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Despite the increasing use of buried cable and Radio Relay systems in the Bell System, a large majority of the existing transmission circuits still consist of the familiar pole-supported telephone lines and cables. Most of the more than twenty-million poles used along these lines are treated with a creosote preservative to extend their useful lives by helping to ward off damaging attacks by fungi and insects. On occasion, however, this creosote oozes out onto the surface and produces "bleeding" poles. The nature of this bleeding tendency is being studied intensively in an attempt to acquire knowledge that may aid in overcoming it.

A. H. Hearn (left) and F. F. Farnsworth measuring the temperature of a pole section in the laboratory. The section is being irradiated by an infrared lamp.

Bleeding Temperatures of Creosoted Poles

L. H. CAMPBELL
Outside Plant Development

Shortly after the turn of the century, about one of every three telephone poles used in the eastern part of the United States, from Massachusetts to southern Georgia, was made from American chestnut. These trees provided an almost ideal source of poles since they grew sufficiently large, and the character of the natural wood chemicals made them resistant to attack by wood-destroying fungi and insects. Chestnut poles, in fact, were given no preservative treatment on the portion above the ground line and only limited treatment at the ground line and below to provide a usable life span of about thirty years. Chestnut was used so extensively that by 1920 the Bell System was setting about 250,000 of these poles annually as replacements or in new lines.

In the early 1900's, however, the fatal chestnut blight was brought into this coun-

Fig. 1 — Bleeding and non-bleeding telephone poles; bleeders at the right and non-bleeders at the left.

try by the importation of Chinese chestnut shrubs. This blight spread at such a rapid rate that by 1925, most of the chestnut north of the Potomac River had been killed and large scattered areas in the southern Appalachian Mountains had suffered attack. By 1930, the living American chestnut had almost completely disappeared. Today only a few dead chestnut trees remain standing in the forests. Some venerable chestnut poles, however, are still in use in telephone lines — proof of this wood's great durability.

Although chestnut formed one of the principal sources of telephone poles in the Northeast before 1920, the rest of the country depended largely on a supply of northern and western cedar. Cedar, too, is a durable and insect-resistant wood. Only a limited number of cedar trees were available, however, that were large enough to meet the standardized requirements for poles in the Bell System and the power companies. Fortunately, the wood-preserving industry in the United States was expanding during this period. This industry, which had previously concentrated on the treatment of railway ties, had made successful treatment of southern pine, western lodge-pole pine, and Douglas fir economically feasible. To make use of these non-durable species as telephone poles, full-length treatment is required because the above-ground portions are normally subject to attack by fungi which cause decay. With the use of poles requiring full-length preservative treatment, however, a number of problems have developed.

The most widely used preservative for these poles is creosote — a black, oily byproduct of the distillation of coal tar. A

TABLE I — Temperatures at Bleeding

	Irradiated by Sun	Irradiated by Infrared Lamp			
		Outdoors for			In the laboratory
		12-15 minutes	5-8 minutes	3-5 minutes	3-5 minutes
Scattered Bubbling	140°-145° F	140°-145° F	140°-145° F	140°-145° F	140°-145° F
General Bubbling	145°-155° F	—	—	—	145°-155° F
Severe Bubbling	155°-165° F	155°-160° F	155°-160° F	155°-160° F	155°-160° F

charge — about 200 to 400 poles — is impregnated in hot creosote applied under pressure. After impregnation, however, this creosote sometimes oozes out on the surface of the wood to result in a "bleeding" pole. This condition may persist for months or even years and it is not only unsightly, but it also makes the poles difficult to climb or handle. The pole sections in Figure 1 illustrate this condition; those shown at the right of the photograph are "bleeders" while those at the left are clean and dry. Through the years, modifications in the methods and techniques of treating poles with creosote have been made in an attempt to correct this bleeding tendency, but none of them has been completely successful.

One of the most disturbing things about bleeding is its apparently inconsistent nature. One charge may be dry and show no evidence of bleeding when the poles are put in use. In another charge, however, all the poles may bleed and, at times, some poles of a charge will show extensive bleeding while the others remain clean dry. Certain poles may bleed while they are resting on skids in a pole storage yard but will dry up when they are set in the ground. On the other hand, some may remain clean and dry for weeks while they are on skids after treatment, but bleed copiously following a weather sequence consisting of hot sunshine, a cool shower, and hot sun again.

Although there has been a great deal of speculation in the past about the causes of bleeding, very few revealing scientific data have been gathered. Recently, therefore, a program was begun to investigate the possible factors involved in the bleeding tendency, such as the amount of preservative retained by the wood, and the surface temperature of the poles at which bleeding occurs. In commercial practice, the amount of preservative retained by the wood is determined at the treating plant by measuring the quantity of creosote absorbed by a charge and then calculating the amount retained per cubic foot. Since the core (heartwood) absorbs little or no creosote, and the distribution throughout the treatable portion (sapwood) varies extensively, however, this method of expressing creosote content bears little relation to the actual amount retained in the thin outer layers of the wood. For example, the usual minimum requirement for pine poles is eight pounds of creosote

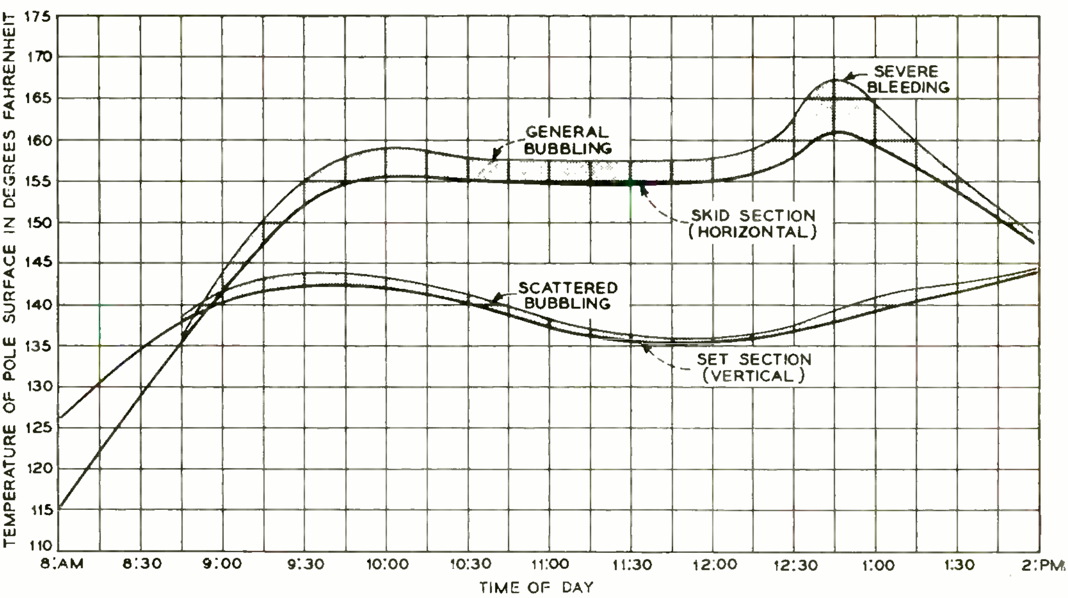

Fig. 2 — Temperature versus time-of-day graphs for horizontal and vertical pole sections. The width of the shaded area indicates the bleeding severity.

per cubic foot. It has been found by extraction studies, however, that the actual content in the outer one-sixteenth of an inch may be as high as 40 pounds per cubic foot.

There are at least two processes by which bleeding occurs in telephone poles. Those that have large amounts of creosote in the outer layers bleed continuously during the daylight hours, dry up at night, and start

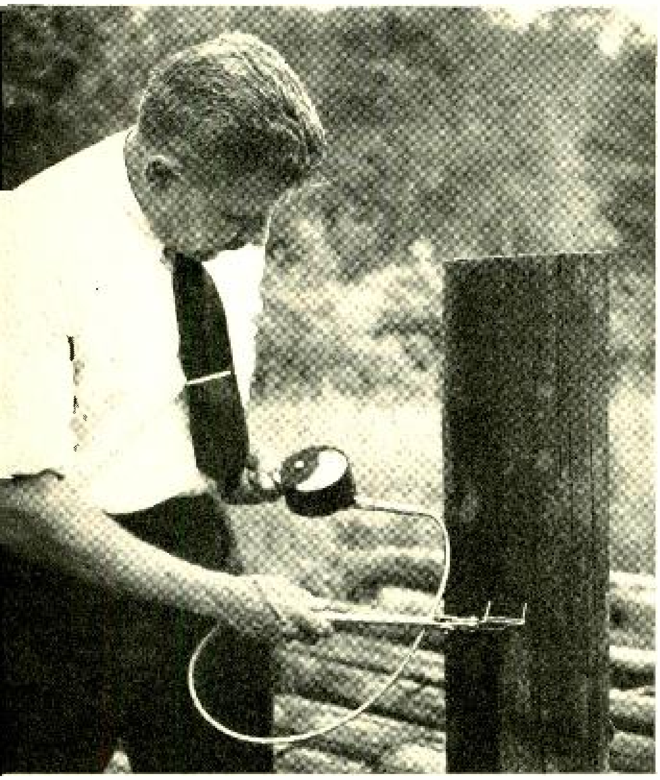

Fig. 3 — A. H. Hearn using a specially developed fine-wire thermocouple to measure the surface temperature of a vertical pole section.

again the following morning. Those with lesser amounts of creosote normally do not bleed but may start if water seeps into the surface cells and emulsifies the creosote. Poles that bleed continuously during the daytime usually follow a definite pattern starting at the same temperature each day and progressing from scattered bubbling, through bubbling over most of the irradiated surface, to severe bleeding. This pattern is illustrated by the temperature-bleeding curves plotted in Figure 2 where the width of the shaded area represents the severity of the bleeding. To measure these surface temperatures accurately outdoors, it was necessary to develop a special fine-wire thermocouple to be described in a subsequent issue.

Ten-foot sections cut from the same pole were used as test specimens to obtain the data in Figure 2. One section was placed horizontally on skids and the other set vertically in the ground as shown in Figure 3. As shown, in Figure 2, the vertical section had a lower surface temperature than the horizontal post throughout most of the day. It was higher only in the early morning when the rays of the sun were more nearly perpendicular to the vertical section. The graphs also show that bleeding starts at the same temperature whether the section is on skids or set in the ground. These two factors explain the rather puzzling observation that many poles exhibit bleeding on the skids but clear up immediately when placed in line. This occurs because the surface temperature of the pole after setting may drop and remain below that at which bleeding begins.

Although the field work on bleeding using pole sections and full-size poles yielded a great deal of valuable information, there was a need for fundamental laboratory studies conducted under less variable conditions than prevailed in the field. The first problem which had to be solved in the laboratory phase of the investigation was to determine a method to induce bleeding on a controlled basis. It was found that bleeding could be caused by shining an infrared lamp on a small section cut from a pole. To determine whether or not infrared heating caused bleeding at the same temperatures as did heating by the sun, the same section used in gathering the data for Figure 2 was irradiated by a 250-watt infrared lamp when the air temperature was 53° F. During the tests, the lamp was held at various distances from the pole to determine whether the rate of heating would effect the accuracy of the method. Following this, a 2-foot section was sawed from the post and brought into the laboratory. Three days were allowed for the pole to come into thermal equilibrium with the room temperature of 76° F. The surface was then irradiated with infrared once more and the bleed-

TABLE II — BLEEDING BEHAVIOR OF A TYPICAL SPECIMEN

	Average Bleeding Temperature		
	Before Wetting	*After Wetting*	*Decrease*
Scattered Bubbling	192° F	155° F	38° F
General Bubbling	199° F	165° F	34° F
Severe Bubbling	212° F	178° F	34° F
Average Decrease			35° F

ing temperatures measured as shown by the photograph at the beginning of this article. The data obtained in these tests are summarized in Table I. As shown, the pole section begins to bleed at the same temperature whether it is irradiated by the sun in summer, an infrared lamp outdoors in late fall, or by the same lamp in the laboratory. In addition, the rate of heating, within the limits tested, has little or no effect on the bleeding temperature.

Additional investigations were carried out using these techniques to study the action of those poles that normally do not bleed but may begin after a sequence including hot sunny weather, a cool shower, and hot sun again. To determine the influence of absorbed water in this process, the bleeding temperatures of several pole sections were measured after they had been irradiated by an infrared lamp in the laboratory. These sections were selected from poles with bleeding temperatures that were above those usually encountered in northern latitudes. A cloth, kept saturated with water, was then placed on the heated area and allowed to remain there while the wood was cooling. The bleeding temperature was redetermined and the resulting data on the behavior of a typical specimen are given in Table II. In each of the specimens tested, the bleeding temperature was lowered and, in each, the exudate appeared to be an emulsion of creosote and water. To further test the response of a non-bleeding pole, a specimen that showed no bleeding at 250° F was soaked overnight in water. Tests the following morning showed general bubbling at 157° F — a decrease of about 100° in the bleeding temperature.

Such tests have added considerable knowledge about the bleeding tendency in creosoted poles, but a great deal more work must be done before a reasonable understanding of the bleeding phenomenon can be gained. For example, investigations must be made to correlate the amount of creosote retained by the entire cross section of a pole with the amount retained in the outer fibers. Moreover, the relation of these retentions to the bleeding tendency must be determined. Preliminary work of this nature has indicated that it is again necessary to develop new techniques and to greatly modify existing apparatus before adequate procedures can be made available. The object of these activities is to obtain a better understanding of the significance of the abnormal amounts of creosote in the outermost fibers of a pole in the hope that remedial measures can be applied at the treating plants to provide clean, non-bleeding poles.

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Fig. 1 – R. L. Miller (right) of the Acoustics Research Department and the author at work at the Vocoder. Here vocal sounds are investigated to discover and take advantage of the redundancies of speech as well as to learn more about other speech characteristics.

Information Theory

C. B. FELDMAN
Transmission Research

The primary purpose of a communication system is, of course, to transmit information from one place to another. The idea of "information," and the measurement of information, have accordingly been given much consideration in recent years. To introduce this subject to readers of the Record, Mr. Feldman here discusses some of the elementary principles of information theory, and a bibliography appears at the end of the article. The Record plans to publish articles on other aspects of information theory in future issues.

Communication theory tries to find the most advantageous methods for transmitting information. In this respect, there is, of course, nothing new in the recent studies of communication systems, for Bell Laboratories and other organizations in the communications field have always sought better and more efficient means of transmission. Recent years, however, have seen a large growth in communication theory, and one of the important considerations involved is an understanding of information and how it may be specified. Readers not familiar with information theory have possibly encountered the term "bits" of information, and may have seen references to the role that probability plays in recent communications research. The concept of bits of information and the idea of statistical probability are fundamental to the theory, and an explanation of these principles will serve as an introduction to what in certain applications becomes a complex mathematical subject.

Suppose we have a very elementary transmission system as illustrated in Figure 2. Electrically it consists merely of a battery, a key, a wire, and an electromagnetic relay. We choose the most basic kind of information for transmission across this wire, a simple yes-or-no reply to a question: a "Yes" indicated by a closed position of the key

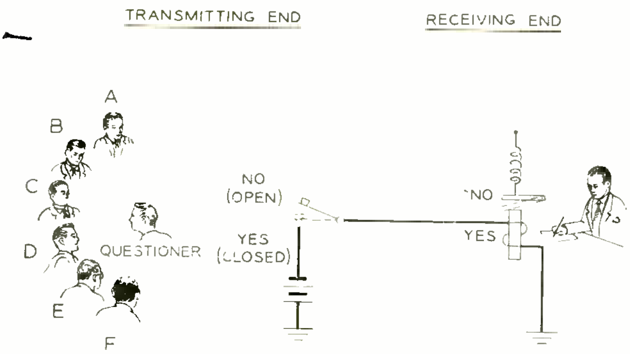


Fig. 2 – Diagram of a simple transmission system. Information about the bank accounts of the six people on the left is transmitted to the receiver on the right. Information theory gives us a quantitative measure of the amount of information going over the wire.

and relay, and a "No" by the open position. In the parlance of information theory, such a yes-or-no reply is a "bit," a contraction of "binary digit." We shall explain at some length how information in general may be measured in bits and transmitted as bits.

Suppose further that for our simple transmission system we have at the transmitting end a questioner who wishes to ask questions of six people, A through F, and transmit their replies to a person at the receiving end. We shall imagine that he asks them the following question:

1. *Do you have a bank account?* Each person is required to answer yes or no, and the questioner will be able to transmit these replies to the receiver by means of the key. To transmit the complete body of information, the questioner will, of course, have to send six yes-or-no replies, and it can be seen that there are exactly 2^6 or 64 possible patterns of replies. These 64 patterns are illustrated schematically in Figure 3, where the shaded areas represent a yes answer and the blank spaces indicate no. We can notice two things here—that the number 64 is determined by raising the number 2 to the appropriate power, and that in this case the power 6 is determined by the number of yes-or-no replies, or bits, needed to answer the question. For this simple question, put to six people, six bits of information are required to communicate the intelligence to some distant spot.

Yes-or-no replies – bits – can also be used to measure and transmit the information elicited by a more involved question; for example:

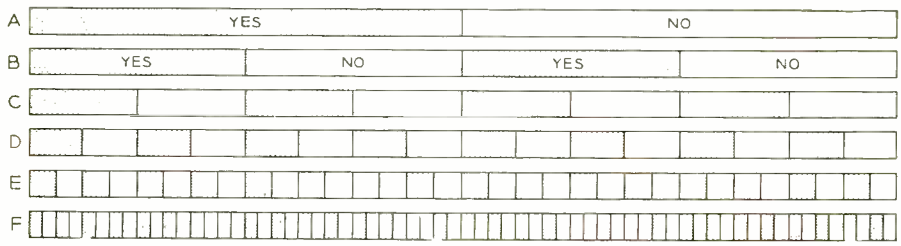
2. *Do you have a bank account, and if so, is it small, medium, or large?* Each of the six people therefore must describe his financial situation by placing himself in one of the four categories. He can do this over our transmission system by, this time, giving two yes-or-no answers: One yes-or-no answer will divide the four categories into two, and the second will place the individual in the correct category. Each person is instructed to give his two answers in accordance with the rules given in Table I.

This pattern of the answer by a single person is illustrated in Figure 4, and if we

TABLE I – RULES FOR ANSWERS, QUESTION 2

Answer 1	*Answer 2*	
No	no	No bank account
No	yes	Small bank account
Yes	no	Medium bank account
Yes	yes	Large bank account

Fig. 3 – When each of six people answers a yes-or-no question, the six answers can fall into any one of sixty-four patterns.



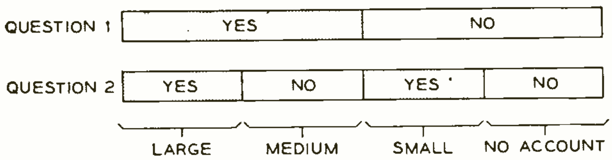


Fig. 4 – When one person answers two yes-or-no questions, he effectively places himself in one of four categories.

were to construct a new diagram of the possible patterns of the answers of all six people, similar in principle to Figure 3, we should find that for this second question there are exactly 64^2 patterns. We notice that 64^2 equals 2^{12}, and that here the power twelve is determined by the fact that each person must answer two questions, or twelve in all. These procedures could, of course, be expanded to highly accurate information on the size of the bank account and to other subjects, the color of eyes, age, etc., and a third illustration will enable us to deduce a quantitative formula:

3. *Into which of eight categories does your financial situation fall?* Here, each of the six people would place himself in the correct category by giving three answers according to the rules given in Table II. There are now a total of eighteen yes-or-no replies and 2^{18}, or 64^3 possible patterns of the complete transmission, Now, instead of twelve bits of information as in the previous example, we need eighteen bits for the complete procedure.

We can now arrange the results of these examples in a more formal manner:

$$\text{Question 1: } 2^6 = 2^6$$

$$\text{Question 2: } 2^{12} = 4^6$$

$$\text{Question 3: } 2^{18} = 8^6$$

It will be noticed that these identities summarize all of the factors discussed in the examples. In the first vertical column we have in each instance raised 2 to a power equal to the number of bits necessary to transmit the information. In the second vertical column we have taken a number equal to the number of categories involved in each question, and have raised it to a power, 6, equal to the number of people polled.

The two columns give us a quantitative expression for the amount of information involved in each transmission, for we can express these columns by the formula,

$$2^{bits} = b^N,$$

where b is the number of categories involved, and N is the number of people being questioned. It is usually more convenient, however, to express this equation as a logarithm function,

$$\text{bits} = N \log_2 b,$$

which, if we solve it for our three examples, will of course yield 6, 12 and 18 as the number of bits of information for the three cases.

This logarithm rule is very fundamental to information theory, and we have gone to considerable lengths in the preceding illustrations to establish it, but an introduction to the theory would not be adequate without a discussion of a second principle. We have been assuming that our simple questioning procedure is the most efficient method of obtaining and transmitting the desired information, but when we realize the role that probability plays in more complex situations, we can see that this is not necessarily true. The over-simplification of our previous examples has resulted from our assumption that each of our six people is equally likely to place himself in any one of the two, four, or eight categories, and that therefore each yes-or-no answer contains the same amount of information, one bit. A more realistic illustration will show

TABLE II – RULES FOR ANSWERS, QUESTION 3

Answer 1	*Answer 2*	*Answer 3*	
No	no	no	No bank account
No	no	yes	Very small account
No	yes	no	Small account
No	yes	yes	Medium account
Yes	no	no	Large account
Yes	no	yes	Very large account
Yes	yes	no	Super large account
Yes	yes	yes	Hyper large account

that one yes-or-no answer can represent less than one bit of information.

Suppose the transmitting end of our transmission system of Figure 2 is in Jacksonville, Florida, and the receiving end in New York, and suppose further that we on the reception end merely want a Jacksonville meteorologist each day to tell us whether or not it snowed in Jacksonville. Because we know that it rarely snows in Jacksonville, most of the daily messages would be "no" and would merely confirm our expectation. The daily messages would be virtually wasted. Over a good many years the message would be "no snow" and the average information would be nearly zero and *would be zero* if there were a *certainty* of no snow. Or, to return to our questions about bank accounts, suppose that among the people being questioned there were some husband-wife couples having joint accounts. It would be wasteful to ask both members of the couples the question, "Do you have a bank account?" A third example in the same vein might be taken by assuming that the people being questioned included some members of the Warramunga tribe of northern Australia, who would certainly have no bank accounts. It would be wasteful to question them at all.

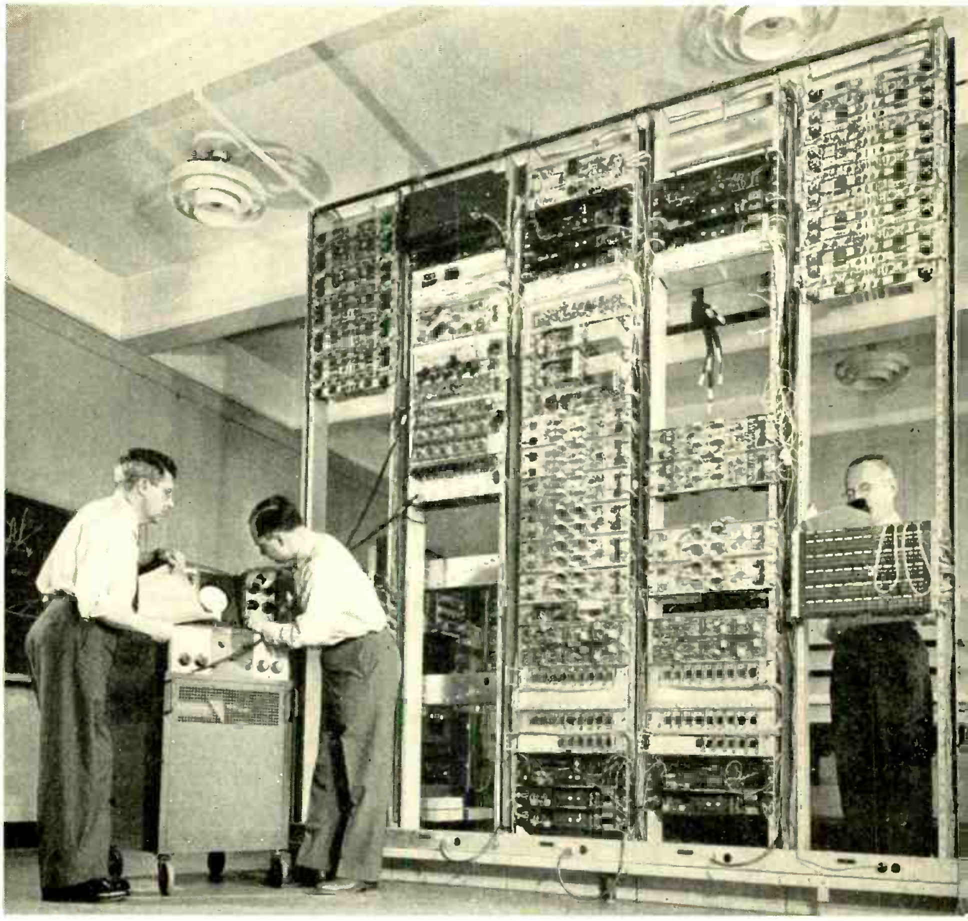


Fig. 5 — The author, L. A. Meacham, and E. Peterson with the pulse code modulation equipment, used in an experimental study of a new transmission system.

Such illustrations hint at the matter of redundancy, for on the average, it would be foolish to provide transmission facilities capable of transmitting so many bits to relay so little information. The illustrations also suggest that a better expression is needed to calculate the minimum number of bits necessary to transmit the information.

Without attempting to derive this equation, we shall merely state it and use it to

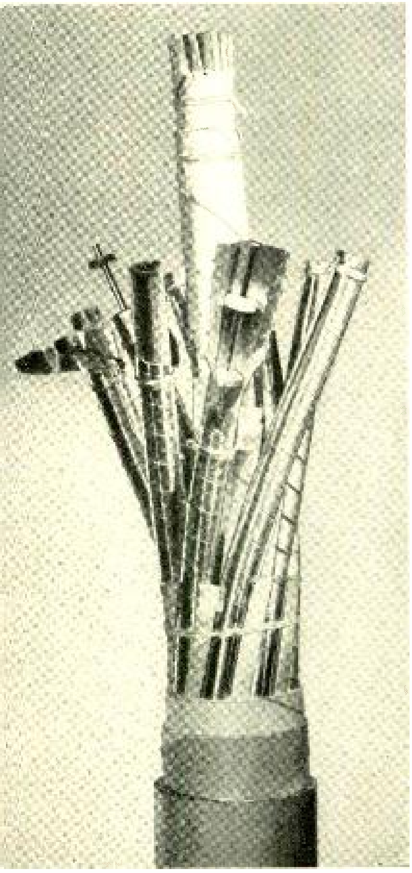


Fig. 6 — This single cable as used in the L3 carrier can carry as many as 5,400 simultaneous telephone conversations. Transmission research seeks to make such transmission systems even more efficient.

show how it often yields more useful results. For situations in which various groups of people are more likely to place themselves in one or another of the categories in question, the *average* number of bits of information required (per person) can be calculated by

$$\text{bits} = p_1 \log_2 \frac{1}{p_1} + p_2 \log_2 \frac{1}{p_2} + p_3 \log_2 \frac{1}{p_3} + \ldots p_n \log_2 \frac{1}{p_n}$$

where $p_1 + p_2 + \ldots p_n = 1$ and p is the probability, expressed as a fraction, that a person will fall into a particular one of n categories.

To give us easy numbers to work with, we now assume that we have eight people at the transmitting end of our system, and that we want to place them in four categories of bank accounts. We further assume that ½, or four of them will have no bank account; that ¼, or two of them will have only a small account; that ⅛, or one of them will have a medium account; and finally, that ⅛, or one of them will have a large account. If we were to use our first equation, we should find that

$$\text{bits} = 8 \log_2 4 = 16,$$

or that an average of two bits of information would be devoted to each of the eight people. The communication channel need not handle this rate of information, however, for our second equation yields a more economical result:

$$\text{bits} = \frac{1}{2} \log_2 2 + \frac{1}{4} \log_2 4 + \frac{1}{8} \log_2 8 + \frac{1}{8} \log_2 8 = \frac{7}{4}.$$

Now only one and three-quarters bits per person need be planned for, and we effect a 12½ per cent saving in the capacity of our communications system. More significant savings are possible when the probabilities are more divergent. To effect such a saving, however, we need a somewhat different method of arranging the answers. Instead of having each of the eight people give two yes-or-no answers, we set up the rules given in Table III. The *no's* in this table may seem superfluous, but they permit the receiver to distinguish between the separate groups. The *no* can be omitted from the final group, however, since three *yes* answers in a row will distinguish this group from the previous three.

The economy of using these rules stems from assigning fewer bits to the more prevalent categories. This saving can be seen in non-mathematical terms by merely counting up the number of yes-or-no bits. Four people will now answer merely one yes-or-no question each, or a total of four bits; two of the eight will answer two questions each for a total of four bits; and the last two people with the larger bank accounts will require three bits each for a total of six. The grand total is 14 bits, and again we find an average of $\frac{14}{8}$ or one and three-quarters bits per person.

Returning to the illustration of the snow reports from Florida, suppose p_1 is the probability of snow; then p_2 (equal to $1 - p_1$) is the probability of no snow, and our equation is

$$\text{bits} = p_1 \log_2 \frac{1}{p_1} + (1 - p_1) \log_2 \frac{1}{(1 - p_1)}.$$

If the probability of snow is 10^{-6}, say, the above equation has a value of approximately 0.00002 bits per message from Florida. Newspapers would not comment on the 999,999 snow-free days out of a million but would likely carry headlines about the remarkable event on the one day that snow fell. We might feel instinctively that a great deal of information was contained in the message for that one day, that it contained more than one bit of information. This, however, is not true. Our equation is expressed in terms of probability and does not measure information on any particular day. Instead, it gives us the average over the years. If the message pertained to an area where the probability is ½, say an arctic region where, on the average, it snowed every other day, then the average information is one bit per message. If the probability is either greater or less, the average information per message diminishes.

TABLE III – RULES FOR ANSWERS, TAKING ADVANTAGE OF PROBABILITIES

No			No account	(4 people)
Yes	no		Small account	(2 people)
Yes	yes	no	Medium account	(1 person)
Yes	yes	yes	Large account	(1 person)

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It will be noticed that the logarithm to the base two appears in both our first and second equations. The role that this logarithm function plays in information theory, and the importance of considerations of probability in finding more efficient transmission systems, are basic to most discussions of the theory, and will recur frequently in the literature on the subject.

The simple transmission system of Figure 2 however, is of course not the only possible one, and those engaged in information theory investigate a large variety of other methods that show promise of enabling us to get a larger number of bits of information over a less expensive communication system. An intriguing method is suggested by the operation of the current television program "Twenty Questions." With our first formula, we can calculate that with twenty yes-or-no questions, a questioner could place an individual in any one of the 2^{20} categories. But in the game of "Twenty Questions" a questioner can arrive at one of a tremendous number of messages – identities of persons, things, or ideas – far exceeding 2^{20}. Anyone hearing the yes-or-no answers but not the questions would, of course, be unable to deduce the message, but if the questioner had an "identical twin" who could be relied upon to think exactly like the questioner – say some sort of electronic brain that had this ability –then this twin would know what the question was and could deduce the message by hearing only the replies. If such a twin were located at the remote end of a transmission system, only twenty bits would be needed to transmit the information. The efficiency of such a system would, of course, be due to the fact that the questioner and his twin do not follow blindly a pre-established set of questions, but instead would follow rules that change in recognition of new probabilities that appear as the questioning proceeds.

Thus communication is a many-sided problem involving the abilities of both the transmitting and receiving apparatus as well as the transmission medium. Information theory attempts to handle these problems in a quantitative, measurable way and to discover theoretical relationships that may ultimately be reflected in better, faster and cheaper communications service. So far it has generated a new kind of thinking in transmission research, has gathered seemingly disparate facts under a common heading, and has put the measurement of information on a scientific basis.

THE AUTHOR: In 25 years' association with the Laboratories, C. B. FELDMAN has been concerned first with research on short wave radio systems, including short wave propagation, antennas, receivers, and transmission lines. During World War II, his attention was directed to radar developments, specifically for microwave radar scanning antennas. Since 1945, he has directed a group engaged in research in the field of new multiplex transmission methods. Recently he has also been concerned with military projects. Mr. Feldman received the B.S. degree in E.E. (1926) and the M.S. degree in E.E. (1928) from the University of Minnesota. He is a Fellow of the I.R.E. and a member of Kappa Eta Kappa.

Throughout the Bell System, accountable telephone messages in the order of about 200 million per month must be recorded, priced, and billed. The immensity of this message accounting job, one that must be done under exacting requirements of accuracy and promptness, made it particularly desirable to mechanize much of this work. Complete mechanization is the ultimate goal, and the present AMA system is making strides in this direction. The tape-to-card converter is one of these steps.

Card column assignments on the IBM control panel of the AMA Tape-to-Card Converter are checked by W. B. Groth.

A Tape-To-Card Converter for Automatic Message Accounting

W. B. GROTH
Switching Systems Development

Billing data for customer-dialed local and toll telephone messages are now recorded and processed by means of the automatic message accounting (AMA) system in the areas of eight principal cities in the Bell System network. This system records the information required for billing the customer in the form of perforations in paper tape in the central office. Recordings are made while the switching machinery is establishing connections between telephone lines, and while the messages are in progress.

These perforated paper tapes are cut daily and forwarded to an accounting center where the information is processed through a series of machines, each of which, except the last, produces new paper tapes. Individual message records are assembled, and chargeable message units or chargeable time, in the case of toll messages, are determined. Individual message entries are sorted by calling line number, message units for a given billing period are added, and finally message unit summaries and individual customer toll slips are printed. The printed output of the AMA accounting center is used by clerical personnel in producing toll service statements and customer bills.

Statement
B
130 2868

NEW JERSEY BELL TELEPHONE COMPANY
TOLL SERVICE STATEMENT

DATE	PLACE CALLED	AMOUNT
1-16	PR 7	.10
1-18	NYEV 4	.15
1-18	PA 6	.15
1-18	PA 6	.15
1-21	NYSL 6	.15
2-8	NYUL 7	.35
2-11	PA 6	.20
2-11	PA 6	.15
2-13	UN 6	.10
2-15	NYSL 6	.15

PLEASE SEE YOUR DIRECTORY FOR CENTRAL OFFICE NAMES AND ABBREVIATIONS OF NEARBY POINTS

U. S. TAX SCHEDULE
TOLL CALLS
UNDER 25¢ . . . 15%
25¢ and over . . 25%

TOTAL U. S. TAX .28
TOTAL CARRIED TO BILL 1.93

A 2486 (11-51)

PLACE CALLED	DATE	AMOUNT	AREA	CALLED C.O.	CALLED TELEPHONE NO.	CONNECT TIME	MINUTES	CLASS
PR 7	1-16	10		777	3900	1045	3	1
NYEV 4	1-18	15	1	384	3264	1727	1	1
PA 6	1-18	15		726	0946	1704	3	1
PA 6	1-18	15		726	0946	0757	5	1
NYSL 6	1-21	15	1	756	2782	1046	3	1
NYUL 7	2-8	35	1	857	4085	1132	13	1
PA 6	2-11	20		726	0946	1324	6	1
PA 6	2-11	15		726	0946	1221	2	1
UN 6	2-13	10		866	5304	1157	1	1
NYSL 6	-15	15	1	756	2782	1044	3	1

130 2868

CODE LL-LONG LINES

TOTAL U. S. TAX 28
TOTAL CARRIED TO BILL 193

EXPLANATION OF CLASS CODES
1. STATION DAY 3. PERSON DAY 5. MOBILE 7. TELEGRAM
2. STATION NIGHT 4. PERSON NIGHT 6. COLLECT 8. REPORT CHARGE

*0*0
*0*0

Fig. 1 — A Toll Service Statement as prepared is in two sections; a section, shown in the upper part of the illustration, is sent to the customer, while the one shown in the lower part of the illustration is retained by the Telephone Company.

It is hoped ultimately to make even this last step automatic. As a step in this direction, IBM machines using punched cards are now used to process toll calls. Designed to make the accounting procedure more efficient, this process is known as tape-to-card conversion and has had a marked effect upon the routines followed in the accounting center. Tape-to-card conversion, therefore, is not merely an adjunct of the AMA system, but a new process intended to supplement AMA in its previous form. A typical toll service statement for the customer is shown in Figure 1.

Since the processing immediately preceding the final preparation of the toll service statement is done with punched cards, it was necessary to develop suitable equipment to convert the information from the perforated tapes used during the earlier stages to punched cards that can be used in the later stages. The result is the tape-to-card converter, which first went into service in Newark in 1951. When this machine is used, the four sorting stages* and the printer that were formerly employed for toll calls are eliminated and the tape-to-card

* RECORD, *July*, 1952, *page* 299.

converter will take over from the output of the computer.

At its input, the tape-to-card converter employs a reader* to which the toll tapes from the computer are supplied. At its output is an IBM card punching machine which punches 3 by 7 inch cards, each card having space for all the essential information for one entry on the input tape. Other IBM machines carry out the rest of the accounting process to produce an individual Toll Service Statement for each customer.

The laboratory installation of the tape-to-card converter is shown in Figure 2. At the left is the card punching machine, next to the right is the reader for the input tape, while the bays at the extreme right comprise the relay equipment of the converter. In brief, the converter consists of a group of input registers for recording the data read from the input tape; a few translators to translate certain items of the input tape entry before they are placed on the card; a group of output registers on which are recorded the data to be punched on the card; and the card punch itself. These various units are indicated in the block schematic of Figure 3.

The information recorded for one entry on a toll tape is shown in Figure 4. Each line of an entry carries five digits of information – The B, C, D, E, and F digits – and the A, or index, digit. Digit 1 in the A position indicates the first line of an entry, and this prepares the converter to accept a new entry. Each of the succeeding lines of the entry will have a zero in the A position, and thus the next appearance of a 1 indicates that the preceding entry has been completed and that a new one is to begin.

Most of the information on such a tape can be transferred directly to the card, but for certain items, such as the calling office designation and the start time, a translation is needed. Only a single digit is recorded on the tape entry to indicate the office – the B digit in the first line. This is because a single tape records only calls handled by a single marker group, and such a group never handles the calls of more than ten offices. The marker group to which the tape applies is recorded at the end of the tape and is set up on the control panel of the converter before the tape is inserted in the reader, and from the marker group and the office index, the B digit of line 1, it is possible to derive the three digits identifying the calling office. This is one of the translations that the converter makes.

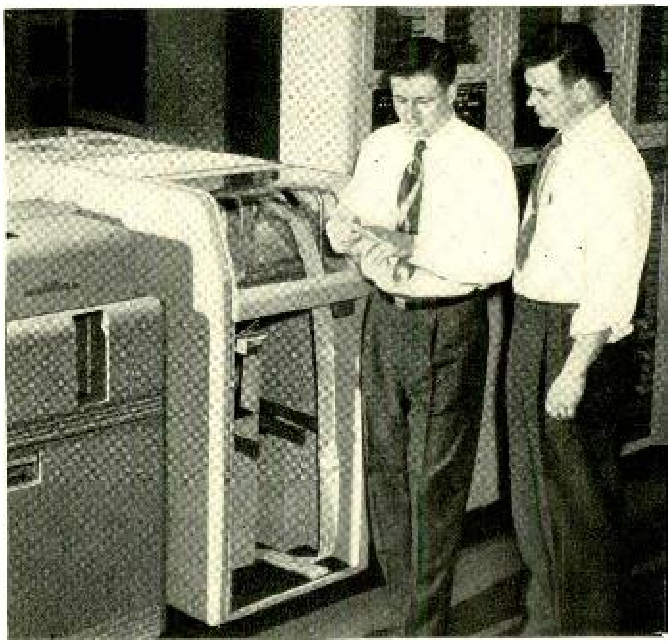
* Record, *June,* 1952, *page* 237.

The start time of the call was originally recorded as six digits: day tens and day units; hour tens and hour units; and minute tens and minute units. As already described,* however, these six digits are recoded so as to require only five digits on the tape supplied to the converter. Another translation is therefore required to reconvert the start time to the original six digits. With these and some minor additional translations, all the information on the input tape is transferred to the card. The card is of the form shown on Figure 5.

Such a card has eighty columns and twelve horizontal rows. These rows are designated, from top to bottom, 12, 11, 0, and then 1, 2, 3, 4, 5, 6, 7, 8 and 9, while

* Record, *September,* 1952, *page* 373.

Fig. 2 – W. B. Groth and L. J. Koos examine a toll message card punched by the AMA Tape-to-Card Converter.



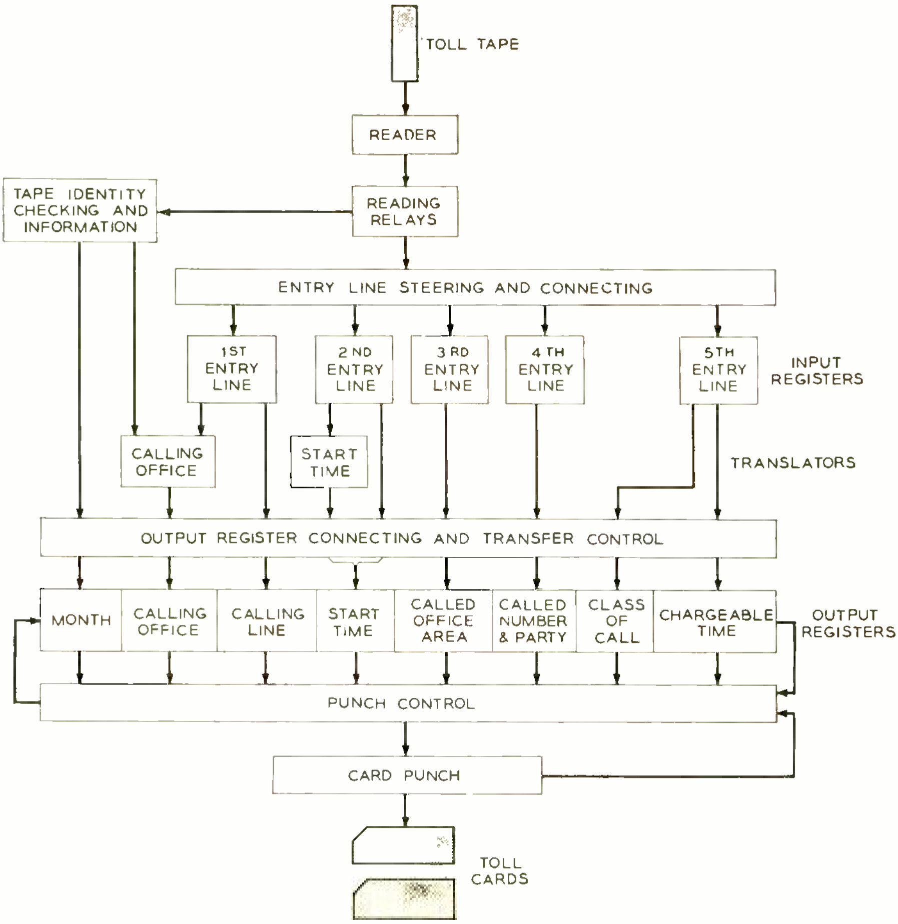


Fig. 3 — Block Diagram of the Tape-to-Card Converter.

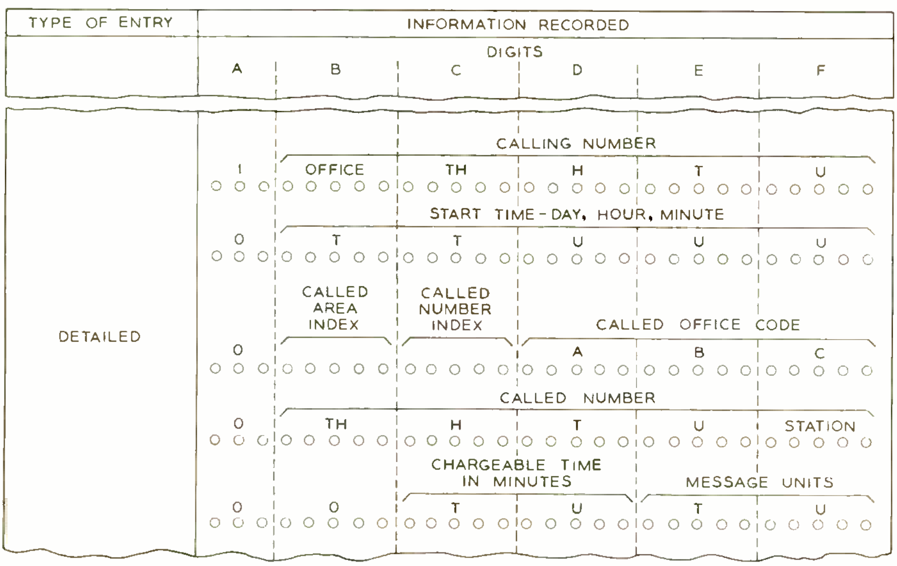


Fig. 4—A diagram indicating the spaces available for a toll entry on an input tape to the converter.

the eighty columns are indicated from left to right along the bottom of the card. Individual items of information are found in one or more columns. Information requiring three digits, for example, will be punched in three columns with one digit in each column. The particular card shown in Figure 5 was for a call from Office 236, and this calling office designation will be found in Columns 55, 56 and 57. An inspection of the card will show that in Column 55, the 2 has been punched out; in Column 56, the 3; and in Column 57, 6. A similar method is employed for all items. The called number for the card of Figure 5 was 1614J, and these digits will be found punched out in Columns 63 to 67, inclusive. Column 62, which is also one of the columns reserved for the called number, is used only in the comparatively rare cases when the number has a digit in the ten thousands place. Rows 11 and 12 at the top of the card are used only for special information such as the type of card and certain check information.

These cards move through the machine at right angles to their length. There are eighty punching magnets, one for each column, and Row 12 is punched first, Row 11 next, then Row 0 and so on. The various items of information are not punched one after the other but rather the zeros in all the items will be punched at one time, then the 1's in all items, and so on.

After all the information of one entry of the input tape is recorded in the input registers and translated where necessary, it is transferred to the output registers where it is then available in the correct form for the punching process. The procedure leading to punching may be followed with the help of Figure 6. A sequence circuit grounds twelve emitter leads one after the other, and following the grounding of each lead, one row of the card is punched and the card is stepped ahead ready for punching the next row. These twelve emitter leads are multipled to the output registers and are so associated with the register relays that a ground on the zero emitter lead, for example, will pass through contacts of the

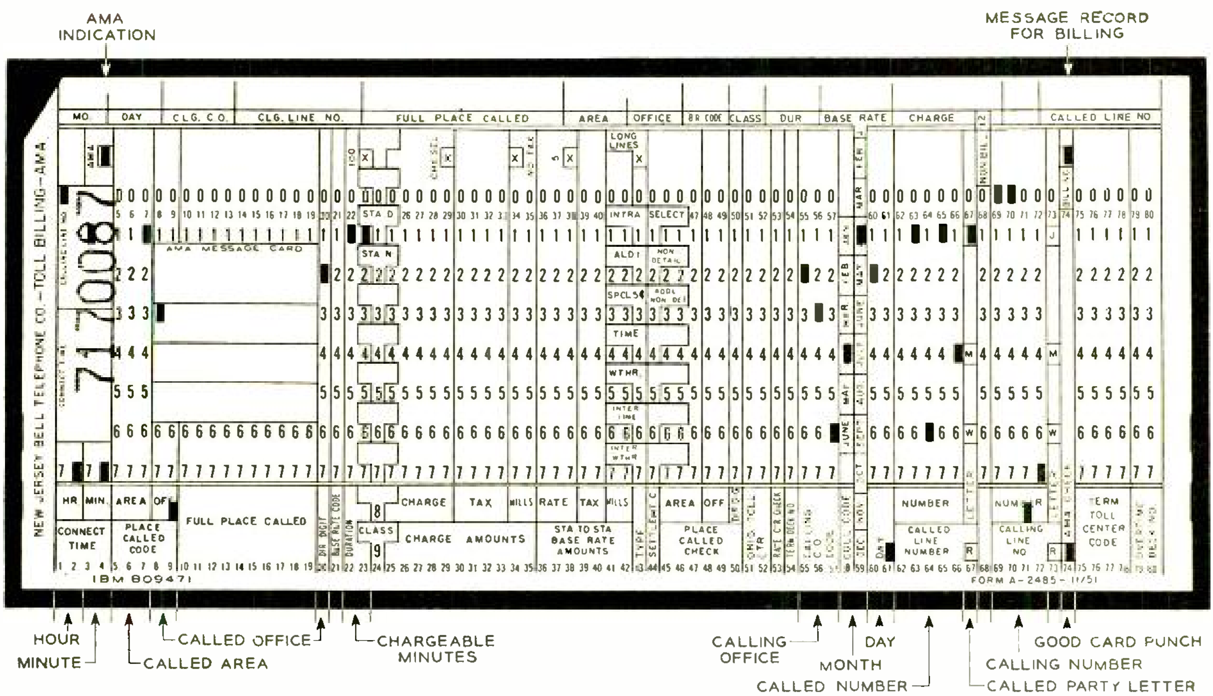


Fig. 5 — A toll card as punched by the tape-to-card converter.

relays of all registers that have a zero recorded to operate a check punch relay and a punch relay in series for each digit of information. Following this, a circuit breaker operates and sends current through the contacts of all the operated punch relays and thus operates the proper punch magnets. The punch relays are released following the punching, but the check punch relays are held operated until the card has been fully punched.

After the sequence circuit has grounded the number 9 emitter lead, all of the check punch relays required for that entry will be

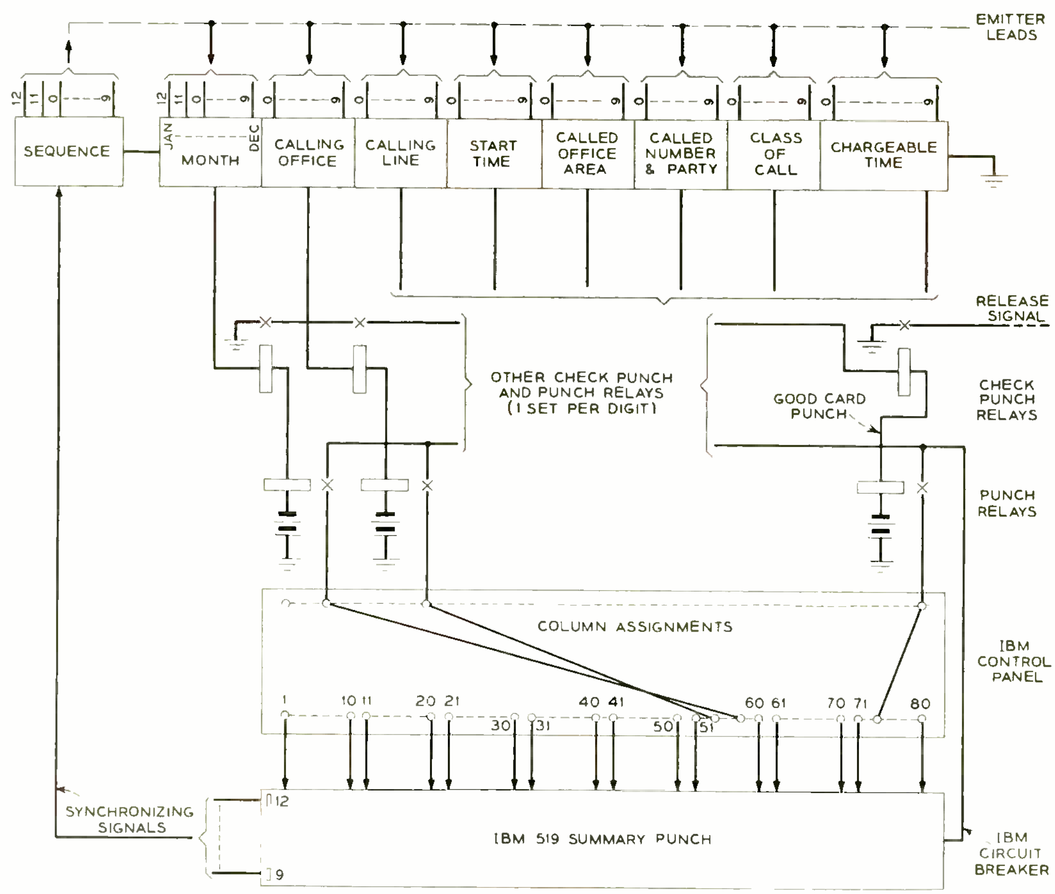


Fig. 6 — Simplified diagram outlining the punching procedure.

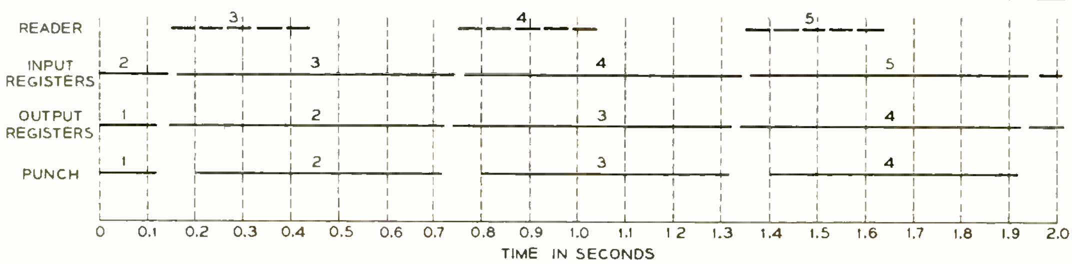


Fig. 7 — Time chart showing overlap operation of the converter. Successive entries are indicated by numerals over the lines indicating the operated condition.

Fig. 8 — L. J. Koos removes toll message cards punched by the AMA Tape-to-Card Converter.

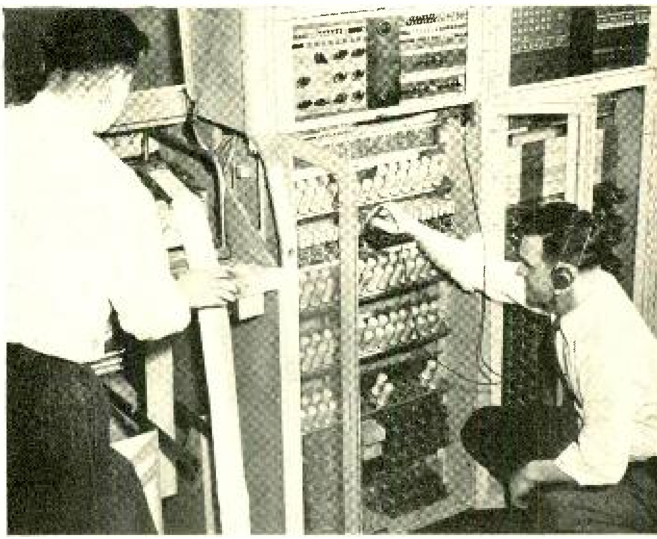


Fig. 9 — W. B. Groth and L. J. Koos test for trouble in laboratory model of the Converter.

operated, since as already mentioned the check punch relays are held operated after the punch relays are released. At the time the last check punch relay is operated, therefore, a circuit will be closed to the good-card punch relay. As a result when row 9 is punched a punch is made in column 74, designated AMA check on the card, to indicate that the correct number of punches has been made in the card. The operation of the check relay for the good-card punch has closed a circuit to the release control, and through it — after the No. 9 row has been punched — the output registers and the check punch relays will be released and the card will be automatically advanced in order to allow a new one to take its place.

The card machine is capable of operating at the rate of 100 cards per minute, and thus only 0.6 second is required to punch the twelve lines of one card. Since the reader operates at sixteen lines per second, it reads the five lines of an entry in only a little more than half of the time required to punch the card. To permit operation at the full capacity of the punch — 100 cards per minute — an overlap operation is provided. Entry No. 2 is being read while the card for entry No. 1 is being punched, and so on. This is indicated in Figure 7. After the last row of a card is punched, the output registers are released

THE AUTHOR: Willard B. Groth has been a member of the group concerned with the development of circuits for the AMA accounting center for the past seven years and has been in the employ of the Laboratories since 1935. Before World War II he was engaged in base metal contact studies for the reduction of telephone noise. During the war he worked on such diverse projects as gun director test set design, relay computer developments and radar systems testing. He was graduated from the College of the City of New York in 1947 with a B.E.E. degree. He has been a member of the instructional staff at City College since that time and is currently teaching a graduate course in switching circuit design.

and immediately afterward the input registers transfer their information for the next entry to them. A check circuit of the output registers then releases the input registers. This starts the reader, which reads the five lines of the next entry and then ceases to advance until the input registers are again released.

The printing on the cards and the type of information put in the various columns may differ at different accounting centers because of local conditions. To permit this flexibility, the contacts of the punch relays and the leads to the punch magnets are connected to jacks on the control panel of the punch machine. Plug leads are used to associate the various punch relays with the punch magnets.

After a card is advanced in the punch beyond the punching stage, it is sensed to insure that the correct number of punches has been made. This is called double punch and blank column detection and may be assigned to columns on a flexible basis through the IBM control panel.

The card may be end printed with quarter inch characters in the next station of the card punch. Connect time and calling line number, selected by control panel wiring, are shown end printed at the left side of Figure 5. These items are used for visually selecting certain message records.

The end printing completes the over-all tape-to-card conversion process. Cards punched by the tape-to-card converter are then processed in a punched card machine system where they are sorted by called place, gang punched in certain of the blank columns with rate and called place information, sorted by calling line number, and finally used in a tabulator for printing the toll service statement. This statement then becomes available for sending to the customer.

Patents Issued to Members of Bell Telephone Laboratories During June

Branson, D. E. – *Keyboard Mechanism for Teletypewriters* – 2,644,038.

Boardman, E. M., and Wooley, M. C. – *Capacitor* – 2,644,122.

Buhrendorf, F. G. – *Apparatus for the Winding of Endless Bands* – 2,642,281.

Cisne, L. E. – *Electron Discharge Device and Method of Fabrication* – 2,641,726.

Fritschi, W. W., Soffel, R. O., and Weaver, A. – *Voice Frequency Signaling Circuit* – 2,642,500.

Hoth, D. F., and Soffel, R. O. – *Automatic Multichannel Selection* – 2,641,757.

Hussey, L. W. – *Stabilized Oscillator* – 2,641,705.

Jones, T. A. – *Receiver for Two-Tone Carrier Systems* – 2,644,036.

Kircher, R. J. – *Photoelectric Device* – 2,641,712.

Kreer, J. G., Jr. – *Wave Translating System* – 2,642,473.

Lewis, B. F. – *Mobile Radio Telephone System* – 2,641,692.

Locke, G. A., and Weaver, A. – *Automatic Message Accounting System* – 2,642,493.

Lovell, C. A. – *Linear Rectifier* – 2,641,695.

Riddell, G., and Soucy, H. A. – *Dial Telephone System – Digit Absorbing Selector Circuit* – 2,642,498.

Rulison, R. L., and Teal, G. K. – *Preparation of Two-sided Mosaic* – 2,641,553.

Shepherd, W. G. – *Electron Discharge Device of the Velocity Variation Type* – 2,641,732.

Shive, J. N. – *Semiconductor Photoelectric Device* – 2,641,713.

Soffel, R. O., see Fritschi, W. W. and Hoth, D. F.

Soucy, H. A., see Riddell, G.

Teal, G. K., see Rulison, R. L.

Thompson, R. K., Jr. – *Fraud Prevention Device* – 2,641,348.

Weaver, A., see Fritschi, W. W. and Locke, G. A.

Winslow, F. H. – *Silyl Aromatic Compounds* – 2,642,415.

Wooley, M. C., see Boardman, E. M.

Historic Firsts:
Volume Indicator

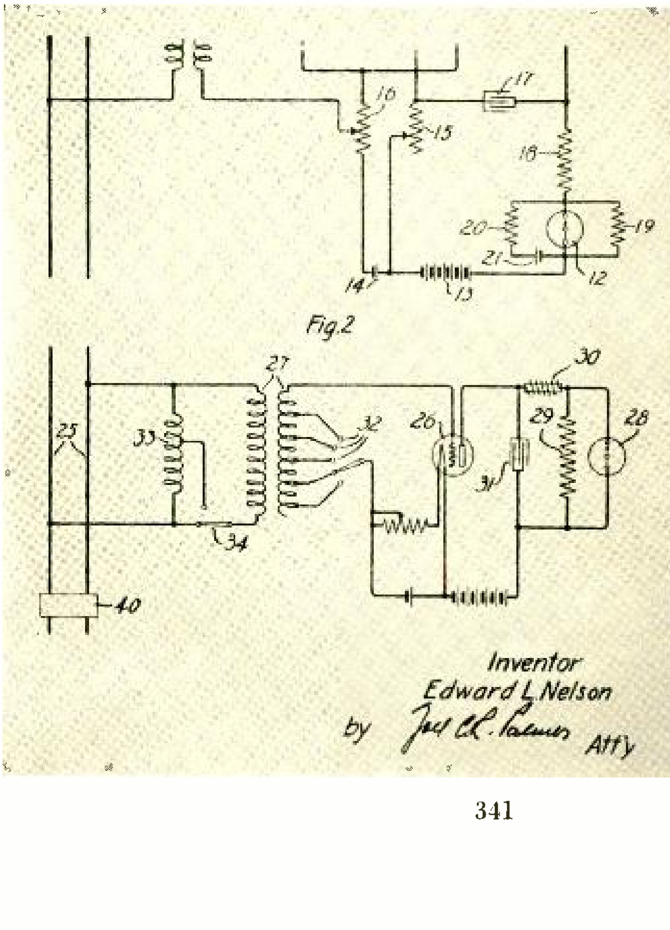
One of the most familiar instruments to radio broadcasters and the operators of radio telephone transmitters in general is the volume indicator. Its use is not limited to these fields, however. It is employed widely in acoustical research and development and on all voice transmission circuits where the amount of energy being transmitted must be observed and controlled. In recent years a special volume unit[1] known as the VU has been adopted, and the more recent volume indicators are graduated in terms of this new unit. Although the VU and the present widespread use of the volume indicator are of more recent origin, the first volume indicator dates from about 1920. Its principles and use were described by E. L. Nelson in a patent[2] filed in August 1922.

Prior to this invention, Mr. Nelson and others had been working on the development of ship-to-shore radio telephony at our Deal Laboratory. It was desirable to maintain the radiated voice signals at as high a level as possible, but at the same time it was necessary to prevent the power output tubes from overloading with consequent distortion of the signal and possible damage to tubes.

Facilities available at that time for measuring radio-frequency currents were not satisfactory for this purpose. The hot-wire ammeter or its thermo-couple counterpart, for example, were too sluggish: high peaks of short duration that would overload a vacuum tube might be flattened out by the integrating action of the instrument so as not to be observable. The string oscilloscope, on the other hand, which was the only type then available, was extremely inconvenient to set up and maintain and was not suitable for day-to-day use. What was needed was an integrating voltmeter that would follow the syllabic level changes of speech but would be slow enough in its response to give readable indications.

As a basis for his work, Mr. Nelson used the vacuum tube voltmeter[3], but he added to it an output circuit to damp the readings of the indicating meter so that it would respond to integrated syllabic voltages rather than to instantaneous voltages. He also added a potentiometer type input circuit so that the device could be adjusted to function over the relatively wide range of speech levels likely to be encountered at various points in the system under examination. It is this combination of a vacuum tube voltmeter with a potentiometer type input circuit and a properly designed output damping circuit that forms a volume indicator. It proved very useful for the studies then in progress, and has found increasing application ever since.

[1] RECORD, *June*, 1940, *page* 310.
[2] 1,523,827.
[3] RECORD, *July*, 1946, *page* 270.



Coin Collector Telephone Equipment for Trains

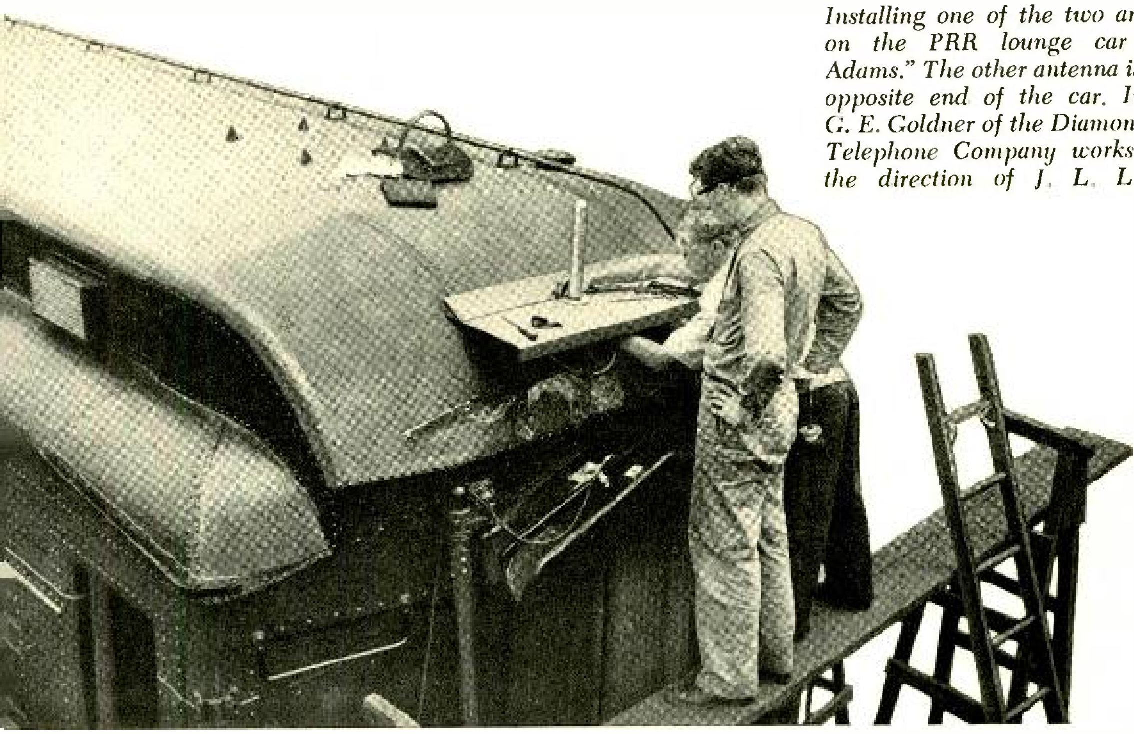
F. B. COMBS
Transmission Systems Development

Radio telephone service for trains has been available for the past six years. Originally, it was necessary for an attendant to set up the connection, but more recently unattended coin collector type telephone sets have begun to replace attended stations.

Vehicular mobile radio-telephone service was inaugurated in St. Louis June 17, 1946*, and on August 15, 1947, Bell System mobile telephone service was extended to passengers on certain trains of the Baltimore and Ohio and Pennsylvania Railroads operating between New York and Washington. This extension of telephone service – on an experimental basis – had been made feasible by the installations of mobile radio systems in and between these terminal cities. Using the same mobile receivers and transmitters, the calls passed through the mobile service operators in the area nearest the train when the call was made.

At the present time nineteen "name" trains on five railroads are equipped for this service. Six of these installations are presently attended stations, that is, calls are set up by a special attendant who is employed by the railroad. Nine have recently been converted from attended to unattended instal-

* Record, *July*, 1946, *page* 267.



Installing one of the two antennas on the PRR lounge car "John Adams." The other antenna is at the opposite end of the car. Installer G. E. Goldner of the Diamond State Telephone Company works under the direction of J. L. Lindner.

lations, using coin collector type telephone sets. Four new installations of a similar type of equipment have been made.

This unattended type of service has been well accepted by the public and is most popular with the railroads. As a result, the Laboratories has recently designed a standardized unattended system. The Bell Telephone Company of Pennsylvania completed the first installations of this type in March, 1952 on the new "Senator" and "Congressional" trains of the Pennsylvania Railroad operating between Washington and New York.

A typical installation of such a system is shown in Figures 1 and 2, which picture the equipment as installed in the parlor-lounge-observation car on one of the new "Senator" trains. Calls may be completed between the trains and any Bell System or connecting telephone, through Bell System general mobile service base stations. These base stations are located in the principal cities through which the trains pass; a typical connection is illustrated in the block diagram of Figure 3. Basically, a single channel installation consists of a receiving antenna, a transmitting antenna, radio transmitter, radio receiver, coin collector type telephone, indicator panel, power distribution and control panel, and power source.

The antennas are a specialized type designed by the Laboratories* to meet the requirements of vertical polarization, close roof top clearance, grounded elements, and rugged construction. They are mounted at opposite ends of the car to provide maximum separation between the transmitting and receiving circuits. Two antennas are employed to permit full duplex operation; that is, the telephone is used in the customary manner rather than on a push-to-talk basis as is done in most mobile systems.

Standard Western Electric phase modulated radio transmitters† and receivers‡ for mobile service are used, and are operated from a 12-volt dc source provided by the railroad. The cabinet shown under the directory shelf in Figure 1 houses the motor generator for supplying the dc power for

* Record, *May*, 1949, *page* 172.
† Record, *October*, 1947, *page* 376.
‡ Record, *September*, 1947, *page* 330.

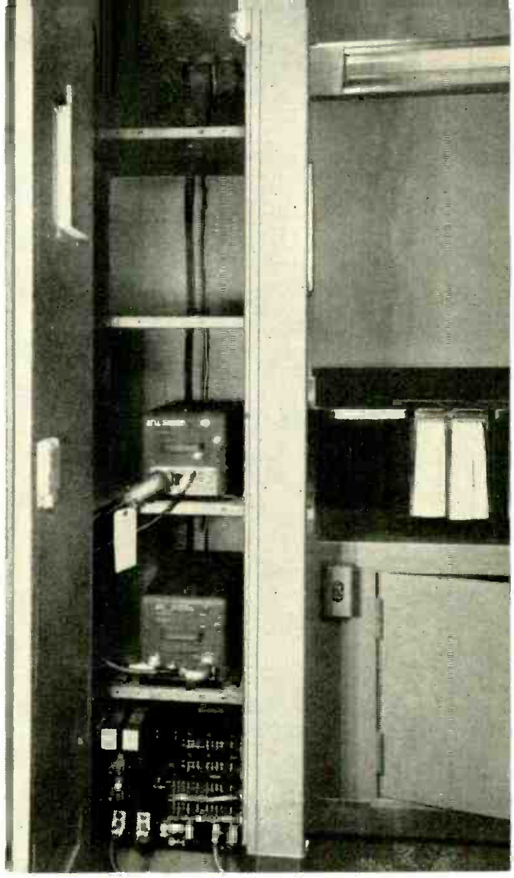
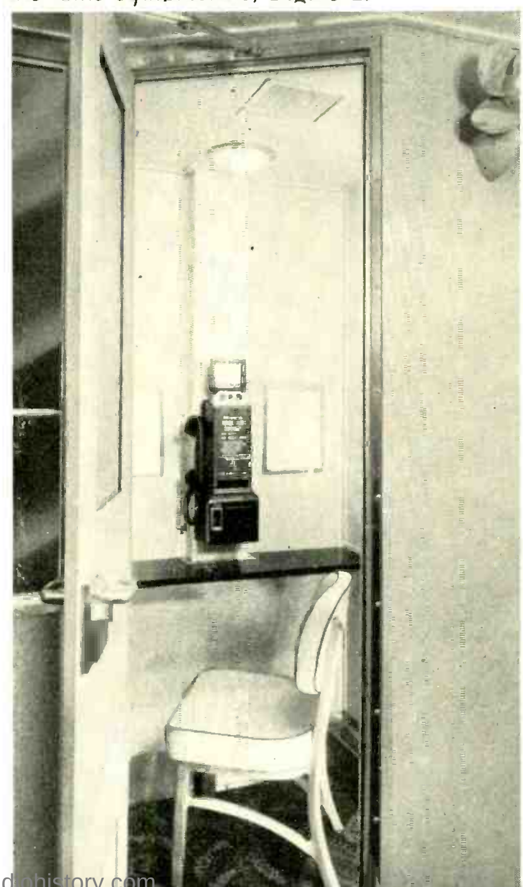


Fig. 1 — Radio equipment and cabinet on one of the Pennsylvania Railroad "Senator" trains.

Fig. 2 — The telephone booth associated with the radio equipment of Figure 1.



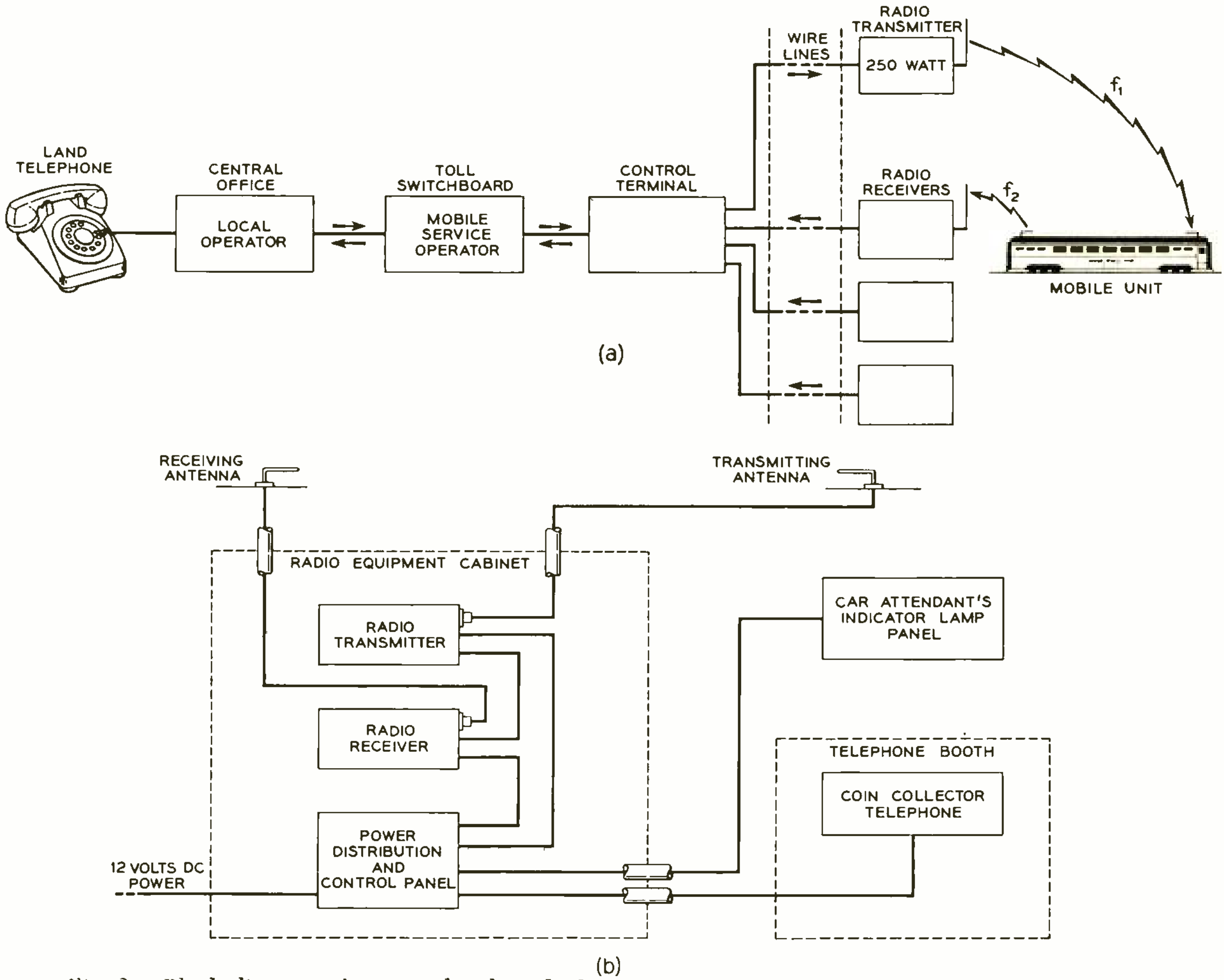


Fig. 3 – Block diagram of a typical radio telephone connection to a railroad train.

the radio equipment on the "Senator".

As shown in Figure 4, the telephone instrument is similar in general appearance to other Bell System coin-operated telephone sets, except that it has an enlarged instruction card and is provided with a transmitter-start push button. This button is used to put the radio transmitter "on the air" at the time the call is originated. The telephone set is also equipped with a dc calling bell, and the handset is a four-wire type.

The power distribution and control panel, shown in Figure 5, contains the power terminations, fuses for both power and control circuits, control circuit relays, and terminal strips. The latter serve as the junction points for the cabling between the various units of the train installation.

In order to be prepared for any incoming call, the radio receiver on the train is in constant operation while the train is in service and is within communication range. Each car is assigned a mobile telephone number, and the incoming calls are dialed by the mobile service operator at the central office. At the control terminal, the dialing pulses are converted into two-tone signals suitable for modulating the base station radio transmitter. Receipt of the properly coded call signal by the train receiver operates the bell at the coin collector telephone set for about four seconds. If the car porter is not within hearing distance of the telephone bell, a signal lamp on an indicator panel, usually located in the far end of the car, notifies him of an incoming call. The

Fig. 4 – The coin collector telephone used in the train booth by E. J. Butler of Bell of Pennsylvania.

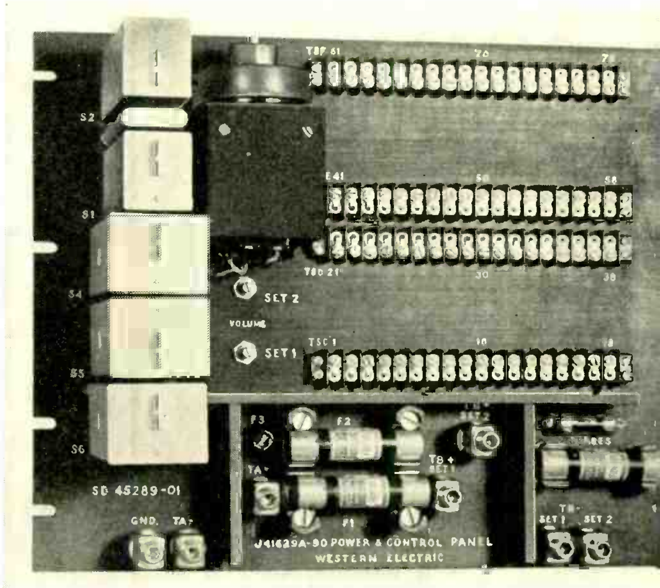


Fig. 5 – Power distribution and control panel for the equipment on trains.

lamp remains lighted until the call is answered. This panel also provides visible indication of "12-volt power-on" and "transmitter-on-the-air" conditions inasmuch as the porter is generally the employee designated to turn the equipment on and off as the car is placed in and out of service.

Operating instructions are provided in the booth to enable the user to understand the method of placing a call. These instructions point out any areas where transmission and reception may not be satisfactory. They also explain that the mobile radio channel is shared by other users, and the passenger is instructed first to listen in on the circuit to learn if it is in use. If there is no evidence that the channel is busy, he then pushes the transmitter-start button which places the train transmitter "on the air". When this transmission from the train reaches one of the base station receivers, a signal is carried over the receiver output trunk through the

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control terminal to the mobile service operator. After answering the signal, the operator sets up the call and collects the charges before connecting the two parties. The operator identifies the amount deposited by the usual coin actuated gong tones.

The normal procedure in obtaining a train installation is for the railroad to apply for this service to the Bell Telephone Company serving the area in which the railroad headquarters are located. Telephone Company engineers then make a survey to determine the type of service best suited for the requirements and the frequencies available in the area through which the train operates. Various types of equipment arrangements that can be made available in the standardized design are:

(a) Operation on a single channel in the 30-44 mc band.

(b) Operation on any one of four channels in the 30-44 mc band.

(c) Operation on any one of eight channels in the 30-44 mc band.

(d) Operation on a single channel in the 152-162 mc band.

(e) Operation on either one of two channels in the 152-162 mc band.

(f) Operation on any one of four channels in the 152-162 mc band.

Multi-channel systems are ordinarily required only on long runs where the train passes through areas having different channels available for this type of service.

Additions to TV Network

Four TV stations were connected to the Bell System's nationwide network facilities over the first weekend in August. They were WGVL, Greenville, S. C.; KBES-TV, Medford, Ore.; and WHB-TV and KMBC-TV, Kansas City, Mo.

The interconnection of the Greenville and Medford stations makes it possible for residents in these cities to view live network programs for the first time. The Kansas City stations represent additions to areas already receiving network programs. Network programs for Greenville's new station are being carried from a microwave tower on the Washington-Atlanta route direct to WGVL's transmitter location.

The new TV station at Medford is being fed network service from a point on the intercity facilities between Sacramento, Calif. and Seattle, Wash. Network programs for the two Kansas City stations are tapped off of the transcontinental radio relay route at Omaha, Neb. and routed over intercity facilities to Kansas City.

Thanks to a new 35-mile microwave link recently placed in service by Long Lines, nationwide network television programs have been made available to KTVH, Hutchinson, Kan., the first TV station to be constructed in that state. Network programs are beamed over the new video link to KTVH from a southbound Omaha-Dallas TV channel. This channel interconnects with the Bell System's transcontinental TV facilities at Omaha and feeds programs to Kansas City, Tulsa, Oklahoma City, Dallas, and five Texas cities south of Dallas.

Network service is now available to 146 stations in 97 cities in the United States.

Plane Tickets by Mobile Telephone

The Pacific Telephone and Telegraph Company is providing mobile telephone service for mobile ticket offices of Trans-World Airlines in the Los Angeles and San Francisco areas. The basic equipment is a one-ton truck, one side of which opens to provide an outside counter, while rear doors admit customers to a small office inside the vehicle. The mobile telephone will be used to reach main reservation centers in the areas served. The airline expects this plan to be useful in reaching potential customers at the gates of large industrial installations in outlying areas or at special events such as football games.

N1 Carrier: Repeaters and Group Units

Fig. 1 — E. H. Perkins (left) and J. B. Evans are examining the modulator wiring of a laboratory modified repeater.

C. S. YEUTTER
Transmission Systems Development

In the N1 carrier system, twelve telephone conversations are carried in both directions over the same cable at the same time, whereas two cables, one for each direction of transmission, are required in the older K carrier system. To accomplish single-cable transmission, the frequencies are transmitted as carrier groups, and, as they pass through the repeaters, they are modulated into alternate high and low groups. Thus the frequencies in one direction are separated from those in the other by a wide margin that avoids troublesome crosstalk.

The concept of "repeater" for a telephone system is more generally understood than that of the new term "group unit," used frequently in describing the N carrier system. Basically, a group unit is the equipment at a carrier system terminal which most nearly resembles a one-way repeater; in earlier carrier systems, equipments that performed this function were called transmitting and receiving amplifiers.

In the N carrier system, twelve voice channels are transmitted as a "carrier group" through the terminal units and the intervening repeaters, so that the "group" idea is not unique to any particular equipment. For clarity, therefore, the terms "Group Transmitter" and "Group Receiver," instead of "Group Unit" will be used.

There are two kinds of repeaters, two kinds of group transmitters, and two kinds of group receivers used in the N carrier system. As described in an earlier article,* N carrier differs from the older K carrier in that only one ordinary telephone cable is required for a twelve-channel, two-way system, whereas K carrier requires two cables, one for each direction of transmission. Two features are necessary to allow single cable operation; first, the two directions of transmission are assigned separate pairs in the cable (the two pairs of the same quad, if quadded cable), and second, the two directions employ a different group of frequencies, called "High Group" and "Low Group". At repeater points, these frequencies are inverted as a group or "frequency frogged". Frequency frogging requires less over-all gain, aids in the effective equalization of attenuation of different frequencies along the cable, and attenuates crosstalk which would otherwise be troublesome. Each repeater receives one of the groups (either low or high) and then modulates this group into the other allocation. This explains why two types of repeaters are required; those which receive high group signals and transmit

* Record, *July*, 1952, *page* 277.

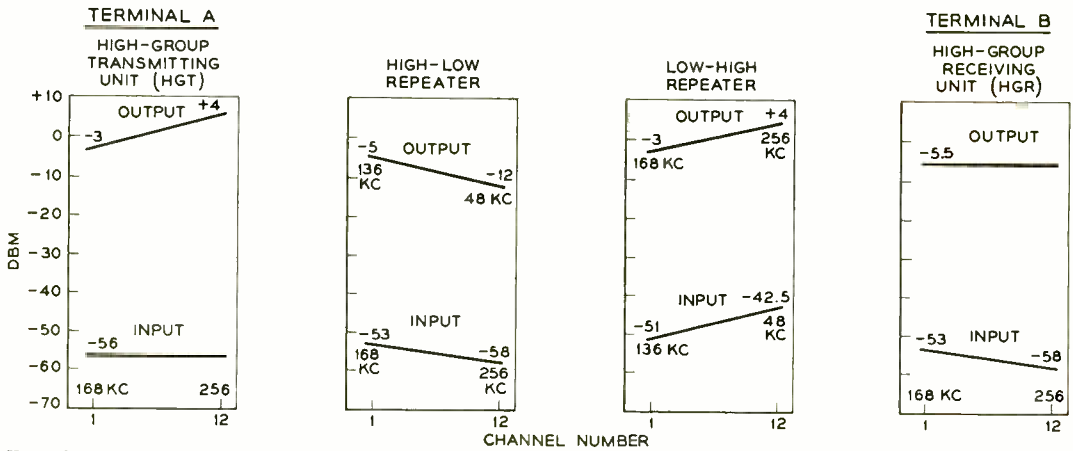


Fig. 2 – Repeater and group unit level diagrams.

low group, called the "High-Low," and the other, which receives low group and transmits high group, called the "Low-High". At each group modulator, the group carrier frequency is 304 kc. To illustrate how a group modulator works, channel 1 in the high group has a frequency of 168 kc and after modulating with the 304 kc carrier, the lower sideband, 304 —168 = 136 kc, becomes channel 1 in the low group. Similarly, channel 12 in the high group has a frequency of 256 kc and for the low group, 48 kc, which is 304 kc — 256 kc. Table I page 350, lists the frequencies for all the channels in both high and low groups, where it may be seen that the sums are always 304 kc.

It can now be appreciated why two kinds of group transmitters and two kinds of group receivers are needed. At a transmitting terminal, if a high group band of frequencies is transmitted, a low group band must be received; or, if a low group band is transmitted, a high group band must be received. To meet all requirements, therefore, high group transmitters, low group transmitters, high group receivers, and low group receivers are required.

There are three simple rules that describe the arrangements of group units and repeaters that make up an N system:

(1) For a system with any odd number of repeaters, the two terminal arrangements are identical.

(2) For a system with no repeater or any even number of repeaters, the two terminals must be different.

(3) There are only two possible terminal arrangements for any given location: (a) HGT, LGR and (b) LGT, HGR

Consider for illustration, the following examples:

Under rule (1), with an odd number of repeaters,

A ———— A or B ———— B

Under rule (2), with an even number of repeaters,

A ———— B or B ———— A

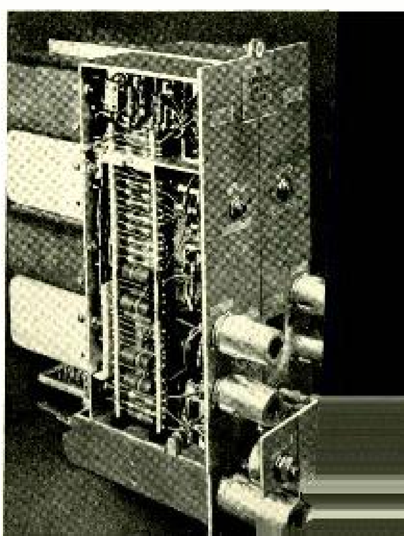
Disregarding the directions of transmission, there are only three types of systems:

A ———— A B ———— B

and A ———— B

A level diagram for a typical system containing an even number of repeaters, is illus-

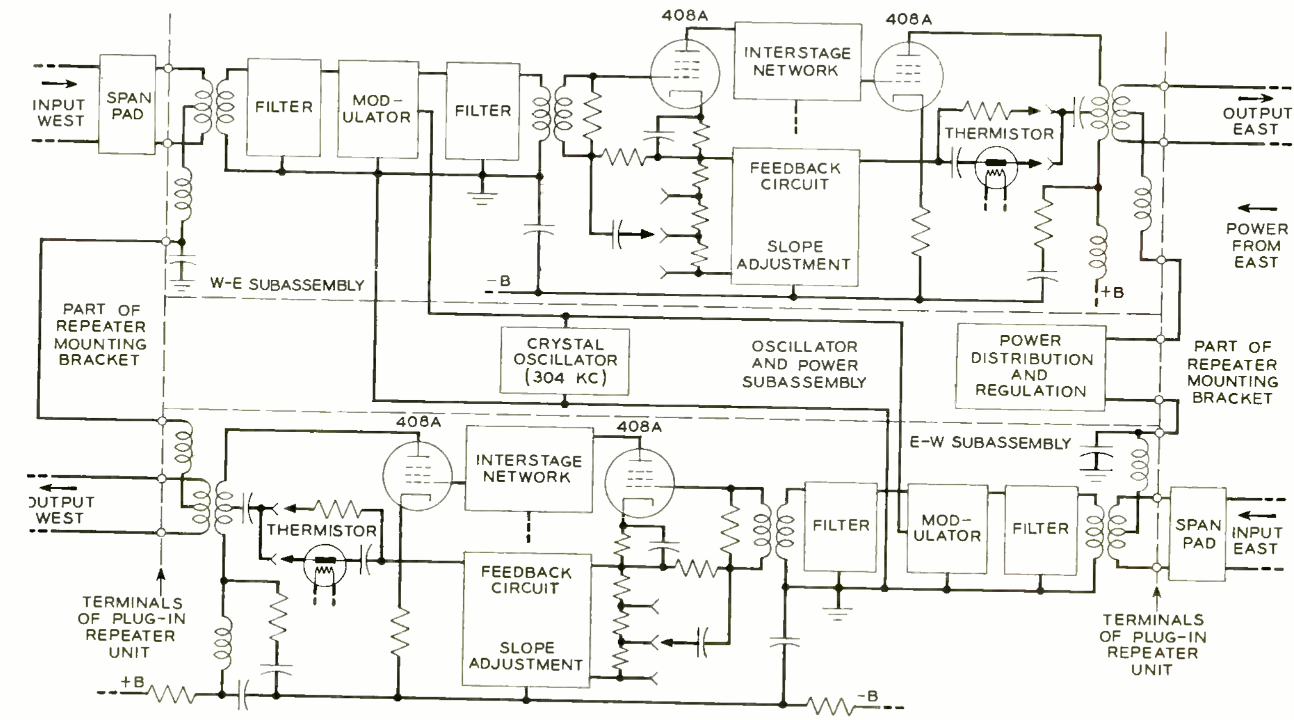
Fig. 3 – A typical repeater, with outer cover removed.



trated by Figure 2. In the direction from terminal A to terminal B, signals are delivered from the channel multiple at —56 dbm for the frequency group of 168 kc to 256 kc. These signals are amplified by the high group transmitter and applied to the cable at powers ranging from —3 dbm to + 4 dbm, with the higher frequencies having the greater gain to partially compensate for the greater losses in transmission as compared to that of the lower frequencies.

At the high-low repeater, the frequencies (shown as 168 kc to 256 kc) are inverted, or frogged, before being amplified, and the output of this repeater becomes 136 kc to 48 kc, at levels of —5 dbm to —12 dbm, respectively. After transmission over the line to the next repeater, these frequencies are received at —51 dbm (136 kc) to —42.5 dbm (48 kc), and frogging to 168 kc to 256 kc takes place. These latter frequencies are then amplified and applied to the cable at powers ranging from —3 dbm to +4 dbm, as at the transmitting terminal, and then proceed to terminal B. Arriving at terminal B at the levels of —53 dbm to —58 dbm, the group is amplified to —5.5 dbm before passing to the channel band receiving filters.

The repeater is composed of three separate subassemblies interconnected by multi-contact plugs and jacks, and mechanically fastened to form a compact unit, as shown in Figure 1. Two of these subassemblies are modulator-amplifier units, one for each direction of transmission. They are identical electrically, but mechanically are mirror-images. The third subassembly, common to both modulator-amplifiers, contains the 304 kc modulator carrier oscillator, power controls and power regulation elements. The major subassemblies of the repeater are shown in Figure 1. The two modulator-amplifier subassemblies are fastened together with the shield between them, and are then assembled to the lower common oscillator and power subassembly. The two twenty-contact connectors below each repeater are multipled and normally have



g. 4 — *Block schematic for a repeater.*

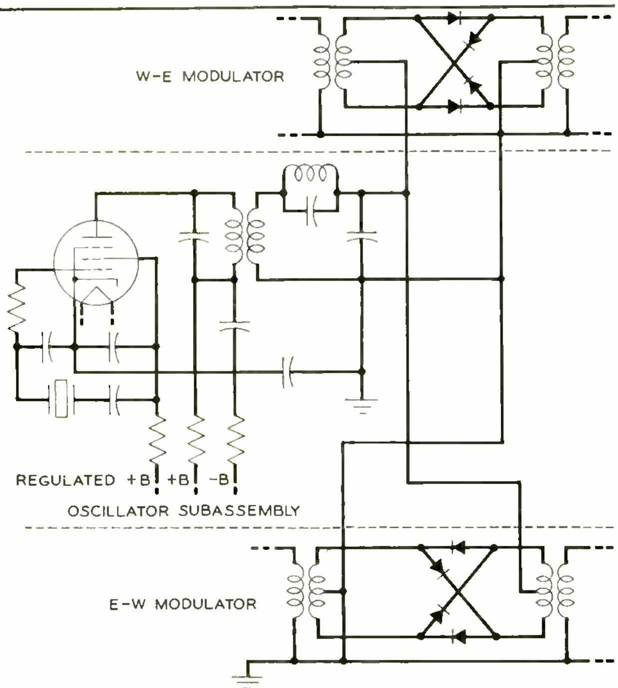


Fig. 5 — Modulator and carrier oscillator circuits.

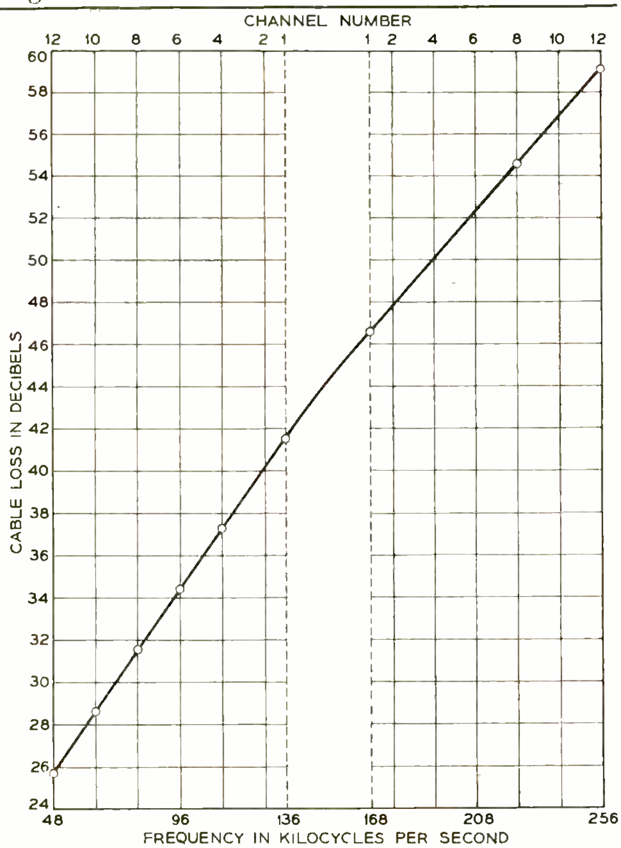


Fig. 6 — Typical loss versus frequency curve.

plug-in connectors in them to complete the connections to the line equipment. For switching and testing procedures, the plugs are removed and test connectors used as required.

More than half of the repeaters in a typical N carrier system are pole mounted and powered over the cable conductors. These repeaters operate at 140 volts and use a gas tube voltage regulator. Power supplies are furnished at every third repeater*, and at these locations, the gas tube is replaced by a plug-in resistor, since additional regulation is not needed.

A block schematic for a repeater is shown

TABLE I — FREQUENCIES FOR BOTH HIGH AND LOW GROUPS

Channel Number	*"High Group" Carrier Frequency, Kc*	*"Low Group" Carrier Frequency, Kc*
1	168	136
2	176	128
3	184	120
4	192	112
5	200	104
6	208	96
7	216	88
8	224	80
9	232	72
10	240	64
11	248	56
12	256	48

in Figure 4. The two types of repeaters, high-low (H-L) and low-high (L-H) are similar both in appearance and circuits. Gain is provided by a two-tube amplifier using simple tuned interstage coupling, and feed-back from the high side of the output transformer to the cathode of the first stage. Gain regulation is obtained by a thermistor in the series arm of the feedback path, which tends to maintain the total power output constant. In the middle range of the regulator about one milliwatt of signal power is dissipated in the thermistor bead. A three-position slope adjustment switch, located in the feedback circuit, provides either a flat repeater characteristic or two sloped characteristics in 2 db increments. This

* Loc. cit.

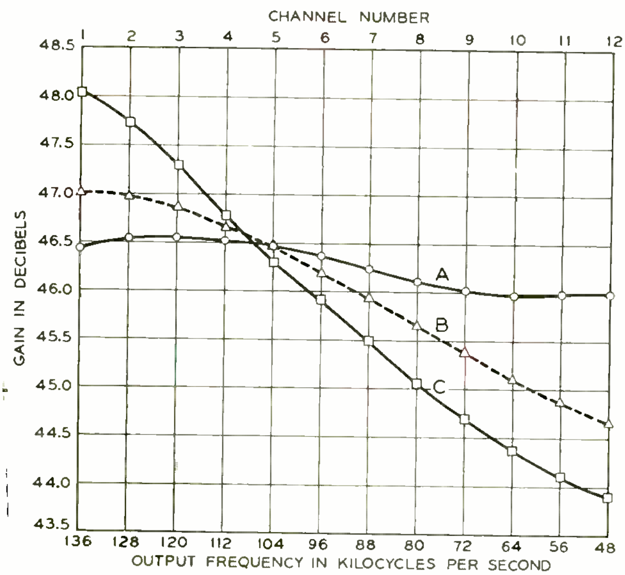


Fig. 7 – Gain versus frequency characteristics of a "High-Low" repeater, for the three positions of the slope switch.

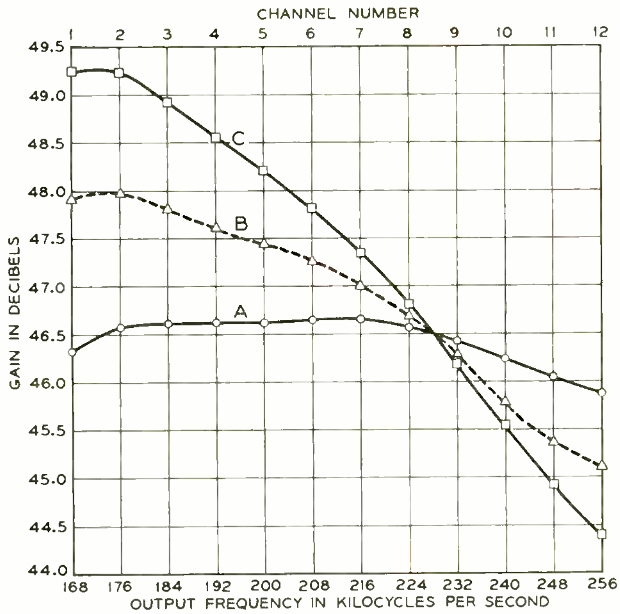


Fig. 8 – Gain versus frequency characteristics of a "Low-High" repeater, for the three positions of the slope switch.

slope feature is used to equalize transmission variations resulting from repeater spacings differing from the mileage values used in design calculations.

At the input of the repeater, a modulator inverts the received line frequencies before they are amplified. For example, in an H-L repeater, the incoming high frequency group is inverted and amplified at the lower frequencies. Filters before and after the modulator are required to suppress possible cross-talk paths around the repeater. The filter after the modulator also protects the amplifier from 304-kc carrier leaks and second harmonics of this carrier, as well as from the principal unwanted sidebands produced in the modulator.

A double-balanced ring type modulator is used, which is composed of small copper oxide discs. It is made linear for multi-channel operation by using a carrier amplitude that is large in comparison to the impressed signals. Modulator and carrier oscillator circuits are shown in Figure 5. The transformers on either side of the modulator have an impedance ratio of 3,000 to 135 ohms, and the 304-kc carrier is supplied to the modulator ring through center taps on the low impedance side of these transformers.

The 304-kc oscillator is crystal controlled, the 408A pentode being used as a triode with the screen as the anode of the oscillator circuit, the regular plate serving as an electron coupling to the tuned output transformer. Additional output filtering is obtained with a low-pass filter having a peak section that suppresses the second harmonic (608 kc) of the oscillator.

Fundamentally, the purpose of a repeater is to provide gain to compensate for the loss in the transmission medium. For a typical pair of No. 19 gauge toll cable having a 7.5-mile span, this loss is illustrated by the slightly bowed characteristic of Figure 6. The loss in two tandem 7.5-mile sections, one section carrying high group signals and the other carrying low group, is obtained by adding the loss for the channel frequency in each group. Because the frequency is frogged between the sections, the average loss over them for 7.5 miles is approximately 44 db, and a repeater must, therefore, supply a gain of this amount.

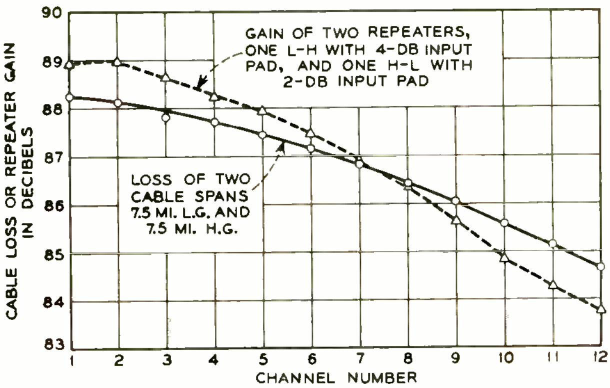


Fig. 9 — Repeater gain and cable loss of a typical tandem circuit of 7.5 miles low group and 7.5 miles high group.

Gain characteristics for the most recent high-low repeater are shown in Figure 7, the curves indicating the gain obtained with the slope adjustment switch in each of its three positions. Similarly, Figure 8 shows the gain characteristics for the most recent low-high repeater. The slope characteristics for both types of repeaters cross each other at one-third of the frequency range below the highest frequency in the group. This has been done to make the thermistor regulator operating point substantially independent of the setting of the slope switch.

The gains shown in Figures 7 and 8 are those obtained when the thermistor regulator is operating in the middle of its regulating range. Actually pads are inserted between the cable and the repeaters to insure mid-range regulation with different lengths of cable. For the typical 7.5-mile cable span being discussed, a 4-db span pad is provided at the input of the low-high repeater, and a 2-db pad placed ahead of the high-low repeater. Figure 9 shows how well the cable losses are balanced by the repeater gains; for two cable spans and two repeaters, as in a normal tandem connection, except for a slight slope difference, the match is very close — within 1 db throughout.

The low group receiver, LGR, has all the features of one direction of a low-high repeater, shown in block form in Figure 4. In addition, it includes a fixed 7-db slope network and a carrier alarm circuit. A block diagram of the low group receiver is shown in Figure 10. The high group receiver, HGR, also shown in Figure 10, is simpler, since no modulator is required, because high group frequencies are delivered directly to the channel band filters. All the other fea-

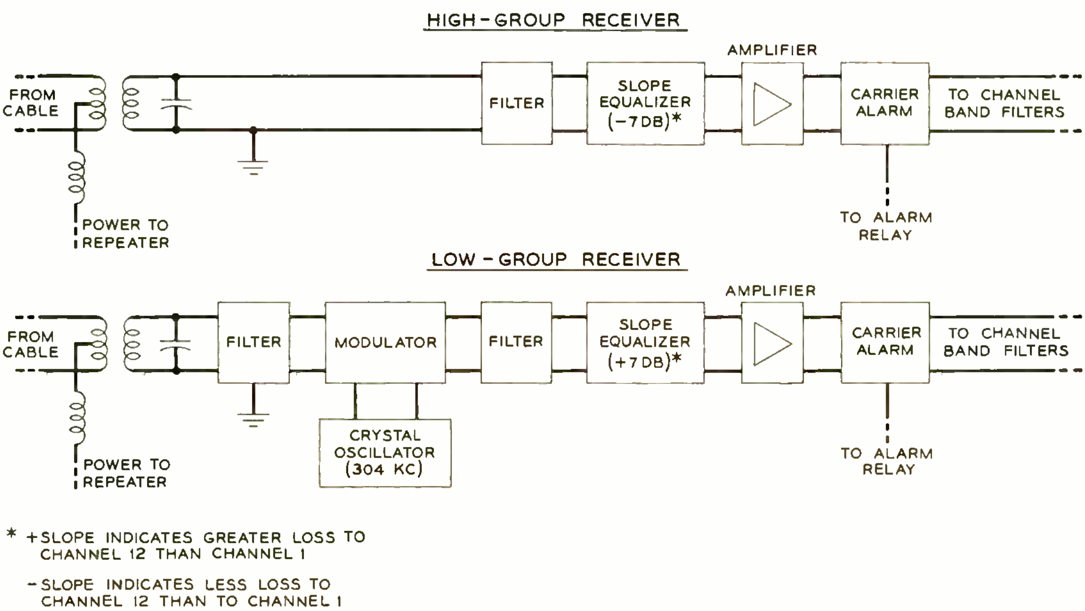


Fig. 10 — Simplified schematic for the group receivers.

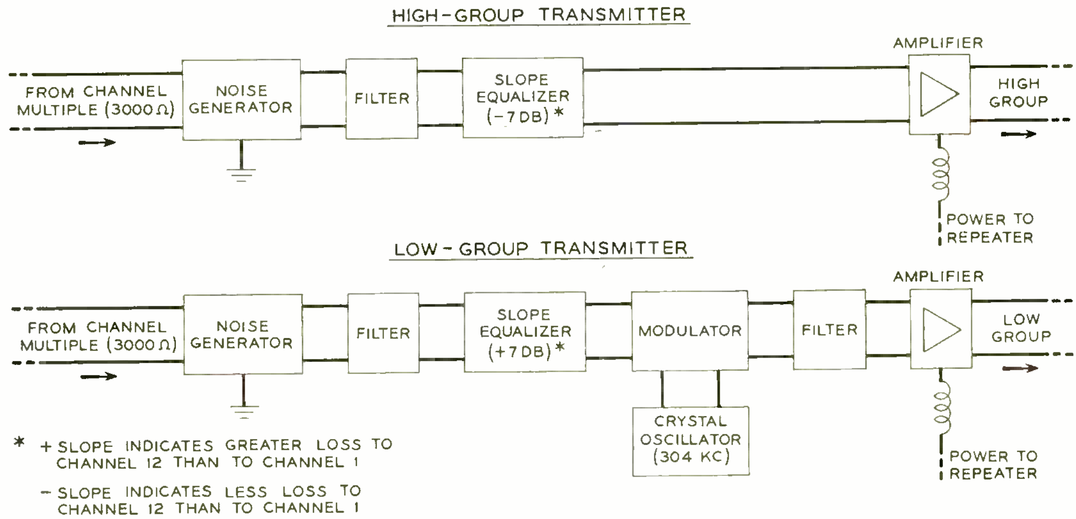


Fig. 11 — Simplified schematics for group transmitters.

tures in this receiver, however, are the same as in the low group receiver.

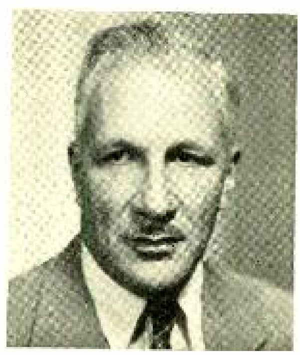
As mentioned in an earlier article*, one cable span attenuates the high frequencies about 14 db more than it does the low frequencies. By sending out the carriers at unequal levels, therefore, it is possible to divide the effect of this 14-db cable "slope" so that all repeaters will transmit their carriers at a nominal slope of 7 db. Group receivers, however, are required to deliver a flat output. To accomplish this, therefore, a 7-db slope network is included in both the high group receivers and the low group receivers. A slope control switch performs the same function and has the same range as that used in the repeater.

The carrier alarm circuit is bridged across the amplifier output. The output of the carrier alarm tube is rectified, and the resulting direct current applied to an alarm relay that is external to the plug-in unit. If the carrier should fail, the alarm relay is released, operating an alarm for the maintenance personnel.

Group transmitters are simpler than group receivers, since no thermistor regulator or slope control switch is provided, and no

* RECORD, *July* 1952, *page* 277.

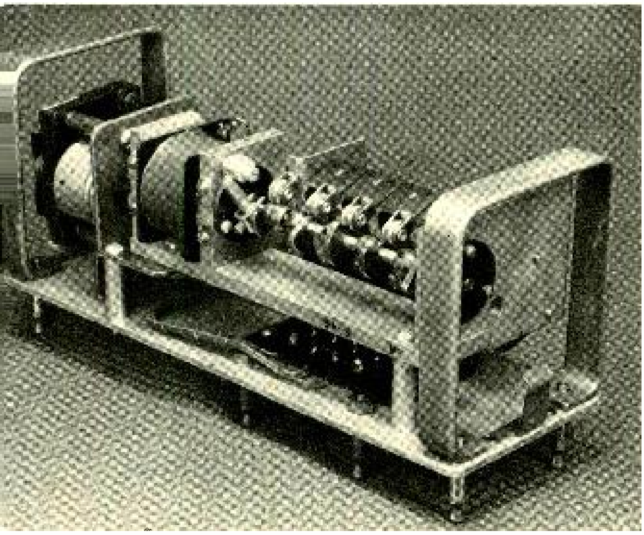
THE AUTHOR: C. S. YEUTTER transferred to the Laboratories from the Southern California Telephone Company in 1929, joining a transmission research group to do development work on wave analyzers and modulation measurement studies. Later, after a year of development work on television terminals for coaxial cables, he directed his attention to carrier telephone systems, with emphasis on feedback amplifiers, repeaters and transmission regulating systems. He was engaged in designing carrier test equipment for shop use at Kearny during 1941 and 1942 while on loan to Western Electric. At Kearny, and later at the Laboratories, he was associated with military projects including pulse multiplex systems. Since 1945 he has been concerned with the development of new carrier systems. Mr. Yeutter received the B.A. degree in 1929 from the University of California at Los Angeles. He is a member of the I.R.E.



carrier alarm tube is required. A noise generator is included, which is a one-tube amplifier that amplifies the resistance noise, inherent in its grid resistor, to the desired output level under control of a potentiometer in the screen supply circuit. The noise is used to mask undesirable crosstalk, but is held well within the usual tolerance limits for cable and circuit noise.

Channel carrier signals are multipled at a 3,000-ohm impedance level, and the group transmitter input impedance matches this source. Ideally, channel signals at the multiple have the same amplitude, —56 dbm, and the outputs applied to the cable are sloped by 7 db. Consequently, a 7-db slope equalizer is required.

Simplified schematics of both the high and low group transmitters are shown in Figure 11. The power outputs are the same as those for the corresponding repeaters, sloped from —3 dbm to +4 dbm for the high group transmitter and —12 dbm to —5 dbm for the low group transmitter.



The 3A Timer

Fig. 1 — Each of the cams is locked individually on the shaft by a set screw, as is the stop arm. This permits each to be adjusted independently of the others.

Timing circuits are widely used with common control switching systems for a variety of purposes. Usually the time intervals required are short, and the period of charge or discharge of a capacitor is generaly sufficient. For the automatic toll ticketing system* in the California area, however, a number of intervals ranging from 12 to 32 seconds was required to insure that the identifiers and senders were not held for longer periods than the normal handling of a call would require. To meet this need the timer shown in Figures 1 and 2 was developed.

* RECORD: *July*, 1944, *page* 445; *October*, 1944, *page* 440; *December*, 1944, *page* 633; *January*, 1945, *page* 29.

An electric clock type motor, at the extreme left in the photographs, drives a shaft at about one rpm through a magnetic clutch. On the driven shaft are five cams each of which, at the selected angle of rotation, raises a small arm that operates a microswitch. The cams are so positioned on the shaft that when the clutch is energized they operate their associated switches in succession beginning with the one at the extreme right. The first switch opens its contacts within 2 seconds, and is used to give an off-normal indication. The second, third, and fourth cams operate to close their contacts at successive 10-second intervals and thus at 12, 22, and 32 seconds after the clutch engages. The fifth cam operates to open its switch contacts, which are in series with the motor, about 40 seconds after the start. This latter operation serves primarily as a safety measure to avoid damage to the switch should the clutch not have disengaged prior to that time.

The cam shaft runs on three bearings – one at the end farthest from the motor and one at each side of the clutch. The core of the magnet consists of two cylindrical pieces bored to fit over the shaft. The half of the core nearer the cams is pinned to the shaft while the other half rotates freely on the shaft and is geared to the driving motor. An annular spring holds the adjacent faces of the two halves of the core separated when the clutch magnet is not energized. The motor runs continuously, rotating the idler half of the core. When the clutch is energized, this idler half of the core is drawn firmly into contact with the half that is pinned to the cam shaft, which then begins to rotate.

When the clutch is released, a coiled spring on the end of the shaft – evident at the extreme right of Figure 2 – rotates the shaft back to its normal position, which is adjustable by an arm evident just to the right of the clutch and most clearly seen in Figure 1. The clutch is operated when a sender is seized and is released as soon as the sender finishes its work. Normally, the operating time is short and the timer runs only a part of its full interval. Over a million operations a year are made in normal operation.

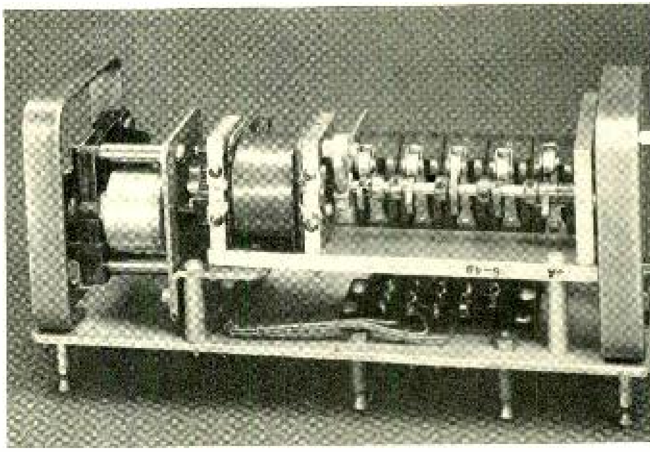


Fig. 2 – The 3A timer with cover removed. The plugs by which the timer is fastened to its mounting plate project from the rear of the base.

The timer is made as a plug-in unit to permit ready substitution, thus insuring continued operation of the associated circuit if maintenance is necessary. A metal cover fits over the cover guides at each end; these guides serve as convenient handles and also protect the mechanism when it is removed from the mounting plate.

Addition to Teletypewriter Network

Fifty-nine teletypewriter stations in plants and offices of the E. I. du Pont de Nemours and Company, Inc., were tied together early in August by a new automatic teletypewriter service. The third installation of the 81-D-1 teletypewriter system, it interconnects machines in thirty-seven cities. At the start, the network is expected to handle approximately 5,000 messages per day.

This new service consists of an automatic switching center in the Du Pont headquarters in Wilmington, Del., and thirteen two-way lines that interconnect outlying locations. The nationwide system is integrated with local private line services which provide teletypewriter service for Du Pont offices in Atlanta, Chicago, Cleveland, Providence, Boston, Philadelphia, and New York City. The local services are furnished by associated Bell Telephone Companies.

In the 81-D-1 system, messages "typed" on perforated tape may be directed by means of a code to any one of fifty-nine teletypewriter machines on the nationwide network, to any specified group of these machines, or to all. Directing codes are perforated on the tape ahead of the message and distribution to various points is automatic. If a receiving machine is "busy," messages are automatically stored, then released when the machine becomes available. Circuits in the system are "duplexed," permitting simultaneous transmission in both directions.

Improved Time-of-Day Facilities for New York City

A. E. GERBORE
Telegraph Development

When a customer in or around New York City telephones to find the correct time, the words and time signal he hears now come automatically from film strips rotating continuously on drums. With the same call, during World Series games, he will also hear an operator announce the baseball score. These services have been made possible by combining the best features of previous time-of-day announcing systems, and by using an accurate time source derived from the Murray Hill Laboratories frequency standard.

For over twenty years, New Yorkers have been able to get the precise time simply by calling ME 7-1212. With this older method, known as the 1B announcement system*, time was indicated every fifteen seconds by an 800-cycle tone, and during the seven and a half seconds preceding the time tone, an operator in a special room at the East 30th Street Central Office would announce "When you hear the tone signal it will be exactly 10:45 and one quarter," or whatever the time happened to be. A lamp on the turret in front of the operator remained lighted as long as at least one customer was connected to the announcement system, and the operator would make an announcement only when the lamp was lighted. Time announcements of this type made exacting demands on the operator, and operators were, therefore, relieved at thirty-minute intervals.

Recently a new automatic time announcing system – the 4A – has been developed for general use in the Bell System, and it was decided to incorporate features of the 4A system into the New York City facilities. In place of the operator the 4A system uses a time-announcing machine leased from the Audichron Company. This machine generates the complete announcement – introductory words, the time in hours, minutes, and seconds, and the time tone at ten-second intervals – by scanning films on continuously rotating drums. Two output channels are provided in this arrangement, and should one channel fail, the announcement is automatically switched to the other. Should both channels fail, an alarm is given and the announcements are made by an operator.

Where the frequency regulation of the commercial power system is not considered satisfactory, power to drive the Audichron motor is supplied by a unit that uses a tuning fork to produce a stable 60-cycle frequency. With this arrangement, an overall accuracy is achieved of about plus or minus one second per week. To improve this accuracy even further for the New York system, a special time checking feature was designed for use in that location only, holding the regulated frequency power supply for the Audichron machine in step with a precision supply. This very accurate power supply will be described in a subsequent issue of the RECORD.

Early in 1952, a major improvement was made in the New York City time announcing system by modifying it to use recorded announcements as does the 4A system, and at the same time retaining the special and advantageous features previously provided. The original 1B system was retained essentially intact, and arrangements were made to switch to it in case of failure of the

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* RECORD, *March*, 1931, page 335; *December*, 1938, page 131; and *May*, 1939, page 272.

Audichron machine. The distributing trunks and the distributing circuits to which the time announcements are supplied were also retained. The 1B system, though it required the use of operators, was very accurate, since it derived the correct time from a precision 60-cycle signal obtained via the Long Lines Building from the Murray Hill Laboratories' frequency standard. Another feature of the 1B system was that it permitted the announcement of baseball scores between time announcements during the World Series. Both of these features have been retaind in the new facilities.

A simplified schematic of the present improved New York system is shown in Figure 3. The normal path of the time announcement is across the top of the diagram from right to left. A pad at the output of the Audichron machine is included to reduce the level of announcements to that used by the 1B system. Only one channel is indicated, but as already pointed out there are two paralleling channels with an automatic transfer from one to the other. Should both channels fail, other than because of a power failure, an alarm would alert a designated operating room supervisor who would dispatch an operator to the Time Bureau turret. On such occasions the operator will operate the emergency transfer TRNS key at the turret and proceed to announce the time in the manner used prior to the introduction of machine announcing. The operation of the TRNS key causes the TRNS relay in the new control circuit to operate, thus disconnecting the distributing network from the Audichron machine and connecting it through the oscillator OSC relay to the microphone at the Time Bureau turret. The operation of the TRNS relay also closes paths from the oscillator OSC relay and the announce ANN lamp in the turret to the clock circuit.

The special electric clock at the turret is equipped with contacts that continuously close for 7½ seconds and remain open for the next 7½ seconds. For the 7½ seconds prior to the time tone, ground from an operated clock contact will light the ANN lamp to indicate to the operator that an announcement is to be made. Exactly on the quarter minute, a relay controlled by the tone-timing circuit operates and in turn causes the OSC relay to operate for a half second. During this period, the microphone is removed from the distribution network and replaced by the oscillator, which emits an 800-cycle tone. The start of the audible tone marks the exact time.

When baseball or other special announcements are to be made along with the regu-

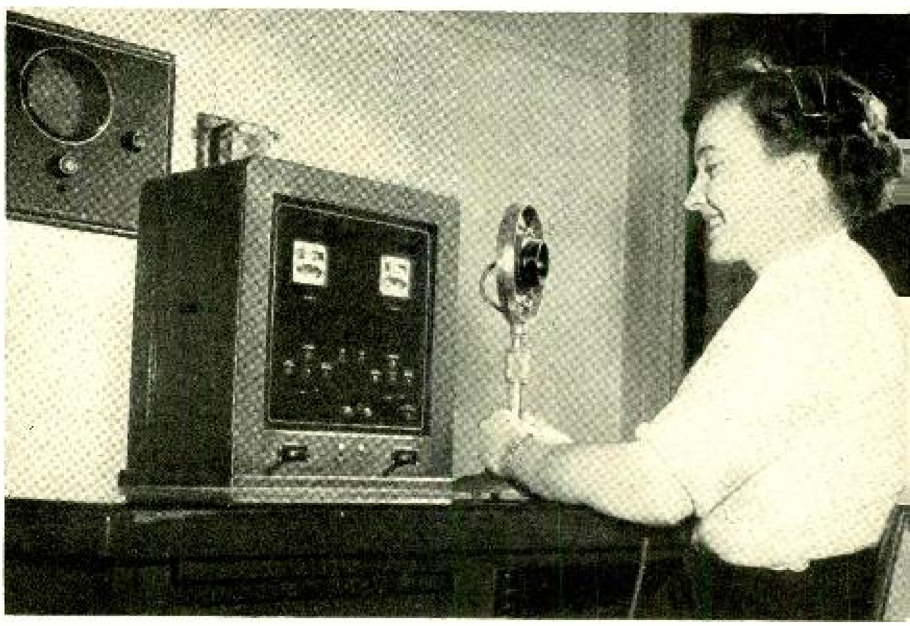


Fig. 1 — Ann Byrne, traffic employee at the East 30th Street Building, New York Telephone Company, at the microphone in the time-announcing room. Here baseball scores and other special announcements are added to the mechanically reproduced time-of-day signals.

lar time announcements, the assistance of an operator is required. To prepare the system for making baseball announcements, an operator at the Time Bureau turret will operate the baseball BB key. This causes the BB relay in the control circuit to operate and also furnishes a start signal to the "every other announcement" timing circuit. Since the TRNS relay is normal, the operation of the BB relay will connect the BB lamp in the turret to a contact of the BBM relay. The "every other announcement" timing circuit will hold the BBM relay operated for a period of one machine announcement every alternate announcement. While the BBM relay is operated, the BB lamp will be lighted and the distributing system will be connected to the operator's microphone. The operator will make a verbal report of the baseball scores while the BB lamp is lighted, and thus ten-second baseball announcements are interposed between ten-second time announcements.

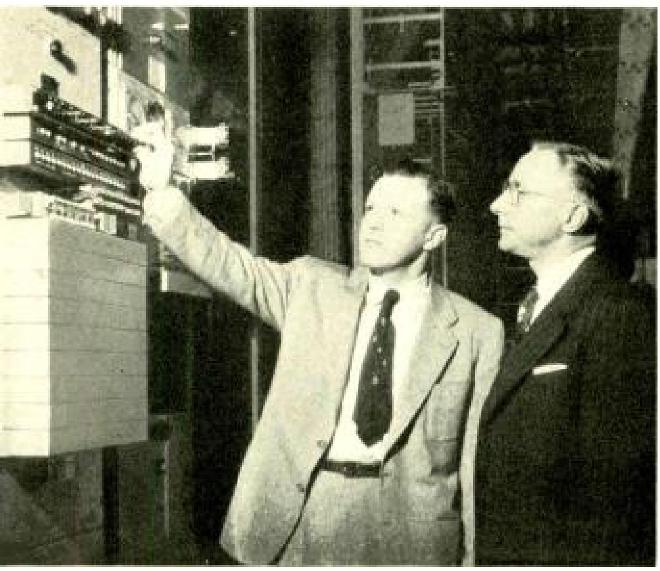


Fig. 2 – The author and Vincent Amoroso, Central Office Foreman of the New York Telephone Plant Department, discuss the equipment that automatically tells customers the time of day.

If the baseball BB key is operated while the system is in the emergency condition, the baseball BB relay, as before, operates. This relay, through contacts of the operated TRNS relay, connects the baseball BB lamp to the clock circuit. The BB lamp then lights during the 7½ second period following a tone signal. A lighted BB lamp again indicates to the operator that a baseball announcement is to be made.

Besides the switching arrangements described, the Time Bureau circuits contain many auxiliary features. These include means for connecting a customer to the distributing bus only at the beginning of an announcement, provision for charging, an arrangement for indicating to the operator at the turret when the volume of her voice is either too low or too high, a means for transferring the distributing network from one channel of the Audichron machine to the other when there is a failure in the operating channel, an arrangement for transferring the Audichron machine motors to commercial power if the precision frequency power supply fails, and provision for adjusting the many amplifiers in the distributing network.

The arrangement for adjusting the distributing network amplifiers is included in Figure 3. The distributing trunks are connected to central offices throughout the metropolitan area, and at points along each connection one or more amplifiers are inserted depending upon the nature and quality of the facilities. When the announcements were made manually, the 800-cycle time tone following every announcement was used as a reference level by which the gains of the remotely located amplifiers were adjusted. This method was possible because the level of the 800-cycle oscillators can be adequately controlled. When the Audichron machine is used, however, the time tone signal is reproduced from the film strip along with the announcements. It was found that the reproduced tone levels varied from the speech levels both within the same channel and between channels. These variations are inherent in film reproduction systems, and although they can be kept within limits sufficient to avoid customer reactions, it is not feasible to use this tone for a reference level. A new procedure thus had to be devised for adjusting the amplifier gains. It was decided to continue to use the 800-cycle oscillator to supply the reference tone. At a prede-

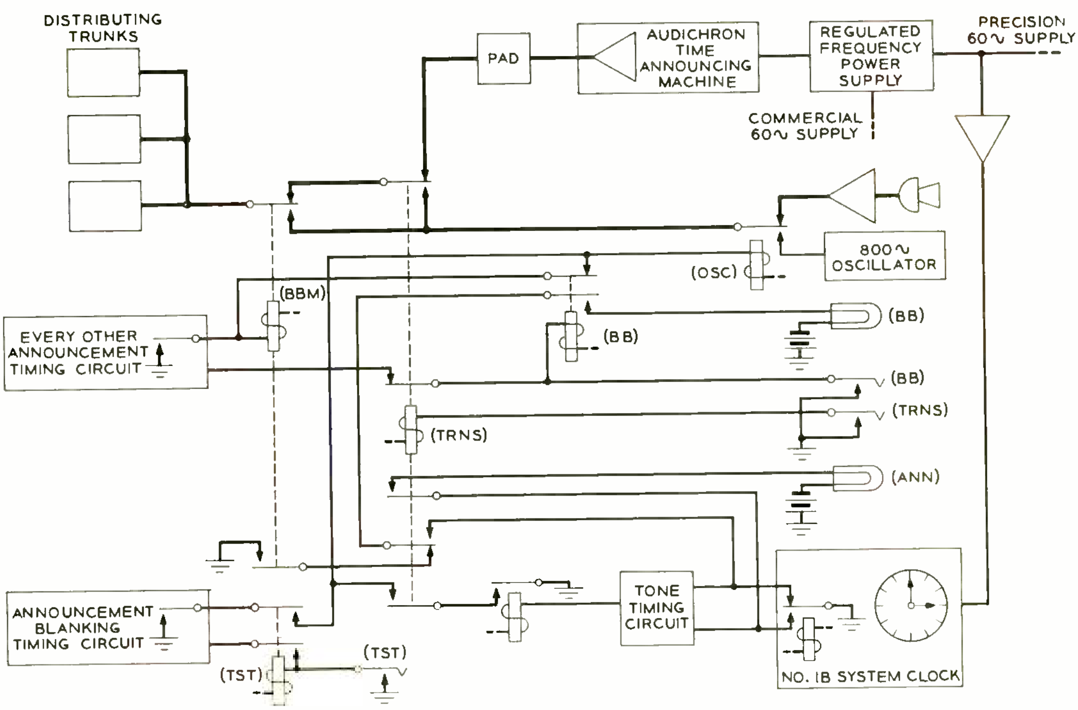


Fig. 3 — Circuit arrangements for the New York City time-of-day facilities.

termined time, usually during the early morning hours, maintenance personnel in each office containing an amplifier of the distributing system will be prepared to make adjustments. A maintenance man at the Time Bureau will hold the test TST key operated until after the completion of a regular announcement. At the completion of the announcement, an "announcement blanking" timing circuit will lock up the TST relay and operate the BBM and OSC relays. The "announcement blanking" timing circuit will hold these relays operated for one complete announcement period, thus causing the 800-cycle tone to be sent over the distributing network for ten seconds. The procedure can be repeated at intervals to assure sufficient time to make amplifier adjustments.

The people of the New York metropolitan

THE AUTHOR: A. E. GERBORE became a technical assistant in 1938, two years after he joined the Laboratories. Transferring from work on switching to the trial installation department in 1940, he spent several years working on field trials of new equipment and supervising model construction, becoming a Member of Technical Staff in 1943. During World War II he served in the Air Corps for three years. When he returned to the Laboratories in 1946, he resumed his duties in the trial installation department. Since 1950, he has been engaged in analyzing special Western Electric orders for non-standard equipment. Mr. Gerbore attended Cooper Union and holds a B.E.E. degree (1950) from New York University.

area, including northern New Jersey, have grown dependent upon the time-of-day service. Since they would react quickly to any interruptions in the service or to inaccuracies in the announced time, an adequate alarm system has been incorporated to detect trouble that might lead to a general service interruption, and to alert maintenance personnel promptly when troubles occur. The accuracy of time announcements is checked several times a day, and for this purpose radio equipment is installed at the Time Bureau. This equipment is used to compare the time on the Audichron machine and the No. 1B system clocks with the Bureau of Standards and Arlington Naval Observatory time signal broadcasts, and corrections are made whenever necessary.

Talks by Members of the Laboratories

During the month of July, a number of Laboratories people gave talks before professional and educational groups. Following is a list of the speakers, titles, and places of presentation:

Transistor Research Conference — Pennsylvania State College

Bennett, D. C., Recent Developments in Zone Leveling.

Burcham, N. P., and Gray, R. A., Mechanical Properties of Certain Point Structures.

Christensen, H., Moisture Tolerance for Germanium *n-p* and *n-p-n* Junction Devices.

Dacey, G. C., Field Effect Transistor.

Early, J. M., see S. L. Miller.

Ebers, J. J., see J. Moll.

Francois, E. E., see J. T. Law.

Gray, R. A., see N. P. Burcham.

Hussey, L. W., and Kleimack, J, J., *n-p-n* Alloyed Transistors with Low Base Resistance.

Kingston, R. H., A Point Emitter-Junction Collector Transistor.

Kircher, R. J., Configurations for Point-Contact Devices Resulting in New Properties.

Kleimack, J. J., Loss of Alpha at Low Collector Voltage in Point Contact Transistors.

Kleimack, J. J., see L. W. Hussey.

Law, J. T., and Francois, E. E., The Adsorption and Decomposition of Gases on Germanium.

Logan, R. A., Prevention of Entry of Thermium into Germanium and Role of Lattice Vacancies As Acceptors.

Miller, S. L., and Early, J. M., Junction Transistor Theory for Triodes and Tetrodes.

Moll, J. L., Semiconductor Delay Lines.

Moll, J. and Ebers, J. J., Alloyed Transistors for Switching Applications.

Pfann, W. G., Redistribution of Solutes by Formation and Solidification of a Molten Zone.

Prince, M. B., Drift Mobilities in Germanium and Silicon.

Smith, K. D., Effects of High Energy Transients on Junction Transistors.

Thomas, D. E., Design of a VHF Point Contact Transistor.

Thomas, J. E., Mechanism of Frequency Cutoff in Point Contact Transistors.

Wilson, D. K., Reverse Voltage Breakdown in Alloy Junction Silicon Diodes.

Zuk, P., High Frequency Parameters of Junction Phototransistors.

Other Talks

Felker, J. H., Transistor Switching Applications, Lecture Course, University of Illinois, Urbana and Chicago, Illinois.

Fine, M. E., Magnetic Structure of Chromium, Gordon Research Conference on Chemistry and Physics of Metals sponsored by the A.A.A.S., New Hampton, N. H.

Honoman, R. K., Technology and Research in Today's Communications, Ohio Workshop on Economic Education, College of Education, University of Ohio, Athens, Ohio.

Hussey, L. W., Transistors, Student Group, RCA Institute, New York City.

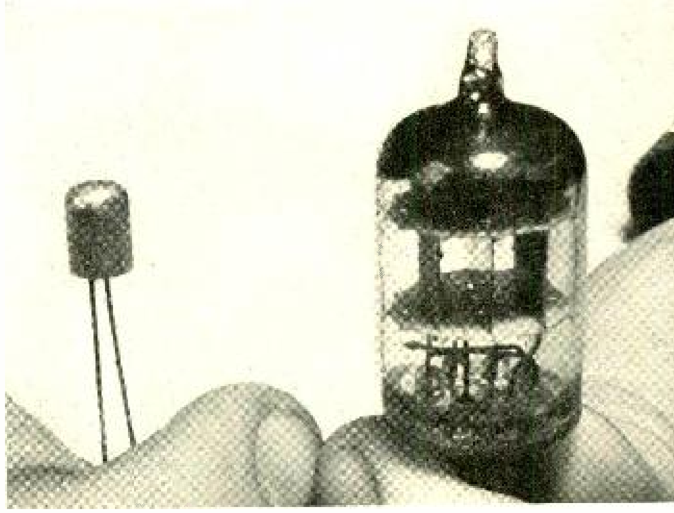
Lince, A. H., The Bell System Microwave Radio Relay, National Convention of Amateur Radio Clubs, Houston, Texas.

Mason, W. P., Temperature and Time Stabilized Barium Titanate Ceramics and Low Temperature Relaxations in Fused Quartz, Physics Seminar, University of Zurich, Switzerland.

McMillan, B., Mathematics in Communications, Mathematics Institute, Rutgers University, New Brunswick, New Jersey.

Ryder, R. M., Junction Transistors, University of Illinois, Urbana and Chicago, Illinois.

Tiny Electronic Switch



The size of the silicon alloy junction diode can be appreciated when compared with the conventional two-element vacuum tube. The encased element of the diode is no larger than a match head.

A new electronic device which may result in significant advances in telephone switching systems and in many kinds of computers has been created at the Laboratories. Known as a silicon alloy junction diode, it serves as an electronic equivalent of a tiny one-way switch, and is capable of operating thousands of times faster than its mechanical counterparts. Switches of this type can perform as deft fingers operating the telephone dial system or enabling mechanical computers to make complex calculations in a fraction of a second.

A diode may be compared to a check-valve in a pipe, allowing water to flow in one direction but blocking its flow in the opposite direction. It may also be thought of as an electronic equivalent of a dam between two bodies of water. Merely by raising the water level on one side, water may be made to flow over the dam. However, lowering the level on this same side will not result in water flowing the other way.

Preventing an electronic "back flow" is never absolutely perfect, so a diode is a somewhat leaky sort of dam. In the new silicon diode, this back leakage is smaller than in any previous diode – about one ten thousand millionth of an ampere. Compared to this, leakage currents of vacuum-tube diodes may be a thousand times greater. Another way of describing the new diode's performance is to say that the ratio of its resistances in the two directions is 100 million to one.

The new diode contrasts sharply with a conventional vacuum-tube diode in that it requires no filament or vacuum. It has an encased element no larger than a match-head, and is an accomplishment growing out of transistor research and development at the Laboratories. Silicon crystals were prepared, containing controlled traces of an impurity. This reduces the normally high resistance of the mineral and enables rectification. Like the transistor, it requires no warm-up period. But, unlike the present germanium transistor or diode, it can operate well under high temperatures. Thus, under these conditions, its life-span should be almost unlimited.

Diodes serve several highly important functions in the Bell System. For example, information in the form of coded numbers must be "remembered" while the call is being completed. This memory is presently provided by circuits containing relays or mechanical switches. Present plans call for the use of the new diode in the memory organ associated with the transistor-operated digital computer.

Under the sponsorship of the Laboratories, the Du Pont Company recently developed a method for the commercial manufacture of high-purity silicon and has thus opened up a virtually unlimited source of the material for electronic usage. Production problems of the new silicon diode are being worked out with the Western Electric Company.

D. A. Quarles

J. W. McRae

G. N. Thayer

W. C. Tinus

Organization Changes

Donald A. Quarles, Vice President of Western Electric Company, President of the Sandia Corporation, and a former Vice President of the Laboratories, has recently resigned those posts to accept an appointment by President Eisenhower to the position of Assistant Secretary of Defense in charge of research and development.

Mr. Quarles has been succeeded by James W. McRae, who has resigned as Vice President of the Laboratories to accept election as Vice President of Western Electric and President of Sandia.

Gordon N. Thayer, Laboratories Vice President in charge of the military development program and relations with the Army, Navy and Air Force in connection with that program, has taken over Mr. McRae's duties as Vice President in charge of switching and transmission development.

William C. Tinus, formerly Director of Military Electronics Development, has been elected a Vice President to succeed Mr. Thayer in his former responsibilities.

Mr. Quarles brings to his new post over thirty years of Bell System experience. Born in Van Buren, Arkansas, he attended public schools there and was graduated from Yale University in 1916 with a B.A. degree. Enlisting in the United States Army in 1917, Mr. Quarles served two years with the A.E.F. in France and Germany and was separated from the service in 1919 as Captain in the Field Artillery.

Late in 1919, Mr. Quarles joined the Engineering Department of the Western Electric Company, which in 1925 became Bell Telephone Laboratories. Until 1924 he was concerned with transmission engineering and research, and then for four years he was a member of what is now the Quality Assurance Department in charge of apparatus inspection.

He was made Director of Outside Plant Development in 1929 and became Director of Transmission Development in 1940. He remained in this post until 1944, and during this time, under his direction, the efforts of the Transmission Development Department were largely concentrated on military electronics, particularly radar. In 1944, Mr. Quarles was named Director of Apparatus Development and served in this post until his election as a Vice President of the Laboratories in 1947.

In March 1952, Mr. Quarles resigned his post as Vice President of the Laboratories and accepted election as Vice President of the Western Electric Company and President of the Sandia Corporation.

Mr. Quarles is a member of Phi Beta Kappa, Sigma Xi, the American Physical Society and the Institute of Radio Engineers. He is a Fellow, member of the Board of Directors, and past president of the American Institute of Electrical Engineers.

During many years' residence in Englewood, New Jersey, Mr. Quarles was active in community affairs, having served as President of the Common Council and Mayor of Englewood. For several years he served as Chairman of the Committee on Electronics of the Research and Development Board.

Mr. McRae, a native of Vancouver, British Columbia, received his bachelor's degree in electrical engineering from the University of British Columbia in 1933 and his master's degree from the same University in 1934. He received his doctorate from California Institute of Technology in 1937 and immediately joined the Laboratories. His early work included research on transoceanic radio transmitters and microwave techniques, both for civilian and military applications.

In 1942 he was commissioned a major in the U. S. Army Signal Corps and coordinated development programs for airborne radar equipment and radar counter measure devices, receiving the Legion of Merit for this work. He was later chief of the engineering staff of the Signal Corps Engineering Laboratories at Bradley Beach, N. J., and subsequently became deputy director of the engineering division with the rank of colonel. He returned to Bell Laboratories in 1946 as Director of Radio Projects and Television Research.

In this post he was associated with the New York to Boston radio relay project. In 1949 he was appointed Director of Apparatus Development I, subsequently becoming Director of Transmission Development. He was elected a Vice President of the Laboratories in 1951.

He is a member of the American Institute of Electrical Engineers and Sigma Xi. A member of the Institute of Radio Engineers since 1937 and a Fellow since 1947, he was formerly chairman of the New York section and is currently serving as president of the national society.

Mr. Thayer takes over Mr. McRae's responsibilities as Vice President in charge of switching and transmission development from his position as Vice President in another area of responsibility.

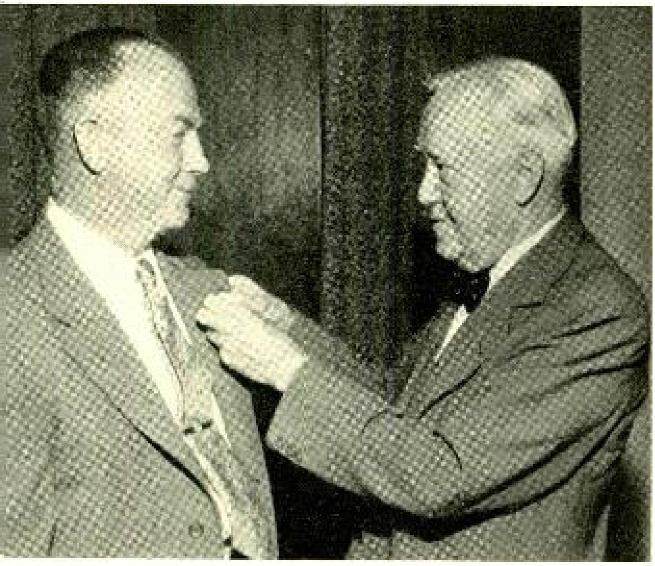
A native of Colorado, he holds a degree in engineering from Stevens Institute of Technology. He joined the Laboratories in 1930, and from that year until 1940, his special interest was the development of mobile radio communication equipment and systems. In 1940 he became affiliated with a group developing radar systems and, later, microwave radio relay systems. In 1949 he became concerned with the development of communications systems, including the transcontinental radio relay system, the Key West-Havana submarine cable system, and overseas radio projects. He was appointed Assistant Director of Transmission Systems Development in 1949 and Director of Transmission Development in 1951. In May, 1952, he was named a Vice President of the Laboratories responsible for its military development program. He is a Fellow of the I.R.E.

Mr. Tinus came to the Laboratories in 1928 from Texas Agricultural and Mechanical College, after graduating with a B.S. degree in Electrical Engineering. He was at first concerned with the development of mobile radio communication equipment and with its applications to commercial airlines, marine and police uses. Later he was responsible for the development of a new radio altimeter which operated on the FM principle.

In 1938, Mr. Tinus' group was transferred to Whippany to conduct the Laboratories' first work on "radio object location" which later became radar. Their early developments became the basis for the Navy's first shipboard fire control radar equipment and contributed to the design of many other Army and Navy radar systems developed at the Laboratories.

During the war, Mr. Tinus was a part-time consultant to the Secretary of War and received a development award from the Bureau of Ordnance. After the war, he became responsible for several long-term projects for the armed forces. In 1948 and '49 he was a member of the Radar Panel of the Research and Development Board and in 1950 became a member of the Technical Evaluation Group of the Committee on Guided Missiles of the RDB.

In 1949 Mr. Tinus became Acting Director of Military Electronics Development and in 1951 became Director of the Military Electronics Department. Mr. Tinus is a Fellow of the I.R.E. and has served as a member of its Board of Editors.



John W. Davis, on behalf of the Board of Directors of A.T.&T., presents Cleo F. Craig, President, with fortieth anniversary service pin. Mr. Craig began his Bell System career as an equipment man in the Long Lines Department in St. Louis on June 24, 1913.

C. F. Craig Sees Bell System Growth

(Editor's note: Wayne Oliver of the Associated Press recently interviewed Cleo F. Craig, President of A.T.&T. Mr. Oliver's story was sent to newspapers throughout the country and the Record *received permission to reprint excerpts from it.)*

Because people like to talk, A.T.&T. is working full time and still can't keep up with the demand for telephones. Even its president says: "I spend a third to half my time on the telephone."

Cleo F. Craig took over the presidency of American Telephone and Telegraph two years ago. He's learned that sometimes no matter how hard you try you can't make enough of a good product.

Since the end of World War II, says Mr. Craig, the Bell System has added 18 million telephones. That's more telephones than there were in the country before the war.

"We can't see at the present any diminution in that rate of growth," he says, adding that the demand for new installations now is 3 per cent greater than a year ago.

In fact, he can't see a saturation point anywhere in the immediate future, even at a gain of more than 2 million phones a year.

"People," he points out, "like to talk and it's nice to be in a business where you make it easy for them."

Dr. Kelly Writes on Transistor

Leading article in the Summer issue of the Bell Telephone Magazine is *The First Five Years of the Transistor,* by M. J. Kelly, President of the Laboratories. The article, illustrated by a number of photographs taken in the Laboratories, is a non-technical account of the origin, present status, and civilian and military potentialities of this important Laboratories development. Dr. Kelly points out that a new technology is growing around the transistor, and that a new industry will grow with it.

"Bell Laboratories," he writes, "continuing in the forefront, will realize for the Bell System and the military services the promise of these five years" since the invention was announced.

Plan Extra New York-Washington Channels

Long Lines has asked the Federal Communications Commission for authority to construct radio transmitters for additional channels on its New York-Washington radio-relay system. Plans are to provide four channels along the entire New York-Washington route, and three additional channels between Philadelphia and Washington.

Two of the New York-Washington channels would be used for northbound network TV service in addition to existing facilities, while one in each direction would be used for protection and maintenance. Of the three Philadelphia-Washington channels, one would be provided for northbound TV services and one in each direction for telephone message service. The projected telephone channels would provide, initially, some 125 additional circuits needed to handle the continually expanding telephone traffic between the eastern and southern states of the country.

At present, two southbound video channels are in use on the New York-Washington system. The addition of the proposed northbound channels would be part of a "round robin" network of two television channels in each direction linking stations from New York to Chicago and St. Louis. Such an arrangement will add considerably to the flexibility of the TV network system.

New Text on Sound

A new and comprehensive text on sound is now available to engineers interested in that field. *Technical Aspects of Sound* is a collaboration of the works of over twenty acoustic scientists from the United States, Great Britain, and the European continent, representing industry and universities.

A complete coverage of the field, the text will appear in two volumes. The first volume was made available in July, and the second volume will come off the press early in 1954. Of the nearly two dozen authorities who share authorship of the volumes on sound, twelve are members of Bell Telephone Laboratories.

Published by The Elsevier Press, Inc., New York City, Volume I covers all aspects of sound except ultrasonics and underwater acoustics. Volume II will cover these latter subjects.

Contributors from the Laboratories include H. L. Barney, B. P. Bogert, H. K. Dunn, N. R. French, M. B. Gardner, F. K. Harvey, W. E. Kock, W. A. Munson, G. E. Peterson, R. K. Potter, J. C. Steinberg, and F. M. Wiener.

Laboratories' Exhibit to Be Displayed at Geneva

Two recent important Laboratories-Western Electric Company developments – the general purpose wire spring relay and solderless wrapped connections – will be exhibited at the Geneva, Switzerland, Headquarters of the International Telephone Advisory Committee (CCIF). A request for a Bell System exhibit was made to the A.T.&T. by M. Georges Valensi, director of CCIF, and the Laboratories is furnishing the display shown above.

The display depicts the wire spring relay and solderless wrapped connections, in various stages of assembly, before a background of relays and crossbar switches. Comparison of old and new relays shows the advantages to be gained with the new developments. Laboratories monographs describing these devices will be made available to visitors.

Design of the display was under the direction of A. L. Jeanne of Transmission Engineering and the late P. E. Buch of Switching Apparatus Development.

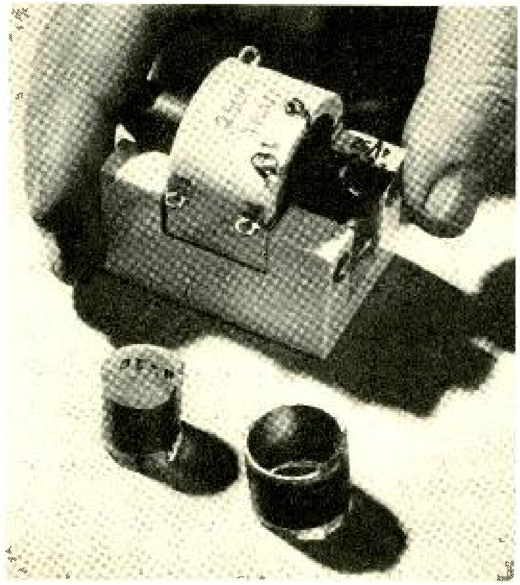
Transformer Coils Wound Without Wire

Tucked unobtrusively away in every amplifying unit of the new L3 coaxial cable system is an amazing little transformer – a transformer manufactured to impressively small tolerances and "wound" in so unusual a manner that its wire can neither expand nor shrink. It's one of many components of the new system developed by Bell Laboratories and made by Western Electric that rival laboratory instruments in accuracy and precision.

L3 carrier, which enables one pair of pencil-size copper tubes to handle simultaneously 1,860 telephone conversations (or 600 telephone calls plus one television program in each direction) can triple the telephone message capacity of existing coaxial cable. To do its job, L3 carrier requires a series of repeater stations spaced every four miles along its route to amplify the message signals. Each repeater includes eight amplifiers, one for each pipe. Each amplifier has two transformers which enable the amplifier to maintain a constant power level over the coaxial tube. They are designed to operate with other apparatus manufactured with similar precision.

The outer and inner coils of this transformer are thin-walled cylinders about the size of spools of thread. They are made from a special glass known as Vicor, a member of the Pyrex family chosen for its stability and lack of susceptibility to physical change, and honed down to a diameter so exact that it doesn't vary more than one ten-thousandth of an inch. Transformers are usually wound with turns of copper wire equally spaced on a tube of paper, silica or similar material. But a coil of far more precise characteristics is called for in this transformer. Diameter of the "wire," for example, must be accurate to five ten-thousandths of an inch, and its length to two ten-thousandths. And the coil must maintain its form without physical change over a long period of time.

To achieve a coil of such critical measurements, electroplating is used. Threads are first cut into the cylinders of Vicor with a diamond wheel, a coating of powdered silver and ground glass is sprayed on, and the copper is then electroplated onto the coil. When the grooves are filled with copper, the coil is ground to smooth off the excess, leaving a fine and exact wire coil – a coil with bonded elements whose dimensions will not vary with time and temperature to upset its electrical characteristics.



Designed for the L3 coaxial cable carrier system, the little transformer shown enables the amplifier to maintain a constant power level. The spool at the left fits into the larger one at the right to form the transformer coil. To achieve the necessary precision, the turns are electroplated onto the spools rather than wound.

The 4A Toll System Grows

On August 16, Newark became the third city in the nation to be provided with the new 4A crossbar toll switching system. Scranton, Pennsylvania was the first, being cut over on May 26; Sacramento, California, followed on June 17.

One of the many important features of this new system is the card translator. This device uses both photo-transistors and transistor amplifiers to provide translation of the digits dialed by either an operator or a customer into the proper routing information required by intermediate and terminating equipment. The card translator, the first major use of transistors in dial switching equipment, also makes possible a greatly increased capability for automatic alternate routing for the nationwide toll dialing plan.

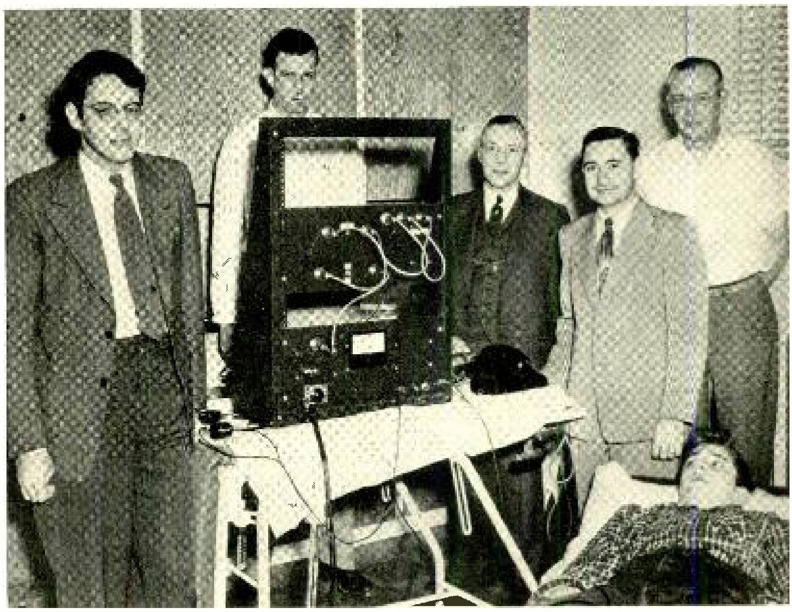
The fourth 4A system to go in service will be cut over later this year at Detroit. Planned for cut-over by the end of next year are Oklahoma City, Syracuse, N. Y., Los Angeles, Richmond, Va., Chicago's third toll office, Charlotte, N. C., Little Rock, Ark., and White Plains, N. Y.

Type-N Carrier Program Service

Broadcasts originating at the mammoth Boy Scout Jamboree at Newport, Calif., were piped to listeners throughout the country over Type-N cable carrier facilities. This marked the first commercial use of 5-kc carrier service for network broadcasts.

Originating at Newport, the broadcasts were sent to Santa Ana, Calif., over open-wire lines. From Santa Anna to Los Angeles, the Type-N carrier system was used. Connection to the network was made here.

Type-N carrier is a twelve-channel, cable carrier system designed for short-haul message service. When used for 5-kc program service, special arrangements are required. Three channels near the middle of the carrier band are removed, and a single 5-kc program channel unit is substituted. Since a Type-N message channel is capable of providing only a 4-kc band in normal service, the program channel overlaps the two adjacent channels. The third channel is available for reversing features, which were not provided during these broadcasts.



A heart signal transmission was under way when this photo was taken. Left to right, Walter E. Rahm, assistant professor, experimental medicine, University of Nebraska, Ed Harris, Northwestern Bell's manager at Ainsworth; I. M. Ellestad, and Dr. John Barmore and Dr. W. Lear of the Ainsworth clinic, University of Nebraska.

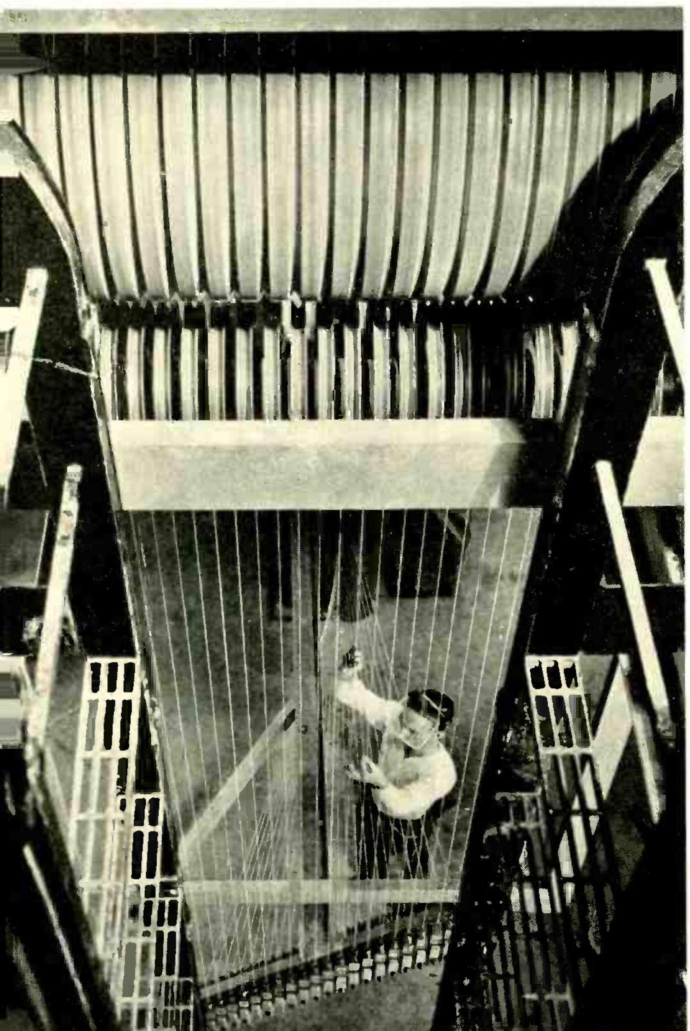
Electrocardiograms by Wire

There's promise that long distance telephone lines may soon be helping heart specialists to "see" the action of an ailing heart hundreds of miles away. Three staff members of the University of Nebraska College of Medicine have developed equipment for transmitting electrocardiograms (heart performance records) over telephone lines. For nearly a year the Northwestern Bell Telephone Company has been cooperating in tests to measure the accuracy with which delicate heart signals can be sent over long distance circuits. The experiments that have been conducted so far point to the time when it may be possible for doctors in small communities to gain quick help for heart patients by sending electrocardiograms into clinics or other points of heart specialization and receive a diagnosis by long distance telephone. Conceivably the doctor at the bedside of a patient could discuss his case with a specialist hundreds of miles away while he and the specialist view the performance of the patient's heart.

Presidential Telephone Services

When the Chief Executive goes traveling, telephone service must go with him. President Eisenhower's recent visit to Dartmouth College necessitated many special facilities, and all departments of the New England Telephone and Telegraph Company worked full force to provide them before his actual arrival.

These facilities included, among others, direct lines from the College PBX to the White River Junction toll office where direct circuits to the White House switchboard in Washington were kept open; a Western Union loop and two additional public telephones for newsmen; a special broadcast circuit from the central office in Hanover to New York City for CBS; telephones for the President's party and the College at the outdoor speakers' platform; a duplicate set of facilities in the gymnasium (in case of rain); a loop from there to Webster Hall where the audience overflow would have heard a broadcast of the address had it rained; a private line from the Hanover Inn to the West Lebanon Airport so that the pilot of the Presidential plane might contact his crew; and moving the lines at the homes where the President and Presidential Assistant Sherman Adams were staying to the College PBX where they could be screened by the Secret Service.



TV Link Completed

A new radio-relay system linking Chicago, Milwaukee and Minneapolis was completed recently. Constructed to provide for telephone growth and TV network extensions, the system is providing initially about 400 additional long distance telephone circuits in this area and a television channel from Chicago to Milwaukee.

Auction by Teletypewriter

Selevision, Inc., an organization dealing in perishables, has ordered teletypewriter service from Lakeland, Fla., to nine eastern and midwestern cities for the purpose of auctioning carload lots of its merchandise. Buyers at the various auction centers will make their bids to teletypewriter attendants, and a customer-owned device will project the bids on a screen. A clock above the screen will be started. When no additional bids are received, the clock will "time out" at the end of 10 seconds, and a signal will indicate that the lot has been sold.

The first spaceship to the moon could string a telephone line back to Earth, if NP drop wire were used. During 1952, the first full year of operation, two and three-quarter billion conductor feet of this drop wire were produced at the Point Breeze plant of the Western Electric Company. This is enough to make a round trip to the moon with enough left over for two loops around the earth at the equator as an anchor.