NOISE ENGINEERING

MEASUREMENT AND EVALUATION OF C-MESSAGE WEIGHTED NOISE ON TWO-WIRE SUBSCRIBER LOOPS

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1. GENERAL

1.01 This section describes the engineering considerations involved in the measurement and evaluation of C-message weighted subscriber loop noise as measured with the 3-type noise measuring set. These considerations are limited to 2-wire loops without gain devices.

1.02 This section has been reissued to renumber to the 870 division, to retitle, and to make miscellaneous changes.

1.03 The factors affecting loop noise, i.e., central office contributions, cable crosstalk, and unbalance, are shown in Fig. 1. The principal source of noise is the inductive influence of neighboring power lines. This may have a significant effect on long loops because of the greater exposure and on party lines because of the inherent unbalance. Figures 2, 3, and 4 show some of the results of the 1964 sample survey of loop noise measured at the line terminals of the station set to a dialed-up central office termination. The ***GENERAL*** results are for loops selected at random from the entire population of Bell System loops and the ***LONG LOOP*** results are for loops selected at random from the population of loops longer than 30 kft.

1.04 Normally, subscriber loop noise is measured at the ***line terminals*** of the station set to a termination in the central office. However, loop noise may also be measured at the central office to ***ON-HOOK*** and/or ***OFF-HOOK*** terminations at the station. From these measurements, the ***expected*** value of noise heard by the subscriber may be estimated to a reasonable degree as shown in Fig. 5, 6, 7, and 8.

1.05 Central office measurements of ***ON-HOOK*** noise may be considered as a first step in the determination of whether a loop noise problem exists since assistance at the station is not required. The method may be used as a tool for indicating loops, routes, areas, etc., which may require further investigation.

1.06 For any given value of ***ON-HOOK*** noise, Fig. 8 shows how an ***OFF-HOOK*** measurement will narrow the range in which noise heard by the subscriber may be expected to fall. However, loop noise measurements at the central office to ***OFF-HOOK*** station terminations may involve subscriber cooperation and inconvenience. The measurements may also include room noise and other effects at the ***OFF-HOOK*** location, which may not be desirable.

1.07 If ***ON-HOOK, OFF-HOOK,*** and ***STATION*** measurements are obtained at the time of service visit for installation, removal, etc., relationships similar to those shown in Figures 5 through 8 may be established on any local operating basis desired. This procedure could more precisely define the relationships and lead to simplified administration of noise analysis and mitgation.

2. NOISE MEASURED AT STATIONS

2.01 ***STATION*** loop noise measurements are required in certain administrative procedures, e.g., trouble clearing processes, investigations of adverse comment, etc.

2.02 The procedure requires that the testing apparatus be connected at the ***line terminals*** of the subscriber's station set (connector block, protector, or cable terminal). The subscriber's station set is not disconnected and must be ***ON-HOOK*** for the duration of the measurement. The noise measuring equipment simulates the ***OFF-HOOK*** condition. An exception is made to this rule in the case of subscribers using tip-party identification, that is, the equivalent of the station set ***OFF-HOOK*** must be established.

2.03 It should be kept in mind that C-message weighting is designed to take into account the frequency characteristic of the 500-type telephone set as well as the hearing of the average subscriber. Therefore, C-message weighting is applicable to measurements made almost anywhere except across the telephone receiver. Hence, the ***line terminals*** of the ***STATION*** set are specified as the point of measurement.

2.04 ***STATION*** loop noise measurements are made to central office test terminations. The terminations are reached by dialing their assigned telephone numbers. The measurements are made with a 3-type noise measuring set, a holding arrangement, and a telephone set or 1011-type handset, as described in Division 331-8 of the Plant Series.

2.05 Where tip-party identification ground is involved, the connection to the 1000-Hz, 900-ohm test line is established with the telephone set in accordance with the conditions outlined in 2.02.

2.06 The coin relay ground path on prepay coin lines must be closed manually and maintained closed during measurements. In addition, continuity must be reestablished between the apparatus on the upper housing and that on the backplate to arrange the circuit for normal operation. If this is not done, the prepay coin telephone presents a highly unbalanced grounded termination to the line which greatly exaggerates the effect of any induced longitudinal noise voltages that may be present. Where a measurement of the metallic noise on the line alone is of interest, it is sufficient to close the coin relay ground long enough to obtain dial tone and then dial the quiet termination. The ground may then be released, interrupting the longitudinal path. The noise under this condition will be that on the loop, which is measured to what is, in effect, a quiet termination. It must be remembered that noise measured this way, may or may not, correspond to what a subscriber would hear when using the prepay coin telephone.

2.07 Where key equipment such as type 1A1 is involved, measurements are made from the key equipment location. Temporary changes in the key equipment circuitry may be required to hold the connection during measurements.

3. NOISE MEASURED AT CENTRAL OFFICES

3.01 The ***CENTRAL OFFICE*** is a practical location for making loop noise measurements. A preliminary evaluation of loop noise conditions may be accomplished with a minimum of time and effort. In addition, the concentration of loops at central offices facilitates the design of surveys on any basis desired, e.g., overall, area, route, etc.

3.02 The Noise Component Plan for the Subscriber Plant Transmission Index obtains information on prevailing noise conditions by means of overall sampling survey techniques. Such sampling techniques are very useful for determining general conditions in a fairly large population, such as a district, division, or an area. A carefully drawn sample will indicate those central offices where additional effort might be required to reduce noise on subscriber lines. However, such surveys generally do not provide the detailed information necessary to identify particular loops which need attention. In addition, a relatively small fraction of the total number of loops is usually responsible for most of the excessive noise. Because of this, overall surveys are generally not satisfactory for remedial purposes.

3.03 A survey may be designed in terms of a stratified sample within loop cable routes or cable complements, etc. In this way, loops that serve the exchange boundary may be investigated. These are the longer loops; hence, satisfactory noise conditions on these loops will usually assure that noise conditions are satisfactory on the shorter loops. On the other hand, should noise conditions prove unsatisfactory, a new sample of loops terminating on an inner boundary may be investigated. This procedure may be continued until a boundary with satisfactory noise conditions is found. This procedure defines the boundary beyond which a detailed investigation is desirable.

3.04 A stratified sample within an open-wire or cable ***route*** may be employed to investigate loops affected by common noise sources along the route, e.g., the inductive influence of power systems (joint use or roadway separation), the ***before-and-after*** noise effect of a change in telephone plant or a change in power system conditions (telephone service rerouted from underground cable to open wire or the installation of a generator whose inductive influence is in doubt), etc.

3.05 Central office loop noise measurements to ***ON-HOOK*** stations may be made with the 3-type noise measuring set and ▶accessory arrangements◀ as described in Division 331-8 of the Plant Series. The telephone set facilitates the seizure of loops and the accessory arrangement facilitates connection to the noise measuring set.

3.06 Central office loop noise measurements to ***OFF-HOOK*** stations may be made in the same way that ***ON-HOOK*** measurements are made except that the loop is placed in the ***OFF-HOOK*** condition by ringing the subscriber.

3.07 Other sections contain procedures for making measurements at various central office test locations. Choice of a particular testboard or test frame for noise measurements depends on the purpose of the measurements. The following list groups test locatons by the preferred types of noise tests:

General Noise Surveys (Specifically for Noise Component of the Subscriber Plant Transmission Index)

Test Distributors—SxS

Master Test Frames (MTF)—No. 5 XB

OGT Test Frames (OGT)—No. 1 XB

▶Main and Intermediate Distributing Frames (MDF and IDF)◀

14-Type Local Test Desk ▶No. 3 Test Cabinets◀ or equivalent when in the same building as the wire center to be surveyed

General Noise Surveys (Other)

All above test locations and in addition Test Trunk Ringing Circuit Appearances

Trouble Shooting Procedures

Any of the above locations, as appropriate.

3.08 When measurements are made at the MDF, the heat coils are removed and the loops are isolated. Measurements at the MDF do not tie up test equipment provided for other operations but do require that loops be monitored on a noninterfering basis. An alternative method of frame measurement may be made at the IDF where loops may be made busy to incoming calls by placing the proper electrical condition on the sleeve to operate the cutoff relay and remove the line circuit.

3.09 When measurements are made at 14-type Local Test Desks ▶and No. 3 Test Cabinets,◀ the loops may be accessed through the position test circuits ▶with accessory arrangements◀ or they may be connected through the MDF trunk circuit using test shoes. The latter procedure requires that loops be monitored on a noninterfering basis.

3.10 Where offices are arranged for remote testing, a test location should be selected within the serving office. Measurements may be made at the test trunk ringing circuit appearance at the MDF, MTF, or SxS test connectors.

4. EVALUATION OF NOISE MEASUREMENTS

A. General

4.01 Loop noise is a problem to the affected customers because the same level tends to be present at all times.

4.02 Noise originating on loops is predominantly power line hum. The hum level is determined by the extent of power line influence, the coupling, and the unbalance (to ground) of the loop and the terminal equipment (central office and station). Noise originating in central offices also makes a contribution to the noise heard by the subscriber.

4.03 The evaluation of excessive noise on loops may be aided by a consideration of ***likely*** contributors with regard to ***long loops*** as opposed to ***short loops,*** and ***individual lines*** as opposed to ***party lines,*** e.g., internal noise is not expected to be a problem on long loops, nor is power line influence on short loops or station unbalance on individual lines. These and other details are shown in Table A below.

TABLE A

LIKELY (X) CONTRIBUTORS TO EXCESSIVE LOOP NOISE

NOISE CONTRIBUTOR	LONG LOOPS		SHORT LOOPS	
	INDIVIDUAL LINES	PARTY LINES AND COIN STATIONS	INDIVIDUAL LINES	PARTY LINES AND COIN STATIONS
Power Line Influence	X	X	Usually Small	Usually Small
Central Office Unbalance	X	X	X	X
Station Unbalance	Usually Small	X	Usually Small	X
Central Office Noise	Attenuated	Attenuated	X	X

4.04 For comparison, the 1964 loop noise survey indicates that:

(a) noise on ***LONG LOOPS*** exceeds noise on loops in ***GENERAL*** by 10 to 15 dB (Fig. 2).

(b) For ***LONG LOOPS,*** noise on party lines exceeds noise on individual lines by 5 to 15 dB (Fig. 3).

(c) For loops in ***GENERAL,*** noise on party lines exceeds noise on individual lines by about 8 dB (Fig. 4).

4.05 With regard to loop noise measurements made in the central office, the first step in the evaluation is the interpretation of the measurement in terms of an ***equivalent level at the line terminals of the station set.*** This may be done with the aid of Figures 5, 6, 7, and 8, e.g., with reference to Fig. 8 it is shown that, if ***STATION*** noise is to fall in the lower part of the noise range, then either the ***ON-HOOK*** measurement or the ***OFF-HOOK*** measurement, or both, must fall in the lower part of the noise range.

B. Objective for Station Measurements

4.06 The subscriber loop noise ***OBJECTIVE*** refers to measurements at the line terminals of the ***STATION*** set to a termination in the central office. This objective is a distribution of measured noise generally below 20 dBrnc. For short loops, measured noise should be entirely below 20 dBrnc; whereas for long loops, a relatively small number of measurements may exceed 20 dBrnc; in no case should measured noise exceed 30 dBrnc. ➧Table B shows➧ the action recommended in relation to measured noise.

4.07 ➧Table B separates short and long loops with somewhat relaxed action recommendations for the long loops. This recognizes the effects of greater exposure, increased susceptibility, presence of gain devices, and increased party line development on the longer loops. Careful long loop design, construction, and maintenance will assure that noise will be minimized, although the final measured result may fall acceptably in the 20 to 30 dBrnc range. When noise on a long loop does exceed 30 dBrnc, further analysis and investigation are certainly indicated to make sure the best possible design, under the circumstances, has been selected and that all construction and installation details conform.

TABLE B

LOOP NOISE OBJECTIVES AND REQUIREMENTS

NMS READING (dBrnc)	LEVEL OF SIGNIFICANCE	ACTION RECOMMENDED	
		SHORT LOOPS	LONG LOOPS*
20 or Less	Objective for *All* Loops	Further Analysis Not Necessary	
21 to 30	Loop Noise Marginal As 30 dBrnc Approached	Further Analysis and Investigation	Review to Assure Design and Construction Best Possible
Greater than 30	Unacceptable	Immediate Investigation	Further Analysis and Investigation

* Loops per "Long Route Design"

An important consideration in accepting noise levels on long loops exceeding 20 dBrnc is that the loop must be ***well*** balanced. A measurement of NOISE-TO-GROUND will, when compared with the NOISE METALLIC, indicate the degree of balance (See 870-200-100). A difference $(N_g - N_m)$ less than 50 dB indicates that the noise level can be reduced by improving the balance of the loop.◀

C. Guides for Central Office Measurements

4.08 Guides for central office measurements were developed from central office and station measurements on the same subscriber loops. Figures 5, 6, 7, and 8 refer to such measurements. The results are based on random sample surveys of 150 to 200 pairs extending into the outer portion of selected exchange areas that contained about 25 percent of the stations plus routes involved in severe inductive exposures. Pairs involving PBXs, wiring plans, line concentrators, and pairs equipped with bridge lifters located in the outside plant were excluded from the sample. The central office method is not considered a satisfactory means for evaluating noise on these loops.

4.09 When evaluating subscriber loop noise measurements at the central office, the guides for action ▶in Table C◀ are recommended.

5. CONSIDERATIONS FOR ANALYSIS AND INVESTIGATION

5.01 As described above, subscriber loop noise is determined in terms of measurements across the ***line terminals*** of the ***STATION*** set, or it may be estimated in terms of central office measurements to ***ON-HOOK*** and/or ***OFF-HOOK*** stations.

5.02 Loop noise surveys have demonstrated that if a measurement at the ***STATION*** indicates excessively high loop noise, it is almost certain that the station is a party line and that the noise is power line hum. As shown in Fig. 3 and 4, party lines, because of the use of grounded ringers and other unbalanced circuitry, are found on the average to be much noisier than individual lines.

5.03 If ***ON-HOOK*** and/or ***OFF-HOOK*** measurements indicate that the noise is excessive, a measurement at the ***STATION*** may be helpful in clarifying the situation.

5.04 Once it is established that subscribers are experiencing excessive loop noise, an analysis and investigation may be directed toward defining the extent of the disturbance and the location of the noise source. Action may take the form of a noisy survey to establish a pattern and a search of office records for existing information regarding the noise source and its effects to date.

TABLE C

LOOP NOISE MEASURED AT CENTRAL OFFICE END

NMS READING — dBrnc		ACTION RECOMMENDED	
TO ON-HOOK STATION	TO OFF-HOOK STATION	SHORT LOOPS	LONG LOOPS
10 or Less	5 or Less	Further Analysis Not Necessary	
11 to 20*	6 to 15	Further Analysis and Investigation	Review to Assure Design and Construction Best Possible
Greater* than 20	Greater than 15	Immediate Investigation	Further Analysis and Investigation

* When measurements are made on loop noise surveys per Section 301-320-501, pattern analysis of results may be desirable before making visits.

5.05 As described in Part 1, loop noise surveys are most readily implemented by tests in the central office to ***ON-HOOK*** stations. If loops with excessive noise are encountered, additional loops in the same complement, or the same route, and terminating in the same general area, may be measured. An alternative to the above procedure is the method described in 3.03.

5.06 In a search of office records for existing information, the following is a suggested list of sources:

Customer Noise Complaints to Repair Service

Service Observations

DDD Service Bureau Noise Reports

Informal discussions with:

Wire Chief
Repair Service
Test Bureaus
Service Bureaus
Testboard Personnel
Installers
Repairmen.

5.07 Should an extensive pattern of excessive loop noise develop, a procedure leading to recommendations for remedial measures may be indicated. This procedure is classical and involves considerations of (a) the inductive influence of power systems, (b) the degree of coupling between the power systems and the telephone system, and (c) the degree of unbalance of the telephone system. Material dealing with these considerations is developed at length in the Electrical Coordination Series of practices.

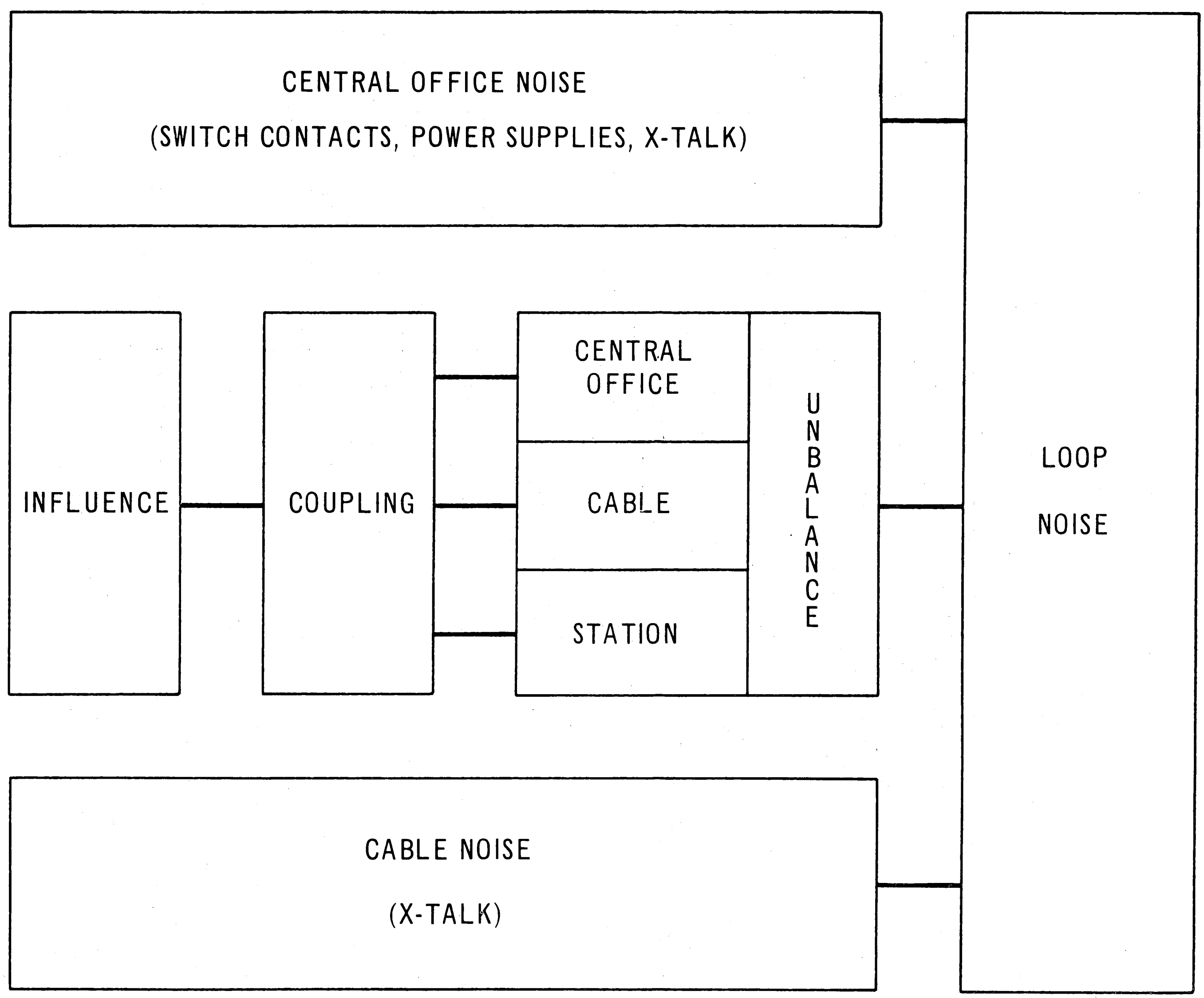

Fig. 1—Factors Affecting Loop Noise

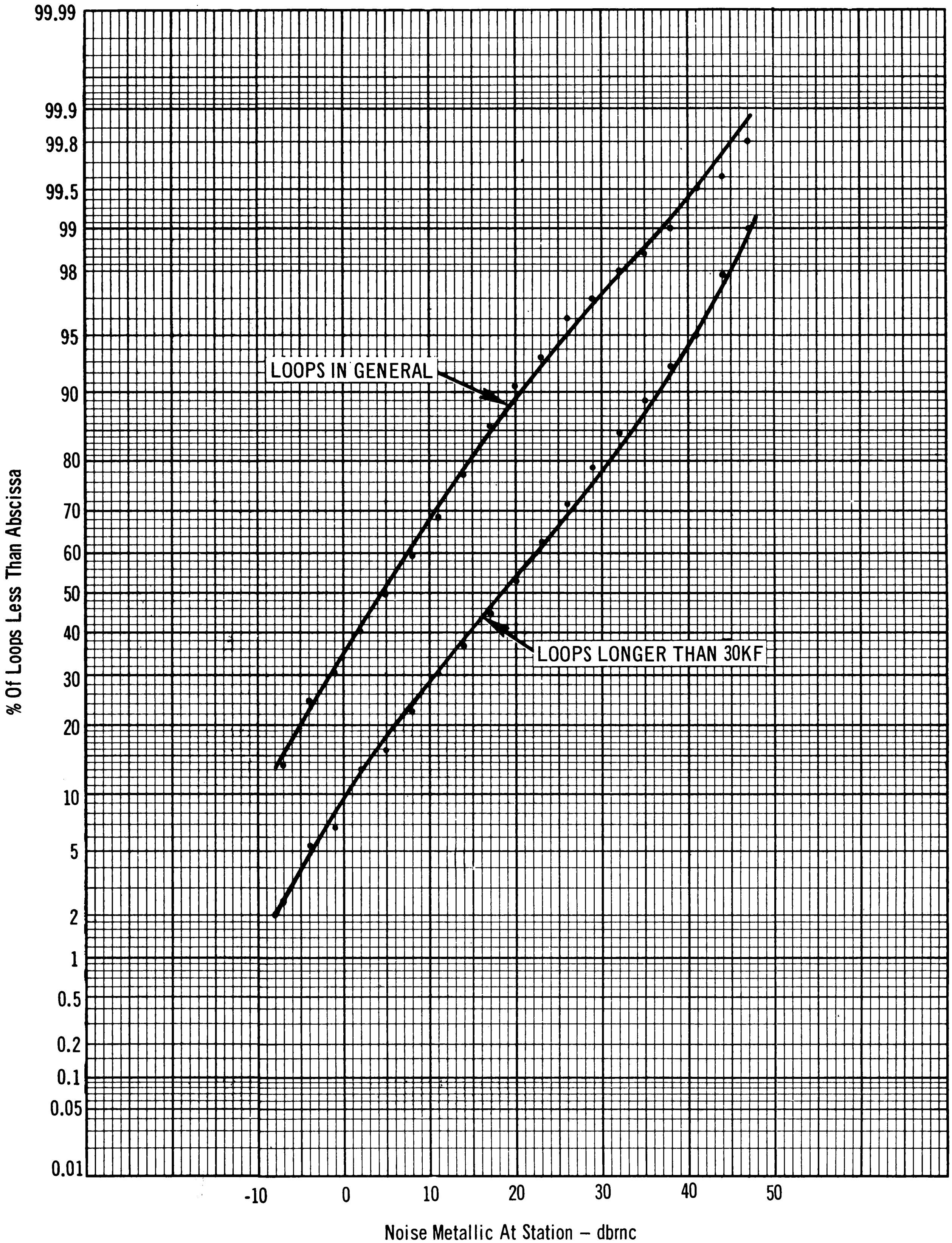

Fig. 2—1964 Loop Noise Survey

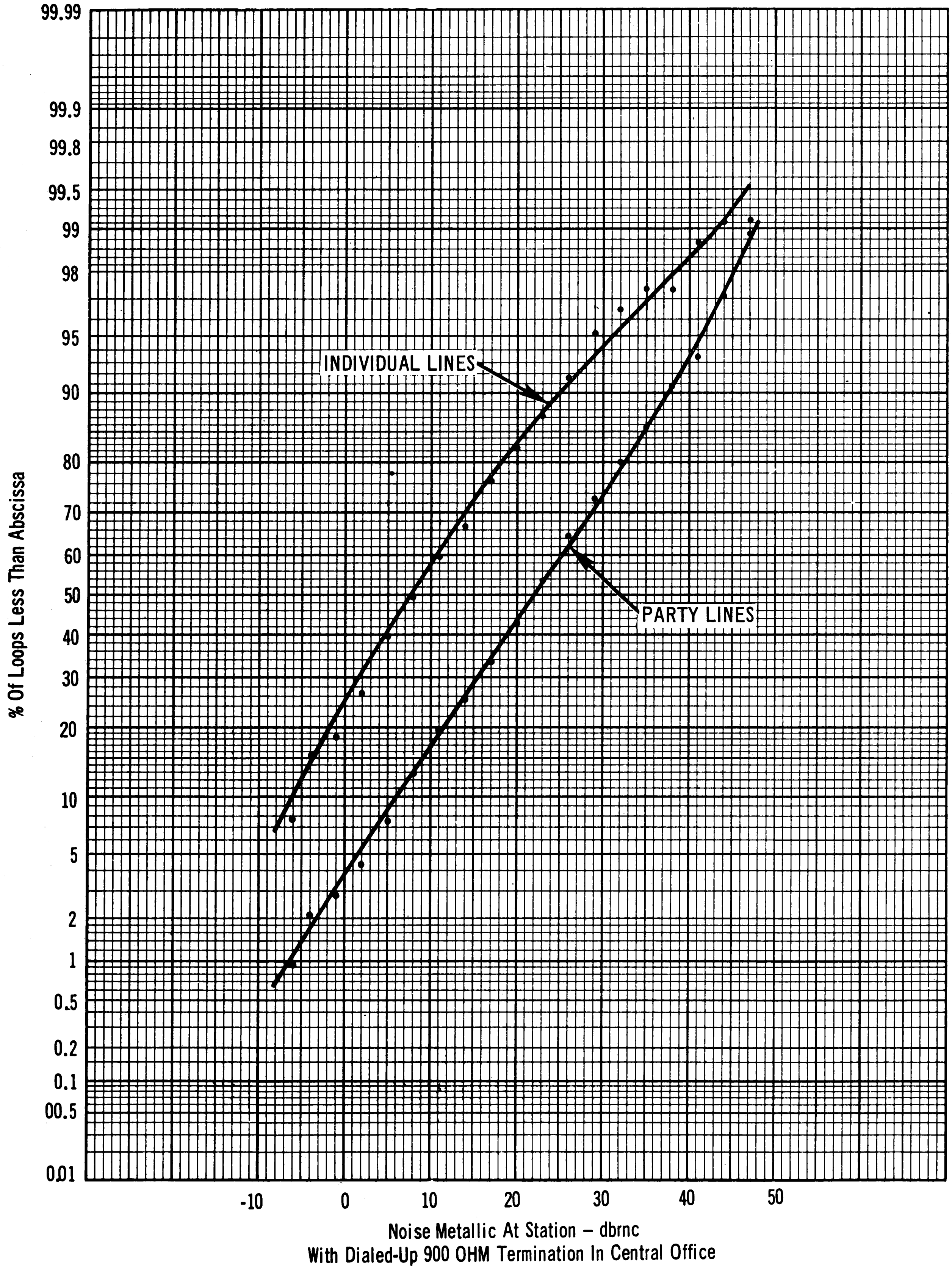

Fig. 3—1964 Loop Noise Survey—Loops Longer than 30 kft

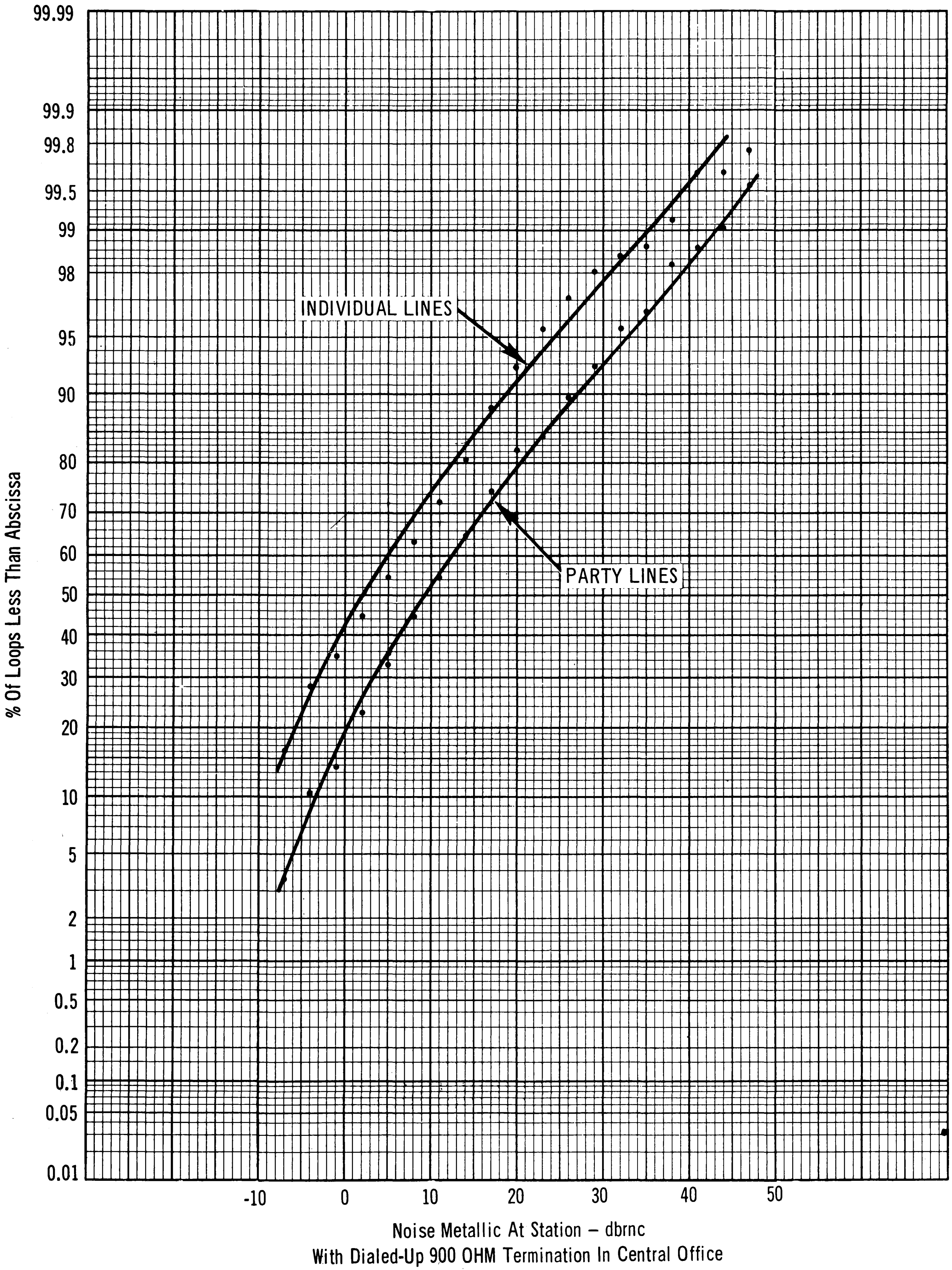

Fig. 4—1964 Loop Noise Survey—Loops in General

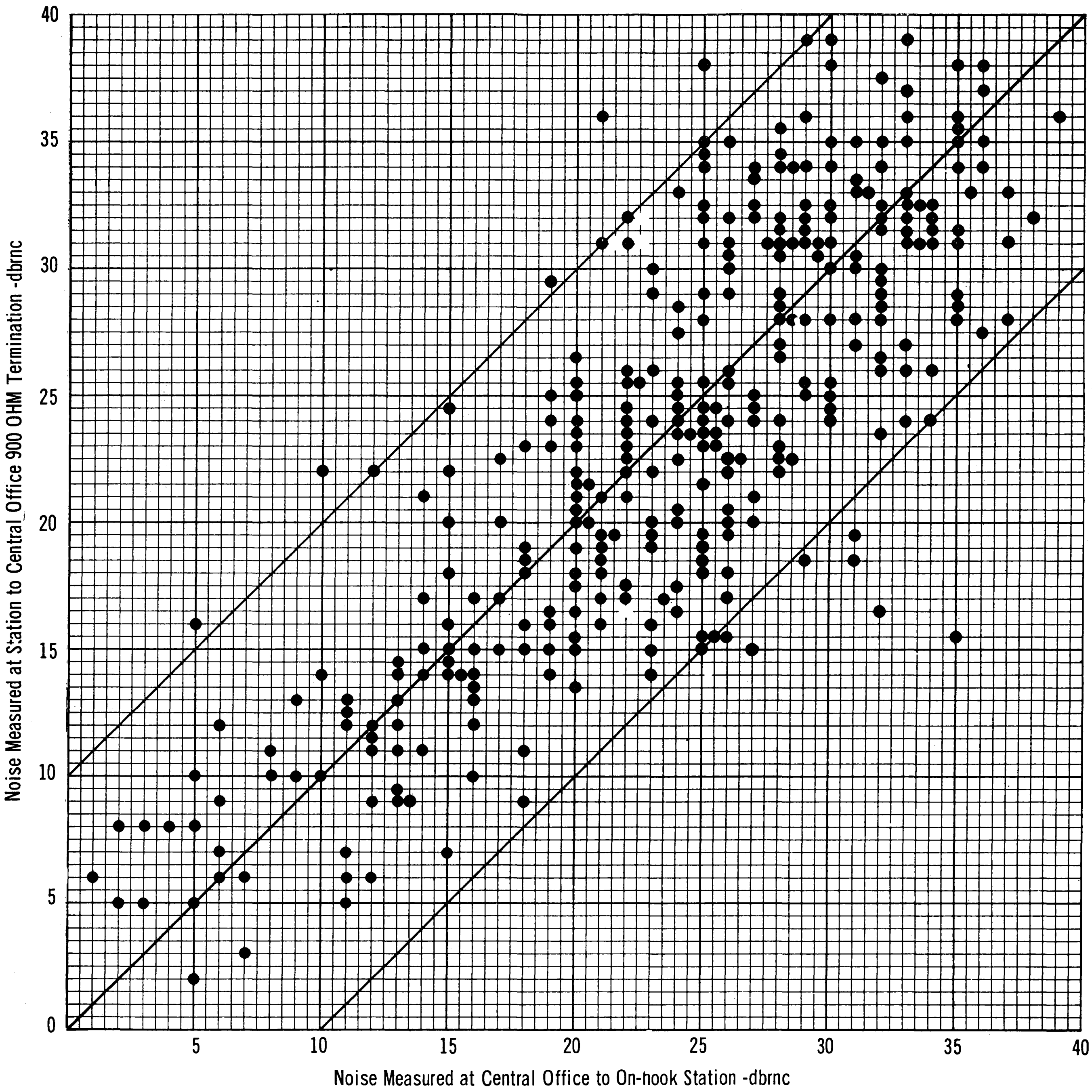

Fig. 5—Subscriber Loop Noise

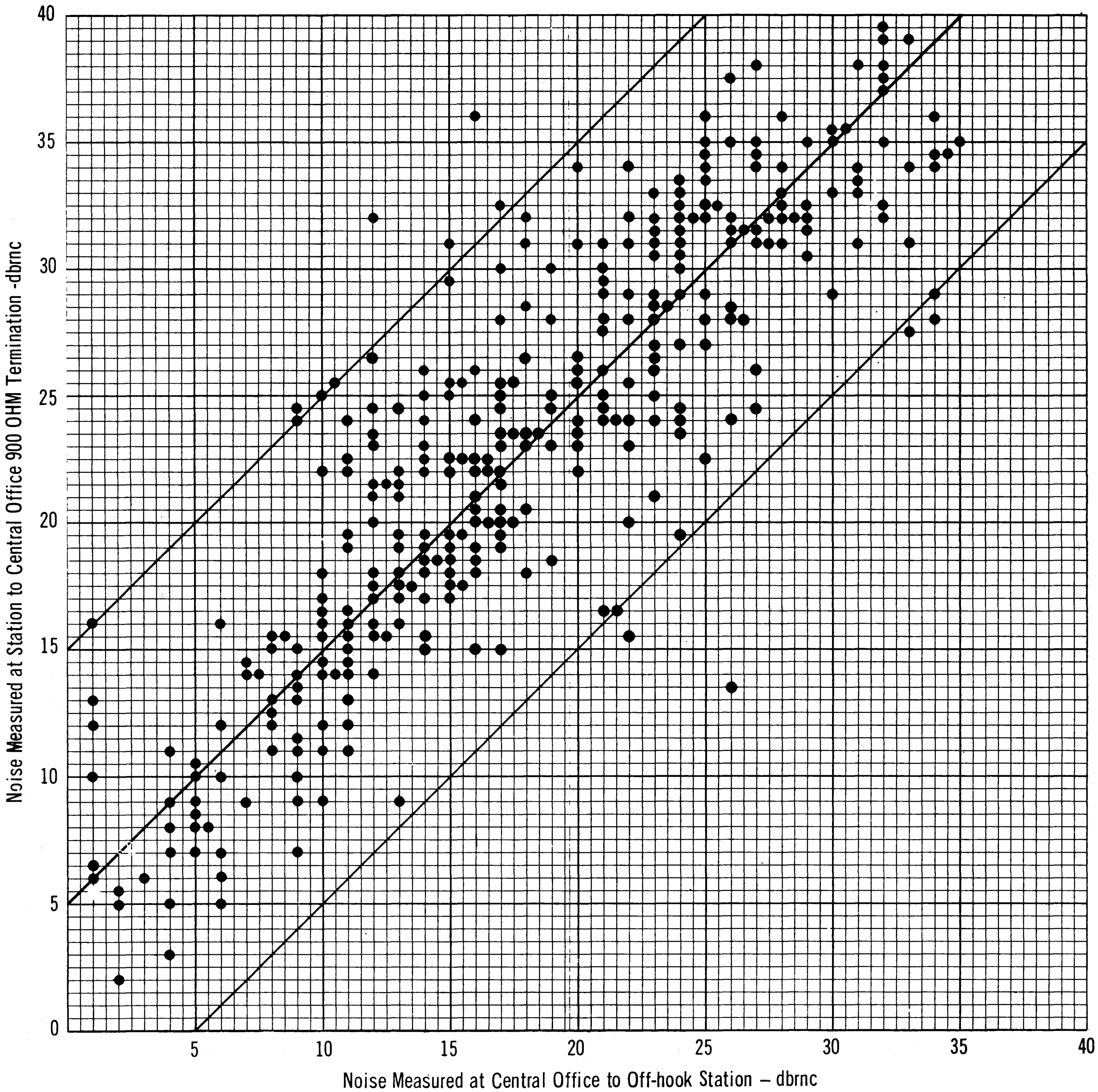

Fig. 6—Subscriber Loop Noise

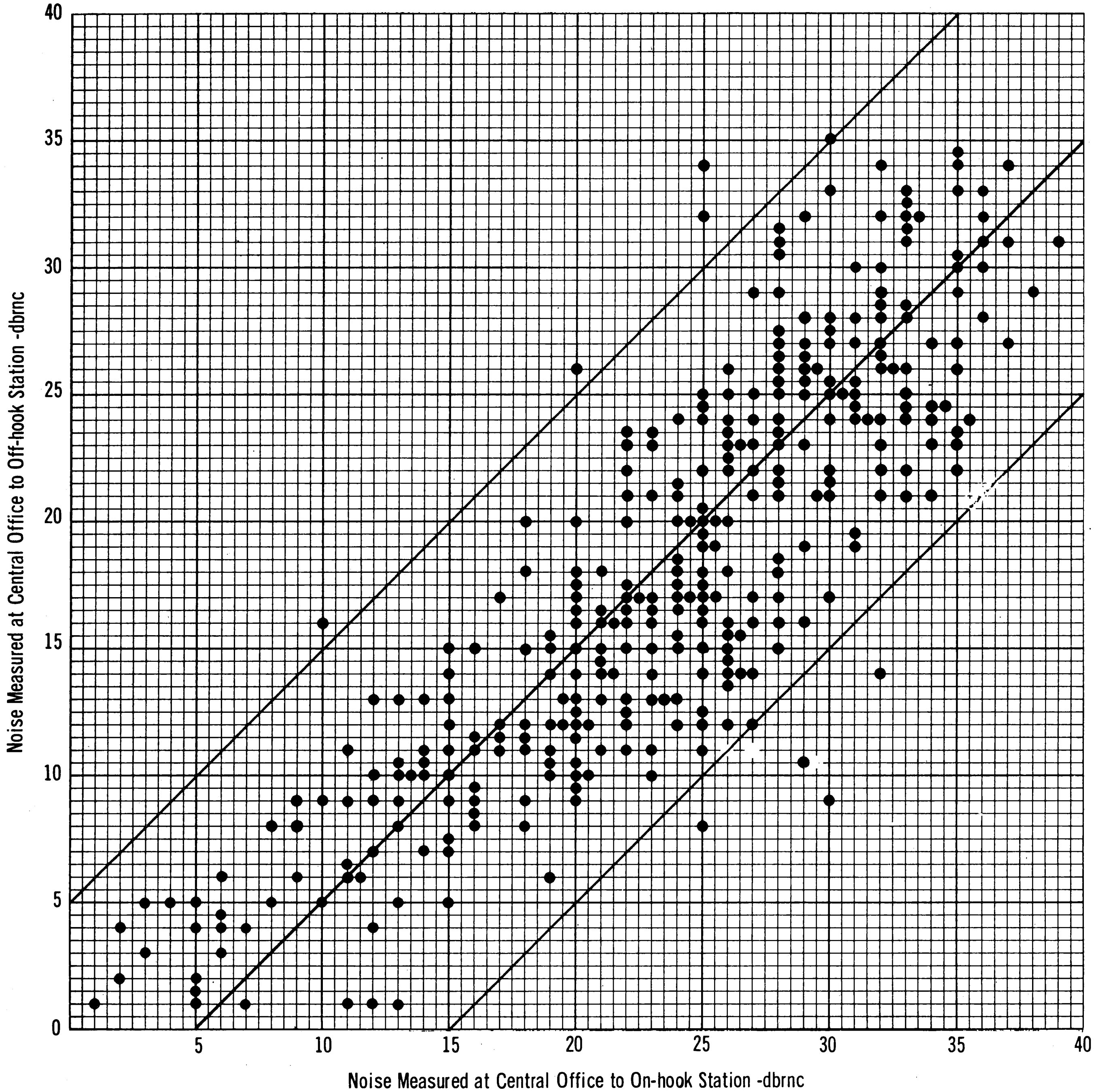

Fig. 7—Subscriber Loop Noise

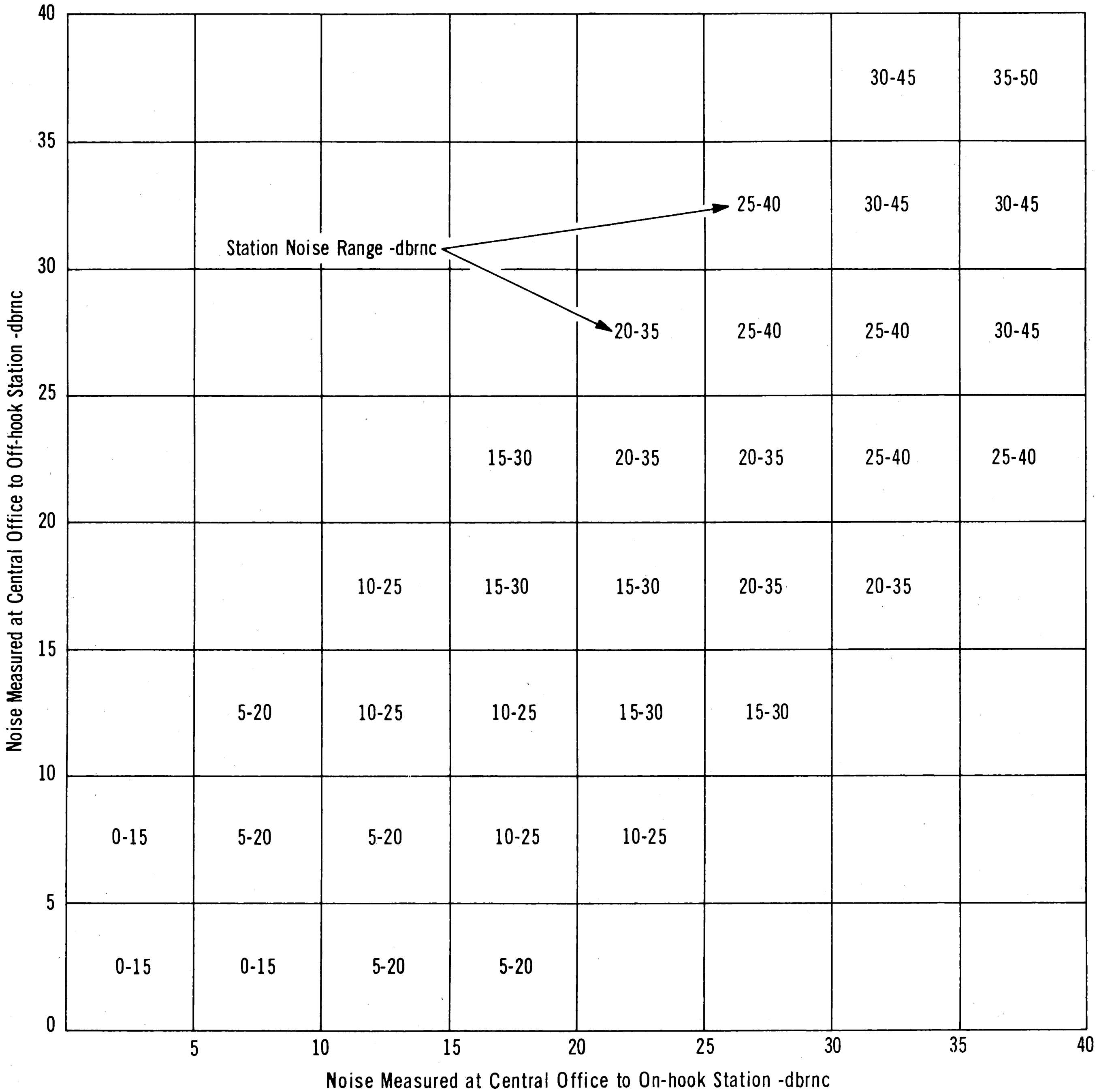

Fig. 8—Subscriber Loop Noise