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Suggested plan for the implementation of a noise reduction program in the Spokane district of the Pacific Northwest Bell Telephone Company

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A SUGGESTED PLAN FOR THE IMPLEMENTATION OF A NOISE REDUCTION PROGRAM IN THE SPOKANE DISTRICT OF THE PACIFIC NORTHWEST BELL TELEPHONE COMPANY

By

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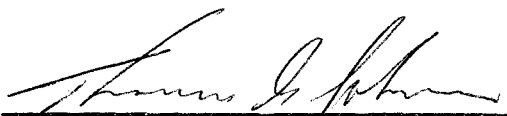

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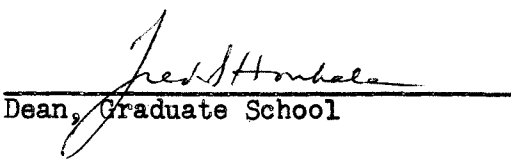

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CHAPTER I

INTRODUCTION

Intelligibility Characteristics of Speech Transmission

There are three characteristics of a transmission system that affect the intelligibility of the received sounds and their naturalness to the listener. These three factors upon which the general adequacy of the received sound is dependent are volume, distortion, and noise.[1]

Volume. If the volume of the received sound is too low, some sounds will be misunderstood or not heard. Where the volume is too high, the overloading of the ear will cause distortion within the ear which will reduce intelligibility.

The decibel (db) is the usual unit for measuring the relative loudness of sounds, being approximately the smallest degree of difference of loudness ordinarily detectable by the human ear, the range of which includes about 140 decibels. The zero on a decibel scale is at the threshold of hearing, the lowest sound that can be heard. On this scale, 20 db is a whisper, 60 normal conversation, 120 loud thunder, and 140 the level at which a sound becomes physically painful.[2] A

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[1]Pacific Northwest Bell Telephone Company, Telephone Transmission Fundamentals (Pacific Northwest Bell Telephone Company, 1962), p. 32.

[2]Henry Clay Smith, Psychology of Industrial Behavior (New York: McGraw-Hill Book Company, 1964), p. 206.

loudness level of 60-70 db is roughly representative of the usual commercial telephone circuits.

Distortion. Distortion, the suppression or elimination of certain frequency ranges or the production of additional frequencies, has its direct effect on the adequacy of the received sound.

The actual speech spectrum extends from below 100 cps (cycles per second) to above 7000 cps. However, intelligibility is impaired only slightly by the elimination of the very low and the very high frequency components of speech. Advantage is taken of this fact in practical telephone and radio communications. The requirements for speech transmission are fairly well met by the transmission of a band of frequencies approximately 2500 cycles wide, beginning at about 250 cps and ending at about 2750 cps.

Noise. Noise is any unwanted sound or signal. When speech is transmitted over an electrical system there is always an interference to the proper reception of such speech because of other sounds. These extraneous sounds which serve only to interfere with reception of the desired speech may be broadly classed as noise. They are transformed from electrical energy to sound energy by the telephone receiver in the same manner as the desired speech. The presence of noise tends to mask the desired sound by reducing the ability of the ear to detect its presence. In effect, the threshold of hearing is raised by an amount which depends on both the volume and the frequency components of the interference.

Generally, the higher the volume of the interference, the greater

the masking effect. And with respect to frequency, a wide-band noise more effectively masks speech than a narrow-band interference. For the narrow band interferences, at low noise levels the high-frequency bands are more effective than bands below 1000 cps. But at high noise levels, however, the low-frequency bands are more effective in masking speech.[3]

Seriousness of the Noise Situation

An American Telephone and Telegraph Company letter (November 29, 1963), directed to all operating vice presidents and general managers, states:

> Over 40% of observed adverse transmission comments are due to noise. One of every nine customers commenting on transmission in the Customer Attitude Surveys attributes his difficulty to noise or crosstalk. And nearly one-half of the toll transmission trouble reports reaching DDD (Direct Distance Dialing) Service Bureaus are due to noise. As our transmission losses approach objectives, noise seems to become more significant and more annoying as a customer problem. Recent laboratory studies of customer reaction to noise, and surveys of DDD network noise confirm these conclusions. Lastly, excessive noise on the DDD network can be the downfall of data service. . . .
>
> As the various performance measures indicate, excessive noise is being experienced on far too many calls. A definite improvement must be brought about if DDD is to provide service which customers have a right to expect. Unless action is taken promptly excessive noise on DDD calls will become increasingly serious as other improvements such as lower trunk and loop losses and the use of more sensitive telephone instruments, become effective. Also, as the DDD network is being used more and more for data transmission and other services, an improvement in the noise situation is a necessity if these services are to be successful.
>
> If it important that an orderly noise reduction program

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[3] J. C. R. Licklider and George A. Miller, "The Perception of Speech," Handbook of Experimental Psychology, ed. S. S. Stevens (New York: John Wiley and Sons, Inc., 1951), p. 1047.

be started now covering all parts of the DDD network, including both trunks and loops.

Usually a relatively small fraction of the total number of loops[4] and trunks[5] is responsible for most of the excessive noise on DDD calls. The problem is to identify the sources responsible for this noise and to apply the necessary corrective action as promptly as possible. The Noise Reduction Program is designed to evaluate the plant from the noise standpoint and to outline a procedure for the detection, identification, and mitigation of undesirable noise sources. It is essential that this program be implemented immediately.

Control of noise in the DDD network is not a "one-shot" affair, but must become a part of the continuing overall program to improve and maintain good service. Like other programs, the Noise Reduction Program can not be effective unless all levels of management and craft are actively motivated. It must be clear to all concerned that noise is an important factor in providing good DDD service and that it must be controlled effectively.

Scope of the Implementation Plan

This implementation plan is designed specifically for the Spokane District of the Pacific Northwest Bell Telephone Company. Much of the data presented is specially directed towards this one

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[4]A loop is a single pair of insulated wires in one covering. An example of a loop is the personal service to a customer at his home.

[5]A trunk is many pairs of insulated wires in one covering, like the interconnections used between telephone central offices.

area, and emphasis is placed on presenting data that would be pertinent to this particular locality.

However, the major content of the plan would be directly applicable to other districts of the Company in other areas. It would also be appropriate for utilization in other continental telephone companies, especially those belonging to the Bell System. Since the management, organization, policies, practices, and procedures are similar for all member companies, adoption of the plan would be especially suitable for other Bell companies.

Transmission problems are common to all of the companies and noise trouble is found throughout the country. The desire for improvement in these areas is general. Thus, the implementation plan for noise reduction could be used in other areas with only minor revision. Even the data showing the results of local surveys would be useful for comparison purposes.

CHAPTER II

JUSTIFICATION OF THE PROGRAM

In order to implement the Noise Reduction Program, management must be given justification for such a plan. This chapter provides evidence showing the seriousness of the noise problem. This information includes results of the Customer Attitude Trend Study and the Subscriber Loop Noise Survey, plus material covering traffic noise observations and the subjective effects of noise. Also included in this chapter are economic and marketing implications of noise reduction and a discussion of the feasibility of the plan.

Noise and Customer Satisfaction

Customer satisfaction is of primary importance to the Telephone Company. Within this concept concentration should be placed on understanding the customer, knowing the customer's needs and desires and setting as an objective of the business the satisfaction of these customer wants.

The Telephone Company product is a means of communication. The company is in business to sell telephone service. A customer buys this Telephone Company product not for its own sake, but the satisfactions, benefits, use, utility or profit derived or expected from it. Therefore, of basic concern to the Company is the degree of satisfaction a customer derives from telephone service.

Noise has a detrimental effect on the degree of satisfaction a customer receives from telephone service. If a customer's line is

quiet, with a noise level below 20 dbrnc, the customer has good high quality service and is receiving complete utility from the product.

If the subscriber hears somewhat annoying noise on the line, in the range of 20-30 dbrnc, the Telephone Company product is of a poor grade, and the customer is not being entirely satisfied. With noise in this range the subscriber will be experiencing some distraction. (This is shown in the report on the subjective effects of noise).

When a line is so noisy that some words are misunderstood or not heard or when the noise is so bad that the speech level has to be raised to a shout, say noise far in excess of 30 dbrnc, then the Company's product is of inferior quality and the customer is dissatisfied with the telephone service. This condition is totally undesirable and entirely unnecessary.

Economic Implications of Noise Reduction

Benefits of the program. After corrective action has been applied on an extremely noisy line, the average time the subscriber spends on each completed call will be shortened. When the excessive noise is eliminated, the time previously spent on repeating misunderstood words or phrases will also be eliminated.

This means that, for any given amount of communicated content, the equipment used during the call will be tied up for a shorter period and that with the same amount of equipment more calls can be completed per unit of time. Therefore, the equipment can potentially be utilized more efficiently and effectively per unit of communication.

Also, with the noise reduced to within tolerable limits, the

customer will find the telephone conversations more effortless. This will tend to result in this person making more frequent use of the telephone service and will tend to increase the total number of toll calls completed per unit of time. A good example of this is someone who conducts business by telephone. Such an individual is more apt to use his telephone, instead of some other means of communication, for a larger percentage of the business he must transact, if his calls are relatively effortless. If there is difficulty with the calls, in hearing or understanding, then he may resort to letter writing for a larger percentage of his business transactions. As a consequence of cases such as this, the revenue realized by the Telephone Company should increase if noise is reduced and calls are made more effortless.

A third economic consideration directly related to noise reduction is sales. The company constantly attempts to sell subscribers additional telephone service. This additional service is in the form of extension telephones, color telephones, princess telephones, extension cords, extension bells, gongs, bell chimes, jacks, etc. If a customer has an excessively noisy line he will have less desire for additional telephone service. On the Marcus exchange in Northeast Washington, one subscriber with excessive noise on his line said that he had told his wife, "to take the damn thing and throw it in the river." Another said she'd "just love to have had the chance to change telephone companies." In both of these instances there was a total lack of interest in additional services. Also, the attitude that these people held towards the Company was quite negative. The dissatisfaction that the customers experienced with the existing inferior quality

telephone service manifested itself in a negative attitude towards operators, installers, the Company, and any attempted sales approach.

On the other hand, if the quality of the customer's telephone service was increased by reducing the excessive noise on the line, then the customer's attitude would tend to be positive in nature. When it is discovered that conversations are now more effortless, the customer will be pleased with the telephone service. This will result in a frame of mind conducive to a sale of additional services. The customer, naturally, will be more receptive to an attempted sales approach. Thus, it can be seen that noise reduction should have a beneficial effect on sales.

These three points, (1) more efficient and effective use of equipment, (2) increased revenue from additional toll calls, and (3) increased revenue from sales of additional telephone service, imply that an effective noise program should result in an ultimate increase in profitability of the firm, all else equal.

In addition, a successful noise improvement program will have an advantageous effect on company image. The reputation of the Company in the community is of considerable significance. It is important in soliciting cooperation from other companies and the public in general, in obtaining rate increases, and in attracting employees to the Company. And although the value of the goodwill aspect of noise reduction cannot be directly measured, it is reasonable to assume that it is of considerable importance.

Feasibility of the plan. Before the noise reduction program is implemented management must study the feasibility of the plan. In

determining the economic worth of any project management must rank it according to its economic desirability and profitability. There are certain methods which systematize management's approach to a sound, final decision. The techniques enable a manager to relate prospective earnings or cost saving to the investment required or the involved expenses. These financial devices include: (1) the hunch, rule of thumb, or intuitive method; (2) the cash pay-back method (also called pay-off, pay-out, or cash savings method); (3) the rate of return on original investment method; and (4) the discounted cash flow or investor's method.[1]

The hunch, rule of thumb, or intuitive method of appraising a project is generally practiced by small or medium-sized firms in which the responsible executive has little or no cost data available. To overcome the lack of more specific knowledge and the lack of a reasonable framework for organizing any information, the executive will insist that his decision is based on "sound business judgment" or "expert opinion." With the growing popularity of more scientific methods, this type of analysis is fast disappearing; yet, a certain segment of the business community still uses these procedures.

The cash pay-back method is based on the idea that a new project must pay for itself in a short period of time, presumably from two to four years. Many users believe this method is the best because it is rather conservative. However, the short pay-back period lacks a logical and scientific basis. In spite of this criticism, the method

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[1]Adolph Matz, Othel Curry, and George Frank, Cost Accounting (Cincinnati: South-Western Publishing Company, 1962), p. 815.

still enjoys considerable use in industry.

The rate of return on original investment method translates annual savings into a return on investment rate by dividing either total original investment or average investment into annual savings. With the rate of return calculated, two questions arise: (1) Does the rate compare favorably with the return on alternate investments, and (2) do the savings and the return offer sufficient compensation for the risk involved? The answers to these questions are not easily determined.

The discounted cash flow method also establishes a rate of return by relating project cost savings or project earnings to the investment. In addition, it converts the annual stream of savings or earnings to a present value by an appropriate discounting for the time value of money. The "time value of money" recognizes the fact that one dollar available now has more economic value than the right to receive one dollar at some time in the future. The previous methods fail to take into consideration the time value of money, an economic analysis phenomenon. When an investment is made, the company buys a series of future incomes whose amount and timing determine the profitability of the investment. The solution of an investment problem by this discounted cash flow method requires the use of interest tables to discount all future net earnings from capital application to the present-day value. The sum total of all these earnings is expressed as a rate of return on the capital to be invested. Like other methods, the discounted cash flow method permits the setting of a cut-off rate below which no capital expenditures will be made in projects giving a

recognizable return.

To determine the economic worth of the program management must collect and analyze the relevant costs and revenue. It is generally advisable to utilize the discounted cash flow method to weigh expected costs against estimated revenue. When Pacific Northwest Bell management considers the feasibility of the Noise Reduction Program they will face the problem of not having revenue figures to base their decision upon. Since there are no data available on the subject, management will lack information concerning variations in sales due to changes in noise levels. Therefore, any attempted forecast of expected revenue variation because of noise reduction would be crude and inaccurate and would not have a valid basis. Because of this, management must evaluate the plan on: (1) the general desirability of the program due to improvements in customer service; (2) the possible economic benefits associated with a reduction of noise (previously discussed); (3) the statement from AT&T executives that noise levels must be reduced; and (4) the expected costs of the program. In making their determination management has a decision to make concerning alternate choices. There will be variations of costs and profit (although profit variation cannot be computed) associated with the different alternatives. Management may decide to meet noise objectives (set down in Chapter III) in all cases or only a percentage of the total number, i.e., 95 per cent or even 90 per cent. There will be different cost figures for each alternate to the plan. And in comparing alternatives, it is necessary to consider only those items of cost that are expected to differ from one alternative to another.

If the decision is made to implement the Noise Reduction Program measures must be taken to control costs of the project. To effectively control costs the Company should initiate a budgetary control system for the program. The essential features of budgetary control are:

(a) A statement of plans for a given period in the future expressed in specific, numerical terms. These plans express management's thinking about what should or is hoped to take place. Both standards and plans are a product of planning and are used to guide the progress of operations. Where standards begin and plans end is a debatable question. For example, is a budget a standard or a plan? Since a budget expresses management's intentions and hopes concerning the future, it is subject to classification both as a standard and as a plan.

(b) Preparation of reports showing a comparison between actual and estimated performance, and revision of the original plan when such reports show that a revision is necessary. If the budget is to be an effective control device, it is necessary that actual performance be compared with the original estimates so that responsibility for failure to meet the plan can be determined.

The budget should not be regarded as a final and unalterable plan that cannot be adjusted to meet different conditions than those anticipated when the plans were prepared. There should be a regular periodic review of the actual performance each month, and this should be compared with the budgets. If this comparison indicates that the budget cannot be followed in the future or if someone in management finds it necessary to change the plans, then corresponding adjustments

can be made in the budget estimates. The principal benefits of budgetary control are: (1) planning is often improved as a result of budgets; (2) coordination of activities can be materially improved by the use of budgets; and (3) control is facilitated by budgets. A sample budget for the Noise Reduction Program is shown below.

Sample Monthly Budget

Direct labor	$4,250
Indirect labor	750
Depreciation of automobiles	110
Depreciation of instruments	70
Space facilities	150
Heat, light, and power	70
Gasoline	900
Maintenance of automobiles	30
Maintenance of instruments	35
Supplies	125
Total estimated monthly budget	$6,490

The capital outlays associated with the sample budget would involve approximately $7500 for three automobiles and $6000 for test instruments. In the actual program the exact figures would be calculated on the basis of the size of the noise reduction team and the involved geographical area. The expected economic life of the items is three years for the automobiles and seven years for the instruments. And although these figures are generally reasonable, the exact amounts would depend on company policy. Based on past company experience with a part-time program, it is estimated that it will require three years to reduce the excessive noise and educate the regular personnel to the extent where they can adequately maintain noise limits as part of the standard maintenance work.

Results of the Customer Attitude Trend Study

Figure 1 is a summary of responses to the Fall, 1964, annual Customer Attitude Trend Study for the American Telephone and Telegraph Company. Of those responding, 13.1 per cent had trouble because of noise.

The troubles attributed to noise are still on the increase. The 13.1 per cent of 1964 is 5 per cent higher than ten years ago.[2] This is quite significant (statistically, at the 95 per cent level, one-tailed test) since service should have improved considerably during this period.

In the survey, the questions asked were: "When using your telephone at home do you ever have any trouble hearing or being heard? What is the difficulty? The questions were answered with write-in responses.

Within the Pacific Northwest Bell region, there were 2044 usable questionnaires returned. This was 74.7 per cent of the total number of questionnaires left with customers. By comparing the sample with the actual population on some specific items of the questionnaire (such as class of service and number of telephones), it was shown that the sample did approximate the universe as far as telephone characteristics were concerned.

To obtain the interviews, a "key address" was first selected from a directory on a random number basis. Then a field worker was instructed to:

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[2]American Telephone and Telegraph Company, Transmission Results, First Quarter, 1965 (New York: American Telephone and Telegraph Company, 1965), p. 11.

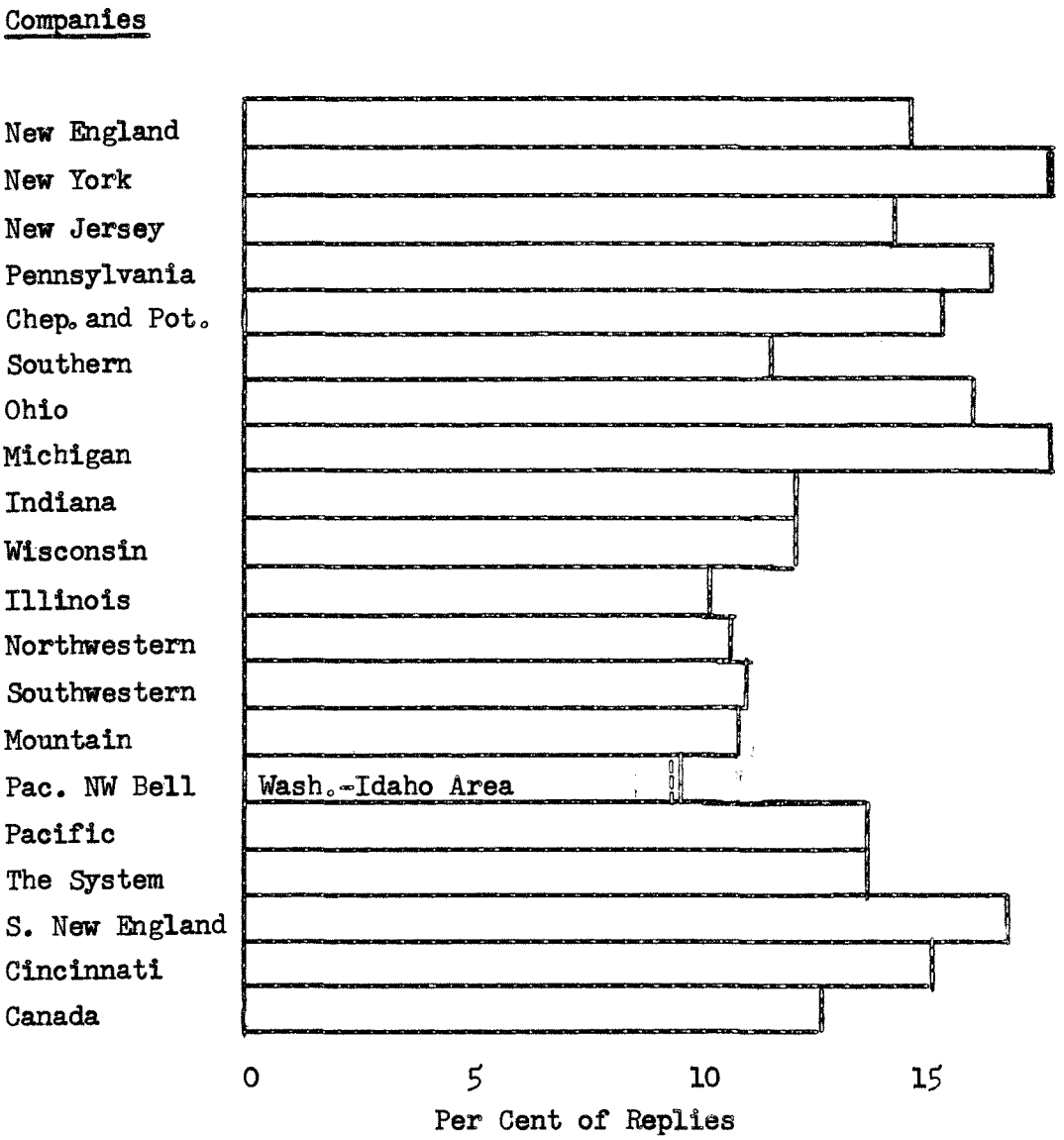

Figure 1. Results of the Customer Attitude Trend Study, Fall, 1964. The percentage of those responding that stated they had trouble because of noise.

Source: Transmission Results, First Quarter, 1965, American Telephone and Telegraph Company.

1. Contact the key address household and attempt to leave one or two questionnaires (depending upon the number of adults in the household).

2. Follow a specific pattern around that block and adjacent blocks until 15 or 16 questionnaires had been left.

3. Return the following day to pick up the completed questionnaires. If the questionnaires were not available the field worker would make two additional pickup attempts.

The interviews were self-administered and under no conditions was the field worker to make personal interviews.[3]

This customer attitude survey measured the customer's opinion of their service. The answers were subjective. Any particular customer's definition of noise may or may not have agreed with the technical definitions. However, since noise is broadly defined as any extraneous sound that interfers with the proper reception of the desired speech, it is quite likely that when a customer said he had difficulty with noise he, indeed, had "noise" difficulties.

Results of the Trend Study showed that in the Pacific Northwest Bell region 9.4 per cent of those replying stated they had difficulty with noise. Within PNB 9.3 per cent of those responding in the Washington-Idaho area indicated they had noise trouble. Therefore, in this area approximately one out of every eleven customers that commented on their telephone service stated they had problems with noise.

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[3]Detailed information concerning the Customer Attitude Trend Study was obtained from R. L. Beach, General Statistician for Pacific Northwest Bell, via a letter on January 16, 1966.

Traffic Noise Observations Results

Figures 2 and 3 show the percentage of calls rated as meeting the Direct Distance Dialing noise objectives explained in Chapter III. The results are for the first quarter, 1965, and are derived from meter observations of noise magnitudes made by Traffic Department service observers.

In Figure 2 data for the various companies of the AT&T are shown. The percentage of calls rated as meeting noise objectives for the total system is 94.1 per cent. The best company was S. New England with 98.8 per cent. Pacific Northwest Bell had a 91.3 per cent rating. Of the twenty companies PNB ranks eighteenth.

Figure 3 is a breakdown for the eleven districts of the Washington-Idaho area of PNB. The rating for the area was 91.0 per cent. In Spokane District, 91.1 per cent of the calls were rated as meeting the noise objectives. This is 3.9 per cent below the goal if 95.0 per cent. Hence there were 78 per cent more "noisy" calls than the 5 per cent objective.

Subjective Effects of Noise

The Bell Telephone Laboratories conducted subjective tests to establish a quantitative description of the effects of noise experienced by telephone users in terms readily translatable into an overall transmission standard.

In setting performance objectives for speech transmission it is important to have a quantitative description of the subjective effects of the transmission parameter under consideration. Assessments made

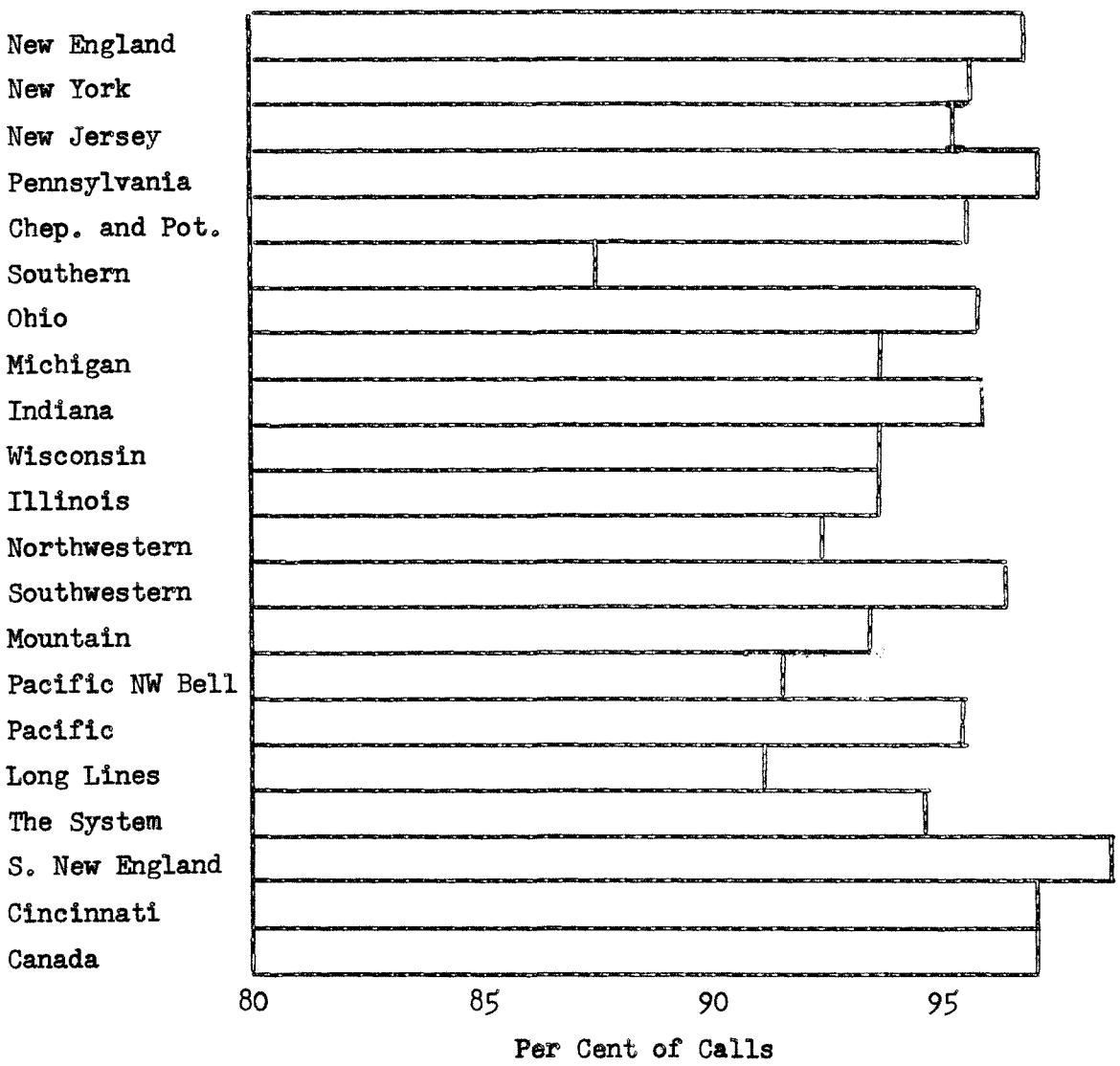

Figure 2. Percentage of Calls Meeting the Noise Objective, U. S.

Source: Transmission Results, First Quarter, 1965, American Telephone and Telegraph Company.

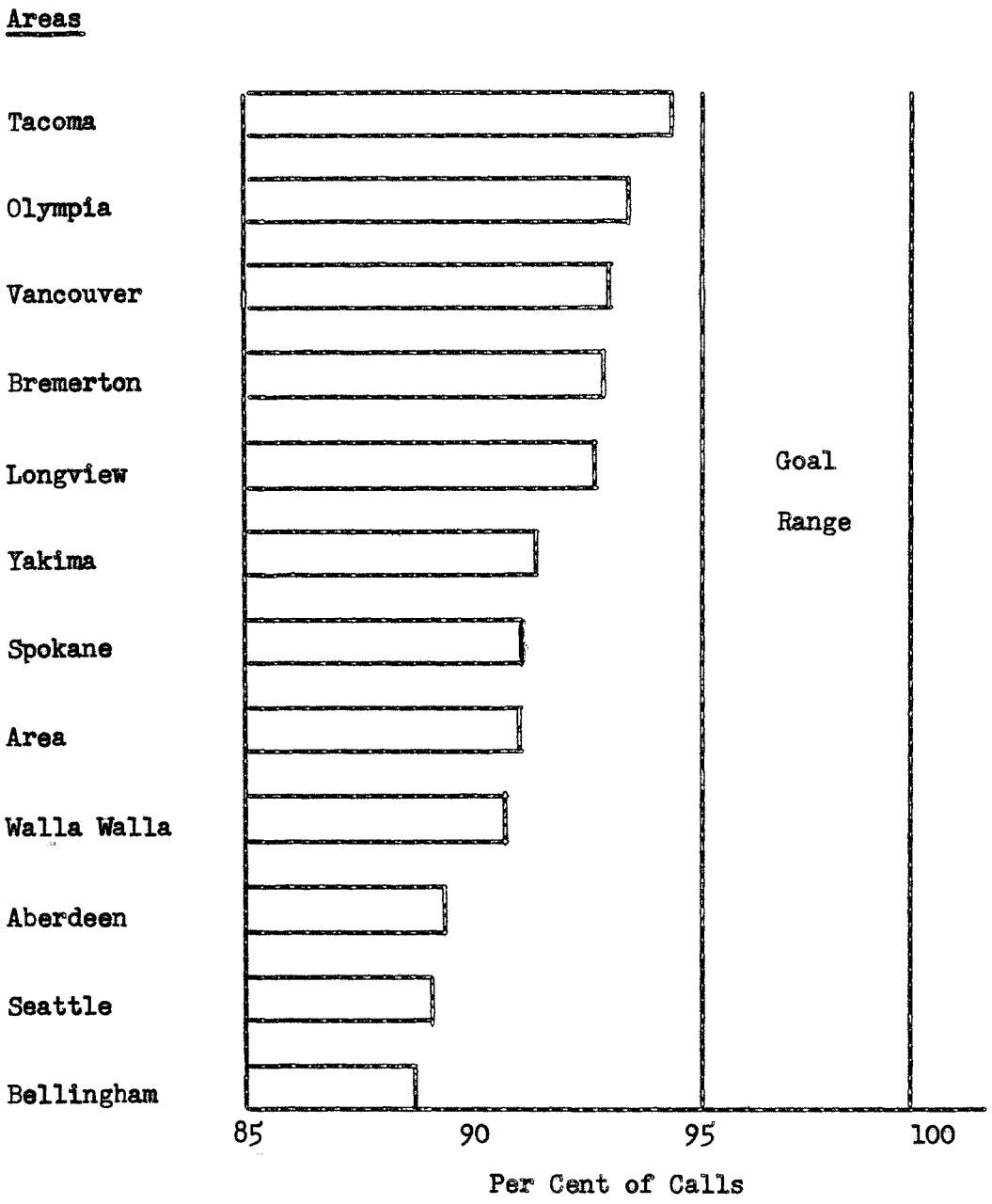

Figure 3. The Percentage of Calls Meeting the Noise Objective, Washington-Idaho Area, PNB.

Source: Transmission Results, First Quarter, 1965, Washington-Idaho Area, Pacific Northwest Bell Telephone Company.

on an absolute basis can be readily transformed into satisfaction criteria which, in turn, can be used as a foundation for overall transmission objectives.

To get a comprehensive picture of telephone user attitude toward noise, subjects were asked to rate various transmission conditions. They were requested to judge each condition and classify it into one of five categories--excellent, good, fair, poor, or unsatisfactory. The respondents were not informed that they were judging varied noise conditions or that noise was deemed important. This procedure was used to avoid bias. To record their ratings, the subjects merely marked an (E), (G), (F), (P), or (U) on the scoring sheet for each of the twelve conditions.

The noise tests were conducted using 500-type[4] station sets with received volume at a constant level, - 28 VU (volume unit), and noise (a composite of power hum, switching office and thermal noise) varied between 18 and 62 dbrnc (set input) in 4-db steps. The noise consisted of 180, 360, and 540 cycle noise (the first three third harmonics which are the predominate harmonics in a typical power system), 3-kc thermal noise, and dial office noise in such a combination as to approximate an actual typical line noise condition.

The simulated speech-noise conditions consisted of two short sentences of spoken material mixed with the noise. The spoken material included all of the sounds and the sentences were so constructed

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[4]The 500-type sets are those commonly in use in most homes and offices at this time.

as to be typical. Trial tests were made using both male and female voices. When the results of these tests were compared it was found that the variation in response was negligible. For the study tape, a male with a good speaking voice did the recording.

The spoken material and the noise were taped on separate recorders and played simultaneously to the observers at the required levels through a network equivalent to 6000 feet of 24-gauge cable, representing a subscriber loop. Groups of six to eight observers were accommodated in a specially constructed subjective test room comprised of individual cubicles equipped with telephones. A loudspeaker placed in the center of the oval array supplied recorded room noise at a sound pressure level of 48db re 0.0002 microbar. The line current in the test circuit was adjusted to 55 ma direct current to each station set.

A total of 666 observers, both males and females, took part; all were chosen at random from among Bell Laboratories employees. None were required to participate more than once.[5]

The results of the noise tests plotted as "noise opinion curves" in cumulated categories are shown in Figure 4. Presented in this way, the set of curves show the proportion of E (excellent), E + G (good or better), E + G + F (fair or better), E + G + F + P (poor or better) judgments at particular noise levels over the range of values tested. In essence, these curves are estimates of p(R/x), the conditional probability of placing a given noise level x in cumulated category R.

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[5]Detailed information concerning the testing done on the subjective effects of noise was obtained from D. A. Lewinski of Bell Telephone Laboratories via a telecon in January, 1966.

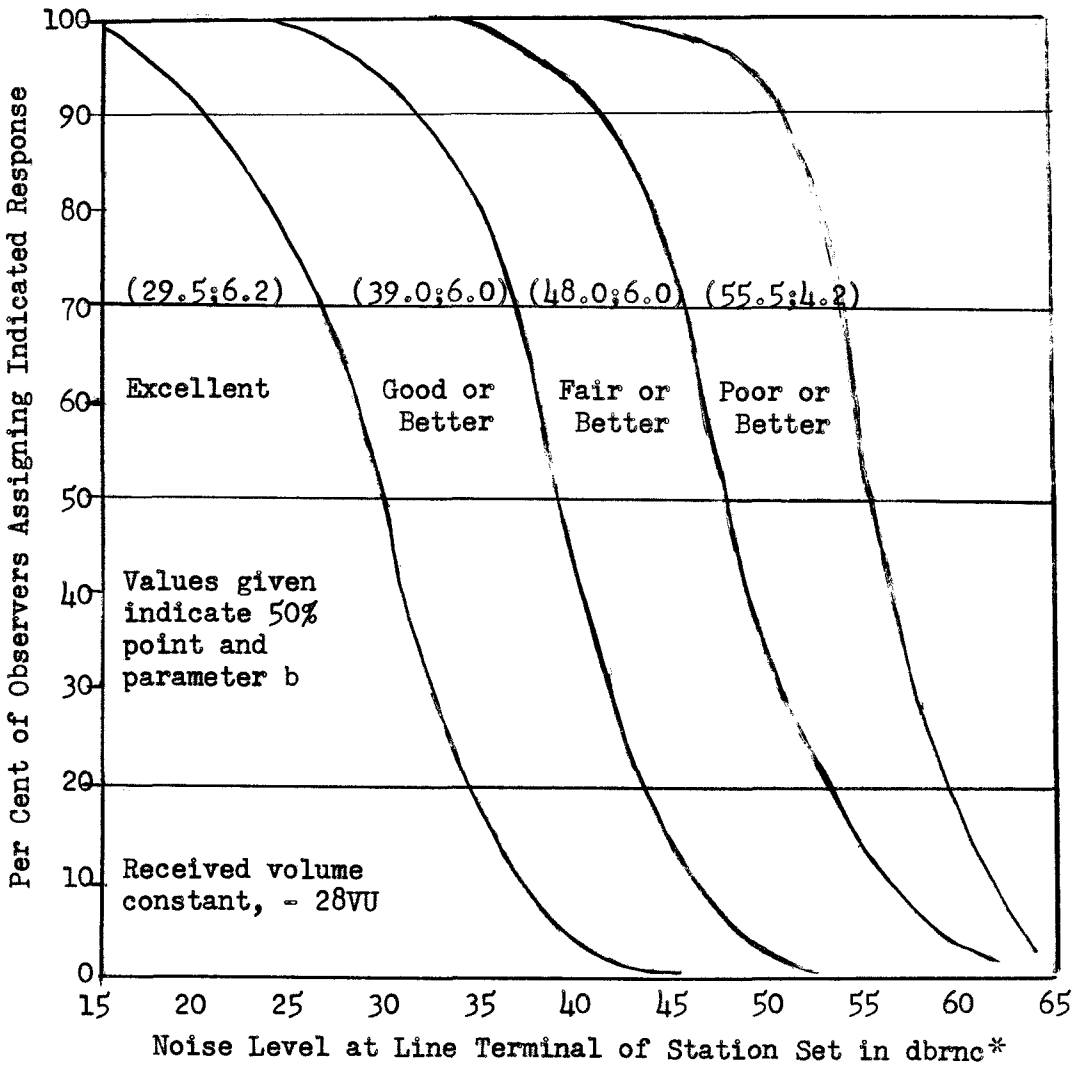

Figure 4. Noise Opinion Curves.

Source: The Bell System Technical Journal, "A New Objective for Message Circuit Noise," Volume XLIII, Number 2, March, 1964, American Telephone and Telegraph Company.

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* "dbrnc" is a relative loudness level unit analogous to "db". On this scale, 0.0 dbrnc equals 1 x 10^{-12} watts.

TABLE I

DATA POINTS FOR NOISE OPINION CURVES

Excellent Rating

db level of noise	Percentage in category
46	.08%
42	1.6
38	8.0
34	21.0
30	50.0
26	72.0
22	85.0
18	94.5

Good or Better Rating

db level of noise	Percentage in category
50	2.5%
46	10.5
42	31.0
38	55.0
34	86.0
30	92.0
26	96.0

Fair or Better Rating

db level of noise	Percentage in category
58	4.0
54	15.0
50	37.0
46	64.0
42	88.0
38	94.5
34	97.3

Poor or Better Rating

db level of noise	Percentage in category
62	8.0
58	28.0
54	64.0
50	95.0
46	97.3
42	98.7

Source: Telecon with D. A. Lewinski of Bell Telephone Laboratories.

A good model of opinion was obtained by fitting normal ogives, i.e., normal distribution functions, to the data points (shown in Table I). As such each curve can be defined by stating the 50 per cent point and the parameter "b", which is computed in the same way as the standard deviation of a normally distributed random variable.

Collectively, these curves indicate that, in the presence of the desired received speech volume, noise levels up to about 30 dbrnc at the line terminals of the station set are quite acceptable.[6] At 30 dbrnc, about 47 per cent of the subjects gave a rating of excellent, 47 per cent good, and about 6 per cent fair. Thereafter degradation becomes increasingly evident; for example, notice the rapid decrease in per cent good and excellent response, as clearly indicated by the rate of change of the good-or-better noise opinion curve.

Results of the Subscriber Loop Noise Survey

Table II is a summary of the data collected in a Subscriber Loop Noise Survey conducted in the Spokane District of the Pacific Northwest Bell Telephone Company during the summer of 1965.

The results are classified according to the percentage of pairs in each office that meet the circuit maintenance requirement, exceed this requirement, and the percentage of lines that fall in the "Immediate Action" category. These classifications are explained in the "Circuit Maintenance Objectives" portion of Chapter III.

Measurements were taken with a 3A noise measuring set. In each

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[6] D. A. Lewinski, "A New Objective for Message Circuit Noise," The Bell System Technical Journal, XLIII (March, 1964), p. 724.

office every pair was tested. Of the 6237 loops measured, 594 or 9.5 per cent exceeded the circuit maintenance requirement. This is 90 per cent above the system objective of 5 per cent. The "Immediate Action" objective of 1 per cent was exceeded by 230 per cent with 204 (3.3 per cent) of the lines in this noise range.

Of the thirteen offices, four met the office objective with 7 per cent or less of the lines being "objectionable" or worse. Only one office, Loon Lake, meets the "Immediate Action" goal of 1 per cent. All other offices require immediate corrective action.

TABLE II

RESULTS OF THE SUBSCRIBER LOOP NOISE SURVEY

Spokane District Office	Number of Lines Measured	Per Cent of Lines in Each Noise Magnitude Range		
		Satisfactory	Objectionable or Worse	Immediate Action
Colfax	1818	92.7	7.3	2.1
Colville	1818	94.0	6.0	2.3
Deer Park	707	94.2	5.8	1.7
Edwall	101	78.2	21.8	10.9
Elk	127	72.5	27.5	13.4
Green Bluff	303	76.5	23.5	2.0
Harrington	303	89.5	10.5	4.3
Loon Lake	202	93.6	6.4	0.0
Marcus	51	78.4	21.6	13.7
Northport	202	84.7	15.3	11.4
Sprague	404	97.0	3.0	2.0
Springdale	202	60.4	39.6	13.9
Tyler	25	64.3	35.7	12.0
TOTAL	6237	90.5	9.5	3.3

CHAPTER III

GOALS OF THE PROGRAM

In order to assess the overall service and maintenance condition of the plant and the effects of remedial measures, data must be accumulated so that actual performance can be compared with objective goals. Such comparisons will enable intelligent decisions to be made as to where a given amount of effort and money will provide the most benefit. For this purpose two sets of goals have been established.[1] One concerns direct distance dialing objectives and the other lists circuit maintenance goals.

Direct Distance Dialing Objectives

This requirement is measured in terms of the percentage of calls meeting noise objectives as indicated by VU meters at service observing positions. These objectives are:

	Percentage of calls meeting noise objectives
Area or company average	95%
No city worse than	93%

Noise measurements are made during a slight pause in the conversation by observing the meter needle position with reference to a threshold line. If the needle stops or fluctuates above the line the call is rated noisy. If the needle swings below the threshold toward

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[1] American Telephone and Telegraph Company, DDD Noise Improvement, (American Telephone and Telegraph Company, 1962), pp. 2-3.

the rest position during the observation, the call is rated as meeting noise requirements.

The basis for establishing the service observing noise threshold was the previously reported series of subjective measurements made by the Bell Telephone Laboratories. The noise level of 30 dbrnc was used as the reference level in service observations. Since the 30 dbrnc is the level at the telephone set terminals, it is necessary to account for normal local loop and toll connecting trunk losses to describe the threshold level at the toll switching office where the cord service observing circuit is bridged on. Eight db has been allowed, five in the local loop and three in the toll connecting portion; this then makes a noise threshold level at the service observing equipment of 38 dbrnc. The Bell Laboratories subjective noise tests were made using an average loop length of 5 db; hence, this loss, plus an estimated toll connecting trunk loss, was used in shifting the noise level from the station set to the service observing bridging point at the toll center. Actually, the subjective effect of noise will be slightly different for customers on short, medium and long loops, yet the difference is small enough to be neglected because of the equalizing properties of the 500 type telephone set. The combined response of a receiving loop and 500 type set is reasonably constant for most customers; therefore, it may be assumed that noise from the intertoll plant received at the station set is independent of loop length. Thus when the noise threshold line of the service observing VU meter is set at 38 dbrnc, valid judgments of subjective noise interference can be made and meaningful data accumulated.

Circuit Maintenance Objectives

Noise performance goals from the maintenance standpoint are derived from: (a) the percentage of circuits measured in which the noise exceeds the specified "circuit order and maintenance requirement," that is, those circuits which fall in the "objectionable" or worse category, and (b) the percentage in which the noise exceeds the "immediate action" requirement.

The objectives are as follows:

Percentage of measurements exceeding:	Area or company average	No office worse than
Circuit order or maintenance requirement	5%	7%
Immediate action requirement	1%	1%

Listed below are the maintenance noise limits for the various circuit types.

Maintenance noise limits for trunks and similar circuits.

Length of Trunk or Circuit in miles	Satisfactory Noise Circuit Order and Maintenance Requirement Met if Noise is Below	Objectionable Noise Requires Investigation and Analysis	Immediate Action Noise Requires Immediate Action if Above
	dbrnc	dbrnc	dbrnc
0-50	31	31-44	44
51-100	34	34-44	44
101-400	37	37-44	44
401-1000	41	41-50	50
1001-1500	43	43-50	50
1501-2500	45	45-50	50
2501-4000	47	47-50	50

When noise is higher than the circuit order and maintenance requirement but below the immediate action requirement, the circuit can be placed or retained in service. Corrective action must, of course, continue until the circuit order and maintenance requirement is met.

However, trunks entirely on newly constructed transmission facilities should not be placed in service unless the circuit order and maintenance requirement is met. Any exception to this policy should be specifically authorized jointly by the Company Headquarters Engineering, Plant, and Traffic Departments.

Trunks on which the noise exceeds the immediate action requirement should be removed from service and immediate action undertaken before restoral to service.

Maintenance noise limits for two wire subscriber loops and similar circuits.

Satisfactory Noise	Objectionable Noise	Immediate Action Noise
Below 20 dbrnc	Between 20-30 dbrnc	Above 30 dbrnc

Subscriber loops on which the noise exceeds the immediate action requirement are left in service, but immediate corrective action is required.

CHAPTER IV

A PLAN OF ACTION

The Company should start now with an orderly plan to reduce noise on DDD. The following procedure is suggested:

A. A noise reduction team should be formed. This group will include a supervisor and approximately ten craftsmen. The primary function of this group is to insure that noise objectives are met in the District. The work will involve collecting test data on noise cases, analyzing the data, applying mitigative action to specific noise problems, and reporting progress of the noise program.

B. The noise improvement program is to be discussed with the supervisors and managers of the Plant Department that will have control over the noise reduction team. Through the discussions, the supervisor of the noise reduction team can exchange facts, ideas, and viewpoints with management and discuss plans for implementing the program.

C. Meetings on noise are to be held throughout the Division. They should be conducted at all locations and with all groups that have a relationship to noise reduction. The purpose of the noise meetings is to convey information on the topic, survey and influence opinions and attitudes, answer questions on the subject, and obtain the necessary concurrence and cooperation from the personnel. If the program is to run smoothly and

effectively the noise meetings are essential.

D. A check procedure should be initiated to insure that circuit order tests and requirements, including noise, are being meticulously observed. These requirements must be met before any circuit is turned up for service. Trunks which are found on test to have noise above the "immediate action requirement" should be removed from service promptly and kept out of service until the cause is corrected.

E. A check method must be set up to insure that noise measurements are, indeed, a part of the installation work on all new PBX's (Private Branch Exchanges), and whenever trunks are added to existing ones.

F. The reports of noise from service observations, customer reports to repair service, and other data must be analyzed to pinpoint those trunk groups, exchanges, and subscriber lines which need attention. Patterns must be looked for which will lead to noise sources which may affect large groups of circuits.

G. In each of the investigations outlined below, the results are to be studied as they are obtained. Then the type of corrective action required can be determined from this information and other available data. In many cases, it is probable that substantial benefits will be obtained by increased or more effective maintenance effort. The important thing is that appropriate action be taken promptly whenever excessive noise is discovered.

H. A routine annual investigation of noise on trunks must be maintained. To facilitate these tests, noise limits should be

entered on the individual trunk record cards. It should be pointed out that, to be significant, noise measurements should be made during the busy hour. During periods of light activity there may be much less noise present.

I. The annual investigation of noise on PBX's must be maintained.

J. An initial investigation of subscriber loop noise in all central office areas must be started. This initial work should be completed within 24 months.

K. Noise on subscriber loops should be subsequently investigated every 3 years to insure that such basic items as power system influence, central office noise, and maintenance and installation activity do not cause deterioration in noise performance.

L. Where capital expenditures are indicated for test equipment and to correct noise conditions, these should be introduced into the program as soon as possible. Those items which can produce the most improvement should be programmed first.

M. Reports must be continually analyzed to insure that progress is being made and that none of the various areas get out of hand. Among the data which should be analyzed are the following:

1. Individual service observations which show excessive noise on connections as indicated by the VU meter.
2. Adverse comments and transmission troubles recorded by service observers which relate to noise.
3. Operator trouble reports to DDD service bureaus which indicate excessive noise.
4. Subscriber reports to repair service of noise, including

any corrective action taken by or comments by the Plant Department.

5. Existing knowledge of individual exchanges and other offices, obtained by informal discussions with the wire chief, test bureau, installers, repairmen, testboard personnel, and service observers.

6. Results of noise checks on trunks by the Automatic Transmission Test and Control Frame.

7. Results of noise checks made at various intervals for trunks, PBX's, and loops as specified in their respective Bell System practices.

CHAPTER V

INFORMING EMPLOYEES ABOUT NOISE

Good communication is vital. Lack of communication is a basic problem common to almost all industry and business. The problems concerning ineffective communication are often difficult and complex. It is a very challenging task to attempt to adequately inform people.

To achieve accurate and full communication, the material that is being conveyed must be comprehended and accepted. For good comprehension the information must be presented in the proper manner. The work of the educational psychologists has produced many principles that can be advantageously applied to communication practices.

Accurately comprehended material is of little value unless it is accepted. Management often neglects to consider the fact that workers may reject what management is attempting to communicate even though the workers comprehend the information. The acceptance problem is essentially a problem of conflicting goals. If the goals of management differ with those of the workers, then management's attempted acts of communication stand more chance of being rejected by the employees. On the other hand, if management has goals common to those of the employees, if they have similar values, then communication has more likelihood of being successful.

The rewards of effective communication are great. When employees comprehend and accept that which is being communicated, then their attitudes can be influenced and their behavior altered. Good

communication is probably one of the best approaches to obtaining cooperation from employees. This section contains four possible ways of informing employees about the noise program.

Meetings on Noise

Meetings are an effective means of obtaining two-way communication. At meetings held on noise, information on the topic can be conveyed, opinions and questions answered, and concurrence and cooperation obtained. Meetings are flexible. Different groups will attach varying degrees of importance to the numerous aspects of the noise problem. Supervisors, deskmen, installers, switchmen, repairmen, and construction personnel will all have questions of differing types. This is due to the noise program relating differently to each occupation class. Noise will mean something different to each group. But noise is important to each of them and each team is correspondingly important to the success of the noise program. Meetings should be held with each of these groups, and at each meeting emphasis should be placed on presenting the material in the manner most meaningful to the group at hand.

Listed below are six ways of doing this:

1. Talk in a straightforward language that the employees can understand.
2. Talk in terms familiar to them.
3. Relate the new material to that already familiar to each group.
4. Explain how the new information ties in with the old.
5. Show how each group can benefit from the new knowledge.

6. Allow the employees to participate.

The main goal of the noise meetings will be to obtain concurrence and cooperation. People have an inherent psychological characteristic of rejecting anything new and different. They tend to perceive only that information which is consistent with their frame of reference, that which is in agreement with their background. It is natural for people to not assimilate information unfamiliar to them.

At the noise meetings explanations not orders will be given. By furnishing explanations and answers each individual's perspective and depth of knowledge will be increased. He will become familiar with noise considerations and implications. The information will be perceived bit by bit and as familiarity increases receptiveness will increase.[1] Thus, as a result, concurrence and cooperation will most likely be volunteered.

This approach is far more preferable for this particular problem, this certain situation, and these personnel than the autocratic "I said do it" attitude. All too often management issues a multitude of orders but submits very few corresponding explanations. Rote orders are, at best, a very weak method of gaining cooperation. The "just get it done" approach usually leads the employee to feel that he is not understood, not liked, and not respected. No wonder workers often reject whatever management carelessly throws at them.

Noise meetings are to be held with each of the above-mentioned occupational classes. The meetings should be conducted throughout the

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[1]Roger Bellows, Psychology of Personnel in Business and Industry (New Jersey: Prentice-Hall, Inc., 1961), p. 316.

District and Division in each construction office, central office, and service garage. They will be presented by the supervisor of the noise reduction team and a Plant District (or Division) staff assistant (transmission specialist). These men will be familiar with all facets of the noise problem, transmission in general, each location, and the activities of each occupational class. At the meetings a noise awareness tape will be played, questions will be answered, and "help wanted-noise" sheets handed out.

The noise meetings, in conjunction with assistance from the noise reduction team, will give the personnel at each location a background from which they can work on their own local noise problems in the future.

The Noise Awareness Tape

The noise awareness tape is to be played at the previously discussed noise meetings. It is approximately one-half hour in length. This length was thought desirable for it is long enough to present the pertinent acquaintance material on noise yet not so long as to tire people to the point where interest decays.

As the tape was prepared there was a serious attempt to present the material at a level that would be most suitable for the groups that are to receive it. It is not presented in a manner that places the personnel in an inferior status. Also, the discussion is not at such a high level that the workers are unable to understand the material. This was done so that more of the information would be assimilated by the group members.

In addition, humor was purposely injected in the tape. Many

people enter a conference room somewhat nervous and tense. Humor not only creates interest but also helps people to relax and become more at ease. In this state they can more easily comprehend the material.[2] Thus, the learning process is facilitated.

This condition is also conducive to participation in the question answering session following the tape. Far more questions will be raised if the group is at ease. Communication will be better and more information will be conveyed. All concerned will be more satisfied with the meeting.

The noise awareness tape contains the following:

1. A description of noise.
2. Some implications of excessive noise (effect on talk circuits and data phone and telemetry systems).
3. Examples of different types of noise (actually recorded).
   (a) Repeater howl
   (b) Teletype crossfire
   (c) Dial crossfire
   (d) Intelligible crosstalk
   (e) Program crosstalk
   (f) Cross modulation
   (g) Microwave failure
   (h) Thermal noise
   (i) Distortion
4. Demonstration of numerous loudness and noise level combinations (good example of varying degrees of noise interference).

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[2] Ibid., p. 316.

5. An actual call over a noisy line.

6. A discussion on common noise sources.

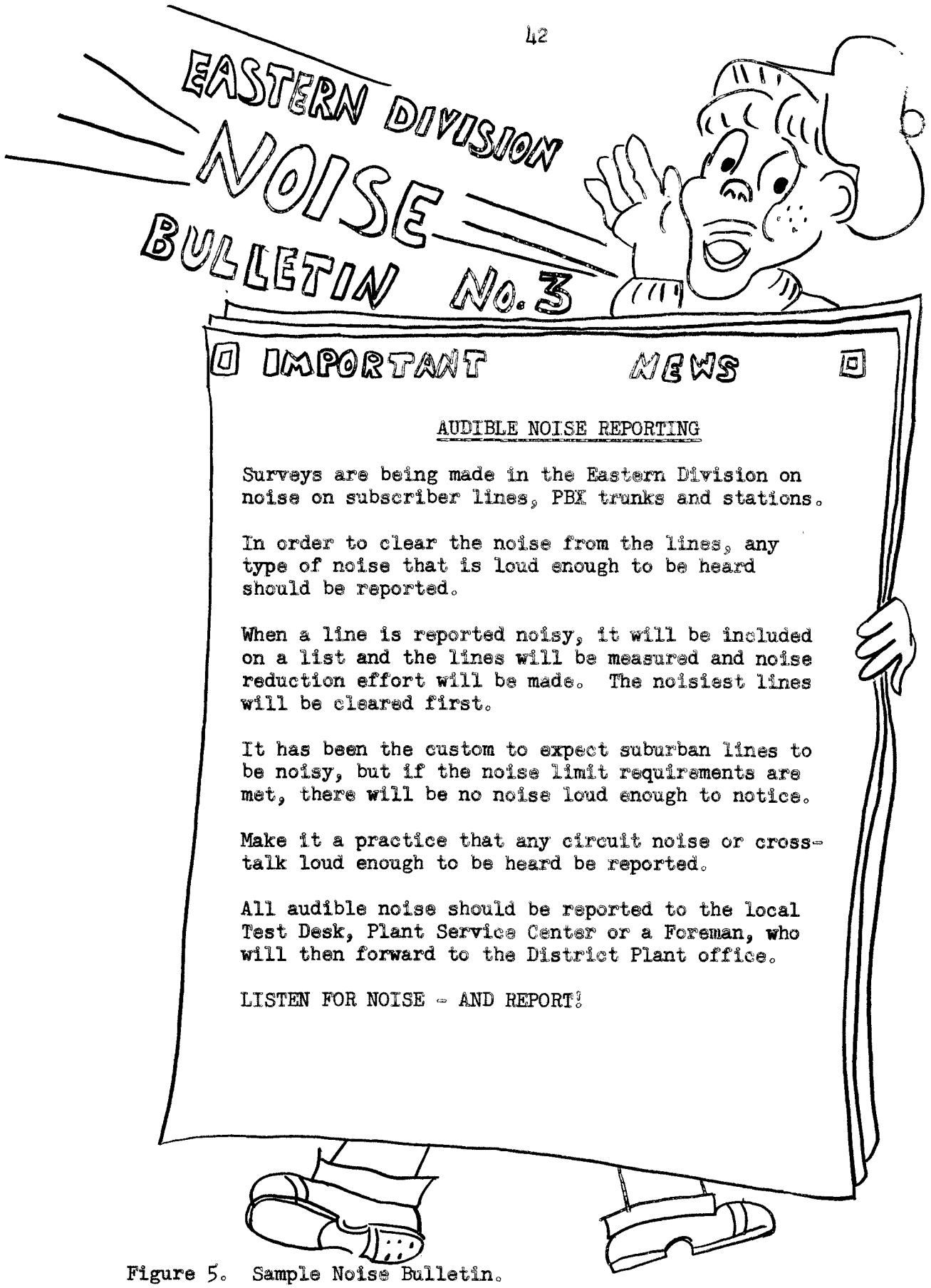
7. An explanation of the importance of noise.

8. A plea for the reporting of noisy lines.

Noise Bulletins

Noise bulletins are another means of communication in the noise program. They can be used for several purposes. The bulletins will, first of all, serve the general purpose of keeping all personnel up to date on progress in the noise reduction program. Also, they can be used to solicit information, as in the example on the following page (Figure 5). In addition to furnishing information, the sample bulletin requests information. It is requested that noisy lines be reported and sets a simple criteria for judging a noisy line. As the noise problems are reported the noise reduction team can correct the defective situation by eliminating the excessive noise through corrective action. The person who has reported the noise case can then be informed that the problem he had reported has been corrected. This is a way of informing the employee of his usefulness and importance and will increase his job satisfaction. It will also tend to motivate the employee to report other noise problems as he comes in contact with them.

Noise bulletins will also be useful to merely keep personnel aware and familiar with the noise reduction program. The program can benefit by keeping both management and non-salaried personnel familiar with its operations. All concerned will be more helpful and cooperative if they are aware of the program and are kept informed about it.



AUDIBLE NOISE REPORTING

Surveys are being made in the Eastern Division on noise on subscriber lines, PBX trunks and stations.

In order to clear the noise from the lines, any type of noise that is loud enough to be heard should be reported.

When a line is reported noisy, it will be included on a list and the lines will be measured and noise reduction effort will be made. The noisiest lines will be cleared first.

It has been the custom to expect suburban lines to be noisy, but if the noise limit requirements are met, there will be no noise loud enough to notice.

Make it a practice that any circuit noise or cross-talk loud enough to be heard be reported.

All audible noise should be reported to the local Test Desk, Plant Service Center or a Foreman, who will then forward to the District Plant office.

LISTEN FOR NOISE - AND REPORT!

Figure 5. Sample Noise Bulletin.

"Help Wanted-Noise" Sheets

The "Help Wanted-Noise" sheets will serve basically two purposes. First, they can be used to report noise cases to the noise reduction team. Any employee can report noise trouble by filling out only a portion of the sheet. This is done by listing the exchange, the number, the date and a description of the type of noise encountered. This information will be extremely helpful to the noise reduction team. This is an inexpensive method of locating noise cases and will facilitate the task of identifying noise sources.

The second function of this form will be its use for record purposes. Personnel other than the noise reduction team will have occasion to work on noise trouble. Repairman, switchmen, installers, and possibly others of the crafts will occasionally work on noise problems. If a craftsman fills out a "Help Wanted-Noise" sheet for each noise case worked on, the noise reduction team then has a record of where the problem was located, what it entailed, the corrective action applied, and to what extent the trouble has been alleviated.

A sample of this form is shown on the following page (Figure 6).

Figure 6.

HELP WANTED - NOISE

Tel. No. _____ Line Location _____

Job No. _____ Date Reported _____

PLEASE DESCRIBE THIS NOISE:

Hum, clocks, scratches, roar, motor-boating or whatever. Is it intermittent, effected by wind, weather, moisture, time of day or anything? Did the trouble begin at the time of power system or telephone plant changes?

LINE MAKE-UP:

Cable Pairs: _____

Station Locations: _____

1 $-R_1$ _____ 2 $-T_1$ _____

3 $+R_1$ _____ 4 $+T_1$ _____

5 $-R_2$ _____ 6 $-T_2$ _____

7 $+R_2$ _____ 8 $+T_2$ _____

Long Line Equipment: _____ E Repeaters: _____

Type of Ringing Tubes: _____ All Alike? _____

Ringer Unbalance: _____

TEST DESK CHECK:

Grounds____ Short____ Crosses____ Capacity Unbalance____ DC Series

Balance____ (Please use bridge for DC series unbalance (varley). Should be less than 5 ohms.)

OUTDOOR INSPECTION CHECK LIST:

Protector carbons	____	Bad clearances	____	Missing Transpositions	____
Tree grounds	____	Bad splices	____	Loose Line Connectors	____
Unused legs or Drops	____	T Zone Inspection	____		

Does disconnecting any drop or leg help, or does any particular section seem to be the cause? Any other information that may help with the problem.

Submitted by _____

WHAT REPAIRS WERE REQUIRED TO FIX TROUBLE:

_____

_____

CHAPTER VI

A TECHNICAL NOISE REDUCTION TEAM

The Team

The noise reduction team is the crucial portion of the noise reduction program. Everything will hinge upon the proper functioning of this group and only through their actions will improvements in the noise situation be seen. The members and leader of this group must be selected with great care and each craftsman is to receive proper training on noise reduction.

The Supervisor. The supervisor of the noise reduction team should be a first or second level supervisor or staff assistant. He will be responsible for the noise reduction effort within the district and will report directly to the district plant manager.

This man must be completely knowledgable with both the theoretical and practical aspects of noise reduction. He must also have a workable knowledge of the theoretical and practical aspects of transmission in general. Since the team will be working on noise problems everywhere in the district they will have to obtain information and assistance from the personnel at all the various locations. The team will receive better cooperation if the leader is well known and well liked throughout the district.

The group leader should also be familiar with the numerous regions in the district. He should have knowledge of the equipment and physical layout in each location. Many times trouble will crop

up in a far-off corner of the state in some rural area. In these instances a general familiarity with the geography of the area and the line routings will be most helpful.

Knowledge of test equipment and test procedure is essential. Tests must be made in the proper manner so that the data collected will be meaningful. Test instruments have to be connected correctly, adjusted properly, and read accurately in order to obtain useful data.

The supervisor's responsibilities will include the collection of test data, analysis of the data, direction of the corrective action effort and the reporting of program progress. He will be responsible for the training of the team. He also will have the responsibility of insuring that noise measurements are a part of maintenance and installation work.

This individual must have the respect and confidence of the team members. He should support his subordinates. The supportive supervisor accepts, likes, and understands his subordinates, generally approves of their activities, and is interested in satisfying their needs. He is "employee-centered". The "employee-centered" supervisor places emphasis on the human problems of the workers. He is interested in helping them with their problems, both on and off the job. He is considerate, friendly, and helpful rather than punitive and threatening. A variety of studies in widely different industries show that supervisors who are getting the best production, the best motivation, and the highest level of worker satisfaction are employee-centered.

The supportive leader identifies with the worker as well as management. He takes the employee's point of view, has more regard

for the feelings of the group, and discusses matters rather than communicating orders by fiat. With this relationship there is less social distance and greater mutual understanding between the employees and their supervisors. The advantage of supervisor "employee-identification" is reported by Katz, Maccoby and Morse.[1]

Results of their study showed that supervisors that identified primarily with employees tended to be heads of high production sections; those primarily concerned with the company tended to be heads of low production sections.

For this work situation, the group members should be allowed to participate in decision-making. Their opinions and views should be solicited. Each member ought to be encouraged to seek and accept responsibility for his own work and for the work of the organization. Each worker should be able to make decisions that pertain to his work and to participate in decision-making that affects him, the group, and the organization. Participation of this type tends to (1) increase the degree of "we" feeling or cohesiveness that workers have with the company; (2) provide the workers with an overall organizational point of view instead of the traditional more narrow group point of view; (3) decrease the amount of conflict and hostility among the workers; (4) increase the individual's understanding of each other which leads to tolerance and patience towards others; (5) increase the individual's free expression of his personality, which results in the employee

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[1]Daniel Katz, Nathan Maccoby and Nancy C. Morse, Productivity, Supervision and Morale in an Office Situation, Part I (Ann Arbor, Michigan: Survey Research Center, Institute for Social Research, University of Michigan, 1950), p. 23.

feeling more responsible to the organization; and (6) develop a "work climate," as a result of the other tendencies, in which the subordinates find opportunity to be more creative and come up with ideas beneficial to the organization. Conclusions of various studies (such as those reported by Kurt Lewin[2] and Coch and French[3]) show the benefits of the participative approach. Group participation and mutual decision-making contribute to a change in attitude. Positive attitudes are associated with increased motivation which results in increased production.

It is usually advisable to train supervisors to be employee-centered and considerate. This human relations training involves the interaction of people: person to person, person to group, group to group, group to organization, and organization to organization. The term is increasingly used to describe a new scientific discipline, one where there is an effort to get a whole view of man in his relationships to other men.[4] The purpose of human-relations training is to develop leaders who are more skillful in handling the problems of their jobs in a more supportive, considerate manner. To achieve this purpose, methods such as lectures, conferences, role-playing, and sensitivity training are used. The supervisor of the noise reduction team, as well as the team itself, should receive human relations training.

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[2]Kurt Lewin, "Group Decision and Social Change," Readings in Social Psychology, E. E. Maccoby, T. M. Newcomb, and E. L. Hartley, eds. (New York: Henry Holt and Company, 1958), pp. 212 ff. and 437 ff.

[3]Lester Coch and J. R. P. French, Jr., "Overcoming Resistance to Change," Human Relations, L:512-32 (1948).

[4]Henry Clay Smith, Psychology of Industrial Behavior (New York: McGraw-Hill Book Company, 1964), p. 294.

The Craftsmen. These individuals should be selected on the basis of their superior technical knowledge, ability to take the initiative and plan their own work schedules, skill in handling new and varied situations, and also, their favorable personality characteristics which are, of course, prerequisites for good relationships with the consuming public. Although selection devices are far from perfect, these personnel tools can be useful in obtaining desirable workers. To select workers with the above mentioned characteristics, it is suggested that a battery of tests be given to possible candidates.

Technical knowledge could be measured by administering an applicable skill test. Planning ability and decision-making skill can probably be determined by aptitude testing. Also, it is highly likely that one of the intelligence tests would adequately predict future job proficiency. Then finally, to make a prediction as to which workers would be the most satisfied or happy with this type work, an interest test could be given. Since the technical problems involved in the best use of tests are quite numerous, technical assistance from an industrial psychologist will probably be needed.

At the beginning of the program the group members are to receive informal technical training on noise theory and methods of noise reduction as outlined in the following section. Also, they will receive instruction on test equipment and test procedures from the supervisor of the noise reduction team. In the training process the supervisor should remember to plan the spacing of the learning periods. Training is more effective when the sessions are well spaced rather than massed. At the first training session, the supervisor should strive to put the

craftsmen at ease. A person does not think properly or learn well if he is embarrassed or excessively anxious. It will also be helpful if the training material is presented in small "doses". People can catch but a few new ideas at one time and really understand them. The key points should be repeated and explained as often as necessary. This is an important point because of the great differences in basic aptitude and learned knowledge that will be found among the members of the group. To determine the benefit of the training, testing can be done both before and after the presentation of the training material. In this manner, test scores can be compared and effectiveness of the training measured.

After receiving the instruction, the supervisor will accompany each man on the first few cases of noise trouble. This will give them practical experience in applying the new technical information they have acquired. At this point, further training will be of the on-the-job variety. As they gain knowledge and skill through experience their proficiency will increase. Generally, the team members will be in daily contact with the supervisor with questions, comments and reports of progress.

For a number of reasons it will be desirable for the supervisor to evaluate the craftsmen of the group. Employee appraisals can be used as a basis for promotions or wage increases. They can also be an aid in making decisions concerning work assignments and further training. In addition, they are helpful in employee counseling and can be utilized as a motivational device. Since this job has so much variety it will be quite difficult to make valid evaluations of the workers'

performance. The assistance of an industrial psychologist may be needed to determine a valid appraisal procedure. Records kept over an extended period of time will show which methods are yielding valid and useful information.

The duties of the craftsmen will include taking noise, gain, loss, and resistance measurements, collecting test data, and carrying out corrective action on noise cases. They will work with ammeters, voltmeters, ohmmeters, bridges, noise measuring sets and gain and loss measuring sets. In a way, they will conduct an informal training and public relations program. As they work on noise problems at the various locations they will be working with local personnel. The knowledge that they pass on to these people will be helpful to them in solving their own noise problems in the future. Also, as the team members work on cases of noise they will be in contact with the public. The image that they create is very important. As they carry out their work, the image that they project to the consumer and the non-consuming public can be a substantial portion of the image that these people have of the company.

Note should be made of the fact that with little direct supervision these men will be expected to conduct this operation in an efficient manner. They are to set their own objectives, plan the work, and maintain a high rate of productivity while completing the details of the task--all with a minimum of direction. So, in effect, the job of supervision will be mainly one of combining high-caliber potential, adequate training, and a good positive attitude--all in one person.

The importance of a good positive attitude cannot be over-

stressed. The amount of effort put forth and the attitude of the employee go hand-in-hand. If the workman has a poor outlook on his work, his boss, the company, and the world in general, then it is highly likely that the work this man does will be of inadequate quantity and quality. A supervisor can help foster a positive attitude of the employee if work interesting to the employee is assigned, if challenging assignments are provided, if the supervisor shows a sincere personal interest in the welfare of the employee, and if accomplishments are recognized by genuine praise and proper monetary compensation. In addition, an honest positive attitude of the supervisor also tends to generate the same outlook in the personnel under his direction. Enthusiasm seems to be contagious. If a leader has a good positive attitude, his outlook tends to spread within the group.

Since the attitudes of the workers are so important, it is highly desirable to know just how the workers feel. This information can best be obtained by an attitude survey. Either employee interviews or printed questionnaires can be used. The attitude surveys should be conducted at least once a year. On the basis of the information obtained by the interviews, the supervisor, and high management, can make better decisions concerning the workers.

Technical Training of the Group

The noise reduction team members are to receive instruction on the following material. This information on noise theory and methods of noise reduction will furnish them with a solid background to base their practical experience upon. It will give them not only a "how" but a "why". The supervisor of the team should explain the information

and answer all questions relating to the subject matter. It will be helpful if each craftsman of the group receives a copy of this material. The copy can serve as a handy reference.

Theory of noise induction. Wires transmitting electrical signals produce electric and magnetic fields about them which may, under certain conditions, cause voltages to appear in other wires located in these fields. In the case of power and telephone systems, the power lines may induce voltages on the telephone wires. The energy associated with these induced voltages is transferred from the power system to the telephone system by the electric and magnetic fields and will appear to the listener as extraneous sound, or noise, when transformed from electric to sound energy by the receiver of his telephone.

In analyzing the noise effects of induction from a power line, a power system must be thought of as not merely a supplier of 60-cycle power but as a source of harmonic frequencies. It is with the harmonic frequencies that we are primarily interested in solving noise problems.

It is desirable to differentiate between the effects of voltages and currents. Here, two terms are used: "Electric induction" is used to refer to noise induction due to the electric field of the power line, and "magnetic induction" is used to refer to the noise inductive effects of currents.[1]

(a) Electric induction. The simplest method of visualizing electric induction is by means of the capacitances involved between a

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[1]United States Independent Telephone Association, Transmission Engineering (United States Independent Telephone Association, 1963), Part 6, p. 5.

single power wire and a single telephone wire. The voltage of the power wire to ground divides over the capacitance between the power and telephone wires and the capacitance between the telephone wire and ground in proportion to their impedances which are inversely proportional to the capacitance values.

Another method of visualizing the effects of electric induction is the practical case where the telephone wire is terminated longitudinally by office equipment or is long enough to be effectively terminated by the characteristic impedance of the longitudinal circuit. In general, the magnitude of the impedance of the capacitance between the power and telephone wires is so much greater than the impedances terminating the telephone wire that the induced curent is, for all practical purposes, independent of the terminating impedances. However, the division of the total induced current between the two ends of the telephone line depends on the relative magnitudes of the terminating impedance at each end.

The voltage-to-ground due to electric induction is the product of the induced current at one end of the telephone wire and the terminating impedance to ground at that end or the induced current at the other end of the telephone wire times the terminating impedance to ground of that end. Since the value of the capacitance between the power and telephone wires is proportional to the length of the exposure, the magnitude of the total induced current is also proportional to the exposure length. And since the impedance of the capacitance between the power and telephone wires is inversely proportional to the frequency, the value of the induced current will be directly proportional to the

frequency of the power voltage. Therefore, the effects of electric induction are consequently directly proportional to the voltage-to-ground on the power line, the frequency of this voltage, and the length of exposure between the power and telephone wires. It is also proportional to the proximity of the lines. However, this effect can be reduced by shielding.

(b) Magnetic induction. The current in a power line produces a magnetic field about it which alternates at the frequency of the inducing current. A voltage is induced along the telephone wire which is proportional to the time rate of change of the magnetic flux (or the frequency).

The voltage-to-ground at each end of a terminated telephone line depends on the terminating impedances and the total magnetic induced voltage. The magnitude of the induced voltage is directly proportional to the power line current, to the coupling inductance between the power and telephone lines (which is proportional to the exposure length) and to the frequency of the power line current.

Determinants of the magnitude of noise. There are three factors which jointly determine the magnitude of noise on exposed telephone circuits from electric or magnetic induction. These are inductive influence, inductive susceptiveness and inductive coupling.[2]

(a) Inductive influence. Inductive influence is a measure of the interfering effect of the power circuit with its associated

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[2]American Telephone and Telegraph Company, Bell System Practices (American Telephone and Telegraph Company, 1949), Section A702, 644, p. 4.

appartus that determines the character and intensity of the electric and magnetic fields which it sets up in the surrounding medium. These characteristics are termed "Influence Factors". Typical sources of trouble are generators, step-up transformers, poor balance-to-ground of the transmission line, step-down transformers and loads (motors, rectifiers, etc.).

(b) Inductive susceptiveness. Inductive susceptiveness is a measure of the balance of the telephone system. There are certain characteristics of a communication circuit with its associated apparatus which determine its responsiveness to external electric and magnetic fields. These characteristics are termed "Susceptiveness Factors".

To minimize susceptiveness, the series impedances of the two sides of a metallic circuit should be identical and the admittance of the two sides to the power lines and the earth likewise should be identical. Deviations from these conditions are called unbalances.

(c) Inductive coupling. Inductive coupling refers to the interrelation of neighboring power and communication lines and the subsequent electric and magnetic induction. The magnitude of the coupling depends upon the exposure length and separation between the power and telephone lines. For ground return currents coupling also depends on the distance of the ground return path below the power phase wires.

Descriptive titles for noise. In the telephone circuit the induced voltages and the resultant currents are known by three

descriptive titles: Noise-to-Ground, Noise-Metallic, and Noise-Longitudinal.[3]

(a) Noise-to-ground. This is a noise voltage that exists between a telephone conductor and ground. It may produce a noise current in the receiver because of unbalances between the two conductors of a telephone circuit pair and ground, unbalances within the telephone set itself, or unbalances of the central office.

(b) Noise-metallic. This refers to a noise voltage that exists between the two conductors of a telephone pair. It produces a noise current in the receiver in the same way that the speech current is produced, i.e., by virtue of a voltage existing across the line terminals of the subscriber set.

(c) Noise-longitudinal. Noise-longitudinal is a noise voltage that is induced along a telephone conductor. It produces a noise current in the receiver if unbalances exist between the two conductors of the telephone pair when they make up part of a ground return circuit.

Noise-longitudinal and noise-to-ground can be controlled by utilizing chokes and drains. Since noise-longitudinal and noise-to-ground result in disturbing noise-metallic when there is unbalance in the circuit pair, their adverse effects can be minimized by avoiding poor joints, brush on the wire, cracked insulators, etc.

Noise-metallic produced by unequal admittances of the two

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[3]United States Independent Telephone Association, op. cit., p. 4.

conductors to the power lines or the earth can be reduced to a minimum by the use of good transposition design and uniform spacing.

General remedial measures for noise reduction.

(a) Reducing power system influence. If upon systematic investigation it is found that the noise problem is primarily one of power system influence, or requires a reduction of influence as well as susceptiveness, the power company has various corrective steps that it may take.

1. Control the harmonics at the source (generator, transformer, etc.) so that they will not flow out over the system and cause problems. This involves improvement of the voltage wave shape at the point or points where the interfering harmonics are generated.

2. Balance the power loads (motors, rectifiers, etc.).

3. Rearrange the distribution system so as to:

   a. Limit the lengths of circuit supplied through a section of line involved in an exposure.

   b. Reroute the feeders to power system loads creating the disturbance.

   c. Break up resonant line conditions.

4. Make use of delta connected capacitors, or where grounded "Y" connections are used, rearrange to an unground system.

5. Control line voltages to avoid excessive transformer exciting currents during light loads.

6. Install shielded conductor or conductors.

7. Install resonant shunts or filters at equipment which proves to be the source of harmonics or on lines where resonance is encountered.

8. Convert single or two-phase systems to three-phase systems.

(b) Reducing telephone system susceptiveness. If the investigation indicates a high susceptiveness in the telephone system, the Company can implement a number of noise reduction measures.

1. Control any shunt leaks such as contacts with tree branches, etc.

2. Control station ringer unbalances. These are unbalances in the telephone instrument arising from the way in which the bell is connected to ground.

3. Control series unbalances in the open wire or cable facilities such as joints.

4. Control any central office equipment unbalances.

5. Check, and if necessary, rearrange the transpositions in an open wire exposure.

6. Install longitudinal choke coils or drainage coils as appropriate.

7. Use shielded conductors or cable sheath grounding.

(c) Reduction of coupling. The third approach to the noise problem, equally as important as the influence and susceptiveness aspects, lies in the consideration of the coupling between the power and telephone systems. It is in the initial planning and design of telephone and power systems that the coupling should be given the most

careful evaluation. Coupling should also be considered when extensions, additions, or changes to existing power and telephone system plants are made. If as a result of an investigation into a serious noise problem, it is found that coupling is very high, then action should be taken either to reduce the exposure length or increase the separation distance between the power and telephone lines so that the coupling may be reduced to a tolerable magnitude.

CONCLUSION

Noise in a telephone system is an interference in communication due to extraneous sound. The presence of this extraneous sound tends to mask the desired sound, or speech, by reducing the ability of the ear to detect its presence. Excessive noise has a serious detrimental effect on the quality of the service that a telephone company provides its customers.

The noise situation in the Spokane District of Pacific Northwest Bell Telephone Company is in need of improvement. Excessive noise is being experienced and is becoming a significant and annoying customer problem. Unless action is taken, excessive noise on Direct Distance Dialing calls will become increasingly serious as other improvements in transmission become effective and make the noise more noticeable. A definite improvement must be brought about if the Telephone Company is to provide service which customers expect.

It is suggested that an orderly noise reduction program be started now covering all parts of the Direct Distance Dialing network. The Noise Reduction Program will evaluate the plant from the noise standpoint and outline a procedure for the detection, identification, and mitigation of undesirable noise sources. It is essential that this program be implemented immediately.

The suggested plan for implementing this program includes (1) justification of the program to management; (2) the establishment of goals and objectives for noise reduction; (3) formation of the necessary plan of action; (4) the education of employees about noise so

that they will be aware of the situation and can cooperate with the reduction program; and (5) the formation and training of a technical noise reduction team.

Control of noise is not a "one-shot" affair, but must become a part of the continuing company program to improve and maintain good service. As with other programs, the Noise Reduction Program can not be effective unless all levels of management and craft are effectively motivated. It must be clear to all concerned that noise control is an important factor in providing good service.

BIBLIOGRAPHY

BIBLIOGRAPHY

A. PRIMARY SOURCES

American Telephone and Telegraph Company. Bell System Practices. New York: American Telephone and Telegraph Company, 1949.

_____. DDD Noise Improvement. New York: American Telephone and Telegraph Company, 1962.

_____. Transmission Results. New York: American Telephone and Telegraph Company, First Quarter, 1965.

Bellows, Roger. Psychology of Personnel in Business and Industry. New York: Prentice-Hall, Inc., 1961.

Coch, Lester, and French, J. R. P., Jr. "Overcoming Resistance to Change," Human Relations, I:512-32 (1948).

Katz, Daniel; Maccoby, Nathan, and Morse, Nancy C. Productivity, Supervision and Morale in an Office Situation. Part I. Ann Arbor, Michigan: Survey Research Center, Institute for Social Research, University of Michigan, 1950.

Lewin, Kurt. "Group Decision and Social Change," Readings in Social Psychology. E. E. Maccoby, T. M. Newcomb, and E. L. Hartly, eds. New York: Henry Holt and Company, 1958.

Lewinski, D. A. "A New Objective for Message Circuit Noise," The Bell System Technical Journal, XLIII (March, 1964).

Lichlider, J. C. R., and Miller, George. "The Perception of Speech," Handbook of Experimental Psychology. S. S. Stevens, ed. New York: John Wiley and Sons, Inc., 1951.

Matz, Adolph; Curry, Othel, and Frank, George. Cost Accounting. Cincinnati: South-Western Publishing Company, 1962.

Pacific Northwest Bell Telephone Company. Telephone Transmission Fundamentals. Seattle: Pacific Northwest Bell Telephone Company, 1962.

Smith, Henry Clay. Psychology of Industrial Behavior. New York: McGraw-Hill Book Company, 1964.

United States Independent Telephone Association. Transmission Engineering. New York: United States Independent Telephone Association, 1963.

B. SECONDARY SOURCES

Jones, Manley H. Executive Decision Making. Homewood, Illinois: Richard D. Irwin, Inc., 1962.

Lindsay, Robert, and Sametz, Arnold. Financial Management. Homewood, Illinois: Richard D. Irwin, Inc., 1963.

McCarthy, Jerome, and Irwin, Richard. Basic Marketing--A Managerial Approach. Homewood, Illinois: Richard D. Irwin, Inc., 1964.

Moore, Carl, and Jaedicke, Robert. Managerial Accounting. Cincinnati: South-Western Publishing Company, 1963.

Newman, William, and Logan, James. Business Policies and Management. Cincinnati: South-Western Publishing Company, 1959.

Schiff, Michael, and Benninger, Lawrence. Cost Accounting. Second Edition. New York: The Roland Press Company, 1963.