FAR END (CODE 104) AND NEAR END TRANSMISSION MEASURING AND NOISE CHECKING CIRCUIT

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1. INTRODUCTION

1.01 This section describes the transmission measuring and noise checking circuit which is used at the terminating end of an intertoll trunk for 2-way transmission loss measurements and noise checks made from the outgoing end of the trunk. Section A204.022 covers the methods of testing the far-end transmission measuring and noise checking equipment. Descriptions of the AOIT and ATTC equipment used at the outgoing end in a No. 4-type toll crossbar office for full automatic tests are given in Sections A728.111 (E40.750) and A728.112 (E40.751), respectively.

1.02 The transmission measuring and noise checking equipment used at the terminating or far end, referred to as "far-end equipment," provides means for making a 2-way transmission loss measurement and noise check from the originating or near end (outgoing end) of a dial-type intertoll trunk. The terminating office (far end) may be a No. 4-type toll crossbar, step-by-step intertoll, crossbar tandem, or No. 5 crossbar toll office. The test may be made on a full automatic basis or the test call may be set up manually. A full automatic test originates from an AOIT in a No. 4-type toll crossbar office. In this case the equipment in the No. 4-type office, sometimes referred to as "near-end equipment," can make a transmission loss measurement of the trunk in each direction and a noise check at each end of the trunk and can record the results on a teletypewriter record on a full automatic basis. For a manually dialed test, a testboard attendant at the outgoing or originating end, which can be any type of toll office, dials code 104 over the trunk to be measured to reach the far-end equipment. The attendant can then measure the transmission loss of the trunk in each direction and make a noise check at the far end without assistance at the far end.

1.03 The general method of making a 2-way transmission loss measurement from one end of an intertoll trunk is as follows. The originating or near end sends 1-mw test power over the trunk and the far end measures the loss. In this process the far end adjusts a transmitting pad so that the transmitting pad loss is equal to the trunk loss in the near-to-far direction, if the trunk loss is less than 10 db. If the trunk loss in the near-to-far direction is 10 db or more, the transmitting pad is adjusted so that its loss is 10 db less than the trunk loss. The far end then returns 1-mw test power over the trunk twice. The first time the far end sends directly over the trunk and the near end measures the trunk loss in the far-to-near direction directly. The second time the far end sends through the transmitting pad and the near end then measures the trunk loss in the far-to-near direction plus the loss of the transmitting pad at the far end. These two measurements at the near end thus provide information from which the trunk loss in each direction can be determined.

1.04 An automatic noise check of the "go-no-go" type is used to determine roughly whether the noise exceeds a prescribed value. For this check the measuring equipment is arranged to integrate the noise voltage over an interval of approximately 5 seconds. By means of optional wiring the noise checking limit may be set to give a noise indication when the noise exceeds a single, preset value of 35, 40, or 45 dba. The value chosen depends upon the general noise conditions to be expected in the particular office. The measuring equipment provides F1A noise weighting during the noise check. At the end of a test the far end returns suitable signals to advise the near end regarding the noise condition at the far end.

1.05 The far-end equipment includes an amplifier, an amplifier-rectifier, adjustable pads which are relay controlled, control circuit relay equipment, and 2, 3, or 4 test lines. The equipment is mounted on a miscellaneous relay rack as shown in Fig. 1. The test lines appear on the outgoing link frames or switches of the office switching train like trunk circuits. Incoming code 104 calls are routed to these test lines. The test lines then connect to the measuring circuit, one at a time, through a sequence chain circuit as the measuring circuit becomes idle. Thus, if test calls arrive from different originating offices at about the same time, they wait on the test lines and are served by the measuring circuit, one at a time, in their proper turn.

1.06 The far-end equipment requires connection to the 115-volt ac power service for the heater circuits of the electron tubes and connection to the +130-volt plate battery and to either the —130-volt telegraph or signal battery or to the —110-volt coin battery for the plate supply. Two outlets are required from the 1-mw test power supply, one 600-ohm outlet and one outlet corresponding to the nominal impedance of the toll office. Usually only one far-end equipment is needed but two or more, each with its own group of test lines, may be provided, if necessary, to carry the office test load.

2. MEASURING METHOD

A. General

2.01 The method of making the transmission loss measurement is shown in Fig. 2. The standard 1-mw source of 1000-cycle test power is used at the sending end. The receiving end includes an amplifier, a set of receiving pads which are relay controlled and an amplifier-rectifier with a 280-type polar relay, P, in its output circuit. The amplifier is always set at a fixed gain of 19.9 db and it includes a considerable amount of negative feedback to keep its gain constant. The receiving pad loss is adjustable from 0 to 19.9 db in 1/10 db steps and is 0 db at the start of a measurement.

2.02 The gain of the amplifier-rectifier is set so that P relay in the output circuit will operate to its No. 2 contact when the power level at the output from the receiving pads in Fig. 2 is 1 mw, or higher, and so that P relay will release and close its No. 3 contact when the power level at this point is reduced to only 0.1 db below 1 mw. Consequently, P relay can detect a power level change at its operating point within very narrow limits.

2.03 The method of making a measurement, therefore, is as follows. When the test power arrives P relay operates to its No. 2 contact. This causes the associated control circuit to function. The control circuit increases the loss in the receiving pads until the power level at their output is reduced to exactly 1 mw. At this point P relay releases and closes its No. 3 contact. This prevents any further increase in the receiving pad loss. The sending end connects the test power for about 3 seconds which gives ample time for the pad adjustment to be completed. Since the gain of the amplifier is always set at 19.9 db, the receiving pad loss, when the adjustment is finished, will be related to the trunk loss as follows:

Receiving pad loss = 19.9 db — trunk loss.

B. Adjustment of Receiving Pads

2.04 The action which takes place during the pad adjustment is illustrated in Fig. 2. The receiving pads consist of nine separate pad units having losses of 10, 5, 4, 2, 1, 0.5, 0.4, 0.2, and 0.1 db, respectively. Each pad unit is inserted in the transmission path by a corresponding pad control relay 10, 5, etc. At the start of a measurement all relays are normal so that the total receiving pad loss is 0 db.

2.05 The windings of the pad control relays are connected to the contacts on a 204-type selector. When the test power arrives, P relay operates to its No. 2 contact and, through means not shown, starts the control circuit. The control circuit includes the pulsing relay which drives the selector at about 7 to 8 steps per second.

2.06 On the first pulse, the pulsing relay operates. This (1) opens the input to V4 tube in the amplifier-rectifier ("M" and "D" leads in Fig. 5), which causes P relay to release and close its No. 3 contact, (2) advances the selector to position 1 and, (3) operates pad control relay 10 through brush 1 and position 1 of the selector. Relay 10 locks and inserts the 10-db receiving pad unit which reduces the power level. A moment later, during the open period of the pulse, the pulsing relay releases and recloses the input to V4 tube of the amplifier-rectifier. P relay will now reoperate if the power level at the output from the receiving pads is still 1 mw or higher; otherwise, it will remain on its No. 3 contact.

2.07 The method of control, therefore, is as follows: If the power level, after the 10-db pad is inserted, is less than 1 mw, P relay will remain on No. 3 contact during the open period of the pulse. The +130-volt battery at No. 3 contact will then be routed through brush 2 of the selector to the winding of relay 10 and cause relay 10 to be immediately shunted down. This removes the 10-db pad unit before the selector is advanced to position 2. However, if power level is 1 mw, or higher, P relay will operate and open its No. 3 contact during the open period of the pulse so that relay 10 cannot be shunted down. Relay 10 will then be left locked in the operated position and will retain the 10-db pad as the selector is advanced to position 2.

2.08 As the selector is advanced, a pad unit is inserted at each step in the order 10 db, then 5 db, then 4 db, etc. If the power level at any step drops below 1 mw, after the pad unit is inserted, the control relay for that pad unit will be shunted down to remove the pad. Then, at the next step, the next lower value of pad will be tried. However, if the power level at any step is still 1 mw, or higher, after the pad unit is inserted, the pad control relay for that unit will remain locked in the operated position to retain the pad. Then, at the next step, the next lower value of pad will be added to further reduce the power level. At position 9 of the selector all nine receiving pad units will have been tried, ending with the 0.1-db pad, and sufficient loss will have been added in the receiving pads to reduce the power level at their output to 1 mw. In this process some of the nine pad control relays may have been shunted down and some left locked in the operated position.

2.09 The pad control relays which are left in the operated position indicate, additively, the receiving pad loss. For example, if the trunk loss is 7.3 db the receiving pad loss will be adjusted to 12.6 db (19.9 — 7.3 = 12.6) by leaving relays 10, 2, 0.5, and 0.1 locked in the operated position. At the near end, contacts on the pad control relays are used to translate the pad control relay settings to the loss of the trunk being measured when the results of the test are recorded. At the far end, the operated relays retain the loss setting of a set of transmitting pads.

C. Transmitting Pads

2.10 The transmitting pads at the far end, shown in Fig. 2, consist of eight pad units having losses of 5, 1, 2, 1, 0.5, 0.1, 0.2, and 0.1 db, respectively. These also are controlled by the pad control relays. The total loss at the start of a test is 9.9 db. When a pad control relay operates to insert a receiving pad it removes an equal loss from the transmitting pads, except for the 10-db pad unit relay. There is no counterpart for the 10-db receiving pad unit in the transmitting pads. Therefore, when the receiving pad adjustment is finished, the loss remaining in the transmitting pads will also be related directly to the trunk loss in the near-to-far direction as follows:

(a) If the trunk loss in the near-to-far direction is less than 10 db, pad control relay 10 will be operated and the transmitting pad loss will be equal to the trunk loss in the near-to-far direction.

(b) If the trunk loss in the near-to-far direction is 10 db or more, pad control relay 10 will not be operated and the transmitting pad loss will be 10 db less than the trunk loss in the near-to-far direction.

2.11 The far end sends through the transmitting pad, as explained in 1.03, to send back to the near end, information regarding the trunk loss in the near-to-far direction. If the trunk loss in the near-to-far direction is less than 10 db, like condition in (a) above, the near end measures a loss which is equal to the sum of the trunk losses in the two directions. For a case like condition in (b), however, the far end will be sending through a transmitting pad loss which is 10 db too low. The near end will then measure a loss which is 10 db less than the sum of the losses in the two directions. In such cases, distinguished by pad control relay 10 not being operated, the far end will return a ½-second "on-hook" signal to the near end just before it sends through the transmitting pad. This is an "add 10" signal. It causes the near end to add 10 db to the near-to-far loss measurement to compensate for the fact that the far end is sending through a transmitting pad loss which is 10 db too low.

2.12 The arrangement described above is used to avoid sending from the far end at very low levels. For example, if the trunk loss in the near-to-far direction were 15 db and if the transmitting pad loss were always equal to the trunk loss the far end would send at a level of —15 dbm when sending through the transmitting pad. By using the "add 10" signal, as described, the far end is never required to send at a level below —9.9 dbm.

D. Range of Measurement

2.13 Whenever pad control relay 4 remains operated to retain the 4-db receiving pad unit, the 2-db and 1-db pad control relays are disabled so that the 2-db and 1-db receiving pad units cannot be inserted in the transmission path as the selector passes over these steps. Similarly, pad control relay 0.4 disables the 0.2-db and 0.1-db pad control relays. This limits the maximum receiving pad loss to 19.9 db which is the maximum range of the automatic measurement. An attempt to measure a loss in excess of 19.9 db will cause the circuits to fail and to bring in an alarm at the near end on an automatic test. On a manually dialed test, a loss in excess of 19.9 db in the near-to-far direction will cause the far end to fail and to return a 120-ipm flashing supervisory signal.

E. Accuracy Checks

2.14 There are 3 pads, A, B, and C, shown in Fig. 2, which are used at the far end for checking purposes. The ½-db pad, A, is normally cut out and the ½-db pad, B, and 0.2-db pad, C, are normally inserted in the transmission path. When the selector, Fig. 2, reaches position 10 the loss measurement is completed and the control circuit then proceeds to check the accuracy of the measurement. Two checks are made, a "trunk check" and a "loop check".

2.15 The trunk check is made immediately after the receiving pad adjustment and before the sending end removes the test power. At this time the test power level at the output from the receiving pads should be very near 1 mw but P relay, Fig. 2, may be on either its No. 2 or its No. 3 contact depending upon whether the test power level, after the receiving pad is adjusted, is just slightly above or slightly below 1 mw. However, if one or more of the pad control relays failed to operate and lock, or if they were not shunted down properly, or if the trunk loss should have changed suddenly during the pad adjustment it may not have been possible to bring the test power level to 1 mw. The pad control relay settings will then be in error and the transmitting pad loss will be incorrect so that incorrect information will be returned to the near end regarding the near-far loss. The trunk check guards against such errors in the following manner.

2.16 If the power level is 1 mw or higher so that No. 2 contact of P relay is closed, the control circuit inserts pad A to reduce the power level ½ db. This should cause P relay to release and open the No. 2 contact. On the other hand, if the power level is slightly less than 1 mw so that No. 3 contact is closed, the control circuit removes pad B which increases the power level ½ db. This should cause P relay to operate and open its No. 3 contact. Should P relay fail to perform as expected, it indicates that the power level is in error by about ±0.5 db or more. A "repeat test" signal will then be returned to the near end so that another trial can be made to secure a better adjustment. If P relay performs correctly, the control circuit restores pad A or B to the original condition and proceeds with the loop check.

2.17 The power level at the output from the receiving pads in Fig. 2 may be adjusted to 1 mw, apparently, but the measurement may still be in error if:

(a) The gain of the amplifier or of the amplifier-rectifier departs from the initially calibrated setting.

(b) The 1-mv test power supply deviates from its standard value.

(c) The individual pad losses are incorrect due to faulty pad control relay contacts or defective pad components.

The loop check guards against errors from such causes.

2.18 For the loop check, the far end disconnects the trunk being tested and connects the local 1-mw test power supply through the transmitting pads to the input of the amplifier as shown in Fig. 2 and removes the 0.2-db pad C. If the trunk loss being measured is less than 10 db, pad control relay 10 will have been left locked in the operated position to insert the 10-db receiving pad. If the trunk loss being measured is 10 db or more, pad control relay 10 will be normal and the far end will then operate relay 10 momentarily to insert the 10-db receiving pad during the loop check period. In either case the total loss in the receiving and transmitting pads during the loop check will be 19.9 db, regardless of the trunk loss being measured. Therefore, with the arrangement shown, the input power to the amplifier-rectifier will be 0.2 db higher than necessary to operate P relay, provided everything is in perfect order. If P relay fails to operate and open its No. 3 contact under this condition, the control circuit will function to return a "repeat test" signal to the near end so that another trial can be made. If P relay does operate under the above condition the control circuit inserts the ½-db pad A. This added loss reduces the input power to a value about 0.2 db below that required to release P relay. If P relay fails to release and open its No. 2 contact under this condition the control circuit will return a "repeat test" signal. If P relay functions correctly in both cases it insures that the measurement is correct and that the cumulative errors from the sources mentioned in 2.17 do not exceed ±0.2 db.

2.19 On completion of the loop check the control circuit restores the connection to the trunk and reduces the loss of the receiving pads to 0 db. P relay then reoperates on the test power from the near end. The far end waits in this condition for the removal of the test power at the near end at which time P relay releases. If all accuracy checks have been passed successfully the far end then prepares for the next phase of the test. If, however, the checks fail in any respect the far end will return a repeat test signal to the near end to request another trial and will restore its pads and control circuit to the original condition to be ready for a new measurement when the near end reconnects the test power for the second trial.

F. Full Automatic 2-way Measurement

2.20 For a full automatic test an AOIT in an originating office (near end) seizes the trunk to be tested and pulses forward code 104 to establish a connection to one of the code 104 test lines at the far end. When the far end equipment is ready to make the test it connects itself to the test line on which the call is waiting and returns a steady off-hook signal to the originating end as a signal that the test may begin. The measurement then takes place in four steps, shown in upper portion of Fig. 3.

2.21 **Step 1:** The near end sends 1 mw for about 3 seconds and the far end adjusts its pads and checks the measurement as previously described. The near end then pauses for a short interval. During this pause the far end will return "repeat test" signal to the near end if the measurement at the far end is not successful.

2.22 If the loss in the near-to-far direction exceeds 19.9 db, the test power received at the far end will be too weak to operate polar relay, P, in the amplifier-rectifier and the measurement will not start. The far end will wait about 6 seconds after seizure for P relay to operate and will then disconnect itself from the test line so as to be free to handle other calls and will cause the test line to return a 120-ipm flashing supervisory signal. This causes the near end to block and sound an alarm. The far end will act in the same way if the near end fails to remove the test power within about 6 seconds after the measurement at the far end is finished.

2.23 If any one of the accuracy checks fail at the far end, the far end will restore to the condition prevailing at the start of Step 1 and will also return a short (about ½ second) on-hook signal to the near end. This is a "repeat test" signal. It causes the near end to reconnect the test power for 3 seconds for another trial. The near end will block and sound an alarm and wait for the attention of the attendant after a third unsuccessful attempt. Consequently, the far end will not receive test power for a 4th trial and therefore will, after waiting about 6 seconds, release itself from the test line, as explained above, so as to be free to handle other calls.

2.24 If the accuracy checks are successful the far end will not return the repeat test signal. After the short pause, the near end then connects a short (about ½ second) spurt of test power which reoperates the P relay at the far end. This is an "automatic test" signal. It causes the far end to function to keep the test power connected for only about 3 seconds when sending toward the near end instead of the 10-second interval required for a manually dialed test. The automatic test signal terminates Step 1.

2.25 **Step 2:** For Step 2 the near end connects a far-near amplifier, a set of far-near receiving pads and an amplifier-rectifier which are similar to those at the far end. The far end disconnects its receiving equipment and returns 1-mw test power over the trunk. The loss in the far-near receiving pads at the near end is now increased as previously described to reduce the power level at their output to 1 mw. The settings of the nine far-near pad control relays at the near end after the adjustment is finished can then be translated to the measured loss of the trunk in the far-to-near direction. After about 3 seconds the far end removes the test power, which terminates Step 2. Each end then prepares for Step 3. The far end will pause a short interval between Step 2 and Step 3 to wait for a possible repeat test signal from the near end.

2.26 **Step 3:** For Step 3 the near end retains the far-near amplifier and the setting of the far-near pads obtained in Step 2 and adds a near-far amplifier and a set of near-far receiving pads in tandem in the input circuit to the amplifier-rectifier. If the loss in the far-to-near direction, as measured in Step 1, was 10 db or more the far end will, after the short pause following Step 2, return an "add 10" signal as described in 2.11. The far end then sends 1 mw for about 3 seconds but this time it sends through the transmitting pads which were adjusted in Step 1. The near end now increases the loss in the near-far pads at the near end to reduce the power level at their output to 1 mw. (As indicated in Fig. 3 the over-all loss of the trunk plus the far-near amplifier and the far-near receiving pads at the near-end was made 0 db in Step 2.) Therefore, the loss being measured in Step 3 is simply the loss of the transmitting pads at the far end which, in turn, is equal to the trunk loss in the near-to-far direction, if this loss is less than 10 db. Consequently, the settings of the nine near-far pad control relays at the near end, after Step 3 is finished, can be translated to the trunk loss in the near-to-far direction. If an "add 10" signal was returned from the far end just prior to sending for Step 3, the near end will add 10 db to its measurement when making this translation. After about 3 seconds the far end removes the test power to terminate Step 3. Each end then prepares for Step 4. The far end pauses a short interval between Step 3 and Step 4 to await a possible repeat test signal from the near end.

2.27 Near the completion of Step 2 the near end makes a "trunk check" and near the completion of Step 3 it makes both a "trunk check" and a "loop check". During the short pause at the end of Step 2 and Step 3, the far end reconnects its amplifier and amplifier-rectifier, as shown for Step 1, so that it can receive test power from the near end. Should the near end be unsuccessful in its trunk check in Step 2 or in either the trunk check or loop check in Step 3, it will, during the pause at the end of Step 2 or Step 3 send a short spurt (about ½ second) of test power to the far end to reoperate the P relay at the far end. This is a "repeat" signal to the far end. Both the near end and the far end then revert to the condition prevailing at the beginning of Step 2 and repeat both Step 2 and Step 3 for a second trial. The near end will block and sound an alarm after a third unsuccessful attempt. If all checks are successful at the near end, no tone spurt will be sent toward the far end and each end then proceeds with the noise check in Step 4.

2.28 **Step 4:** For Step 4 the near end removes the near-far amplifier and the far-near and near-far receiving pads and increases the gain of the amplifier-rectifier for a noise check at the near end. The far end removes the receiving pads and increases the gain of the amplifier-rectifier for a noise check at the far end. Each end rests in this condition while each amplifier-rectifier integrates the noise voltage over an interval of approximately 5 seconds. At the end of that time the polar relay in the amplifier-rectifier at either end will operate to its No. 2 contact and register a high noise condition if the single preset noise checking limit for its own office (35, 40, or 45 dba) is exceeded.

2.29 When the far end completes its noise check it releases itself from the test line and causes the test line to return an on-hook signal to the near end to indicate that the test is finished. This will be a 120-ipm flashing signal if the far end has registered a high noise condition or a steady on-hook signal if the far end has not registered a high noise condition. The near end distinguishes between the steady on-hook and the flashing signal to determine the noise condition at the far end.

G. Manual 2-way Measurement

2.30 To make a manual test a testboard attendant in an originating office takes up the dial intertoll trunk at its test jack and pulses forward code 104. The exact procedure may, of course, vary somewhat in different offices depending upon the type of secondary testboard involved, but it is the same as when setting up any outgoing call over a dial-type intertoll trunk. In any case the 1-mw test power supply should be prestarted and kept operating throughout the test so that it will be up to full power when Step 1 starts; otherwise, the far end will probably fail in its trunk check and return a repeat test signal. After pulsing, the attendant restores the test cord TALK key to normal or operates it to the MON position and proceeds with the test. Care should be taken that no excess loss is introduced and that the testboard position circuits are in a condition to insure that the switching pad in the intertoll trunk being tested is in the condition for a terminating connection. The test takes place in four steps as shown in the lower portion of Fig. 3.

2.31 **Step 1:** When the transmission measuring and noise checking circuit is ready for the test it returns a steady off-hook signal which retires the attendant's test cord supervisory lamp. The attendant then connects the other end of the test cord pair to a 1-mw SEND jack for about 3 seconds. During this time the far end measures the loss, adjusts the transmitting pads and checks the measurement as previously described. As the test power is disconnected the attendant observes the test cord supervisory lamp. A momentarily lighted lamp indicates an unsuccessful measurement at the far end and he should then reconnect the test power for a second trial. If the supervisory lamp remains steadily dark the attendant connects the test cord to the REC jack of the transmission measuring circuit to prepare for Step 2. If the attendant fails to connect the test power within about 6 seconds after the off-hook signal is received or, if he leaves the test power connected for more than about 8 seconds, the far end will time out and return a 120-ipm flashing supervisory signal. It is then necessary to release the intertoll trunk and start a new test. A 120-ipm signal will also be returned if the trunk loss in the far-to-near direction exceeds 19.9 db.

2.32 **Step 2:** During the pause between Step 1 and Step 2 the far end will not receive the short spurt of test power as an "automatic test" signal (2.24). The far end waits about 2 seconds for this signal. This gives the attendant at the near end time to connect his receiving equipment. Since the far end did not receive the automatic test signal it sends 1 mw directly over the trunk for about 10 seconds. This gives the attendant at the near end time to measure and record the loss in the far-to-near direction. When the test power is removed at the far end the meter reading at the near end drops back to the position of no current and the attendant should observe the cord supervisory lamp at that time. A momentarily lighted supervisory lamp is an "add 10" signal to indicate that 10 db should be added to the next measurement and a steadily dark lamp indicates that the next measurement should be made without correction. This completes Step 2.

2.33 **Step 3:** The far end will pause about 2 seconds between Step 2 and Step 3 and then will send 1 mw through the transmitting pad which was set up in Step 1. The attendant at the near end now measures the trunk loss in the far-to-near direction plus the loss of the transmitting pad at the far end. This will be equal to the sum of the losses in the two directions if an "add 10" signal was not received. If an "add 10" signal was received, the attendant adds 10 db to the actual measurement to obtain the sum of the losses in the two directions. The difference between the measurements of Step 3 and Step 2 is the trunk loss in the near-to-far direction. After about 10 seconds the far end removes the test power and the meter reading at the near end drops back to the position of no current, indicating the completion of Step 3.

2.34 **Step 4:** For Step 4 the attendant simply leaves the connection intact and waits for a disconnect signal from the far end. The far end proceeds with a noise check in the same way as if this were a full automatic test. After about 5 seconds the transmission measuring and noise checking equipment at the far end completes the noise check and releases and causes the test line to return a disconnect signal. This lights the attendant's test cord supervisory lamp to signify completion of Step 4. A steadily lighted lamp indicates that the noise checking limit at the far end was not exceeded and a flashing lamp indicates a high noise condition at the far end. If a noise measurement at the near end is desired, or if a measurement seems advisable because of audible noise conditions observed, it must be made with auxiliary noise measuring equipment at that end. Should the attendant disconnect immediately after the near-far transmission loss measurement, the far-end equipment will release immediately without completing the noise check.

3. DESCRIPTION OF CIRCUITS AND EQUIPMENT

A. Amplifier

3.01 The amplifier, shown in Fig. 4, is a 2-stage amplifier with negative feedback. Its input impedance matches the toll office impedance and its output impedance is 600 ohms. An input potentiometer provides a limited range of gain adjustment to enable the gain to be set at exactly 19.9 db. Feedback through E resistor maintains constant gain. The gain at 1000 cycles is slightly higher than at higher or lower frequencies. The output network consisting of C inductor, F and L resistors, and G capacitor, provides approximately F1A noise weighting for noise checks. This network is omitted from the near-far amplifier at the near-end (see Fig. 3).

3.02 Negative 130-volt telegraph or signal battery or —110-volt CC (coin collect) battery is connected to the cathode of V2 tube to increase the effective plate potential. This is to prevent overloading of V2 tube when the trunk loss being measured is very low. A noise filter, mounted on the amplifier-rectifier panel, is used to avoid noise from the plate supply. The heaters of the tubes are operated from a 6.3-volt ungrounded ac supply to avoid excessive potential difference between the heater and cathode of V2 tube.

B. Amplifier-Rectifier

3.03 The amplifier-rectifier, shown in Fig. 5, consists of a 2-stage amplifier; tubes, V1 and V2; a voltage doubling rectifier, V3; and a current amplifier, V4. The panel includes a switching relay, N, the contacts of which are shown in Fig. 5, to change the internal connections while making noise checks. With N relay normal, as shown, the amplifier-rectifier is in the condition for transmission measurements.

3.04 In the transmission measuring condition PT potentiometer provides gain adjustment over a limited range. The gain is set as described in 2.02. Feedback through P resistor stabilizes the gain over V1 and V2 amplifiers. V2 amplifier is a twin triode with the 2 sections in parallel to provide sufficient output. The cathode of V2 tube is returned to —130-volt telegraph or signal battery, or to —110-volt coin collect battery to increase the effective plate potential to avoid overloading.

3.05 The output of V2 tube is connected through F capacitor and C resistor to V3 tube which is a voltage-doubling rectifier of the cascade type. This tube is a twin triode with the grid and plate elements of each section strapped so that it can be used as a twin diode. When an ac input is applied through C resistor, a dc voltage somewhat less than twice the peak input voltage appears across G capacitor and R and K resistors. This voltage is connected to grid terminal 3 of the current amplifier, V4, in opposition to the 90-volt dry cell biasing battery.

3.06 V4 tube is a twin triode with section 2-3-4 normally biased beyond cutoff by the 90-volt dry cell battery and section 6-7-8 normally conducting. Series resistors, D and E, are provided in the plate supply and the winding of polar relay, P, is connected directly across plate terminals 4 and 6. With section 2-3-4 at cutoff, part of the plate current in section 6-7-8 flows through E resistor and the winding of P relay in the direction to hold P relay on its No. 3 contact.

3.07 When an input power arrives nothing happens unless the dc output voltage from V3 approaches that of the 90-volt biasing battery. Section 2-3-4 then starts to conduct and the drop in voltage at plate terminal 4, due to the plate current through E resistor, reduces the current through P relay. When the plate current in section 2-3-4 exceeds that through section 6-7-8, the current in P relay reverses and the relay operates to the No. 2 contact. Due to the gain through V1 and V2 tubes and the voltage-doubler action of V3 tube, a small change in the input power to the amplifier-rectifier results in a relatively large change in the grid voltage at terminal 3 of V4 tube. This makes P relay very sensitive to such changes at its operating point.

3.08 In the transmission measuring condition, the input circuit to grid terminal 3 of V4 tube is looped through normally closed contacts of a relay in the associated control circuit. This is shown as leads "M" and "D" in Fig. 5. Operation of the relay in the control circuit opens this path to force P relay to its No. 3 contact. This is done, for example, during the process of inserting a receiving pad to avoid false operation of P relay from possible transients in the transmission path coincident with the pad switching operation. The control circuit then recloses this path after such transients have disappeared to permit P relay to function normally.

3.09 When a noise check is to be made, the control circuit operates N relay on the amplifier-rectifier panel which performs the following functions.

(a) Connects the input to the PN potentiometer circuit through a pad. The pad loss will be set, by means of optional wiring, to 0, 5, or 10 db depending upon whether a noise checking limit of 35, 40, or 45 dba, respectively, is chosen for the office. PN potentiometer provides a small range of gain adjustment in the noise checking condition.

(b) Inserts N resistor in series with the feedback path to reduce the feedback and disconnects the 9100-ohm resistor, X, which is normally in parallel with screen dropping resistor, Y. This increases the 1000-cycle gain over V1 and V2 tubes to a value about 24 db above the gain in the transmission measuring condition.

(c) Substitutes a — 13.5-volt biasing battery for the 90-volt battery for V4 tube. This causes P relay to operate on a much smaller positive input voltage to grid terminal 3 of V4 tube.

(d) Connects the output from the V3 voltage doubler through V resistor and M capacitor to ground. M capacitor is normally shunted by a low resistance in the control circuit to insure that M capacitor will be completely discharged at the start of the noise check.

3.10 When the noise check is to be started the control circuit starts a 5-second (approximately) timing interval and at the same time removes the shunt from M capacitor to permit it to charge slowly through V resistor. The output from the V3 voltage doubler will be dependent upon the noise voltage on the trunk under test. The voltage charge accumulated on M capacitor will be directly proportional to the integrated noise voltage on the trunk over the 5-second timing interval. At the end of the timing interval the control circuit connects M capacitor to the grid circuit terminal 3 of V4 tube for a short interval so that its voltage is in opposition to the voltage of the 13.5-volt dry cell battery. If the voltage on M capacitor is high enough P relay will operate to its No. 2 contact and will cause a relay in the control circuit to operate to register the high noise condition. If P relay does not operate, the relay in the control circuit remains normal and the trunk test proceeds to completion without a high noise indication.

3.11 For calibrating purposes 1000-cycle test power of —50, —45, or —40 dbm is connected to the input of the amplifier, Fig. 2 for noise checking limits of 35, 40, or 45 dba, respectively. The associated control circuit is placed in operation so that it will measure off a 5-second noise timing interval and make a noise check as on a normal test. PN potentiometer is adjusted so that P relay will operate and give a noise indication under these conditions but will not operate when the test power is reduced 1 db.

C. Multivibrator

3.12 As indicated previously, the control circuit is required to provide various timing intervals as a test progresses. For example, the far end returns test power for 3 seconds on an automatic test but holds the test power connected for 10 seconds on a manually dialed test. The various time intervals are provided by a multivibrator timing circuit. The multivibrator also acts as a pulse generator to drive the 204-type selector and control circuit through its various steps while adjusting the receiving pads and making the accuracy checks. Fig. 6 is a schematic of the multivibrator.

3.13 V1 tube is a double triode. The two sections V1.1 and V1.2 have their grids and plates interconnected through capacitors C1 and C2, C4. The grid circuit of section V1.1 includes Y resistor and several other resistors that can be connected in parallel with it through relay contacts. The grid circuit of section V1.2 includes Z and Z1 resistors in series and several other resistors which can be connected in parallel with them.

3.14 V2 tube is a double triode with the two sections in multiple. Its grids are connected directly to the grid of section V1.2 of V1 tube so that V2 tube functions as a slave of section V1.2. When section V1.2 conducts, V2 tube also conducts and MV relay in the plate circuit of V2 operates. When section V1.2 is cut off, V2 tube is also cut off and MV relay releases. MV relay, operated and released, provides the marking and spacing intervals, respectively.

3.15 Section V1.2 of V1 tube is normally biased beyond cutoff by the —48-volt battery through AI resistor. This blocks the multivibrator in the spacing condition. The bias may also be switched to section V1.1 of V1 tube to block the multivibrator in the marking condition. When timing is to be started the —48-volt bias is removed. The multivibrator is then in the free running condition.

3.16 In the free running condition, section V1.2 and V2 tube, and section V1.1 are alternately conducting and nonconducting causing MV relay to alternately operate and release. The speed with which this takes place depends upon the resistors in the grid circuits. The marking interval (time during which MV relay is operated) is determined, for the most part, by the combined resistance of Y resistor and the resistors in parallel with it. The higher the combined resistance, the longer the marking interval. The spacing interval (time during which MV relay is released) is determined, for the most part, by the combined resistance of Z and Z1 resistors in series and the resistors in parallel with them. As a test progresses contacts on relays in the control circuit, as shown in Fig. 6, connect the marking and spacing resistors in various combinations. MV relay therefore keeps changing its pace as the test progresses to provide the proper timing interval for each step in the test. These intervals are summarized in the table on Fig. 6.

3.17 The multivibrator is sensitive to transient voltages on the grid circuits which may cause it to flip from the marking to the spacing condition or vice versa. The plate supply includes a noise filter consisting of B inductor and C3 capacitor and the voltage divider resistors, CW, CV, and CX, provide a potential of +30 volts to the grid circuits to reduce such effects. Shielded conductors are used for the grid circuit wiring to the resistors and relay contacts to avoid pickup of transient voltages caused by the operation and release of relays in the control circuit. The various timing intervals can be checked with a timing test set if incorrect timing intervals are suspected.

D. Provision of Tests and Adjustments

3.18 The transmission measuring and noise checking circuit functions on a more or less "nonattended" basis in response to calls incoming from various originating offices. Normally the local maintenance forces may be unaware of any malfunctioning of the far-end equipment until a report is received from an originating office of inability to secure a satisfactory measurement. Therefore, means are provided so that the adjustments can be checked quickly and easily in case of trouble. It might be noted that, on full automatic tests, the attendant at the originating office may be able to give a clue as to the type of trouble from the trouble lamp display on the AOIT.

3.19 Departure of the 1-mw test power supply from its standard value will cause corresponding errors in the measurements at the near end, and, if it departs more than 0.2 db from the correct value, the far end will fail in its loop check. Two 1-mw supply outlets are provided, (1) a 600-ohm outlet for test purposes, which terminates in the TST MW jack and (2) an outlet which matches the office impedance and which is connected through the MW jack. These may be checked with a 7A transmission measuring set. This should be done only in conjunction with the use of a 2AA milliwatt reference set to insure the accuracy of the 7A set. When measuring at the MW jack with the 7A set a correction for impedance mismatch should be made if the office impedance is other than 600 ohms. This correction is —0.2 db, —0.5 db, or —0.9 db for 900-ohm, 1200-ohm, or 1500-ohm offices, respectively.

3.20 A jack-ended precision pad is provided to facilitate checking the amplifier gain and the over-all gain. The pad has a loss of 19.9 db and matches the impedance of the office. To adjust the gain of the amplifier, the 19.9-db IN jack is patched to the MW jack and the 19.9-db OUT jack is patched to the IN jack on the amplifier panel. A transmission measuring set (such as a 7A, 21A, or 40B) known to be in accurate calibration is patched to the OUT jack on the amplifier panel. The potentiometer in the amplifier panel is adjusted so that the set reads 0.0 db.

3.21 A key, ADJ PT, connects PB and PF lamps to the No. 3 and No. 2 contacts of the polar relay, P, in the amplifier rectifier to give a visual indication of the position of polar relay when checking the over-all gain of the amplifier and amplifier-rectifier. The 19.9-db pad circuit includes a 0.1-db unit which can be added by means of REL PT key to facilitate this check. To check the over-all gain, ADJ PT key is operated, which lights PB lamp. The 19.9-db IN jack is patched to the MW jack and the 19.9-db OUT jack is patched to the IN jack on the amplifier panel. The polar relay should operate and retire PB lamp and light PF lamp. Operation of REL PT key inserts the 0.1-db loss which releases the polar relay and retires PF lamp and lights PB lamp. If these requirements are not met the 1-mw test power supply and the amplifier gain are checked, as described in 3.19 and 3.20 and PT potentiometer on the amplifier-rectifier panel is then adjusted until the requirements are met.

3.22 For checking the operation of the measuring circuit, operation of pad control relays, etc, the TST MW jack is patched through an adjustable attenuator to the B REC or D REC jacks and a test call is simulated locally to measure the loss in the attenuator. A jack-ended test pad circuit, adjustable from 0 to 1.2 db in 1/10 steps, is provided and may be used in tandem with a 600-ohm attenuator, such as the 5A, so that this measurement can be made in 10-db steps.

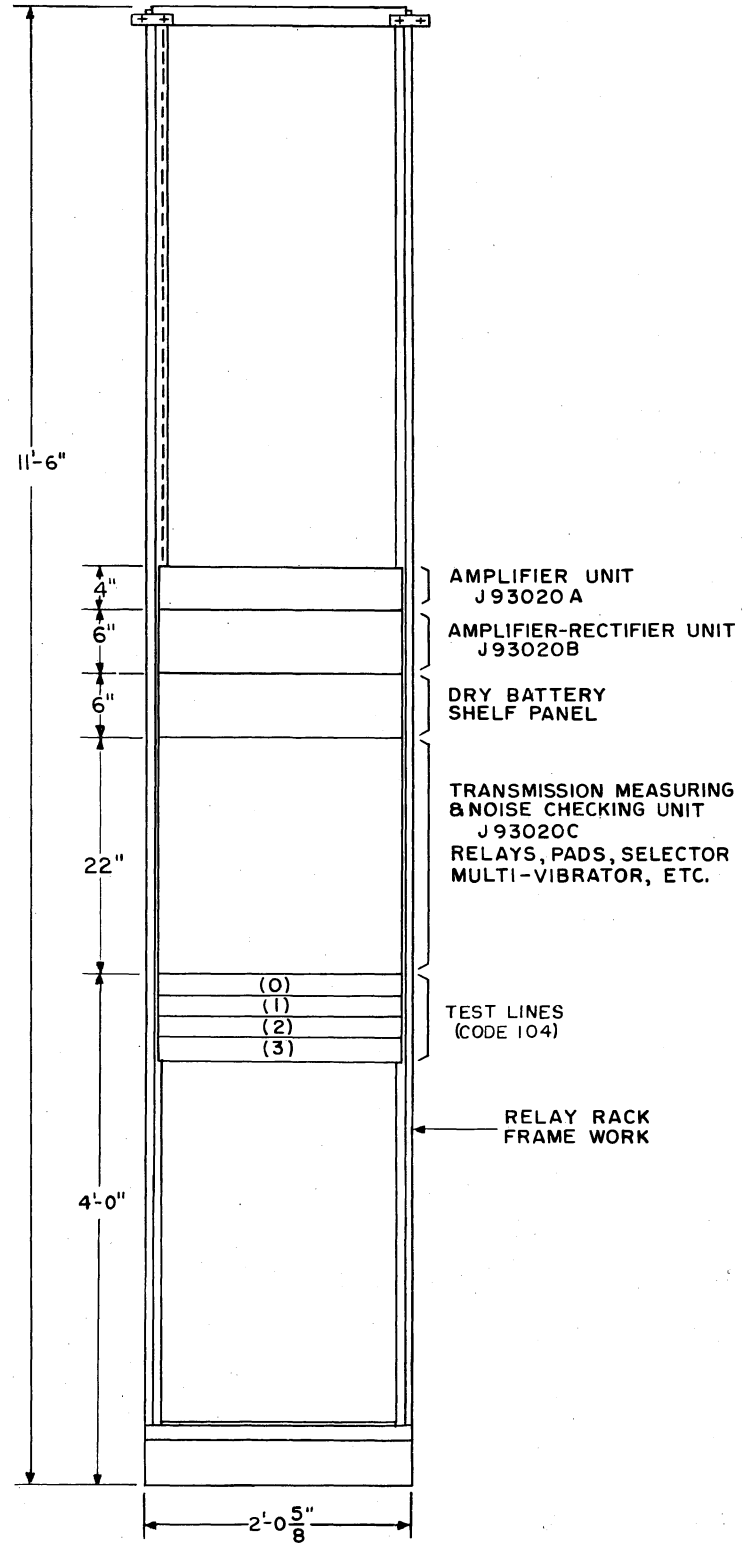


Fig. 1—Far-End (Code 104) Transmission Measuring and Noise Checking Equipment

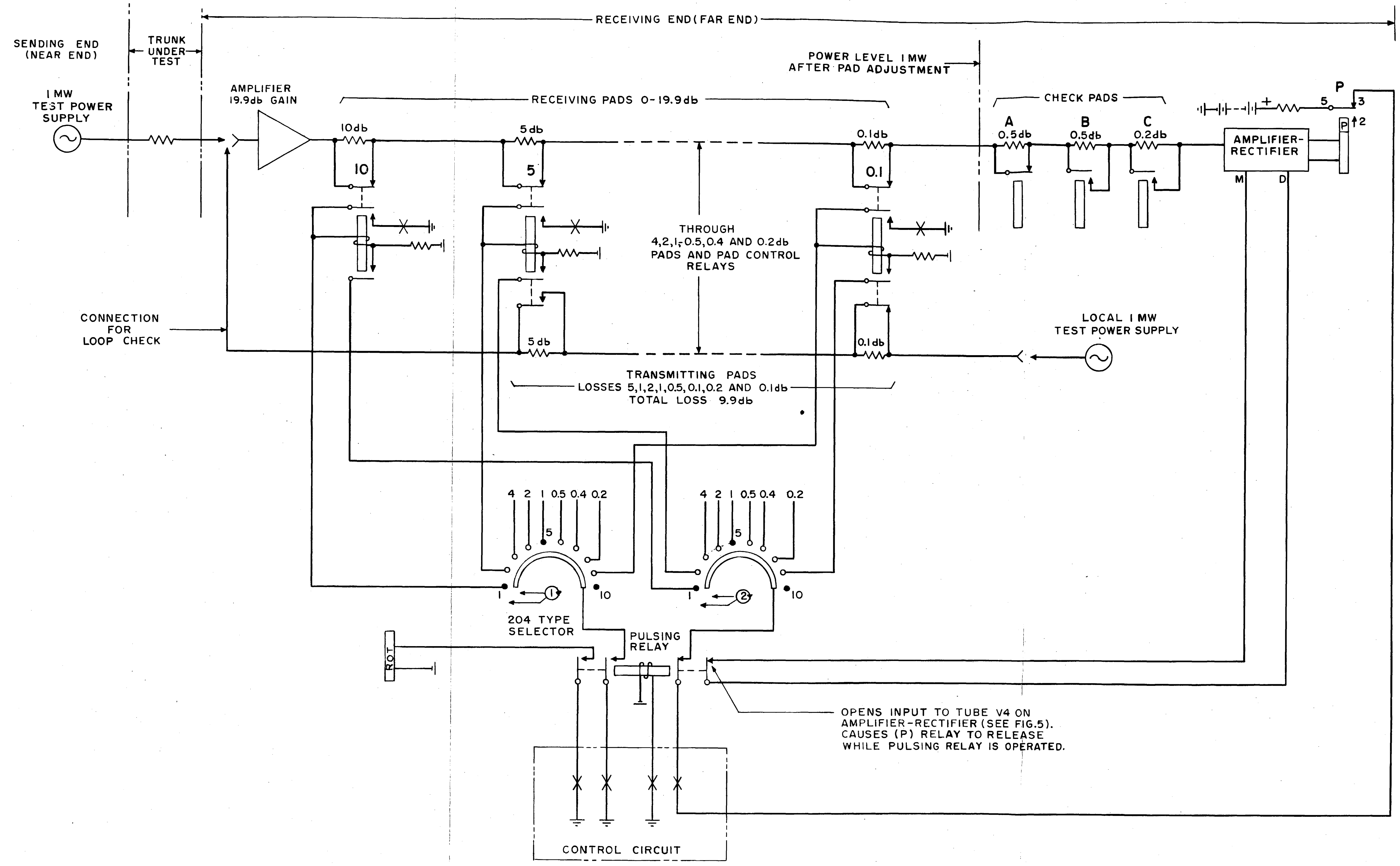


Fig. 2—Schematic of Transmission Loss Measurement

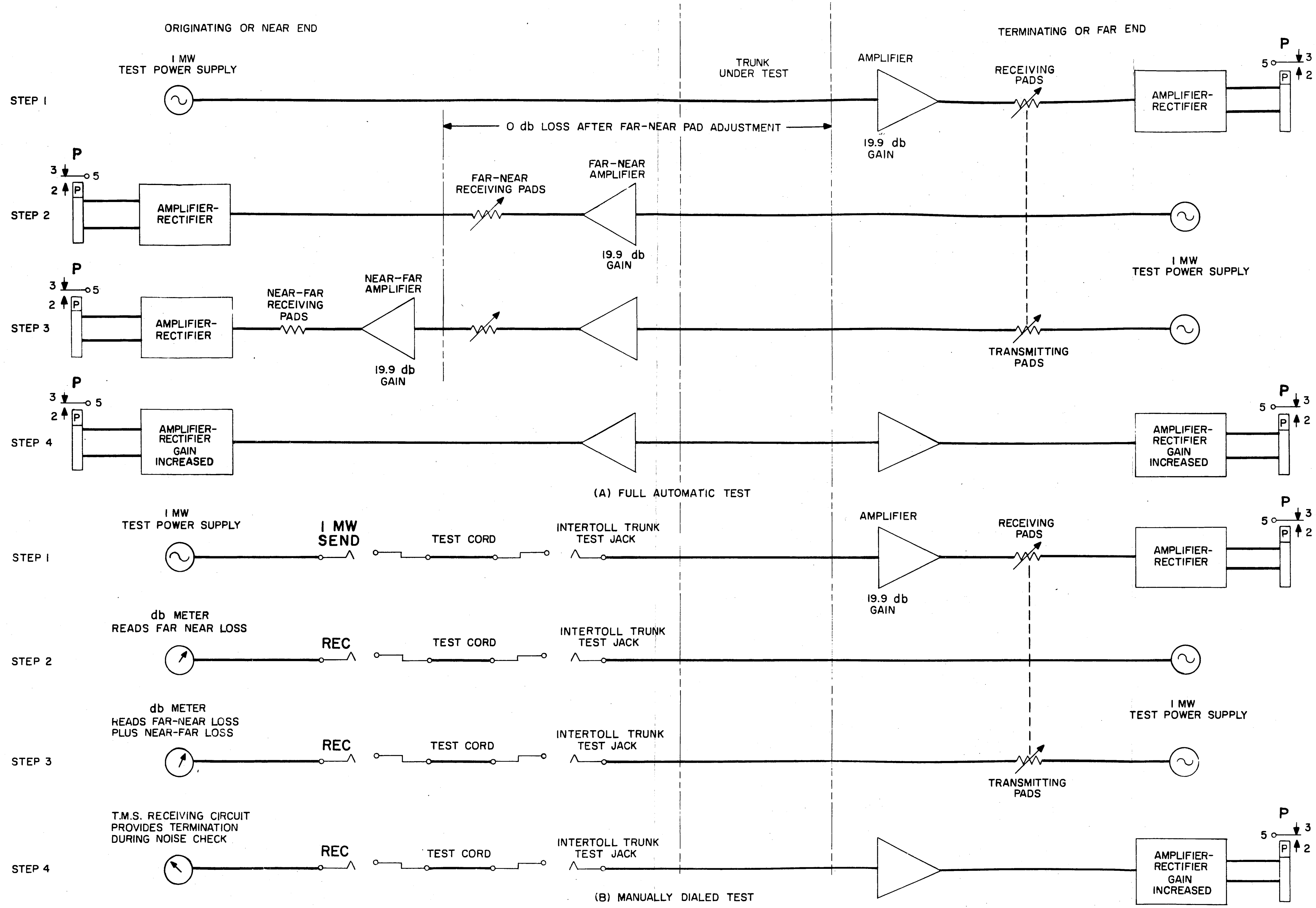
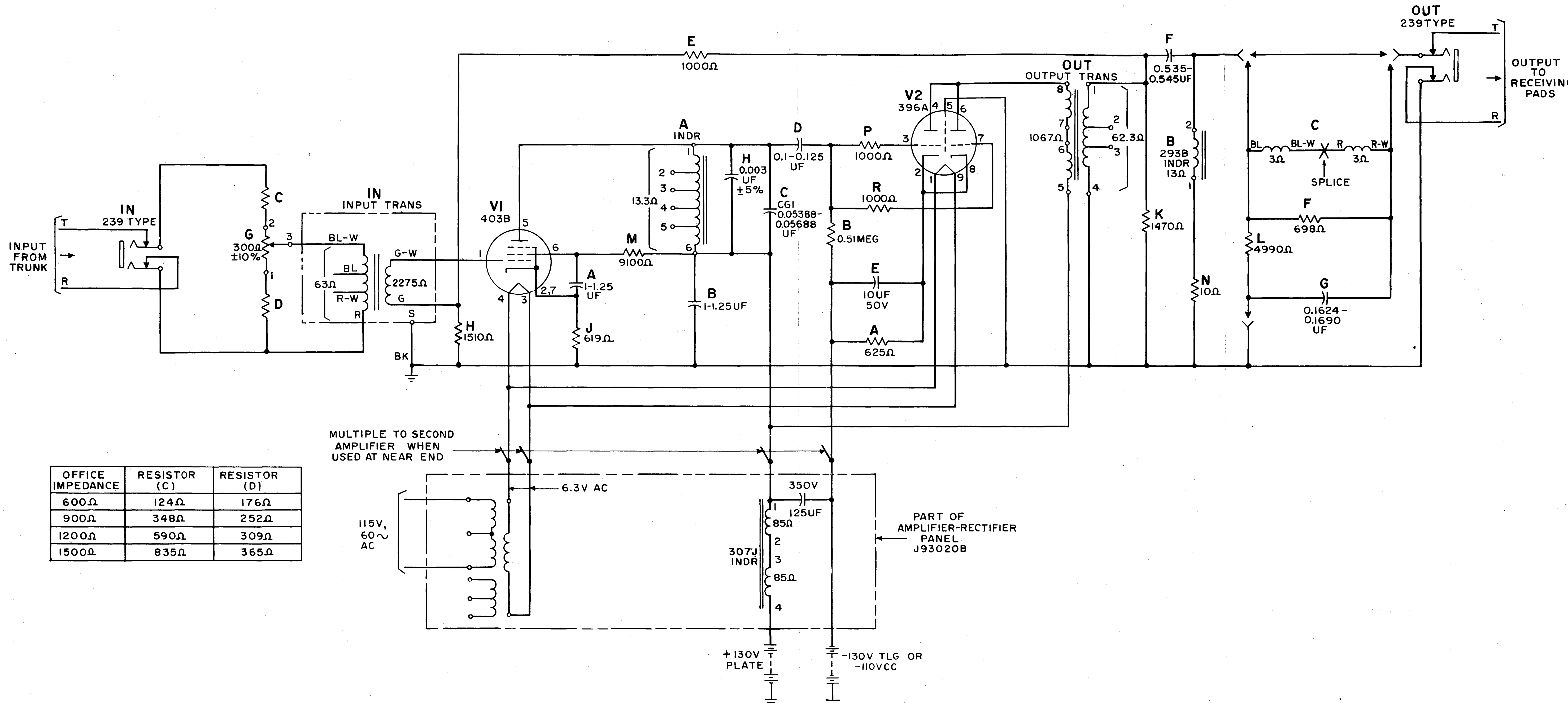


Fig. 3—2-way Transmission Test



OFFICE IMPEDANCE	RESISTOR (C)	RESISTOR (D)
600Ω	124Ω	176Ω
900Ω	348Ω	252Ω
1200Ω	590Ω	309Ω
1500Ω	835Ω	365Ω

Fig. 4—J93020A Amplifier

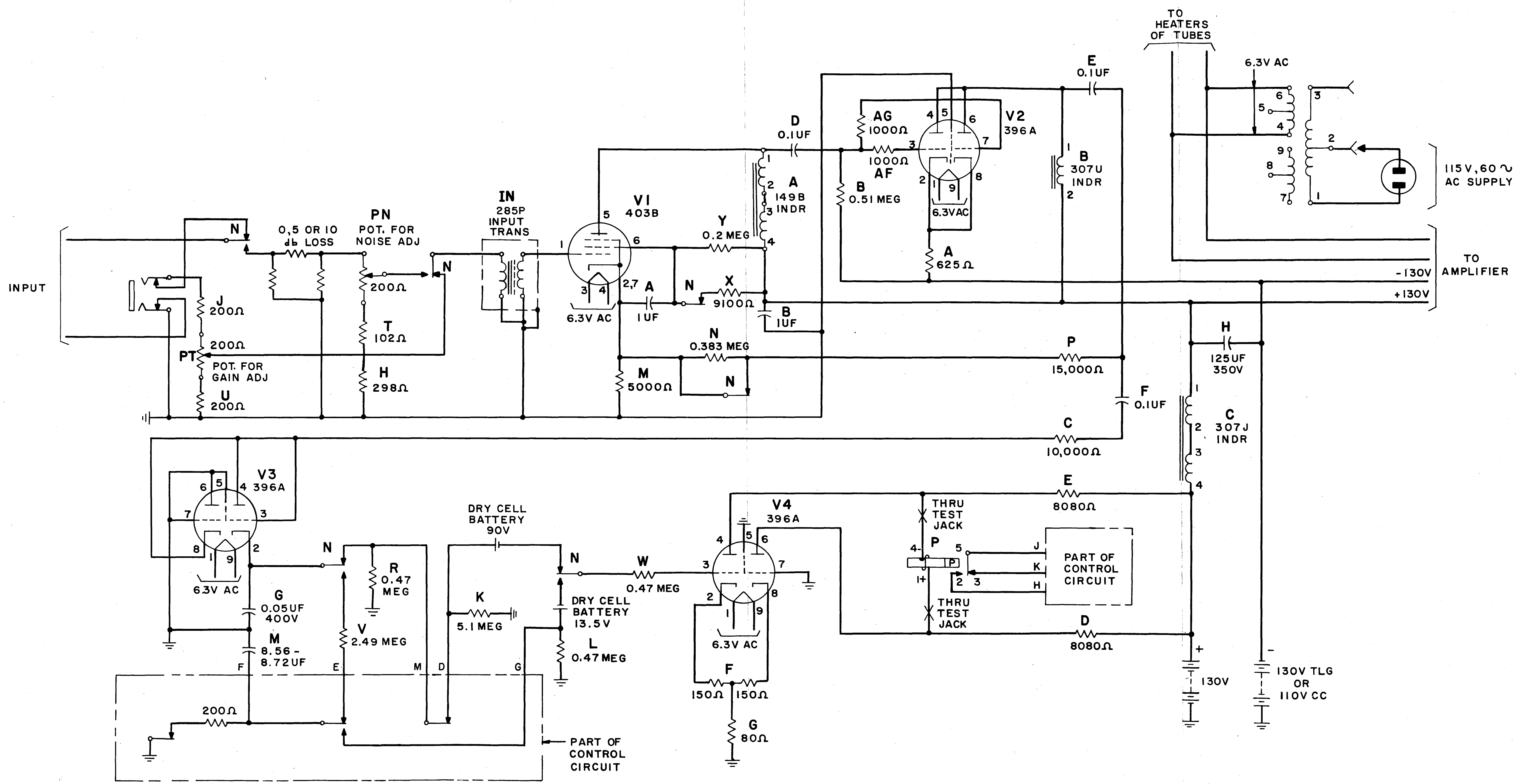


Fig. 5—Amplifier-Rectifier

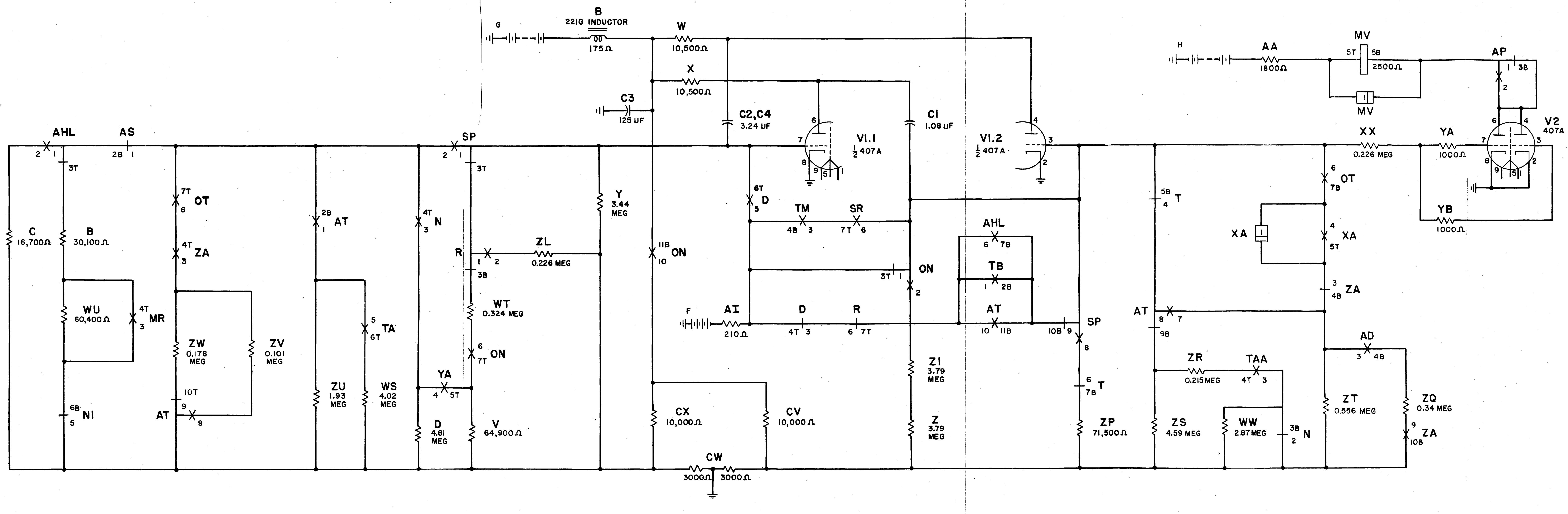


TABLE A

MARK TIMES (SECONDS)	RESISTANCES SHUNTING (Y) RES.	REMARKS
0.050	C	ATT. CHK.
0.090	B	ATT. ADJ.
0.150	(V)(D)	RELEASE
0.200	B + WU	FIRST ATT. ADJ.
0.350	ZV	OVER-TEN SIG. (AUTO.)
0.500	ZW	OVER-TEN SIG. (MAN.)
0.500	ZL	REPEAT SIGNAL
0.800	WT+V	SEIZURE
3.0	ZU	1ST. TONE TRANS. (AUTO.)
3.0	(ZU)(WS)	2ND. TONE TRANS. (AUTO.)
5.0	D	NOISE CHK.
10.0	NONE	TONE TRANS. (MAN.)
SPACE TIMES (SECONDS)	**RESISTANCES SHUNTING (Z) & (Z1)**	**REMARKS**
0.070	ZP	ATT. ADJ. & CHK.
0.200	(ZR)(ZS)	AFTER 2ND. TONE TRANS. (MAN.)
0.200	(ZT)(ZQ)	AFTER OVER-TEN SIG. (AUTO.)
0.450	ZT	AFTER TONE TRANS. (AUTO.) BEFORE O-T SIG. (MAN.)
1.45	(ZR+WW)(ZS)	AFTER NOISE CHK.
2.30	ZS	BETWEEN TONE TRANS. (MAN.)
6.0	NONE	TIME-OUT

NOTE: + INDICATES RES. IN SERIES.
( ) INDICATES RES. IN PARALLEL

Fig. 6—Simplified Schematic of Multivibrator