is found, the selector advances to connect the busy condition (ground) to the sleeve lead. The time interval between recognition of an idle sleeve and connection of busy ground to that sleeve is approximately 5 msec. This unguarded interval is inherent in the circuit operation and although unavoidable can be controlled. However, the sleeve may subsequently become ungrounded as the selector circuit advances to complete its functions if the moving parts of the selector apparatus are not in proper adjustment. The mechanical adjustment of the C commutator brush, the sleeve multiple brushes, or the up-drive mechanism (i.e., clutch, cork, roll, rack, and selector rod), or the electrical adjustment of the L relay, or a combination of these factors may be the source of trouble. The adjustments recommended in this section for the various apparatus are within BSP requirements

but are closer tolerance to minimize unguarded intervals. The ideal BSP relationship of the selector apparatus which is described in detail in Part 6 is illustrated in Fig. 1.

**1.03** District or office selector circuits which have excessive unguarded intervals can be detected by the use of the unguarded interval test set, SD-21986-01. The test set, which operates in conjunction with the selector test frame, may be preset to provide one of six different timing intervals by means of a flexible terminal strapping arrangement and a three-position key. On each cycle of the test frame, the test set monitors the sleeve lead and times any open interval which occurs from the time busy ground is applied until the selector functions are complete. When an open on the sleeve lead exceeds the time setting of the test set, the test set causes the test frame to block and bring in an alarm. The operation of the unguarded interval test set is covered in Section 215-203-501 and 215-304-501 for the link type and sender selector type district selector automatic test frames respectively. Section 215-112-501 covers the office selector automatic test frame.

**1.04** By setting the unguarded interval test set at the maximum time interval, the district or office selector circuits which have the longest unguarded intervals and are therefore most susceptible to double connection failures are detected. When these circuits have been analyzed and corrected by the procedures outlined in the following paragraphs, the entire process of testing, analyzing, and correcting may be repeated with the unguarded interval test set adjusted for shorter and shorter intervals until corrective measures have been applied to all faulty district and office selectors in an office.

**1.05** Incoming selector circuits suspected of unguarded interval troubles due to the frequent recurrence of unresolved failures may also be analyzed by the procedures outlined in the following paragraphs. Where this analysis reveals excessive unguarded intervals on the sleeve lead, the suggested corrective measures may be applied. The unguarded interval test set SD-21986-01 cannot be used with the incoming selector automatic test frames or portable test set.

**1.06** In the analysis of all types of selector circuits an oscilloscope is used to examine the sleeve lead of the faulty circuit under actual operating conditions. By careful analysis of the sleeve lead trace, each unguarded interval may be related to a probable source of trouble. As the corrective measures which are recommended are applied, the resultant circuit action may be observed on the oscilloscope.

**1.07** *Preparation* describes the test connections required and the setting of the oscilloscope controls.

**1.08** *Trouble Analysis of Typical Sleeve Trace* describes the step-by-step procedures for analyzing a sleeve trace and suggests corrective action which may be taken to reduce open sleeve intervals. A diagram of a typical trace on which each deviation from the ideal grounded sleeve condition is labeled and defined is used for illustration.

**1.09** *Step-by-Step Procedures in the Practical Application of Analysis Techniques* describes the analysis of actual sleeve traces obtained in the field and illustrates the effect of each corrective action in photographs of the sleeve trace. A summary of the step-by-step analysis and correction procedure is outlined in table form.

**1.10** *Mechanical Relationships* describes and illustrates the ideal mechanical relationship of the panel selector apparatus when adjusted in accordance with BSP requirements.

**1.11** *Reference Material Covering Detailed Adjustment Procedures* lists the associated BSP information which may be required in applying the recommended adjustments. This paragraph also describes a method of checking the brush spring location with a tool especially developed for this purpose.

**1.12** The analyzing and correcting procedures outlined in this section do not alter standard requirements for the individual pieces of apparatus affected, and do not exclude from consideration any routine mechanical or electrical adjustments normally applied but not specifically mentioned here.

**2. APPARATUS**

**2.01** Oscilloscope, type 560, with P2 phosphor (alternate — type 561A, with P2 phosphor), equipped with one 1-megacycle amplifier, type 60; one time base unit, type 67; one oscilloscope cart, type 201, part No. 016-030; one probe P6017, part No. 010-056; and one viewing hood, part No. 016-001, manufactured by Tektronix Inc. or equivalent oscilloscope similarly equipped.

**2.02** No. 9761 clamp (combination tool consisting of clamp, lamp, go-no-go gauge, and holder for 121A dial gauge) for use in checking vertical alignment of multiple sleeve brushes in panel central offices, manufactured by Acme Engineering Works  
11126 Rush Street, El Monte, California.

**2.03** 121A gauge for use with No. 9761 clamp.

**2.04** Two testing cords, No. 893, 3 feet long with No. 360A tool both ends (1W13A cords), equipped with two KS-6278 connecting clips for connecting lamp terminals of No. 9761 clamp to battery and multiple sleeve terminal.

**2.05** KS-13490, List 1 resistor (1/2 watt, 51,000 ohms), equipped with two No. 30 cord tips; two No. 893 cords, 3 feet long with No. 360A tool both ends (1W13A cords); and two KS-6278 connecting clips. (Assemble as shown in Fig. 2.) Use to bias input to oscilloscope.

**2.06** Neoprene tubing, 1/4 inch I.D. 1/16 inch wall, to cover KS-13490, List 1 resistor, cord tips, and 360A tools as shown in Fig. 2. (Obtain locally.)

**2.07** All of the apparatus listed in the BSP section covering adjustment of the panel selector apparatus involved.

**2.08** Optional additional apparatus for recording oscilloscope trace.

(a) Oscilloscope record camera, model 196A, equipped with camera carrying case HP-196A-45 (use Polaroid Film, Type 47), manufactured by Hewlett-Packard Co.

(b) Bezel part No. 014-010 for attaching camera to oscilloscope, manufactured by Tektronix, Inc. or corresponding part for other oscilloscope.

**3. PREPARATION**

**3.01** To analyze the sleeve condition of a district or office selector circuit, an oscilloscope is connected to the sleeve lead of the test line (to which the selector is directed by the test frame) at some convenient location, preferably the selector bank terminal of the frame on which the selector is mounted. The probe pincers are connected to the sleeve lead and the ground clip connected to the framework. Since the open input trace (base line) on an oscilloscope coincides with the grounded input trace, it is necessary also to connect —24 volts through a 51,000-ohm resistor (for isolation) to the bank sleeve terminal. This bias voltage provides a distinctive trace on the scope when an open occurs on the sleeve lead. A schematic showing the oscilloscope connection to the bank sleeve terminal associated with the hunting circuit of a district selector is shown in Fig. 3. Connection to the bank sleeve terminal of the office selector circuit shown in Fig. 4 may be made in a similar manner. The setting of all oscilloscope controls in the positions required for unguarded interval analysis is shown in Fig. 5. The triggering level control setting is critical and may differ slightly from Fig. 5. Some oscilloscopes are more stable with the triggering coupling switch in the dc position. Once the controls have been set, it should be necessary only to adjust the intensity of the trace and operate the ON-OFF switch.

**3.02** With the district or office selector automatic test frame arranged to make repeated tests of the faulty selector circuit, the condition on the sleeve lead during the trunk hunting process may be observed on the scope from the instant that the sleeve brush touches the test terminal to 50 msec following. The trace repeats at approximately 30-second intervals.

**Caution:** While testing district or office selector circuits with the unguarded interval test set (SD-21986-01), the connection to —24 volts must be removed from the sleeve terminal.

**3.03** To analyze the incoming selector circuits, manual tests must be originated with the portable incoming selector test circuit SD-20050-01, as described in Section 215-522-501. In preparation for these tests, the following

steps should be taken. The incoming selectors to be tested should be made busy at the originating office. A particular brush (0, 1, 2, 3, or 4) to be tested and a particular final choice appearing in the associated bank should be selected. The first three (approximately) final selectors in this choice should be made busy. With the oscilloscope set up as described for district or office selector test, 3.01, the input probe should be connected to the sleeve terminal immediately above the last made-busy final terminal. The test set is then connected to the incoming selector and, using the numerical keys, a call is directed to the final choice to be used for the test. The condition on the sleeve lead of the incoming selector may be observed on the scope from the instant that the sleeve brush touches the test terminal to 50 msec following. A schematic of the incoming selector circuit is shown in Fig. 6.

**3.04** If a camera is used to record the sleeve lead trace, the shutter opening may be coordinated with the circuit action by observing the movement of the selector sequence switch. The shutter should be opened just prior to advance of the sequence switch into the trunk hunting position and closed in the position following trunk hunting.

#### 4. TROUBLE ANALYSIS OF TYPICAL SLEEVE TRACE — FIG. 7A AND 7B

**4.01** The hunting circuits of district, office, and incoming selector circuits are similar, with the exception that the functions of the L relay of the district or office are performed by the T relay in the incoming. Therefore, the following method of analysis may be applied to any of these circuits. For illustration, the analysis of a district selector circuit is described. The oscilloscope trace of the sleeve lead of this circuit, which is shown in Fig. 7A, is typical and has been exaggerated in certain details to illustrate salient points in the analysis. The circuit action indicated at each deflection of the trace may be followed with the use of the schematic and description of operation shown in Fig. 3. It should be remembered that the oscilloscope probe is connected to the bank sleeve terminal and is biased to  $-24$  volts. Unless the bank terminal is contacted by a sleeve brush, a  $-24$  volt trace appears on the scope. When the sleeve brush contacts the bank terminal, the

potential applied to the sleeve lead by the selector circuit appears on the scope; the effect of the  $-24$  volt bias is made negligible by the 51,000-ohm resistor. It should be noted that 1, 2, or 3 unguarded intervals may occur. The first of these, designated I, is inherent in the circuit operation and therefore unavoidable. It has a duration of about 5 msec and is made up of "dip 1," the "porch," and "dip 2." The second and third unguarded intervals which are due to L relay reoperation and overriding of the selected terminal, respectively, are avoidable and their duration together may be over 40 msec (intervals designated L and O on trace). Fig. 7B shows the trace with a time scale and the abbreviated nomenclature which has been assigned to portions of the trace to facilitate discussion. Reference should be made to both Fig. 7A and 7B for each step of the following analysis. As indicated at point X of trace (Fig. 7A), the oscilloscope triggers when the selector brush touches the idle test line terminal.

##### A. Dip 1

**4.02** "Dip 1" starts when the lower edge of the sleeve brush breaks from the busy terminal below, removing ground from the test line terminal and the primary winding of the L relay. A negative pulse is generated by the opening of the primary winding which, added to the  $-48$  volt battery at the winding terminal, reaches approximately  $-100$  volts. Since the L relay is held operated on its secondary winding, this potential appears at the sleeve terminal. The primary field collapses in about 1 msec and the sleeve terminal voltage decays to  $-48$  volts.

##### B. Porch

**4.03** The "porch" is the voltage level of the sleeve terminal at the instant the C commutator breaks. In Fig. 7B it appears as a steady  $-48$  volt trace lasting about 2 msec. However, if the C commutator spring breaks before "dip 1" has decayed to  $-48$  volts, the "porch" will appear as a pip of less than 1 msec duration occurring at a greater negative potential than  $-48$  volts.

**4.04** The "porch" and "dip 1" are thus inter-related and are dependent upon the relative adjustments of the C commutator and the

sleeve brush. It is desirable to have the "porch" as short as possible. This requires the C commutator to be on the high side of the BSP requirement and the sleeve brush to be on the low side of the BSP requirement. The ideal BSP relationship of these parts is covered in Part 6. Since only one of the five brushes associated with a district or office selector may be checked with the oscilloscope, the other four brushes should be mechanically checked with the No. 9761 clamp and the 121A gauge. The method of checking with the clamp and gauge is described in Part 7.

### C. Dip 2

**4.05** "Dip 2" starts as the C commutator brush breaks, opening the holding path through the L relay secondary winding. A voltage surge is induced into the primary winding, causing the sleeve terminal voltage to increase sharply from the "porch" level to approximately -300 volts. The magnetic field of the secondary winding usually collapses in 3 to 4 msec. The voltage decay trace is cut off by the closure of ground through the L relay back contacts when the relay has released. The release time depends upon the L relay tension and the amount of follow on upper 4 and 5 back contacts.\* It is desirable to have as much tension on the L relay as possible and still meet BSP requirements. Upper 4 and 5 back contacts should have maximum allowed follow. It is also desirable to have minimum allowed follow on bottom 1 and 2 front contacts so that the path for the updrive magnet will be opened as soon as possible. From point Y of the trace on, the sleeve terminal will remain grounded until the selector circuit releases, unless the L relay reoperates falsely or the sleeve brush overrides the selected terminal.

### Camel Effect

**4.06** "Camel effect" is not indicated in the typical traces of Fig. 7A and 7B since it is rarely found in the sleeve trace of a district

\*The L relay is extremely fast and its mechanical condition is critical. A bent pole piece, twisted armature, or ineffective nonfreezing disc can easily double the release time. On traces showing L relay irregularities, visually check whether or not the armature touches the pole piece. Correct or replace relays which have this defect and do not meet Table A requirements.

selector circuit. However, it may appear in the traces of office selector circuits as a disturbance during "dip 2," usually taking the form of a single hump. It is an indication of maladjustment of the L relay. Although a diode can be inserted in the secondary winding to eliminate the "camel effect," the real trouble lies in the release time of the L relay. Unless "dip 2," which depicts the release time of the L relay, is less than 4 msec, the minimum unguarded interval conditions cannot be obtained. It is important that the L relay release time be as short as possible.

### D. Seventeen

**4.07** Seventeen msec is a fixed interval of time, measured from the start of the trace, which provides a direct means of identifying the start of "dip 3" as the "a" or "b" portion. The "bridge" which separates "dip 3a" and "dip 3b" in Fig. 7B is not always evident and the "plateau" which is also used in distinguishing "dip 3a" from "dip 3b" varies depending on the earlier portions of the trace. However, "dip 3" can be directly identified as the "a" portion if it starts before the 17-msec mark, or as the "b" portion if it starts at or after the 17-msec mark. Seventeen msec was determined by calculation to be the time required for the sleeve brush to travel across the selected terminal from the point of break from the preceding terminal to the point of break from the selected terminal (0.125 inch divided by 0.075 inch/msec). This is based on the assumption that the selector rack is in firm contact with the cork roll and does not slip.

### E. Plateau

**4.08** The "plateau" starts when ground is placed on the sleeve terminal through the back 4 and 5 contacts of the L relay. It ends when one of the unguarded intervals, "dip 3a" or "dip 3b," begins. The length of the "plateau" is important since it can substantiate various pieces of information diagnosed from other portions of the trace. If the C commutator and sleeve brush are adjusted as recommended in 4.04, the "plateau" starts after an inherent unguarded interval of 5 msec. If the "plateau" lasts for 12 msec, the remainder of the 17-msec interval described in 4.07, it can be assumed that the L relay remained normal ("dip 3a" missing from trace). An unguarded interval

occurring after that point is due to the sleeve brush overthrowing the selected terminal ("dip 3b"). If the "plateau" is less than 12 msec, it can be assumed that "dip 3a" is occurring due to the L relay reoperating momentarily on a surge from the updrive magnet. When the L relay releases, remaking its back contact, ground is again closed to the sleeve (portion of trace designated "bridge") for the remainder of the seventeen msec. An unguarded interval occurring after this point is due to the sleeve brush overthrowing the selected terminal. If the "plateau" has a ragged appearance, it is due to relay bounce and indicates poor L relay adjustment.

#### F. Dip 3a and Bridge

**4.09** "Dip 3a" may or may not be present as pointed out in the discussion under "plateau." It is dependent upon the L relay tension and the release time of the clutch. The L relay secondary winding and the updrive magnet have a common ground through the L relay bottom 1 and 2 contacts when the C commutator is closed. Although the two devices are not connected at the instant that ground is removed by the release of the L relay, the C commutator later remakes, closing a path between them. At the time the C commutator remakes, the magnetic field of the L relay has collapsed but the field of the updrive magnet is still large. Therefore, the L relay secondary provides a path for release of the remaining energy in the updrive magnet. Depending upon the adjustments of the clutch and the L relay, the L relay may reoperate fully, partially, or not at all. To eliminate the interaction between these two inductive elements, a diode may be inserted in the path of the L relay secondary winding. This feature has been made a standard option on district, office, and incoming selector circuits. (The L relay secondary winding of the district or office corresponds to the T relay primary winding of the incoming.) Fig. 7 (A or B) shows the case where the L relay fully reoperates ("dip 3a"). Not only is ground removed from the sleeve terminal, but -48 volts is momentarily applied. Reoperation of the L relay also closes the operate path for the updrive magnet.

**4.10** A "bridge" indicates that ground is restored to the sleeve lead after the momentary operation and release of the L relay. It is only present when "dip 3a" occurs.

#### G. Dip 3b

**4.11** "Dip 3b" is due to the sleeve brush overriding the selected terminal as indicated at point Z of trace. It may occur for the following reasons:

- (a) C commutator adjusted too low.
- (b) Sleeve brush adjusted too high.
- (c) L relay release too slow.
- (d) L relay reoperates.
- (e) Clutch release too slow.
- (f) Uneven cork roll.

**4.12** As described before, when the L relay releases, a front contact opens the ground path for the updrive magnet. However, the updrive magnet has considerable energy that must be dissipated before it will disengage the updrive. Therefore, the selector rod continues to travel upward, and the sleeve brush may or may not leave the selected terminal (test line). If the sleeve brush overrides the selected terminal, the potential of the test line becomes -24 volts ("dip 3b"). Under service conditions, the sleeve terminal would be open unless contacted by a multiple brush. When this selector drops back on the selected terminal, ground is restored to the test line.

**4.13** All of the previously mentioned trouble conditions have a cumulative effect in causing "dip 3b." When corrective measures have been taken to eliminate "dip 3a" and to reduce the inherent unguarded interval to a minimum, "dip 3b" should disappear. If it is still evident, the six conditions mentioned above should be checked, with particular attention to (e) and (f). Since the cork roll is susceptible to wear and climatic changes, it is best to make the clutch adjustment last. The closer the other adjustments are to the prescribed limits, the less critical is the clutch adjustment.

#### H. Sawtooth

**4.14** "Sawtooth" occurs when the sequence cam springs in the ground path are pitted or dirty. Referring to the schematic of Fig. 3, the H and E cams are evidently responsible for this trouble condition. On some circuits this condition may be concealed by sleeve brush overthrow.

**5. STEP-BY-STEP PROCEDURES IN THE PRACTICAL APPLICATION OF ANALYSIS TECHNIQUES — FIG. 8 THROUGH 14**

**5.01** To best illustrate the manner in which corrective measures may be taken at each step in the analysis of a defective selector circuit, actual field studies of certain faulty selector circuits will be discussed. Pictures were taken of the sleeve lead trace of each circuit as it was found and again after each corrective measure was applied. The sequence of pictures obtained for a particular circuit thus illustrates the effectiveness of each step in the correction procedure. The lower trace of picture 8B shows the perfect sleeve condition which is the ultimate goal in this analysis and correction procedure. The trace is made up of two parts: an inherent unguarded interval lasting approximately 5 msec, followed by uninterrupted ground. In the discussion which follows, reference is made to the abbreviated nomenclature used in Fig. 7B (Typical Trace) in describing each portion of the trace.

**A. Dip 1**

**5.02** "Dip 1" is caused by the opening of the L relay primary winding as described in 4.02. The pictures of sleeve traces taken in the field show 1 to 2 msec for "dip 1," depending upon the point at which the C commutator breaks. The desired relationship of the C commutator spring with the sleeve brush and the adjustment procedure for obtaining it are covered in the discussion on "porch," 4.04.

**B. Porch**

**5.03** The "porch" appears in pictures 8A and 8B as a pip of less than 1 msec duration, indicating a satisfactory adjustment of the C commutator and sleeve brush. When this district selector circuit was checked, the C commutator was found to be 0.004 inch above BSP ideal and the sleeve brush was at BSP ideal of 0.075 inch.\*

\*Amount of upward travel necessary for the lower sleeve spring to move from a rest position (centered on terminal) to a point of break from the same terminal (Fig. 1C to 1A). This measurement is always made at the reference terminal without regard to the location of the test line terminal.

**5.04** Pictures 9A, 9B, and 9C show a "porch" of about 2 msec. The C commutator was 0.004 inch above BSP ideal, but the brush was high (0.065 inch). This series of pictures shows the results of adjustments made to improve the L relay operation with no attempt made to reduce the "porch." Since the C commutator adjustment cannot be bettered, it is advisable to improve this circuit by adjusting the sleeve brushes between 0.075 inch and 0.080 inch.

**5.05** Picture 10A shows a "porch" of about 5 msec. Picture 10B shows that this "porch" was reduced to 3 msec by adjusting the C commutator to BSP ideal. Picture 10C shows that the "porch" was reduced to less than one msec by adjusting the C commutator to 0.004 inch above BSP ideal and adjusting the sleeve brush from 0.068 inch to 0.078 inch.

**C. Dip 2**

**5.06** "Dip 2" may be controlled by the mechanical adjustment of the L relay as described in 4.05.

**5.07** Pictures 8A and 8B show about 3 msec for the L relay to release. This indicates that the L relay has sufficient tension and adequate follow on 4 and 5 back contacts.

**5.08** Pictures 9A, 9B, 9C, 10A, 10B, and 10C also show about 3 msec for the L relay to release indicating a satisfactory adjustment.

**5.09** Pictures 11A, 11B, and 11C show about 5 msec for the L relay to release. The longer the L relay release time, the more critical the other adjustments become. It is recommended that relays showing a release time ("dip 2" only) of over 4 msec be adjusted as described in Table A.

**Camel Effect**

**5.10** "Camel effect" may be observed in the sleeve traces of office selector circuits, pictures 12A and 12B. It is a disturbance occurring during "dip 2" which appears as a single hump and is caused by improper adjustment of the L relay.

**5.11** The L relay in one office circuit, picture 12B, had ineffective stop pins which allowed the armature to touch the pole piece. As

a result the relay release time could not be reduced below 6 msec by adjustment alone. The addition of a diode eliminated the "camel effect" but the relay release time was not improved, and the unguarded interval remained as shown. The relay was adjusted to just operate at 17 ma but this had little effect on the release time. However, when the P163914 armature stop\* was attached to the pole piece, the release time dropped from 6 msec to 2-1/2 msec. The diode then had no observed effect on this circuit. Reducing the just operate to 12 ma increased the relay release time to 4-1/2 msec. The disturbance on the "plateau" was due to dirty 3 and 4 contacts.

5.12 The L relay in another office circuit, picture 12A, was in poor electrical and mechanical adjustment. By meeting all electrical and mechanical requirements (especially balance), the relay release time was reduced from 6 to 3 msec. As expected, the improved release time eliminated the unguarded interval.

5.13 The "camel effect" appears more frequently in office selector circuits than in district selector circuits because of the difference in design of the L relays of the two circuits. The stop pin thickness specification for the R6006 relay of the district is 0.005 inch to 0.007 inch but for the R136 relay of the office it is 0.002 inch to 0.007 inch. R6006 relays with badly worn stop pins may require the P163914 armature stop (0.0065  $\pm$  0.0005 inch) to meet the release requirements. However, some R136 relays with 0.002 inch or 0.003 inch stop pins, which are within requirements, may also need the armature stop.

#### D. Seventeen

5.14 Seventeen milliseconds measured from the start of the trace marks the point at which the sleeve brush may override the selected terminal (start of "dip 3b"). It is a valuable frame of reference in discussing other portions of the trace. "Seventeen" is described in detail in 4.07.

**\*Caution: It is extremely important that the P163914 armature stop not touch the stop pins when the relay is operated. See Section 040-500-801 for method of installation.**

5.15 Picture 8A shows the start of "dip 3" occurring at approximately 13 msec. Therefore, this must be the start of "dip 3a." The start of "dip 3b" is hidden by the overlap of these two unguarded interval conditions.

5.16 Pictures 10A, 10B, and 13A show "dip 3" starting at approximately 17 msec, indicating that this is "dip 3b" and that "dip 3a" does not occur.

5.17 Picture 9C shows the start of "dip 3" at about 19 msec. In this case, the selector rod started to decelerate before "dip 3b" began, delaying the start of "dip 3b" beyond 17 msec. An uneven cork roll may increase the time of this portion of the trace.

#### E. Plateau

5.18 The "plateau" starts when ground is closed through the back contacts of the L relay as described in 4.08. Assuming that the C commutator and sleeve brush adjustments are ideal, the length of the "plateau" provides a means of distinguishing between two unguarded interval conditions (L relay reoperation and overthrow) which may occur in sequence and frequently overlap.

5.19 The upper traces of pictures 8B and 9C have "plateaus" of less than 12 msec and clearly illustrate the two unguarded intervals, "dip 3a" and "dip 3b," separated by the bridge. The bridge may not appear if these intervals overlap as shown in the upper trace of picture 8A.

5.20 The upper trace of picture 8A has a "plateau" of 7 to 8 msec. Since the inherent unguarded interval appears to be close to the ideal of 5 msec, this indicates L relay reoperation. The L relay release and "bridge" are hidden by the sleeve brush overthrowing the terminal. Only about 5 msec of the unguarded interval was due to the opening of the L relay back contact. This is shown by a comparison with the lower trace of picture 8A where the reoperation of the L relay has been eliminated by the addition of a diode.

5.21 Both traces of picture 10A show a "plateau" of only 7 msec. However, in this picture the C commutator and sleeve brush had

not been adjusted to the ideal condition. The entire unguarded interval was due to the sleeve brush overthrowing the selected terminal. This was also indicated by checking the 17 msec point on the trace as described in 5.17. With the C commutator and brush adjusted, picture 10C, it can be seen that the L relay reaction was almost negligible.

**5.22** The upper trace of picture 9A shows a "plateau" with several breaks shortly after the ground is applied. This is relay bounce and obviously indicates poor L relay adjustment. The relay tension was checked and found to be low and the follow on upper 4 and 5 contacts was found to be almost negligible.

#### F. Dip 3a and Bridge

**5.23** "Dip 3a," when present, indicates the reoperation of the L relay on the energy released from the updrive magnet into the L relay secondary winding. The degree of reoperation depends upon the L relay tension and the release time of the clutch. This momentary reoperation of the L relay may be eliminated, if the relay is in proper adjustment, by the insertion of a diode in the path of the L relay secondary winding as described in 4.09. In those cases where the rear clutch magnet gap is less than 0.015 inch (factory adjustment) it is impractical to attempt to completely eliminate reoperation of the L relay without either using a diode or resetting the rear clutch magnet. Since 1932 the factory minimum requirement has been 0.010 inch. Before 1932, the minimum gap adjustment was 0.018 inch.

**5.24** The upper trace of picture 8B clearly shows the L relay reoperation since "dip 3a" is separated from "dip 3b." A comparison with the upper trace of picture 10A shows that the adjustment of the clutch reduced the length of "dip 3a" but failed to prevent over-riding of the selected terminal. The rear magnet gap for this district selector was 0.015 inch. It was necessary to add a diode to prevent reoperation of the L relay thereby eliminating both unguarded intervals, "dip 3a" and "dip 3b," as shown in the lower trace of picture 8B.

**5.25** Picture 8A, if observed closely, illustrates another method of distinguishing "dip 3a" from "dip 3b" in addition to observing the length

of the "plateau." In the upper trace, where "dip 3a" and "dip 3b" are overlapping, both curves have the same smooth start, but "dip 3a" drops sharply to -48 volts as the front contacts of the L relay momentarily close. This gives a rough appearance to the trace of "dip 3a." In the lower trace, where "dip 3a" has been eliminated by the addition of a diode, the start of "dip 3b" is observed to be a smooth curve, starting a few msec later than before.

**5.26** Pictures 9A, 9B, and 9C compose a sequence illustrating the sleeve condition as found and the effect of each corrective measure applied. The upper trace of picture 9C is a duplication of the trace described in Fig. 7B. In the upper trace of picture 9A, the "bridge" is preceded by a 5 msec break which is due to L relay and updrive magnet interaction. The lower trace shows a small break (about 2 msec) even with the diode added. This is due to insufficient tension on the L relay and was described previously as bounce. Picture 9B, which illustrates the circuit action after the relay was adjusted with the 35-type test set, shows considerable improvement over picture 9A, but the tension on the L relay was still insufficient. (L relay was adjusted for operate, 15.5 ma and nonoperate, 10.9 ma.)

**5.27** A "bridge" appears in the trace only if ground is momentarily restored to the sleeve terminal between "dip 3a" and "dip 3b." It is very short in the upper trace of picture 9B but its existence signifies L relay and updrive interaction. It is an easy characteristic to recognize. In the lower trace of picture 9B, relay bounce and reoperation (indicated by the slight break in the "plateau" at 8 msec) is still evident although the addition of the diode has practically eliminated the updrive magnet and L relay interaction.

**5.28** The upper trace of picture 11B shows another case of L relay and updrive magnet interaction. The "bridge" does not appear (even though the "porch" is short) since the L relay reoperation takes far more time than the usual 5 msec. As can be seen in the upper traces of pictures 8B and 9C where the L relay was in proper adjustment, the time from the start of "dip 3a" to the start of "dip 3b" is about 7 msec. The corresponding interval in picture 11B is

about 9 msec. The trace of picture 11B is not clearly defined with respect to "dips 3a" and "3b." However, it is apparent that the L relay is reoperating since the sleeve voltage drops to approximately -48 volts, indicating that the L relay front contacts 1 and 2 or 3 and 4 are closed while the sleeve brush is still in contact with the terminal. After the sleeve brush leaves the terminal, only the -24 volt bias connected to the probe lead of the oscilloscope can appear.

**5.29** The lower trace of picture 11B shows that the diode has almost eliminated the L relay and updrive magnet interaction but the L relay reoperation is indicated by the two small breaks. This is similar to the lower trace of picture 9A. Again, this is a case of either insufficient tension or lack of follow on 4 and 5 contacts, or both.

**5.30** When the L relay varies in degree of reoperation, the total unguarded interval will vary widely from test to test (on the same circuit). The top two traces of picture 11C and all traces of picture 14B show this effect. The top trace of picture 11C shows a 15 msec "dip 3b" but the middle trace shows no "dip 3b." Picture 14B is an excellent display of the variation to be expected.

#### G. Dip 3b

**5.31** "Dip 3b" may or may not be present. The appearance of this interval is due to the sleeve brush overthrowing the terminal. Since it is affected by all the previously mentioned adjustments it may disappear in the process of correcting the "porch" and "dip 3a." If not, the clutch must be adjusted.

**5.32** As can be seen from the traces shown in picture 8A, the diode has eliminated the reaction of the updrive magnet on the L relay. Without any adjustments, the unguarded interval has been reduced from a duration of over 40 msec to less than 25 msec.

**5.33** The lower trace of picture 8A shows an overthrow of the terminal without any complications from the L relay. Notice the smooth beginning of the trace. This is characteristic of a simple override of the selected terminal. Notice also that the "plateau" is about

13 msec (see 4.08). After the clutch was adjusted, a perfect trace was obtained as shown in the lower half of picture 8B. The remaining 5-msec break is the inherent unguarded interval and cannot be eliminated.

**5.34** The lower trace of picture 9B shows a 23-msec break which is shown completely corrected in the lower trace of picture 9C. Again it was necessary to adjust the clutch.

**5.35** It must not be assumed from the above cases that adjusting the clutch first would completely remove "dip 3b." If the clutch had been adjusted first, it still would have been necessary to make the other adjustments.

**5.36** *An uneven cork roll is one condition which will cause confusion if not recognized immediately.* However, if the recommended step-by-step procedure is followed, there should be no difficulty. An out-of-round cork roll will cause "dip 3b" to change radically from test to test (on the same circuit). Circuits displaying this tendency should first be checked for C commutator, sleeve brush, and L relay adjustments. Finally the clutch should be adjusted. If "dip 3b" has not been eliminated by these steps, it may be necessary to grind or replace the cork roll. In the initial stages of this program it may not be profitable to spend time correcting a small intermittent unguarded interval due to an out-of-round cork roll (see 5.43). This circuit defect should be recorded for future attention since a slight deterioration in the clutch adjustment could create an appreciable unguarded interval. It is expected that a correlation between mechanical and oscilloscope checks of cork rolls will be developed through experience.

#### H. Sawtooth

**5.37** A "sawtooth" is an intermittent open which may occur if the sequence switch cam springs in the ground path are pitted or dirty.

**5.38** Pictures 13A and 13B show obvious cases of "sawtooth." Both circuits failed the 40-msec timing test.

5.39 Picture 13C shows the trace of a circuit which also failed the 40-msec test but the "sawtooth" is not so obvious. However, repeated tests on this circuit did produce traces with a more pronounced "sawtooth."

5.40 Better "sawtooth" detail can be obtained by increasing the oscilloscope vertical sensitivity and by using the 5X sweep magnifier.

#### SUMMARY OF STEP-BY-STEP PROCEDURES IN ANALYSIS OF UNGUARDED INTERVALS

5.41 Table A is a condensation of the information in the preceding paragraphs and is a suggested outline for a step-by-step procedure to be used in correcting unguarded intervals. It is important to attack unguarded interval troubles in a given sequence in order to interpret the oscilloscope traces properly. As each correction is applied, the resultant circuit action should be observed on the oscilloscope. More than one trace of a specific selector circuit should be observed in order to evaluate "dip 3b" properly.

5.42 With regard to the extent to which corrective measures should be applied, it should be noted that almost every circuit being

corrected can be adjusted as easily to a zero (avoidable) unguarded interval as to some low value.\* Since aging and wear adversely affect adjustments, it should be kept in mind that the unguarded interval on a circuit will tend to increase rather than decrease with time (excluding the effect of relative humidity on cork rolls).

5.43 Central offices which cannot closely control relative humidity do not have a stable unguarded interval condition year around. In these central offices, serious consideration should be given to the relative humidity before changing clutch adjustments to reduce the unguarded interval. Air-conditioned panel central offices do not have as severe climatic problems and therefore have more stable unguarded intervals.

\*In reducing the total unguarded interval, the inherent unguarded interval is often concurrently improved. It is not unusual to reduce this interval from a duration of 10 msec to one of 5 msec. This is a significant improvement.

TABLE A

STEP	PORTION OF TRACE	DURATION	CHECKS	SUGGESTED CORRECTIVE ACTION
1	Porch	> 2 msec	C Commutator Position	0.004 Inch Above BSP Ideal (ter. 49)
			Sleeve Brush Position	0.075 Inch +0.005 Inch -0.000 Inch (ter. 49)
2	Dip 2	> 4 msec	L† Relay Release Time	1 — Increase Relay Tension Just Operate ma — R6006 of Dist. 15.5 R136 of Off. 17 R6010 of Inc. 31 2 — Increase Follow on 4,5T (L) Relay — Dist. 3,4T (L) Relay — Off. 2, 3B (T) Relay — Inc. 3 — Use P163914 Arm. Stop Per BSP Section 040-500-801 4 — Consider L† Relay Replacement

† Corresponds to T relay of incoming.

> Greater than

TABLE A (Cont)

STEP	PORTION OF TRACE	DURATION	CHECKS	SUGGESTED CORRECTIVE ACTION
3	Plateau*	$\approx 7$ msec	L† Relay Reoperation (if porch is 1 msec)	See Dip 3a
		$\approx 13$ msec	Sleeve Brush Overthrow (if porch is 1 msec)	See Dip 3b
	Start of trace to start of Dip 3	$< 17$ msec	L† Relay Reoperation	See Dip 3a
		$\geq 17$ msec	Sleeve Brush Overthrow	See Dip 3b
4	Dip 3a* (usually rough start)	$< 5$ msec	L† Relay Reoperation	1 — Insert Diode 2 — Recheck 1 & 2 of Step 2 3 — Decrease Follow on 1, 2B (L) Relay 3, 4T (T) Relay 4 — Adjust Rear Clutch Magnet Gap to 0.018 Inch
		$> 5$ msec $< 8$ msec	L† Relay Reoperation (recheck Step 2)	
5	Dip 3b (smooth start)	$> 0$ msec	Sleeve Brush Overthrow	1 — Recheck Step 1 — If possible, reduce both Porch and Dip 1 to 1 msec 2 — Recheck Step 2 — See note regarding L relay, Page 5 3 — Adjust Clutch
		Irregular (same circuit)	Uneven Cork Roll	1 — Adjust Clutch 2 — Grind or Replace Cork Roll
	Dip 3 (both a & b) (usually rough start — with or with- out bridge)	$> 0$ msec	L† Relay Reoperation and Sleeve Brush Overthrow	Correct Dip 3a
Irregular (same circuit)		L† Relay Variation in Degree of Reoperation		
6	Sawtooth	Various	Pitted or Dirty Cams	Clean Cams and Check Spring Tension

\* Ragged plateau indicates poor L relay adjustment.

† Corresponds to T relay of incoming.

$<$  Less than

$>$  Greater than

$\geq$  Greater than or equal to

$\approx$  Approximately

## 6. MECHANICAL RELATIONSHIPS

**6.01** Fig. 1A, 1B, and 1C show the ideal BSP relationships between the rack, pawl, multiple sleeve brush, bank terminals, C commutator spring, and the commutator.

**6.02** Fig. 1A shows the relationship of these elements at the instant the sleeve brush leaves the busy terminal.

**6.03** Fig. 1B shows the relationship at the instant the C commutator breaks. The rack must travel 0.025 inch upward for the pawl to engage and the sleeve brush must travel 0.100 inch upward in order to break from the selected terminal. During the time the updrive magnet is energized, the rate of travel is 0.0075 inch per msec. Therefore, if it takes the L relay 3 msec after the C commutator breaks to open the updrive magnet circuit, the selector rod will travel 0.0225 inch in that time. The overthrow from that point depends mainly on the de-energize time of the updrive magnet, the inertia of the rod, and friction.

**6.04** The C commutator insulated section (0.040 inch) less the C commutator spring thickness (0.016 inch) is 0.024 inch. With normal updrive, the interval of open spring should be 3.2 msec (calculated).

**6.05** Fig. 1C shows the mechanical relationships when the selector brush nest has come to rest on the selected terminal. The left brush will meet the ideal BSP requirement when it is exactly centered on the terminal. That is, it will not break from the terminal until it has been raised 0.075 inch. The right brush can be adjusted anywhere between the position of the left brush and the dashed brush (maximum stagger). There is no advantage in brush stagger except ease of adjustment.

## 7. REFERENCE MATERIAL COVERING DETAILED ADJUSTMENT PROCEDURES

**7.01** Apparatus adjustments recommended in this BSP may be made in accordance with the following BSP sections covering requirements and adjusting procedures:

026-120-701 — Panel Selector Commutators and Commutator Brushes.

026-125-704 — Elevator Apparatus, Panel Selectors (in 2.13 and 3.13, Bridging Spring Location — Use of 9761 clamp and 121A gauge replaces use of 396A rack locator and flash-light. Upward travel of sleeve spring should be 0.075 inch +0.005 inch, -0.00 inch. See 7.02).

026-115-701 — Clutches, Helical Spring Type Without Release Springs.

026-115-702 — Clutches, Helical Spring Type With Release Springs.

**7.02** Vertical alignment of the multiple sleeve brushes is accomplished with the use of the 9761 clamp. The clamp is a combination tool incorporating a clamp, lamp, slide gauge, and holder for a 121A dial gauge. It was designed especially for the checking and adjustment of sleeve brush positions and provides greater facility and accuracy than methods formerly used. A photograph of the clamp, with dial gauge attached, mounted on the selector frame in position for checking (sliding gauge extended) is shown in Fig. 15. Fig. 16 illustrates the manner in which the sliding gauge must be inserted to raise the selector rod 0.075 inch.

**7.03** The procedure for using the 9761 tool is as follows:

**Note:** Replace the plunger extension on the 121A gauge with the one which comes with the 9761 clamp. Add washer if it is necessary to increase the plunger extension.

(1) Attach the 121A gauge to the post with the knurled nut so that the plunger stem fits into the slot in the clamp.

(2) Raise selector rod to 49th terminal and trip desired brush.

(3) Attach 9761 clamp to rod on the top side of a convenient bearing plate. The slide-gauge at bottom of clamp must be pulled out so the front edge of the clamp body can rest firmly on the bearing plate.

SECTION 215-171-301

- (4) Adjust 121A gauge for a zero dial reading.
- (5) Connect lamp in series with 90-volt battery box, multiple sleeve brush, and 49th sleeve bank terminal. Lamp should now light.
- (6) Push in the slide-gauge. The rod should move up and the 121A gauge should indicate the amount of travel. The sleeve brush should remain in contact with the 49th terminal unless the rod is moved up more than 0.075 inch +0.005 inch, -0.000 inch. The slide-gauge has a lo-step and a hi-step. The lamp usually will be extinguished between steps if the sleeve brush is positioned prop-

erly. Adjustment of the sleeve brush can be made on either step. The proper step for adjustment is the one which gives a reading between 0.075 inch and 0.080 inch on the 121A gauge. Step selection is necessary because of tolerances on the slide gauge and the fact that some bearing plates are not perpendicular to the rods.

*Note:* The back edge of the slide-gauge will be flush with the rear edge of the clamp body when the lo-step is on the bearing plate.

*Caution:* When the slide-gauge is pushed in all the way, the rod will rise above the hi-step.

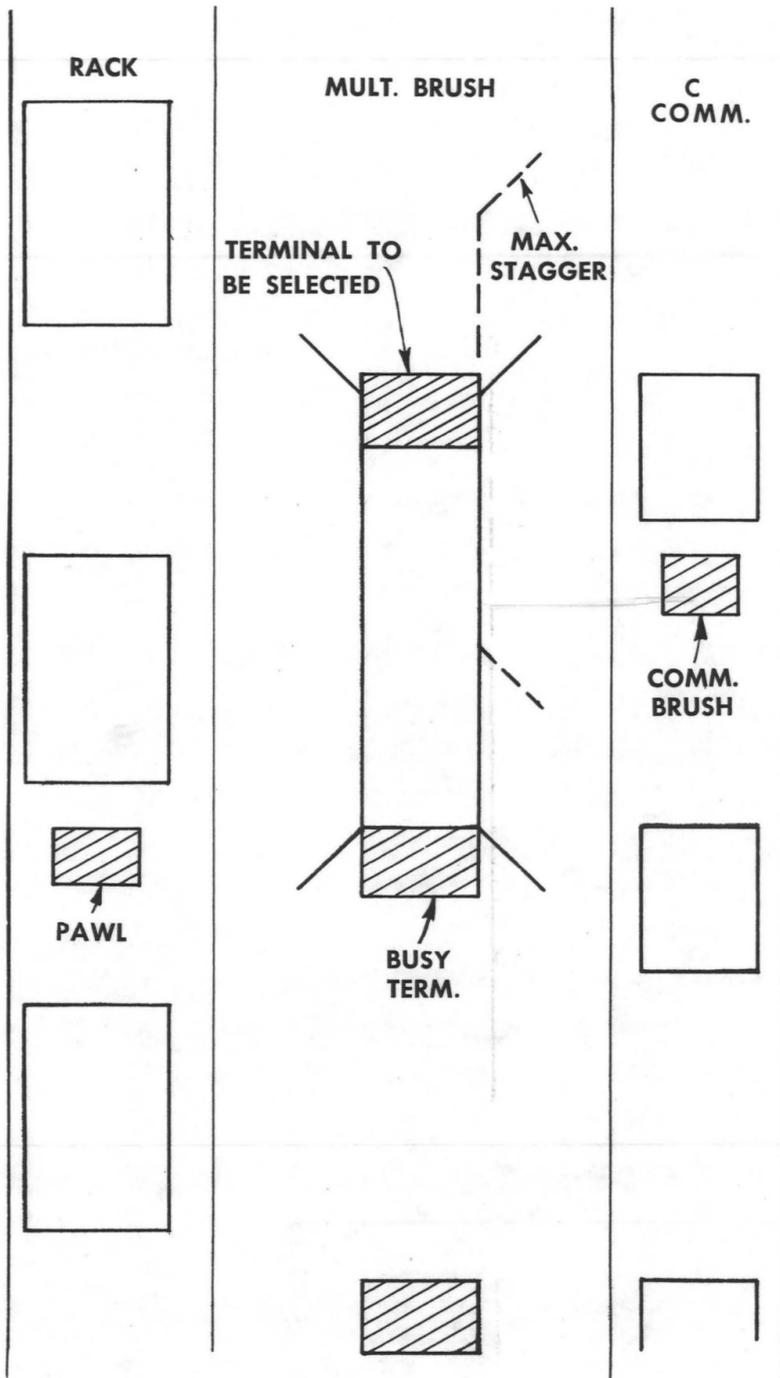


Fig. 1A

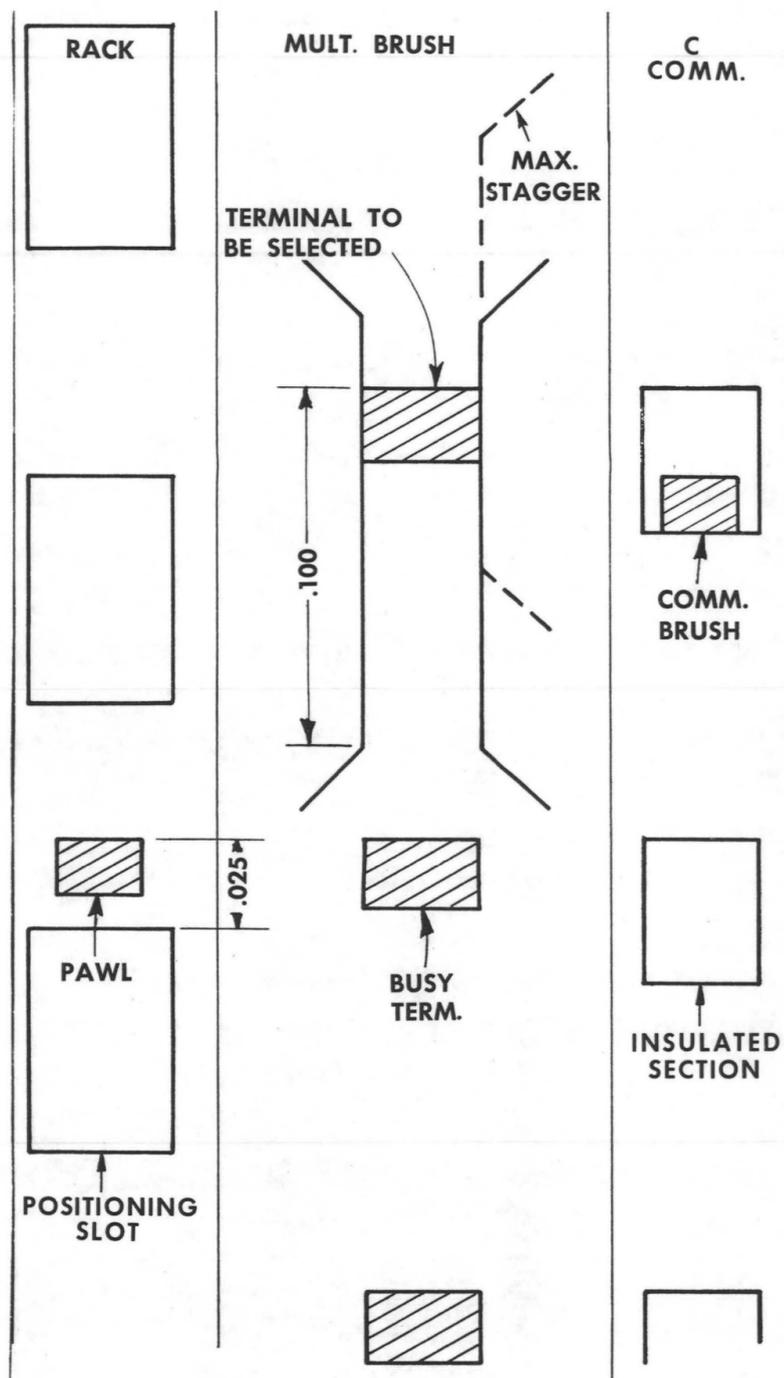


Fig. 1B

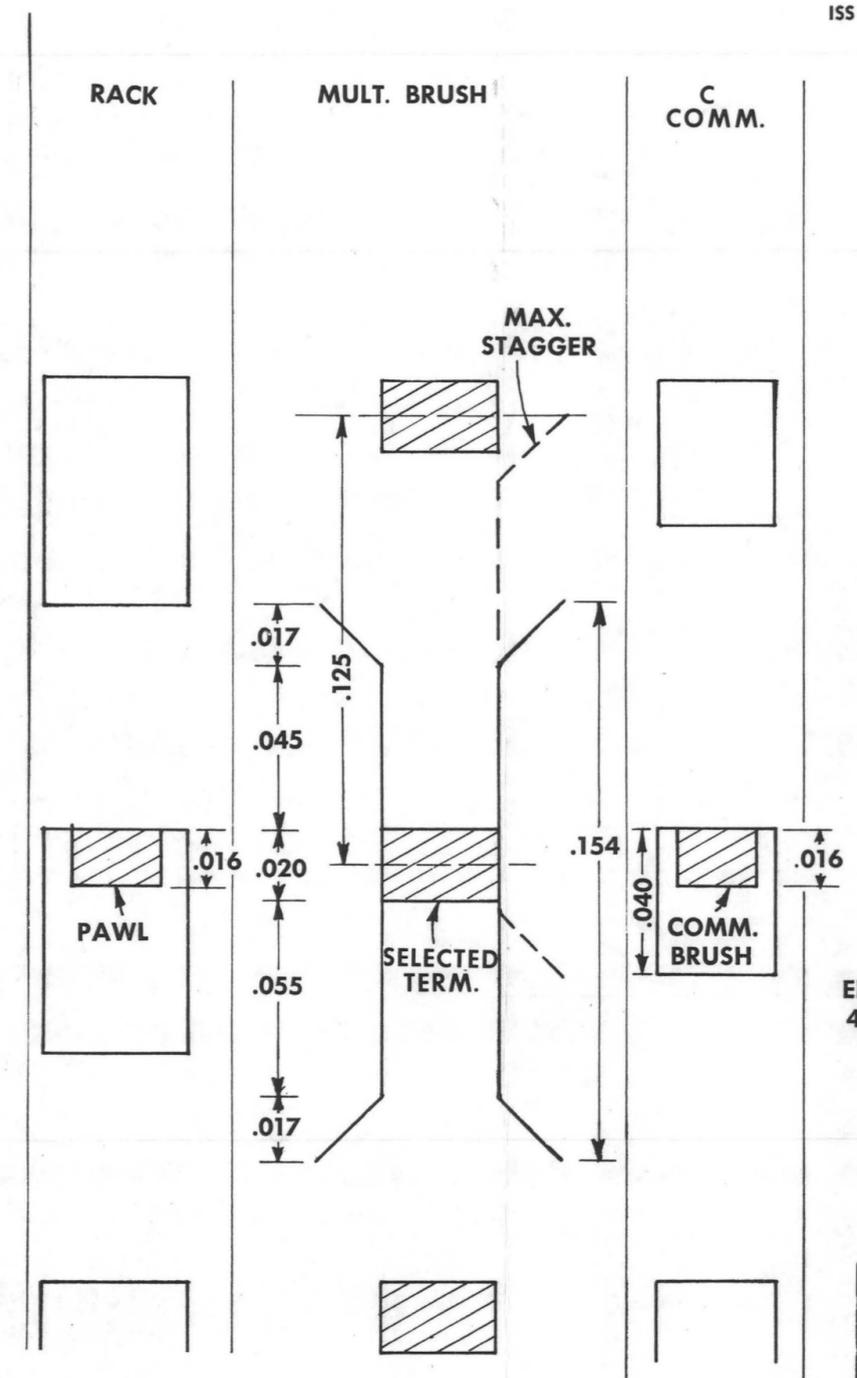


Fig. 1C

Fig. 1 - Ideal Adjustment of Sleeve Multiple Brush and Commutator Brushes

ENGINEERS SCALE  
40 DIV./INCH OR  
.001" x 1/40"

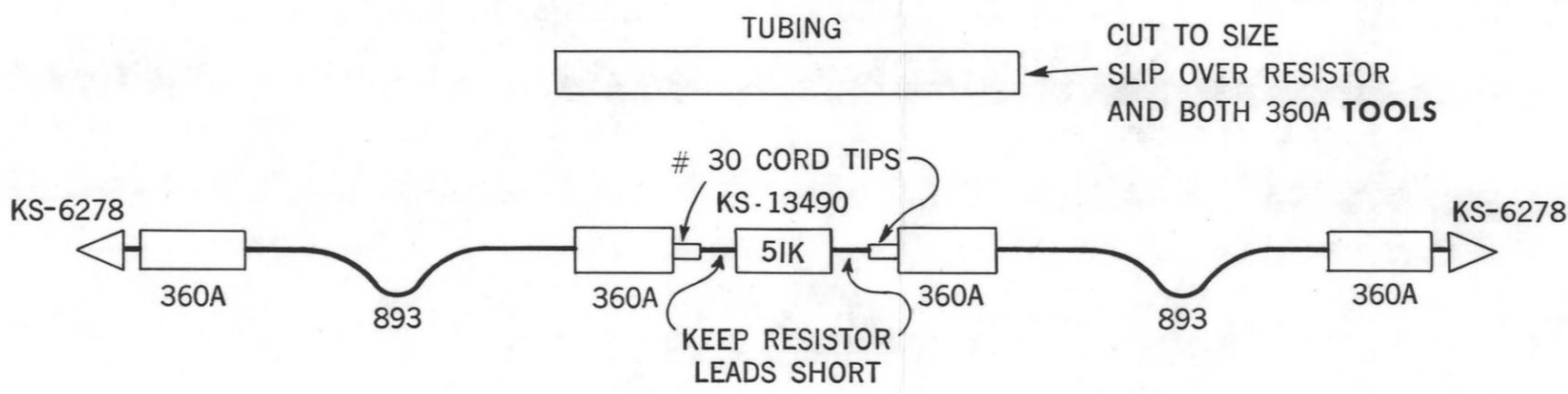
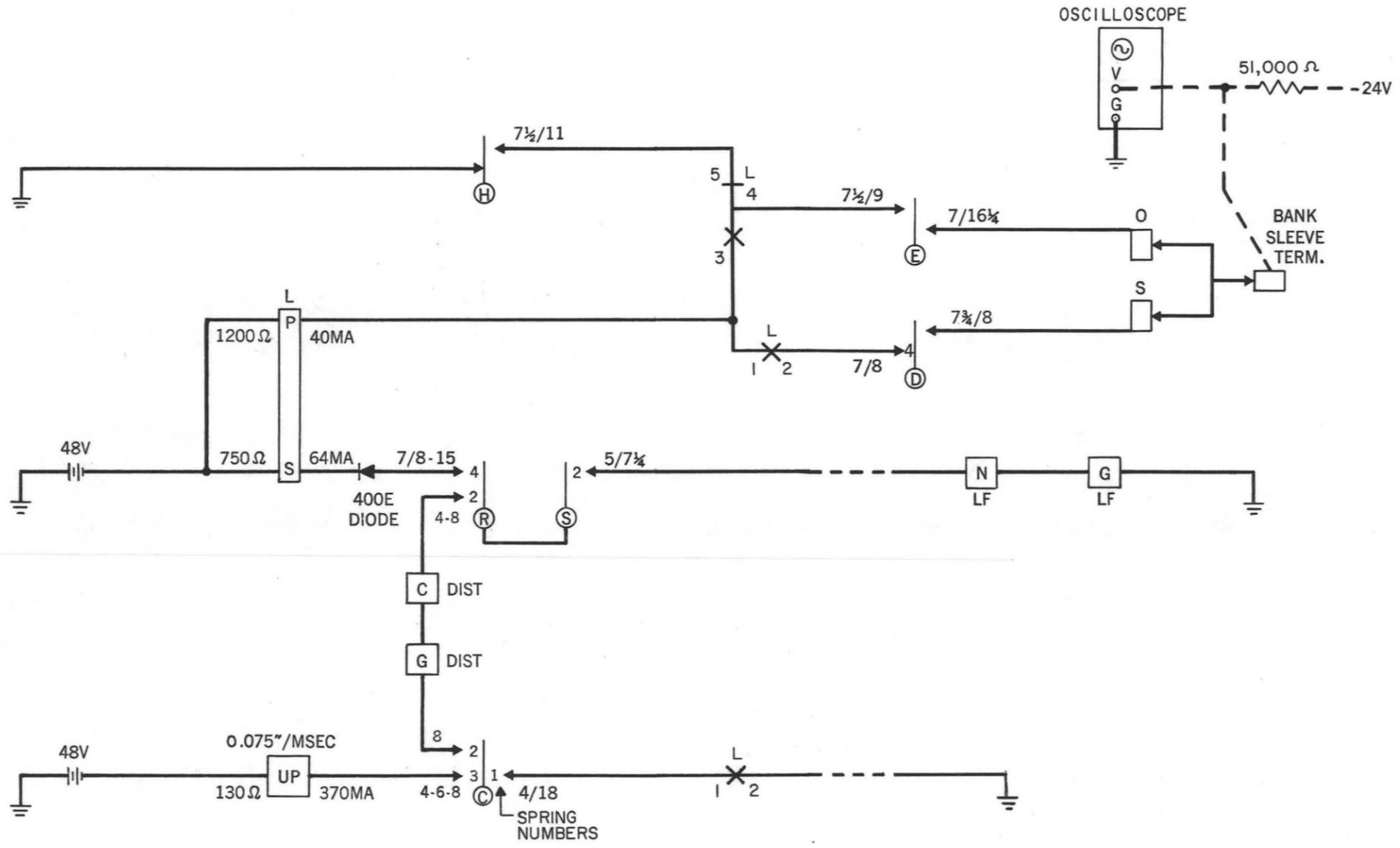


Fig. 2 - Oscilloscope Test Lead

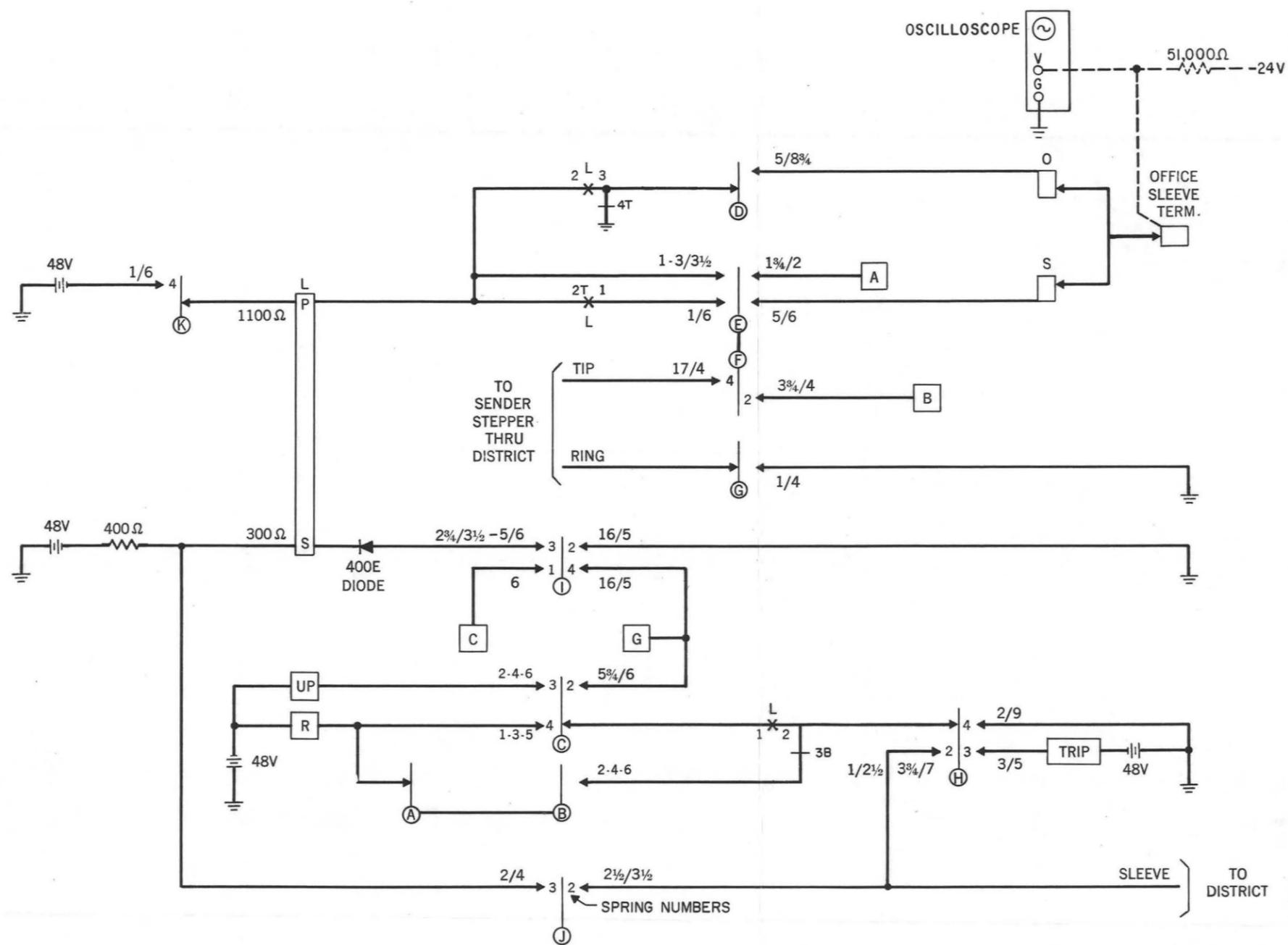


SEQUENCE SWITCH  
5°/20 MSEC  
20° BETWEEN POSITIONS

FROM SD 21627

Sequence Switch Position	Operation
7	L operates on secondary through N and G
8	Selector updrive magnet energized
Circuit Action Preceding Start of Trace	Hunt for idle terminal
	L holds on primary through busy sleeve terminal
	L secondary also energized each time C commutator brush makes
Circuit Action Observed on Scope	Reach idle terminal
	Sleeve brush breaks from preceding terminal
	L primary opens since idle sleeve is open
	L holds on secondary through C commutator
	C commutator brush breaks
	L releases
	Updrive magnet releases
C remakes	
	Sleeve brush centers on selected terminal

Fig. 3 - District Selector Hunting Circuit



FROM ES 240252

Fig. 4 - Office Selector Hunting Circuit

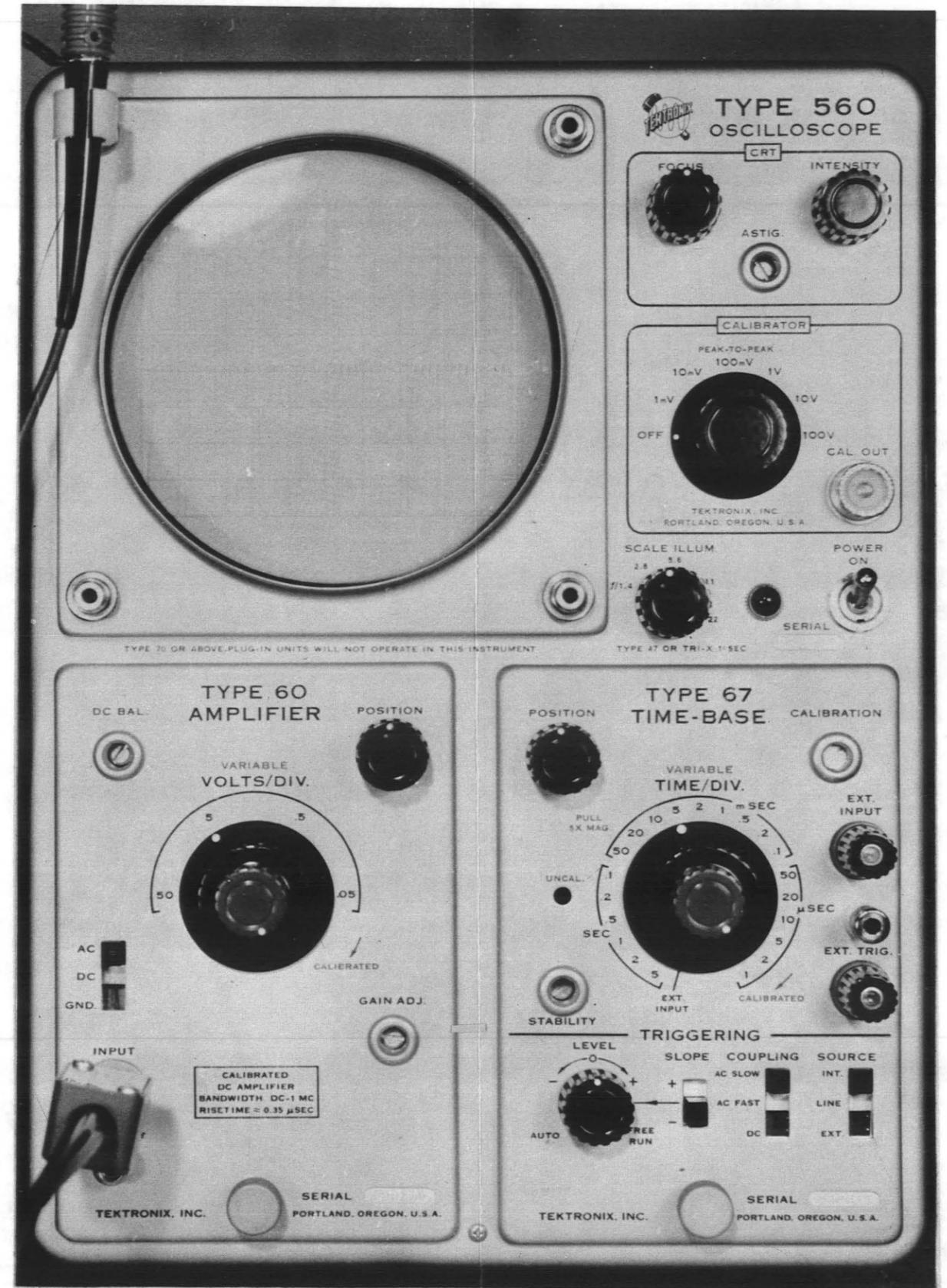


Fig. 5 - Setting of Oscilloscope Controls



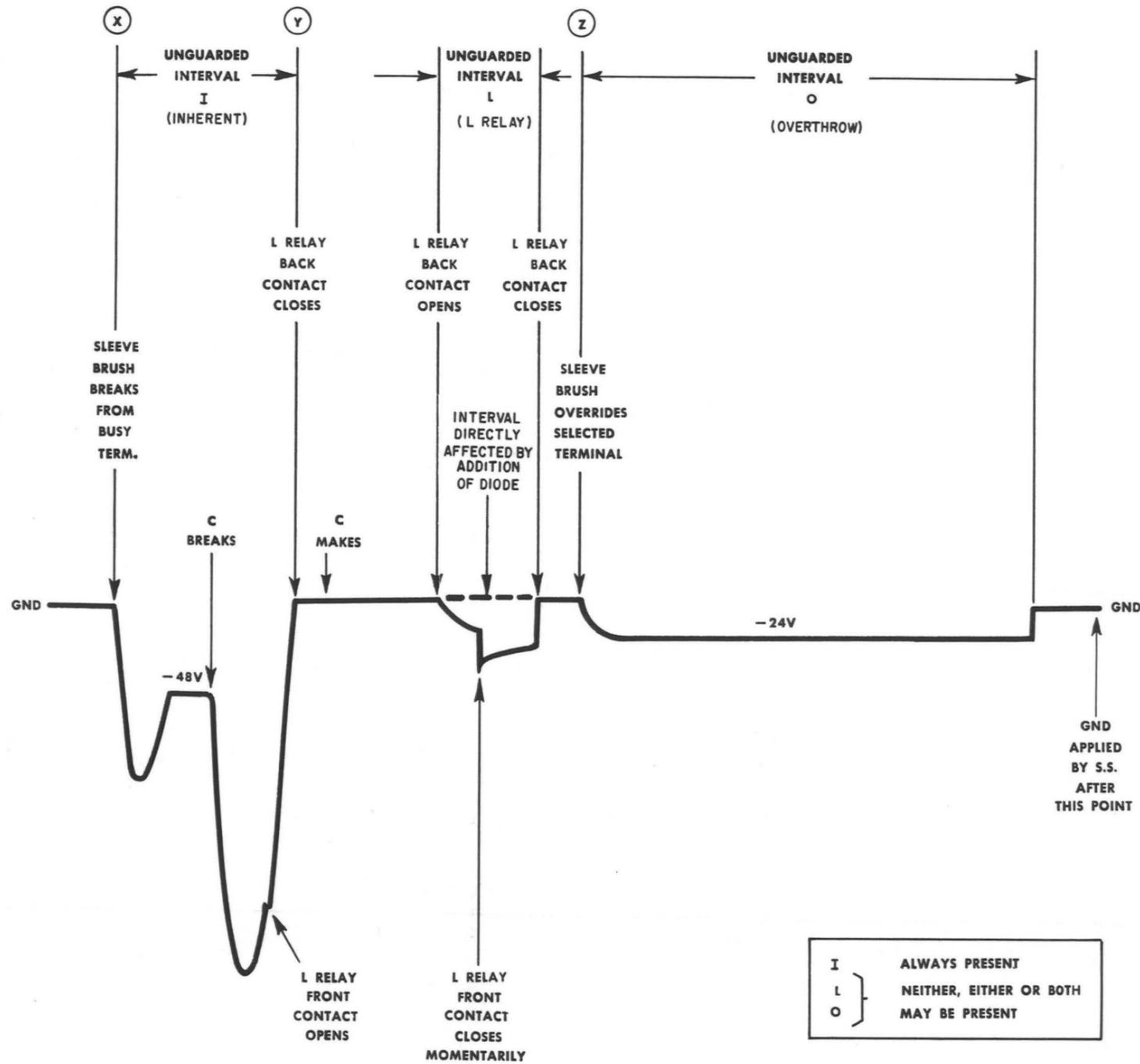


Fig. 7A - Diagram of Typical Oscilloscope Trace of Unguarded Intervals on Test Sleeve Terminal

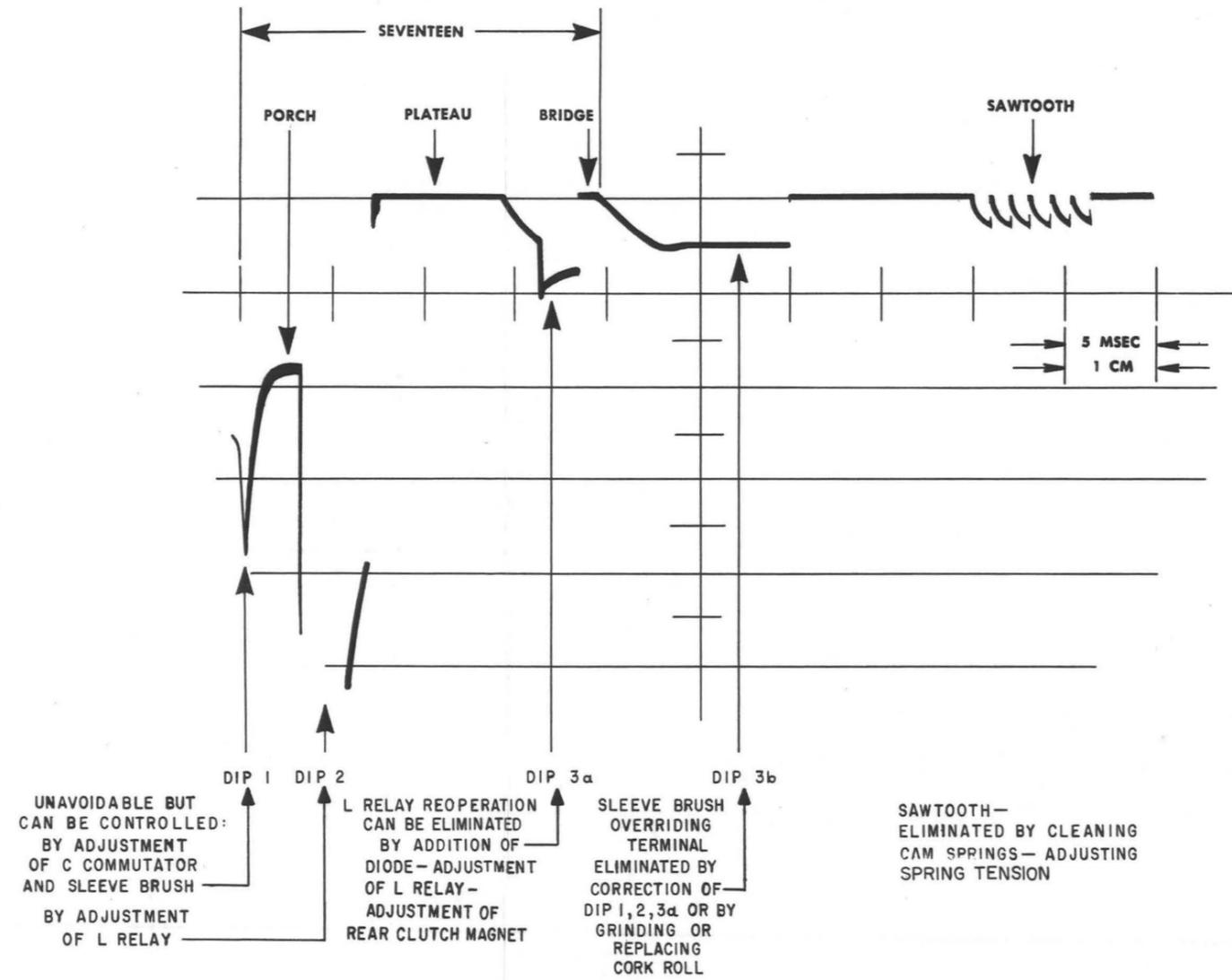
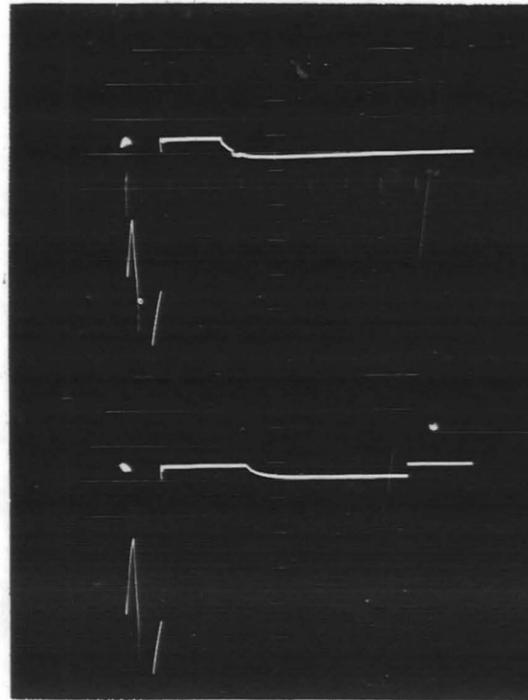


Fig. 7B - Sketch of Typical Oscilloscope Trace of Unguarded Intervals with Time Scale and Abbreviated Nomenclature

Fig. 7A and 7B

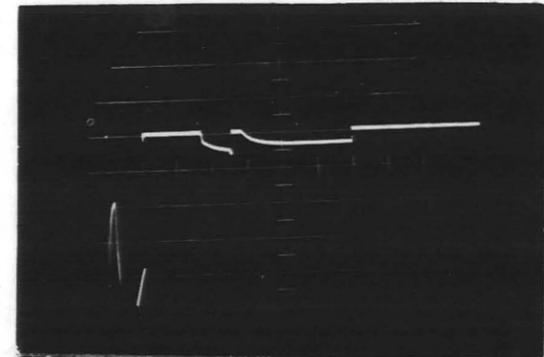
AS FOUND



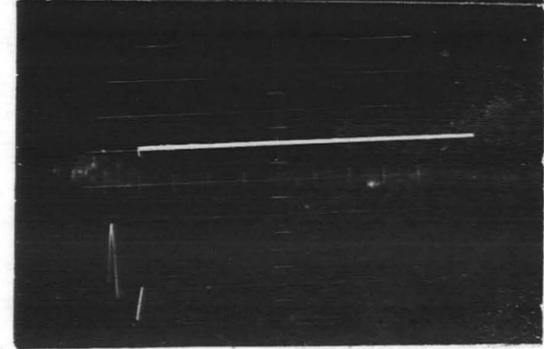
Picture 8A

CLUTCH ADJUSTED

DIODE OUT



DIODE IN

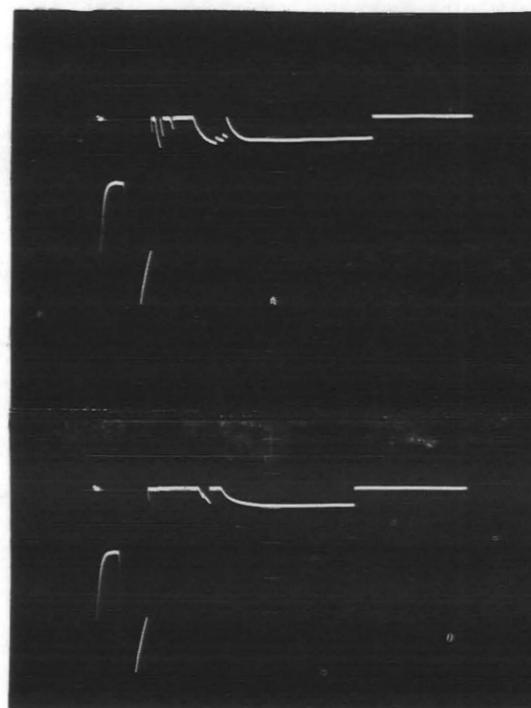


Picture 8B

SCALE 5 MSEC/CM

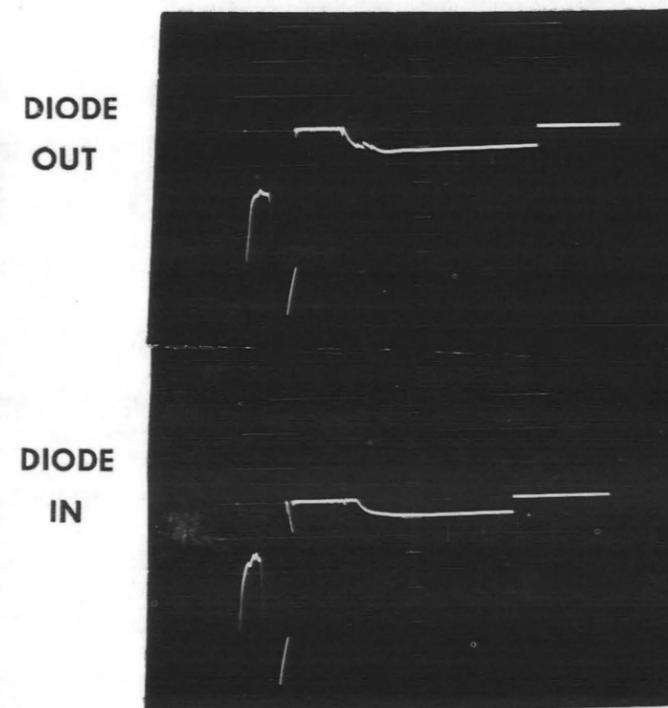
Fig. 8 - Sleeve Traces Obtained from Operating Equipment - District Selector Circuit

AS FOUND



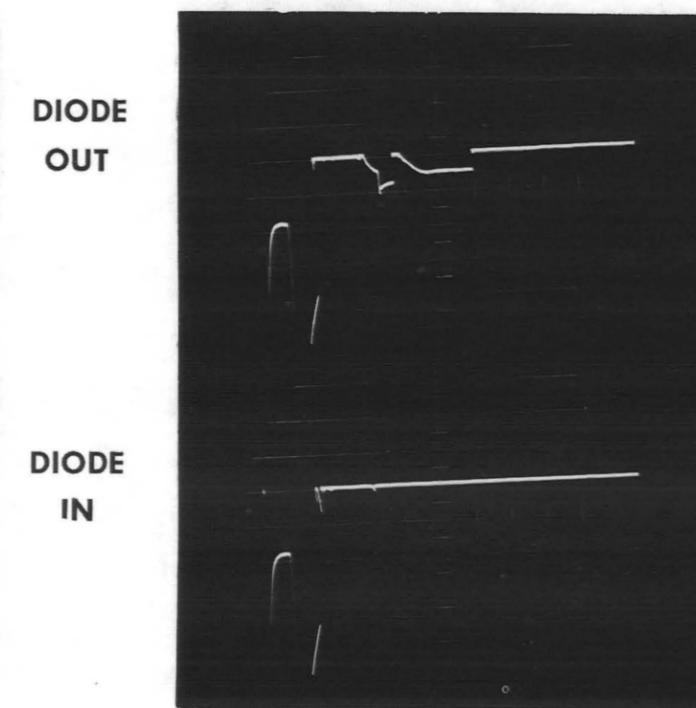
Picture 9A

L RELAY ADJUSTED



Picture 9B

CLUTCH ADJUSTED



Picture 9C

SCALE 5 MSEC/CM

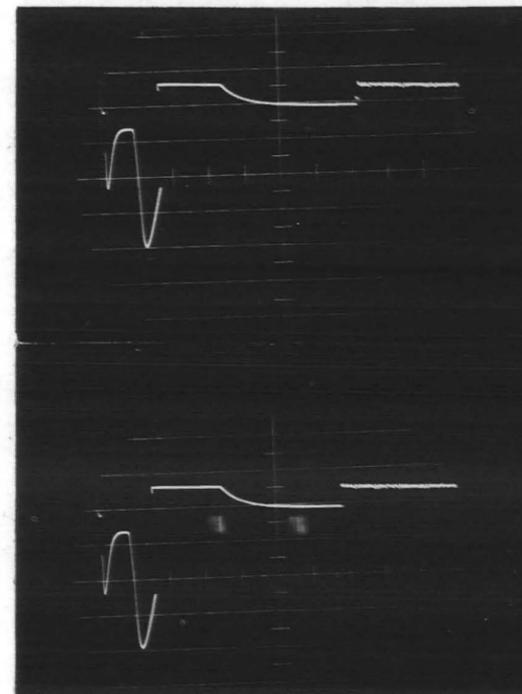
Fig. 9 - Sleeve Traces Obtained from Operating Equipment - District Selector Circuit

AS FOUND



C COMMUTATOR ADJUSTED  
WITHIN BSP REQUIREMENT

DIODE  
OUT

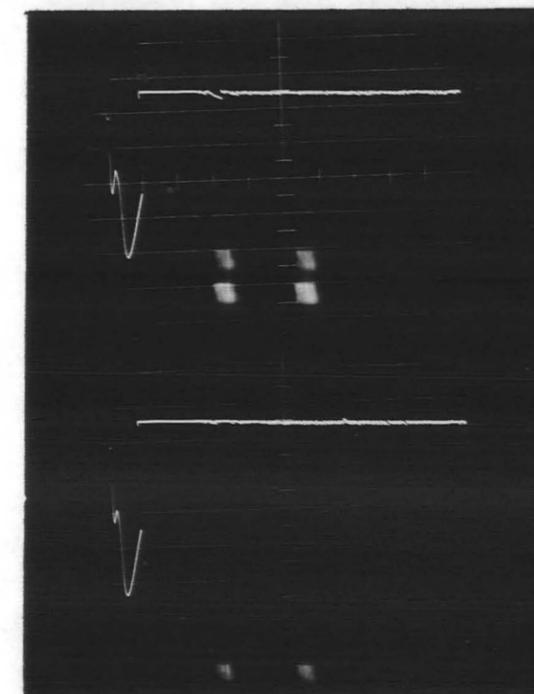


DIODE  
IN

1. C COMMUTATOR  
RE-ADJUSTED TO HIGH  
SIDE OF BSP REQ.

2. SLEEVE BRUSH ADJUSTED

DIODE  
OUT



DIODE  
IN

Picture 10A

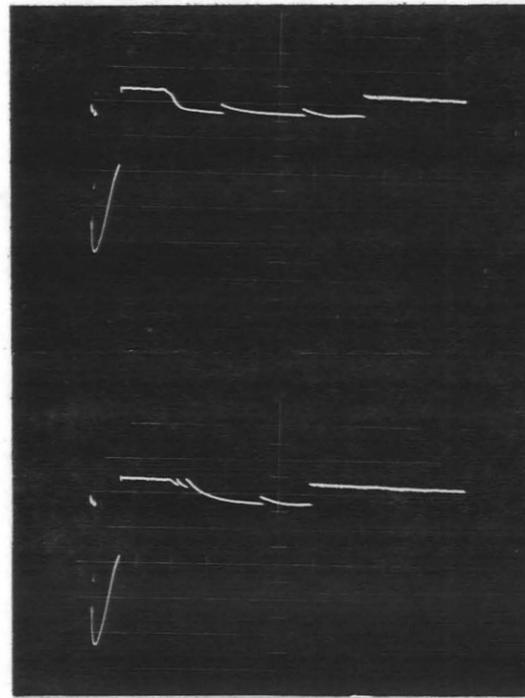
Picture 10B

Picture 10C

SCALE 5 MSEC/CM

Fig. 10 - Sleeve Traces Obtained from Operating  
Equipment - District Selector Circuit

AS FOUND



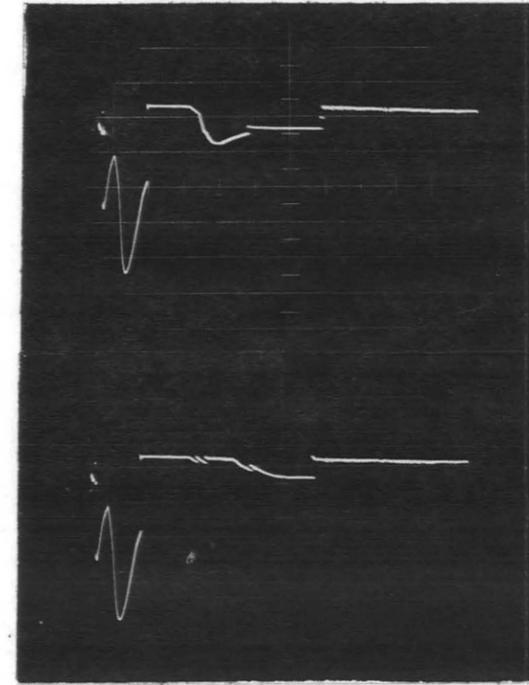
DIODE  
OUT

DIODE  
IN

Picture 11A

SCALE 5 MSEC/CM

SLEEVE BRUSH ADJUSTED  
(.020" HIGH)

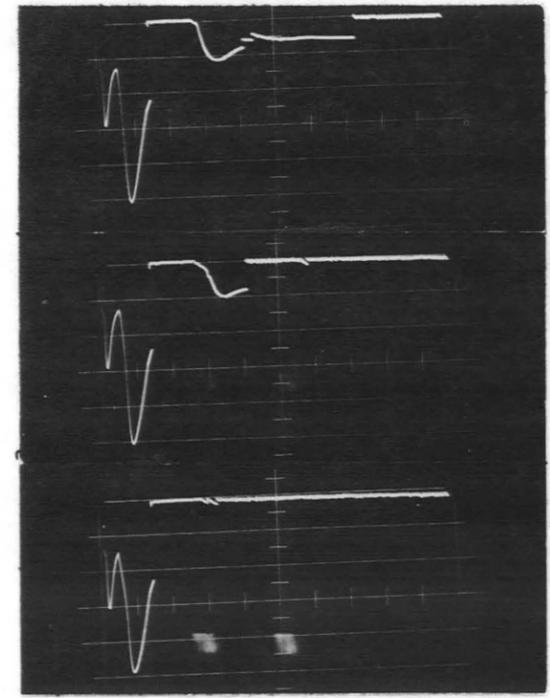


DIODE  
OUT

DIODE  
IN

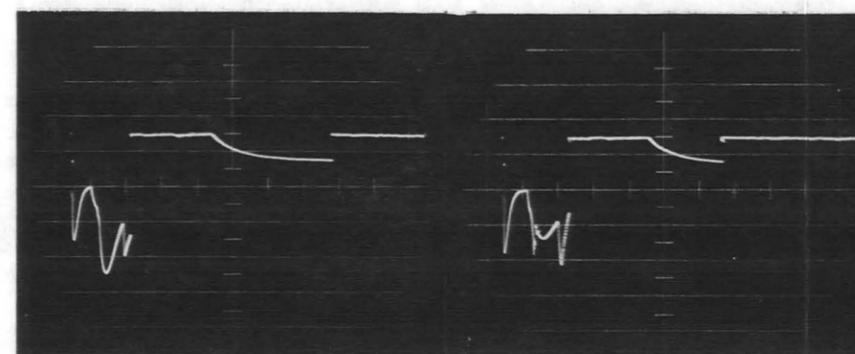
Picture 11B

CLUTCH ADJUSTED

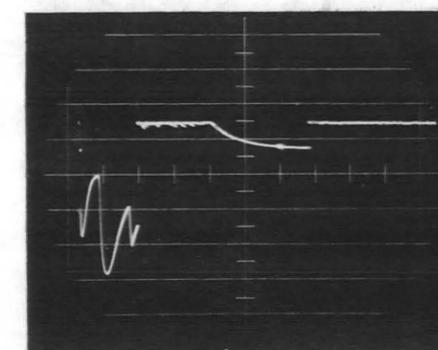


Picture 11C

Fig. 11 - Sleeve Traces Obtained from Operating Equipment - District Selector Circuit (Cork Roll Slightly Uneven)

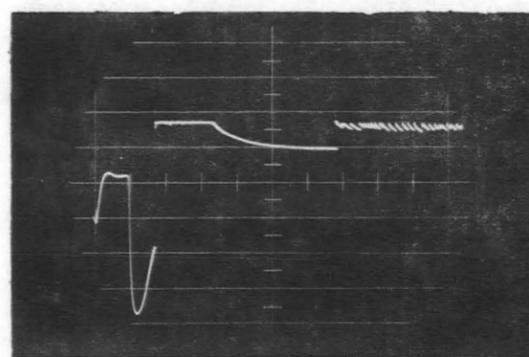


Picture 12A

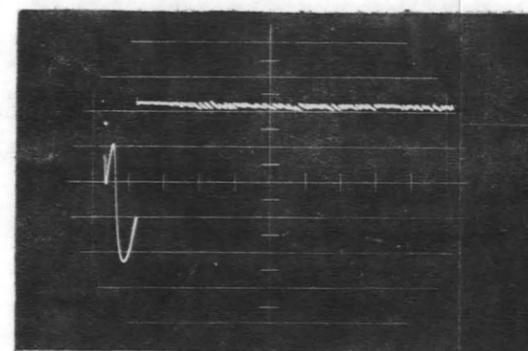


Picture 12B

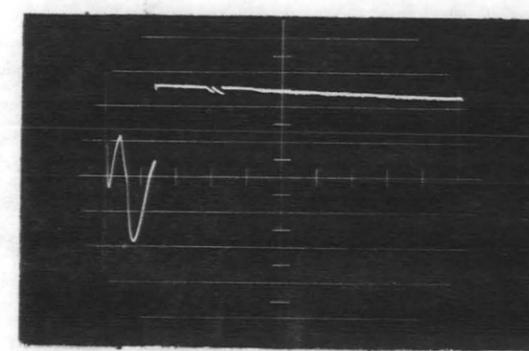
Fig. 12 - Sleeve Traces Obtained from Operating Equipment - Office Selector Circuits - As Found Sleeve Terminal



Picture 13A



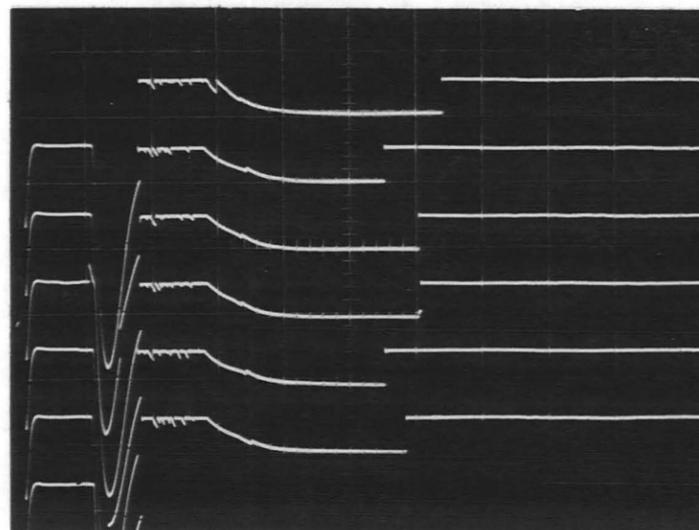
Picture 13B



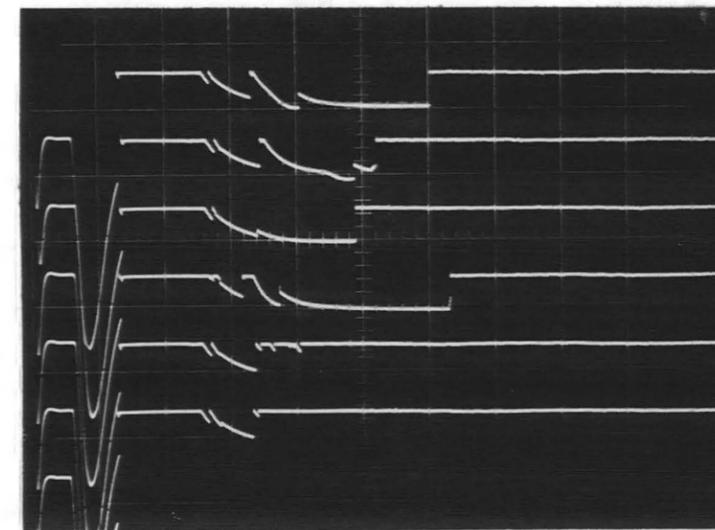
Picture 13C

SCALE 5 MSEC/CM

Fig. 13 - Sleeve Traces Obtained from Operating Equipment - District Selector Circuits - As Found Sleeve Terminal



Picture 14A



Picture 14B

SCALE 5 MSEC/CM

Fig. 14 - Sleeve Traces Obtained from Operating Equipment - District Selector Circuits - As Found Sleeve Terminal

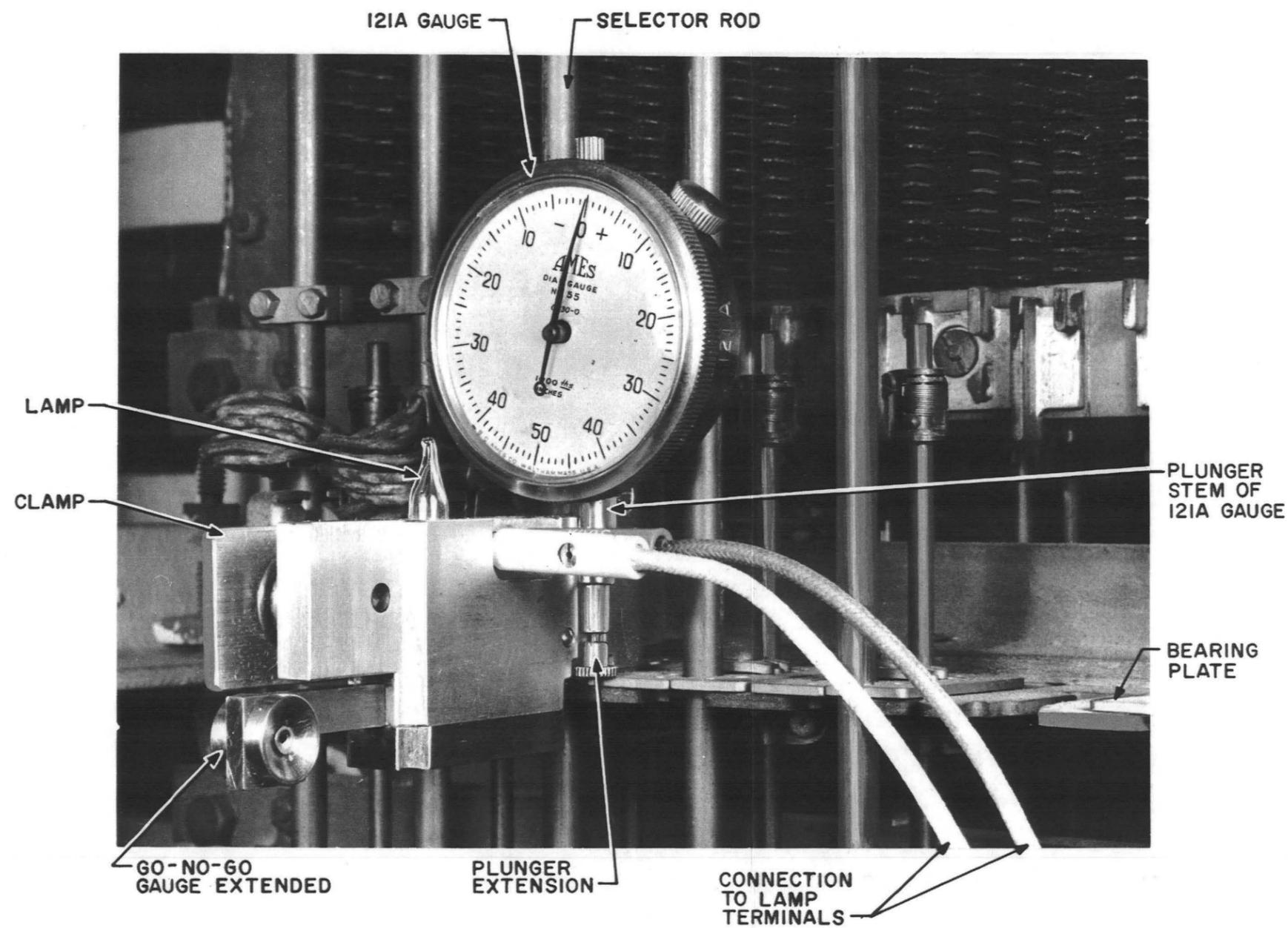


Fig. 15 - 9761 Clamp — Used with 121A Gauge in Checking Alignment of Sleeve Multiple Brushes — Brush Centered on Terminal

GO-NO-60 GAUGE  
INSERTED TO RAISE  
SELECTOR ROD 0.075"

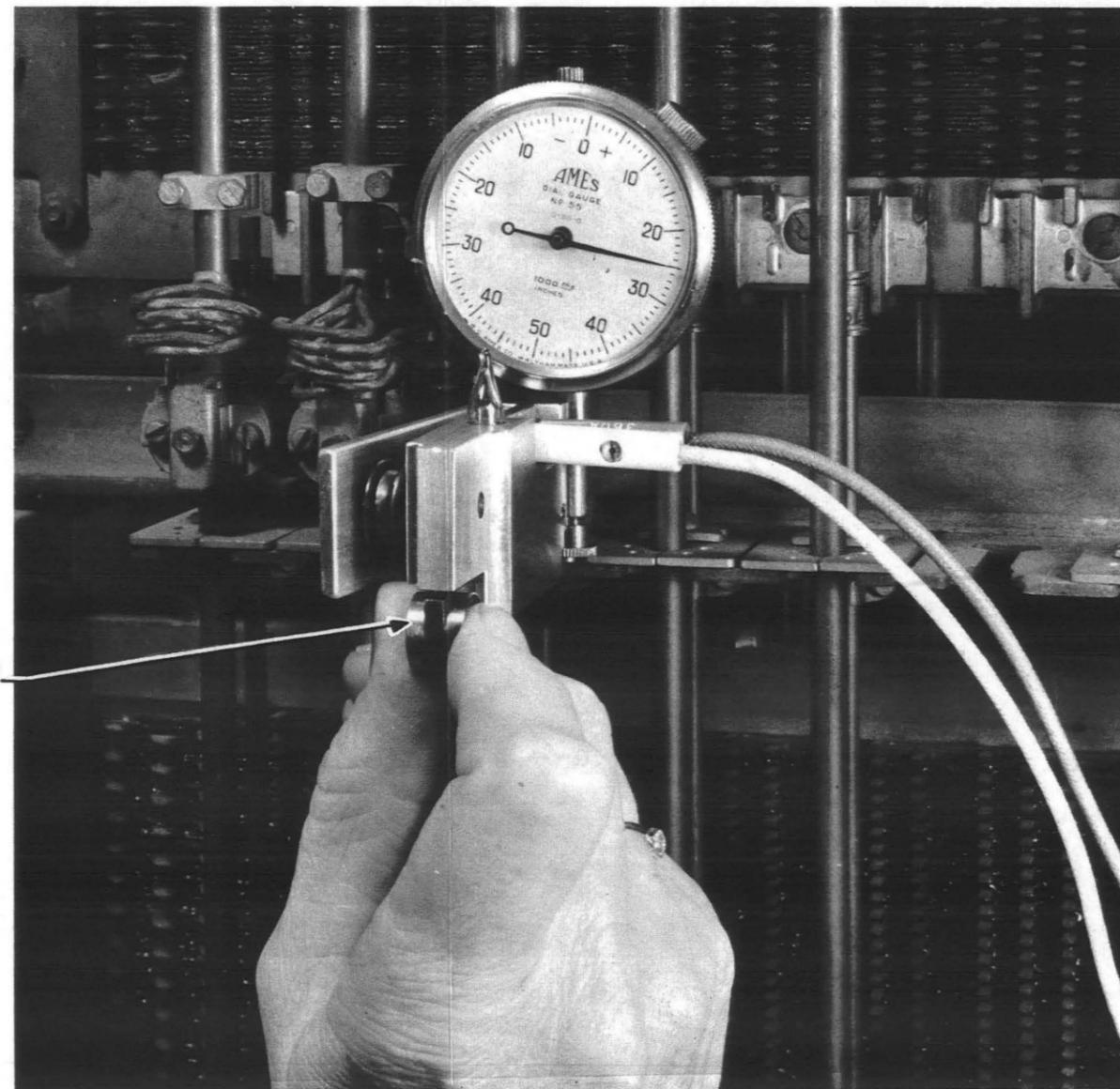


Fig. 16 - 9761 Clamp - Used with 121A Gauge in  
Checking Alignment of Sleeve Multiple  
Brushes - Selector Rod Raised 0.075 Inch