IMPULSE NOISE
CENTRAL OFFICE TEST PROCEDURES AND INVESTIGATION

CONTENTS PAGE

1. GENERAL

1.01 This section describes procedures used in a central office for the investigation and mitigation of impulse noise on intraoffice calls. Procedures for calls requiring interoffice trunks and associated equipment are described in Section 331-400-500.

1.02 The procedures described in this section are applied to an office that is to be evaluated only following a specific noise complaint which has been traced to the office.

1.03 The requirements and techniques used in the measurement of impulse noise are described in Section 331-200-100. A description of impulse noise is presented in Section 331-100-101.

1.04 There are certain procedures described in this section that are beyond the responsibility of the plant maintenance forces. These are labelled "For Engineering Consideration." If the procedures performed by the craft personnel fail to reduce the impulse noise to the required value, the problem should be referred via supervisory channels to the engineering forces, who should be advised of all measurements, action taken, and the results obtained.

2. CENTRAL OFFICE MEASUREMENT PLAN

A. General

2.01 This part describes a sampling plan for measuring impulse noise in central offices. The office is defined as all of the equipment and cable that is required to complete a connection from one termination on the main distributing frame (MDF) to some other termination on the MDF. For ease of administration, a single office is defined as including only those MDF terminations assigned to a single exchange number, even though more than one such number may exist for a given switching machine.

2.02 Since there is an extremely large number of possible paths that may be taken for a connection between two arbitrary MDF terminations and there are N(N − 1) possible MDF termination pairs (where N is the total number of such terminations), a sampling plan is required to evaluate the impulse noise encountered on connections through an office.

B. Apparatus

2.03 The following apparatus is required when making intraoffice impulse noise tests:

QUANTITY	DESCRIPTION
2	Locally fabricated test boxes; see Section 331-700-130 for details.
2	Line-connecting cords for above; see Section 331-700-130 for details.
2	Meter-connecting cords for above; see Section 331-700-130 for details.
1	Handset, 1011-type or equivalent.
1	6F noise measuring set, or equivalent impulse counter.
1	3C noise measuring set, or equivalent.

C. Procedure

2.04 The population from which a test sample is to be drawn is all of the spare MDF terminations included in a single exchange number. Two line-finder groups, line link frames, or line link networks are picked at random. One spare terminal in each group is assigned a directory number and designated as the called terminal. Within each group, ten other spares are picked arbitrarily (strict random sampling is not necessary). In offices with a high fill, eleven spares may not be available in any one group. In these cases, any 22 spares may be used. Calls are established sequentially from each of the 10 spares within each group to the called terminal within the group. If the 22 spares are not equally divided between two groups, a call must be made from each of 10 calling-number terminals to one called terminal and from each of the remaining calling terminals to the other called terminal.

2.05 Using the locally fabricated test boxes, mark one box A and the other B. Make measurements of C-message and impulse noise as follows:

(a) Connect box B to the called-number terminals using a line-connecting cord. Operate the switch to CALL position.

(b) Connect a 1011-type handset to the A box TEL jack. Connect the 3C (or equivalent) noise measuring set to the METER jack with a meter-connecting cord. Operate the switch of the box to DISC.

(c) Connect the A box to a calling-number terminal using the line-connecting cord.

(d) Operate the A box switch to the CALL position. When dial tone is heard, dial the number assigned to the called terminal (see 2.04).

(e) Observe the lamp of box B to see whether the ringing signal (indicated by a flashing lamp) has reached the called number. If audible ringing is heard and the lamp on box B does not indicate that the called number has been reached, let the ringing continue a few times to see whether anyone answers. If someone does answer, inform the person that you are testing and obtain the called number for checking records. If no answer is received, operate the A box switch to DISC, then back to CALL and redial the called number.

(f) When the B box lamp flashes, turn the switches of both boxes to the MEAS-L position.

(g) Measure the C-message noise. All measurements of C-message noise should be 18 dBrnc or less. If they are not, see Sections 331-700-501, 331-700-503, 331-700-504, and 331-700-505 for specific cross-office noise procedures. The C-message noise should be reduced to 18 dBrnc or less before continuing with the procedures outlined in this section.

(h) Set the 6F selector switch to the MEAS position.

(i) Disconnect the 3C noise measuring set (or equivalent) from the A box meter jack. Connect the 6F impulse counter (or equivalent) to the A box meter jack.

(j) Set the DBRN switch on the 6F to the level specified in Table A. Use C-message weighting. Set timer for 5 minutes.

TABLE A

DBRN SWITCH SETTING FOR 6-TYPE COUNTERS

LEVEL AT CENTRAL OFFICE

TYPE OFFICE	LEVEL - 6A, 6E, 6H	LEVEL - 6F
Crossbar	54 dBrnc	24 dBrnc
Step-by-step	59 dBrnc	29 dBrnc
ESS	47 dBrnc	17 dBrnc

(k) Record the number of counts on the counter with the lowest threshold.

Requirement: No more than 5 counts in 5 minutes on 50 percent of test calls using the sampling plan. Immediate action limit is 100 counts or more in 5 minutes.

Use a form like that shown in Fig. 1 to record the results. If the number of counts at the end of 5 minutes is 5 or less, mark a zero (0) for that test. If more than 5 counts in 5 minutes are recorded, mark a one (1) for that test.

(l) Continue testing by operating the switch on box B to CALL and the switch on box A to DISC. Move the line-connecting cord of box A to a new calling-number terminal. Operate the switch on box A to CALL and repeat the procedure described in (d) through (k) above.

(m) Make twenty measurements, ten in each group. (See 2.04.)

(n) The office is acceptable from an impulse noise standpoint if no more than ten "1's" are recorded in total and no more than six "1's" are accrued in either of the two groups of ten measurements. This criterion ensures that 50 percent of calls through the office will have 5 counts or less in 5 minutes with 90-percent confidence.

2.06 Since it is proposed that an office be evaluated only following a specific noise complaint which is traced to the office, the measurement results should be forwarded to the appropriate evaluation group for follow-up action.

2.07 Impulse noise problems in other than SXS offices will probably require engineering assistance for mitigative measures. In SXS offices, cleaning and adjusting of switches according to standard practices usually results in improved performance. In SXS offices containing rotary-out-trunk switches (ROTS), the impulse noise level is often much higher and, therefore, most calls may have a higher impulse noise count than offices not equipped with ROTS even though the calls are not directly routed over the ROTS. Section 331-400-500 contains information about impulse noise in ROTS offices.

3. INVESTIGATION AND MITIGATION—SWITCHING SYSTEMS

A. General

3.01 The detailed investigation and resulting mitigative measures in switching systems and associated terminal equipment are discussed in this part. The need for investigation is normally identified after a sample test (Part 2) of the central office has been made

(a) During a survey;

(b) As a result of sectionalizing procedures carried out while investigating a data loop or trunk on which noise of an impulse nature (see Section 331-100-101) has been reported;

(c) If it has been found that a number of RX loops have been established bypassing the central office.

3.02 In general, the procedure consists of an overall measurement (either on a sampling basis as described in Part 2, if not already done, or on a specific basis if the out-of-limit paths have already been identified). The overall section is then sectionalized by cutting off one piece of equipment after another, and a new terminated measurement is made each time. One of the two following courses of action must be taken:

(a) If the noise count drops to less than 50 percent of the overall count when a section

IMPULSE NOISE TEST SHEET

OFFICE _____ DATE _____

LFG-LLF-LLN GROUP 1_____ TESTER _____

GROUP 2_____ ACCEPT ____

REJECT ____

TEST LEVEL _____

GROUP 1 CALLED TERMINAL_____ TEL NO _____

TEST NUMBER	CALLING TERMINAL	3C NMS DBRNC	0's	1's
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
		TOTAL		

GROUP 2 CALLED TERMINAL_____ TEL NO _____

TEST NUMBER	CALLING TERMINAL	3C NMS DBRNC	0's	1's
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
		TOTAL		
		TOTAL GROUP 1 & 2		

ACCEPT IF NO MORE THAN TEN "1's" ARE RECORDED IN TOTAL.
REJECT IF MORE THAN SIX "1's" ARE RECORDED IN EITHER OF THE TWO GROUPS OR IF MORE THAN TEN "1's" ARE RECORDED IN TOTAL.

REFERRED TO _____ (SEE BSP SECTION 331-701-500.)

Fig. 1—Sample Form

is cut off, that section must be further investigated and appropriate remedial measures taken.

Note: It must be remembered that impulse noise may vary in any given time interval and, therefore, more time should be allowd when isolation procedures are used.

(b) If the noise count drops gradually all along the connection, the entire path must be corrected.

3.03 An alternative to the count measurement method above is to set the level registers so as to bracket that level which yields 5 counts in 5 minutes. If, upon cutting off a section, the level drops 2 dB or more, then that section must be investigated further and the situation remedied.

3.04 The procedure for sectionalization of typical equipment trains within a central office is detailed below. Investigation should start with the talking path, then follow on secondary circuits (such as battery and ground supplies). The generation and propagation of impulse noise is described in Section 331-100-101.

B. Sectionalization of Local Central Office From Subscriber Line Terminal to Number Terminal

3.05 Sectionalize between the following equipment units in the complete local central office (CO):

(a) ***SXS Switch Train:***

(1) MDF,

(2) Linefinder,

(3) First through fifth selectors,

(4) Connector,

(5) MDF.

(b) ***Crossbar Switch Train:***

(1) MDF,

(2) LLF,

(3) LLF,

(4) MDF.

(c) ***No. 1 ESS Train:***

(1) MDF

(2) LS

(3) LJS

(4) LJS

(5) LS

(6) MDF.

C. Mitigative Measures—SXS Systems

3.06 The following mitigative measures are to be applied as required in the connector hundred group (in the case of trouble with a data loop) and on battery-supplying relays and repeating coils. These measures are also generally applicable as required for CO noise.

(a) ***Common Mode Unbalance:*** The greater portion of the noise due to CO unbalances during the talking interval is associated with unbalances in the circuits supplying battery to the various portions of the connection. This is because the coil or inductive portions of these circuits are likely sources of longitudinal unbalance and these circuits often carry a high longitudinal current. It is a misconception to assume that windings of repeating coils, relays, etc, are balanced if the dc resistance is equal. Unless the windings are noninductive or special winding techniques are employed, the windings are a potential source of noise.

(1) Replace tandem windings of battery-supplying relays with sandwich-type windings (such as windings for 221FAK, 221FAC, 221ND, etc) in the A and D relays of the connector.

(2) On SXS connectors installed prior to 1942, the T and R leads go straight between the A and D relays. Reverse these leads as shown in Fig. 2. Provide transient suppression by using option N of SD-30228-01 and SD-30220-01. Also, ensure that the 2-μF T and R capacitors are matched.

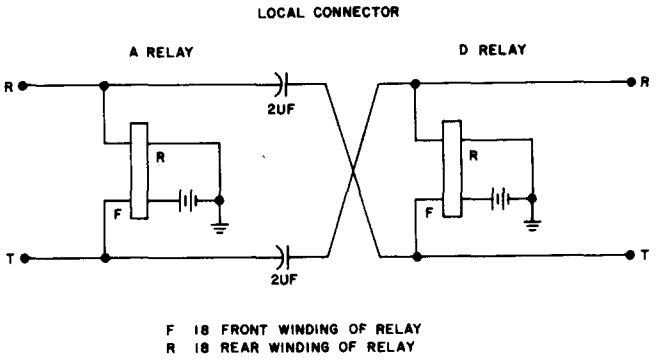

Fig. 2—Reversed Connection of Tandem-Wound Relay

(3) On new equipment, specify balanced relay options.

(b) ***Maintenance of 197-Type Switches*** (See Sections 030-705-704 and 069-501-801 for maintenance procedures of 197-type switches.):

(1) Clean banks using KS-16436, L2 washing fluid. Do not use KS-8760 washing fluid, as it produces temporary opens.

Note: Normal cleaning may not be sufficient and abrasive cleaning may be required.

(2) Replace flat wipers with wipers having precious metal tips if flat spot is more than 1/32 inch. Very high impulses are caused by flat wiper contacts bridging adjacent bank terminals.

(3) Adjust wiper gap as close as possible to 0.008 inch and check follow. This can be checked by plugging a receiver into the switch jack, dialing up on the terminal, and wiggling the shaft. If the wiper is loose or dirty, a hissing noise will be heard.

(4) Test wiper cords for electrical continuity and inspect carefully for worn insulation.

(5) Adjust bank rod collar assembly to minimize vibration.

(6) Inspect bank insulators for fungus growth, using a strong light and a magnifying glass. If necessary, replace with mylar plastic insulators. (See Section 030-705-806.)

(7) Check shelf jack springs (U-jack) and switch plugs for poor spring pressure and dirt.

(8) Clean and adjust cut-through relay contacts.

(c) ***SXS Switch Train:***

(1) *Linefinders:* Clean the banks and wipers regularly and test for noise as described in Section 226-215-500. If necessary, use 185A or 186A suppression networks across the A or B and D relay windings

(2) *Selectors:* Maintain switches and check the distributing terminal assembly (DTA) for loose or unsoldered joints.

(3) *Connectors:* If interference is being caused to a data line by other connectors releasing and sweeping over a working data terminal during the ringing interval, assign a number ending in 0 (zero) to the data line. On connectors using reverse battery supervision, install a 185A or 186A suppression network from tip to ground and from ring to ground between the switch plug (U-jack) and the D relay. This is necessary to stop interference on toll connecting trunks. Connect a 2-μF, 400-volt miniature capacitor across the talk battery and ground terminals on the switch shelf to improve balance and filtering. Check talk battery supply and shelf ground.

(d) ***Miscellaneous:*** Other measures to be taken in SXS offices are as follows:

(1) Maintain relative humidity above 35 percent to reduce static electricity. Humidifying equipment may be required. Do not, however, exceed recommended percentage.

(2) Ground all switches and repeater shelves if they are presently insulated.

For Engineering Consideration

3.07 The following procedures are available under the administration of the engineering personnel.

(a) Where a No. 5 crossbar switching unit exists in the same building or in the same multioffice exchange area as the step-by-step switching unit, route all data calls through the crossbar office;

no corrections need to be applied to the step-by-step switching unit.

(b) Provide dedicated decentralized battery filter. (See 4.02.)

(c) Locate multiple banks so as to minimize the length of multiple cables.

D. Mitigative Measures—Crossbar System

3.08 ***No. 5 Crossbar:*** If it is suspected that the balance of the windings of U- and Y-type relays may be unbalanced, replace windings as required; use, for example, UA 1-type coil in SD-25578.

4. INVESTIGATION AND MITIGATION—COMMON SYSTEMS

A. General

4.01 The investigation and mitigation of impulse noise in common systems should be undertaken at the same time a particular central office is being investigated. The various items which fall into this cateory are described below.

B. Decentralized Battery Filters

4.02 The following procedures are to be applied where decentralized battery filters have been installed. All talk battery supplies must be tested using a 3-type noise measuring set in the bridge condition. (See Section 331-701-501 for testing methods and investigation.)

(a) Check to see if the capacitor main fuse is blown or missing. Remove the alarm fuse and check the continuity of the main fuse. The method for charging the capacitor without blowing the main fuse is described in Sections 032-110-501 and 032-110-701.

(b) Every two years, check for worn-out electrolytic capacitors (Sections 032-110-501 and 100-105-101).

(c) Check the filter connections (Fig. 3). The inductor must be next to the battery and the capacitor next to the load. The low end of the capacitor must be connected to circuit ground. The alarm fuse must be assigned to a talk battery fuse panel.

(d) Measure hum on a talk battery fuse with the lights on and with them off. If the difference is more than 1.0 dB (flat weighting), the filter is too close to fluorescent lights and must be moved.

For Engineering Consideration

4.03 The following procedures are available under the administration of the engineering personnel:

(a) Provide decentralized filters on all bays for the following equipment:

(1) Connectors,

(2) Miscellaneous talk battery fuse panels.

(b) In order to prevent the switching noise from spreading back into the battery supply and central office, it may be necessary to filter the battery supply to markers. The filter and fuse must be dedicated and close to the load with the inductor on the load side. It may be necessary to increase the size of the feeders from the battery to the marker.

(c) Where community dial offices (CDO) are required to handle data calls, provide a filter in the battery discharge lead (the charge lead filter is not enough). Separate the talk battery supply to circuits from signal battery supply to line finders, selectors, etc.

(d) Check to be sure that the distance to the farthest equipment served does not exceed 25 wire feet. This means at least one filter per lineup of equipment.

(e) Check peak load current using a clamp-on ammeter. If load is greater than filter capacity, an extension must be engineered.

C. Battery, Ground, and Power Connections

4.04 ***Test Procedure:*** To test a connection in a ground equalizer, battery feeder, fuse, or equipment frame bond, use one of the following procedures:

(a) Using a voltmeter with a scale and capability of indicating 0.005 volts dc, touch the leads to each side of the joint, across the two ends of a fuse, or between adjacent bays in the same

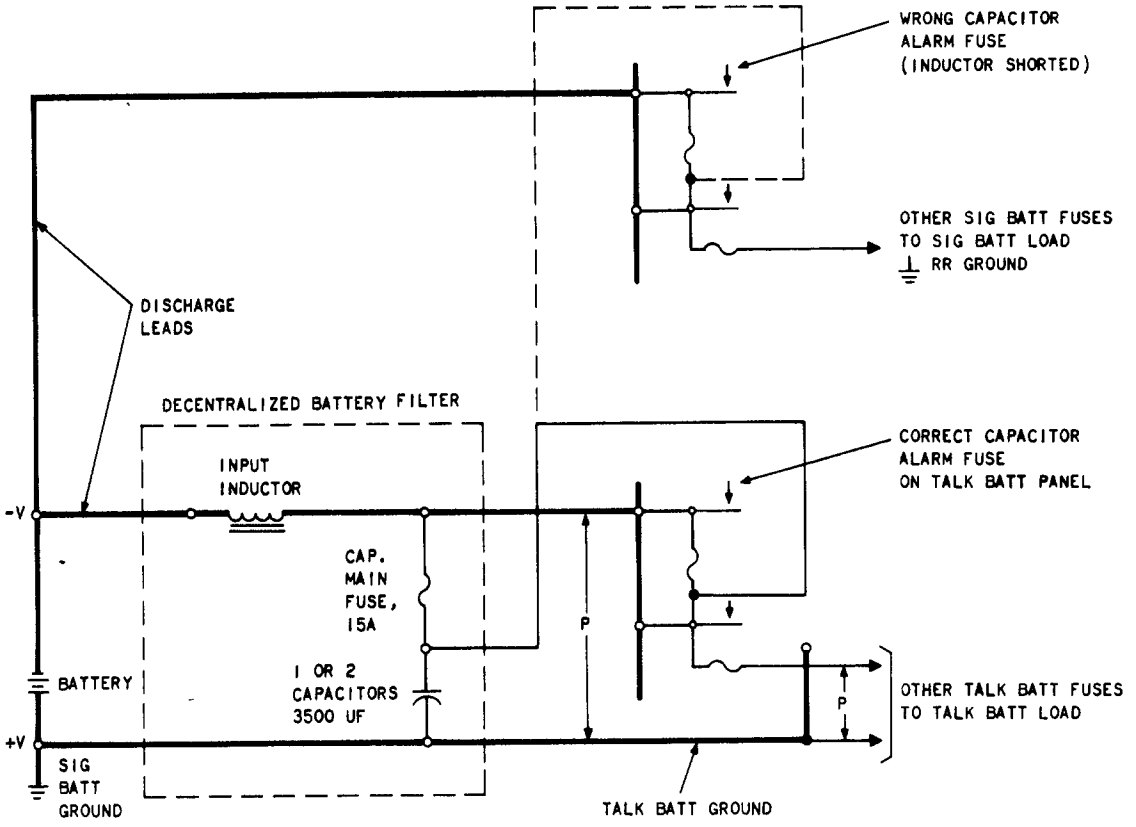

Fig. 3—Typical Decentralized Battery Filter Circuit (SD-95571-01)

lineup. If the meter reads 0.005 volts or more, there is a potential across the joint, fuse, or bay ground which can cause noise.

(b) Or, use a sensitive receiver (such as a No. 716C); if a click is heard in the above-mentioned areas, the same condition exists as that indicated by the meter.

4.05 ***Mitigation Measures:*** The following procedures are to be applied where battery, ground, or power connections are suspected of being sources of impulse noise:

(a) Check to be sure that power supply connections are tight and clean. Be sure that there are no signs of overheating or discoloration. Test the tightness of the connection (see test in 4.04). Places to check are as follows:

(1) Rear of power board,

(2) Busbar connections,

(3) Busbar tap-offs,

(4) Rear of generator control panels,

(5) Battery cell connections,

(6) Battery-distributing fuse bays.

(b) Replace solder lug connections and Allen setscrew lugs on generator leads with crimped lugs, since solder crystallizes and screw connections "cold flow" and loosen.

(c) On connecting aluminum busbars and cell connectors, sandpaper to remove the hard oxide, then apply a coat of NO-OX-ID or Alcoa No. 2 and clamp together within 5 minutes.

(d) Clean and tighten fuse holders and replace fuses where they are found to be noise sources.

(e) Clean carbon dust, copper filings, and excess lubricant from generators. Check brushes and commutator for sparking and arcing. Chamfer leading edge of commutator bars to reduce brush wear. Check brush pressure. Replace brushes if necessary. Also check the commutator color, as described in Section 171-110-701, and take appropriate action as required.

(f) Check voltage variation of selenium rectifier stacks. If the variation is more than 3 volts, replace the stacks. Also check stack temperature. If it is more than 194°F, overloading is indicated (refer to engineering personnel). Check for spurious tones (for example, 3400 Hz), and if there are any, replace the rectifier. Use a 4A frequency analyzer for checking these tones.

(g) Measure all signal battery supplies with a 3C noise measuring set (as described in Section 331-701-501) and a 6F impulse counter. Steady-state noise must not exceed 55 dBrnc and impulse noise must not exceed 15 counts in 15 minutes at 75 dBrnc. The following items could cause those limitations to be exceeded:

(1) Fast marker operation,

(2) Charging generators or rectifiers,

(3) Charge lead filter,

(4) Multicontact relays,

(5) Linefinders,

(6) DC telegraph and coin control,

(7) Interrupter distributor,

(8) Alarms,

(9) Answering time recorder,

(10) Traffic usage recorder,

(11) Make-busy contacts.

If one of these loads generates high impulse noise, treat per 4.03(b). Check to be sure that spark suppressors are adequate and not worn out.

(h) On signal battery, check to be sure that leads supplying battery distributing fuse boards and fuse panels are paired and of the same size. Also check to be sure that circuits grounded to local frame ground have a copper or aluminum return path to the fuse bay. Refer to engineering personnel if the above conditions are found.

For Engineering Consideration

4.06 About 20-dB improvement in impulse noise mitigation may be realized when generators are replaced by rectifiers. This should be considered when plans are made for changes in battery supplies. Also check the following conditions:

(a) Check to be sure that circuits requiring signaling battery are being fed from signal battery leads and not from talk battery leads, and vice versa. Reassign leads if necessary.

(b) Check to be sure that talk battery fuse panels are fed from the talk battery bus. If they are not, reconnect them.

(c) Check to be sure that talk battery and ground leads are paired from the fuse bay to the equipment served, not grounded at local frame ground. Check to be sure that leads are properly separated from ac wiring or signal leads. Check to be sure that leads from power room to the battery distributing fuse board and fuse panels are alternately + and − on the runway and that battery and ground leads are the same size. Correct as required (Section 802-005-180).

D. Central Office Grounding System

4.07 A number of changes have been made in the central office ground system. These are covered in Section 802-001-180 and SD-81899-01. The system (Fig. 4) consists of a central office ground considered as the zero potential point to which ground equalizer leads from various sources are connected. These equalizers must be large and well connected so as to drain off stray currents with negligible voltage rise. The following items are to be checked:

(a) ***When Ground Is at Water Intake:*** Be sure that

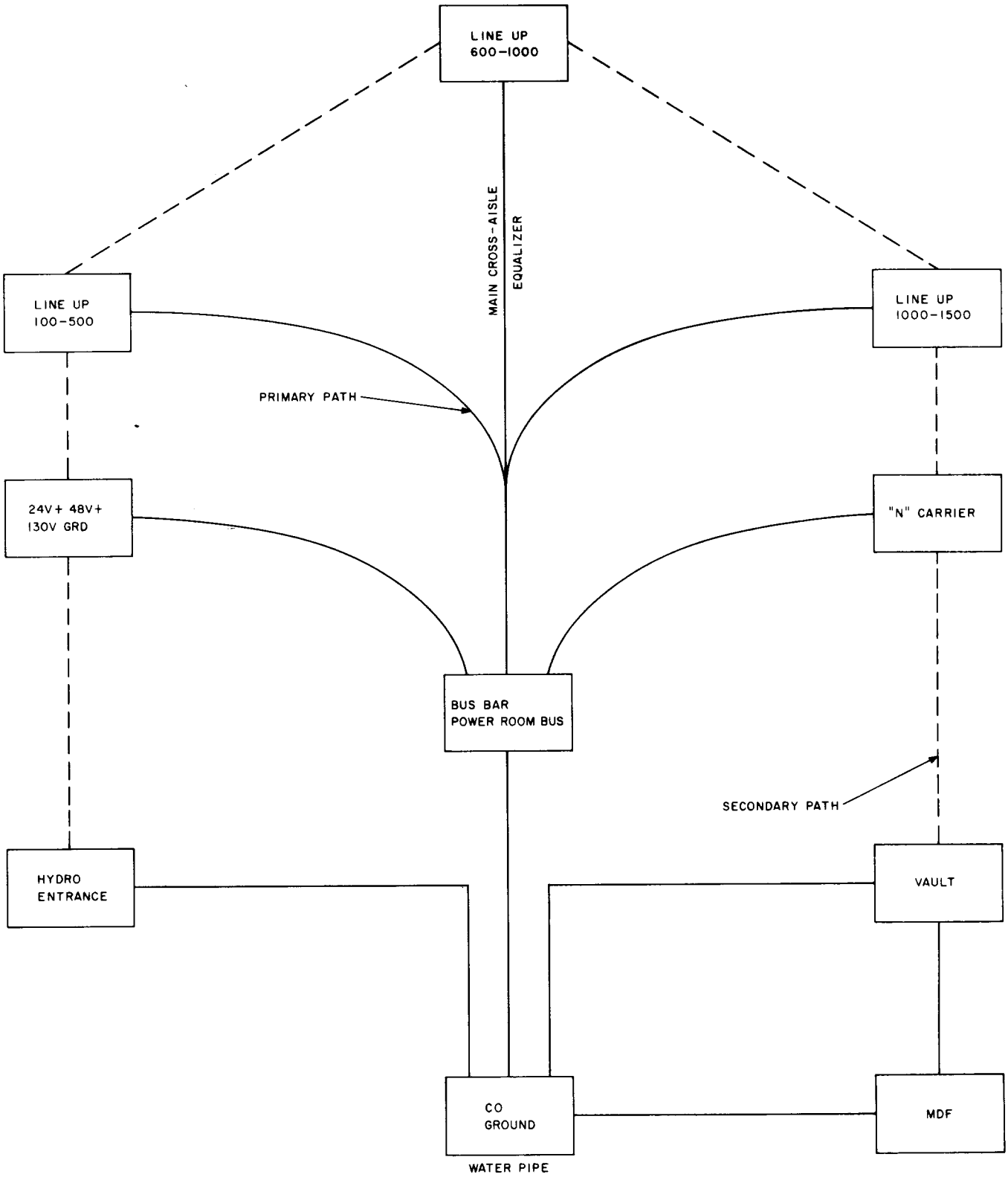

Fig. 4—Typical Central Office Ground Network Showing Primary and Secondary Paths

(1) The ground wire is connected to the street side of the water meter,

(2) Bonds are placed across water meter and other insulating joints,

(3) Contacting surfaces are clean, free of paint and corrosion [test for potential differences as described in 4.04(a)],

(4) Ground lead circuits are connected to the central office ground,

(5) The water pipe is metal, not plastic.

(b) ***When Ground Is Not at Water Intake:*** Be sure that, for example, in the power room, ground is connected to the water intake or "made ground" (driven rod) by a ground equalizer. Check to be sure that all connections are correct as in (a) above.

(c) Be sure that MDF protector ground connections are clean and tight. Check to be sure that all cable sheaths are bonded to the iron framework. Measure the potential difference between the cable sheath and the copper plate MDF ground as described in 4.04(a). Recheck bond if necessary.

(d) Test for potential differences, as described in 4.04(a), between equipment frames in the same lineup.

For Engineering Consideration

4.08 The following items should be considered by engineering personnel when assisting plant personnel in the mitigation of impulse noise or when making engineering changes or planning:

(a) ***Driven Rod Grounds:*** Install and measure in accordance with information provided in Section 876-700-100. If the resistance exceeds 5 ohms (Section 802-001-180), a likely source of impulse noise exists and corrective action should be taken as described in Section 876-700-100.

(b) ***AC Power Neutral:*** The ac power neutral should be connected to the central office ground by a minimum No. 0 wire.

(c) ***Vault Ground:*** The lead from the vault to the central office ground should be a No. 0 wire or larger. See Sections 802-001-180 and 638-300-011. The vault should be bonded to the water intake via the shortest route (SD-81899, Note 212), not only via the MDF. The latter path is too long to provide adequate draining of impulse noise interference.

(d) ***Equipment Frame Grounds:*** The frames should be grounded with a direct metallic connection of either wire or busbar. On duct-type bays (classed as noncircuit grounding), No. 6 copper wire or larger should be installed per Sketches A and C of SD-81899. This will supplement the iron pipe ground, which is unreliable (Section 802-001-180).

(e) ***Equipment Lineups:*** Connect only one end to the main cross-aisle equalizer. The return currents of one lineup should not flow through busbars of another lineup. The return currents of switching and signaling equipment should not flow through the busbars of carrier or amplifier equipment.

E. Protectors

4.09 The following items should be checked:

(a) Check for heat coils which are corroded, partially operated, damaged, or which have poor spring pressure (Section 069-315-801). Replace as required.

(b) Check for noisy carbon blocks and replace as required. If excessive operation is occurring in high lightning areas, gas tube protectors should be used.

F. Relays and Relay Circuits

4.10 In addition to measures described in 3.06, the cut-through relays should be checked for dirty and pitted contacts and contact spring pressure for good follow. Microphonics and interruptions to data signals are caused by poor follow, dirt, and vibration.

For Engineering Consideration

4.11 The following measures should be considered by engineering personnel in the mitigation of noise in relay circuits:

(a) ***Reversing and Pulsing Relays:*** Apply shunt suppression where transients are a problem,

such as in connectors, transmission selectors, dial-up terminations, test tones, and cut-through relays. Check to see if the capacitors in existing suppression networks are worn out.

(b) ***Dial-Up Quiet Balance Termination:*** Provide the option for steady off-hook supervision. This is required for all data loop and trunk testing.

(c) ***Alarm Circuits:*** Apply transient suppression per SD-96188, Figures 41 to 63, Option XR. Pair the leads as shown in Figure 83 of the SD.

(d) ***Traffic Usage Recorders:*** Apply transient suppression on select and hold magnets and control relays. Also suppress the traffic register at the master test frame and elsewhere.

(e) ***30, 60, and 120 IPM Circuits:*** Remove busy flash.

(f) ***Transmission Measuring System:*** Apply suppression to all relays and to the projection meter. This area is also a source of impulse noise when measuring at the testboard or VF patch bays.

G. Patch Bays

4.12 The following procedures apply to patch bays:

(a) Clean jacks and plugs regularly.

(b) Check for loose jacks which may be causing intermittent shorts or grounds.