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Vibralloy— A New Ferromagnetic Alloy

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During the past several years, the metals research group of Bell Telephone Laboratories have been studying the fundamental factors controlling the modulus of elasticity in metals and its variation with temperature. This study recently uncovered a new alloy, which has been named vibralloy. Its temperature coefficient of elastic modulus may be controlled over a wide range, and in addition it has substantial ferromagnetic permeability and high mechanical strength. This is an attractive combination of properties for many purposes, such as for the reeds of vibrating reed selectors.*

In such selectors, tuned reeds vibrate when driven magnetically by a signal of the proper frequency. These reeds must have adequate strength for mechanical stability, and they must respond to the same signal frequency over a rather wide temperature range, approximately −40 to +80 degrees C. Since the reed is magnetically actuated, moreover, it must have substantial ferromagnetic permeability over the full temperature range. The tuned frequency of a reed, that is the signal frequency to which it responds, depends upon its dimensions, on the density of the reed material, on Young's modulus of the reed material, and on the parameters of the magnetic circuit of which it is a part. In general, all of these factors change with temperature, and the response frequency of the reed will also change with temperature unless the changes in frequency due to the four factors are balanced. The desirability of controlling the temperature variation of Young's modulus is thus immediately apparent.

In metals, Young's modulus, E, (ratio of tensile stress to tensile strain) ordinarily decreases on raising the temperature. In iron and copper, for example, the modulus decreases 250 and 325 parts per million per

* RECORD, *January*, 1950, *page* 2 and *February*, 1950, *page* 72.

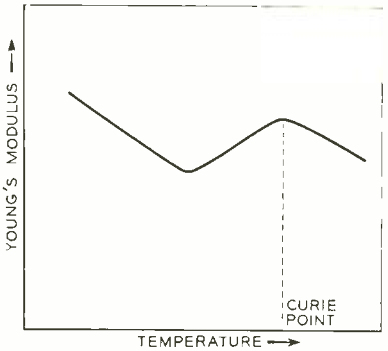


Fig. 1—Variation of Young's modulus with temperature in iron-nickel alloys.

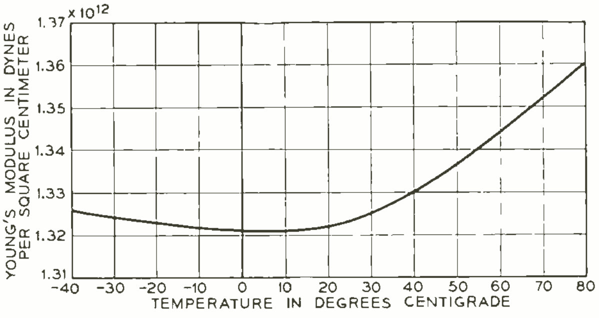


Fig. 2—Plot of Young's modulus against temperature for a fully-annealed iron-nickel alloy containing 40 per cent nickel.

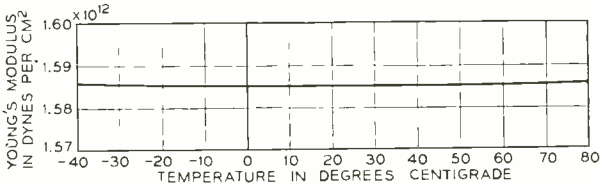


Fig. 3—Plot of Young's modulus against temperature for a cold-worked iron-nickel alloy with its minimum occurring at room temperature.

degree centigrade, respectively. In certain ferromagnetic alloys, a different thermal behavior is observed. Ferromagnetic alloys are not ferromagnetic at all temperatures; on heating they gradually lose their ferromagnetism until a temperature is reached above which they cease to be ferromagnetic. This is the Curie temperature.

Loss of ferromagnetism in certain alloys such as iron-nickel alloys causes a profound change in modulus of a type shown in Figure 1. On heating from far below the Curie temperature, the modulus decreases as with non-magnetic metals, but when the loss of ferromagnetism becomes important with respect to the modulus, the curve turns upward. On further heating, the modulus increases until the Curie temperature is reached. Above the Curie temperature, the modulus again decreases.

As a result of this particular characteristic, the modulus is constant over a limited temperature interval at two points in the curve, a minimum and a maximum. Since the alloy has essentially lost its ferromagnetism at the Curie temperature, only the region of the minimum of Figure 1 is suitable for an application requiring an alloy with small thermal variation in modulus and substantial ferromagnetism, and the minimum should be broad and should occur at room temperature.

In an iron-nickel alloy with 40 per cent nickel, and annealed at 1000 degrees C, the minimum in the modulus-temperature curve occurs at room temperature, as shown in Figure 2, but it is comparatively sharp, and the modulus is nearly constant only over a small temperature interval. The minimum can be made much broader by adding chromium, and this was the basis of the thermally constant-modulus alloy, Elinvar, developed in France many years ago. The minimum can also be made much broader by cold working the alloy. This is the basis of vibralloy. The modulus temperature curve of a cold worked iron-nickel alloy with minimum at room temperature is given in Figure 3. The modulus changes so little between −40 and +80 degrees C that a second look is required to see that the curve isn't a straight horizontal line. Cold working also changes the temperature at which the minimum occurs, and thus it was necessary to use an alloy with 43 per cent nickel to have the minimum occur at room temperature. Cold working also hardens the alloy, increasing the mechanical strength. As mentioned previously, this is desirable for mechanical stability. After cold working and before use, the alloys are annealed at 400 or 500 degrees C to stabilize them.

A convenient method of comparing the temperature variations of modulus for various alloys is to plot the change in the modulus on heating from –40 degrees C to other temperatures up to +80 degrees C relative to the modulus at 20 degrees C, that is to plot $(E_T - E_{-40})/E_{20}$ as a function of T. A group of curves of this type for alloys with from 40.8 to 45.0 per cent nickel, cold-worked condition, is given in Figure 4. Such curves permit a more ready comparison of the E-T characteristics for various alloys since they all radiate from a single point. The slope of these curves at temperature T is proportional to the slope of the corresponding E-T curve at the same temperature. The minimum of the $\Delta E/E$ curve will occur at the same temperature as that of the E-T curve. Consequently, a positive slope, Figure 4, at any temperature T indicates the minimum is at some lower temperature; a negative slope indicates the reverse. If a curve in Figure 4 is completely positive in slope, then the minimum occurs at a temperature less than –40 degrees C; if the curve is completely negative, the minimum occurs at a temperature higher than 80 degrees C. Alloys with a minimum between –40 and 80 degrees C will be represented in Figure 4 by curves, initially negative, passing through a minimum, and then becoming positive. These curves thus show that as the nickel content is increased, the temperature of minimum increases, and the slope at a given temperature gradually changes from positive to negative.

Besides iron and nickel, vibralloy also contains 9 per cent molybdenum. The molybdenum has a dual purpose. In the first place adding 9 per cent molybdenum to these iron-nickel alloys increases the mechanical strength. The limit of elasticity (proportional limit) for the cold-worked condition, for example, increases from approximately 50,000 to 110,000 lbs. per square inch, that is the molybdenum-containing alloy is a better spring material. In the second place, the thermal variation of modulus in the 9 per cent molybdenum alloy is less sensitive to changes in nickel than the molybdenum-free alloys. This is shown in Figure 5 which gives curves like

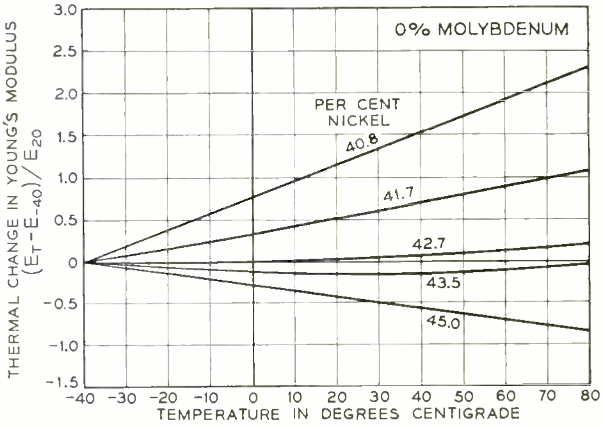


Fig. 4—A plot of $(E_T - E_{-40})/E_{20}$ against temperature for cold-worked iron-nickel alloys of different percentages of nickel.

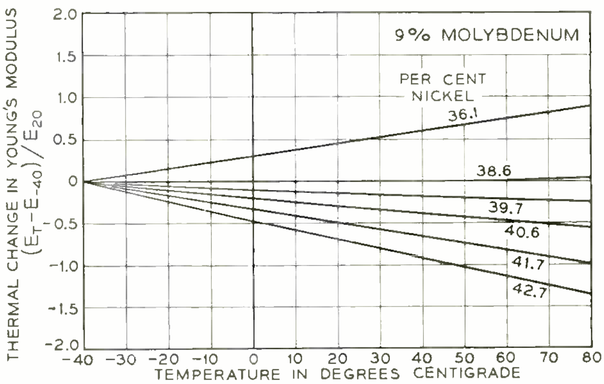


Fig. 5—Plot of $(E_T - E_{-40})/E_{20}$ against temperature for a number of cold-worked iron-nickel alloys containing 9 per cent molybdenum.

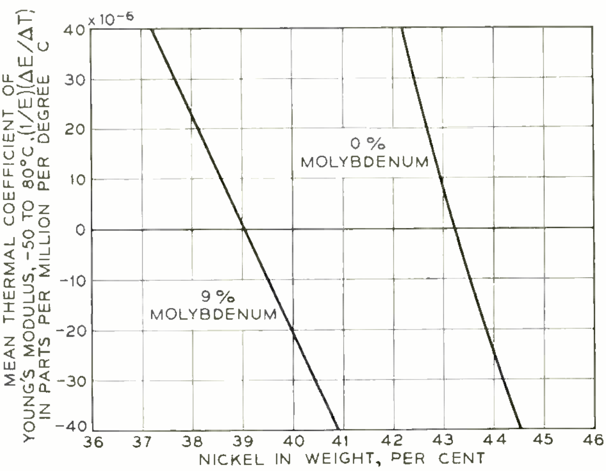


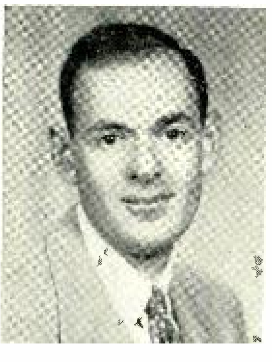
Fig. 6—Plot of mean thermal coefficient of Young's modulus against nickel content for iron-nickel alloys.

those of Figure 4, but for a set of cold-worked alloys with 9 per cent molybdenum. Although the range of nickel for alloys of Figure 5 is more than 50 per cent greater than that for Figure 4, the curves fan out less. This is very desirable from the standpoint of controlling the thermal variation in modulus by controlling the composition.

Molybdenum does reduce the ferromagnetism, but a 9 per cent molybdenum alloy has sufficient ferromagnetism for efficient magnetic actuation of vibration. The permeability at 3500 gauss of the 9 per cent molybdenum alloy, work hardened, remains between 700 and 850 over the temperature range −40 to +80 degrees C.

The curves contained in Figures 4 and 5 can be summarized briefly by plotting their mean slope against nickel content as abscissas. The mean slope is obtained by dividing the relative change in modulus on heating from −40 to +80 degrees C by 120, the temperature range over which the change is taken. Curves obtained in this manner, one for 0 per cent molybdenum and one for 9 per cent molybdenum, are given in Figure 6. The addition of 9 per cent molybdenum has diminished the sensitivity of the mean thermal coefficient of modulus to changes in nickel content by a factor of 2, which is shown by the greater slant of the curve for the 9 per cent molybdenum alloys.

From such curves as these, it is very easy to select the particular alloy required to secure the desired temperature-modulus characteristics. These curves hold, however, only for a definite amount of cold working. With a different cold working, different curves would be obtained. The curves of Figure 6 were obtained with cold-worked rod samples of 0.200 in. diameter. Rolling the material to 0.015 in. thick reeds for the vibrating reed selector displaces the curve for 9 per cent molybdenum in Figure 6 to a somewhat higher range of nickel content.



THE AUTHOR: M. E. FINE joined the Laboratories in 1946 and since that time has been engaged in metallurgical studies. Before joining the Laboratories Mr. Fine was employed on the Manhattan Project at the University of Chicago and later transferred to Los Alamos to continue work on this nuclear energy project. Mr. Fine was graduated from the University of Minnesota in 1940 with the degree of Bachelor of Metallurgical Engineering. While on a research fellowship and later as an instructor in physical metallurgy at the University, he received an M.S. degree in 1942 and a Ph.D degree in 1943.

Test Tapes for Automatic Accounting Centers

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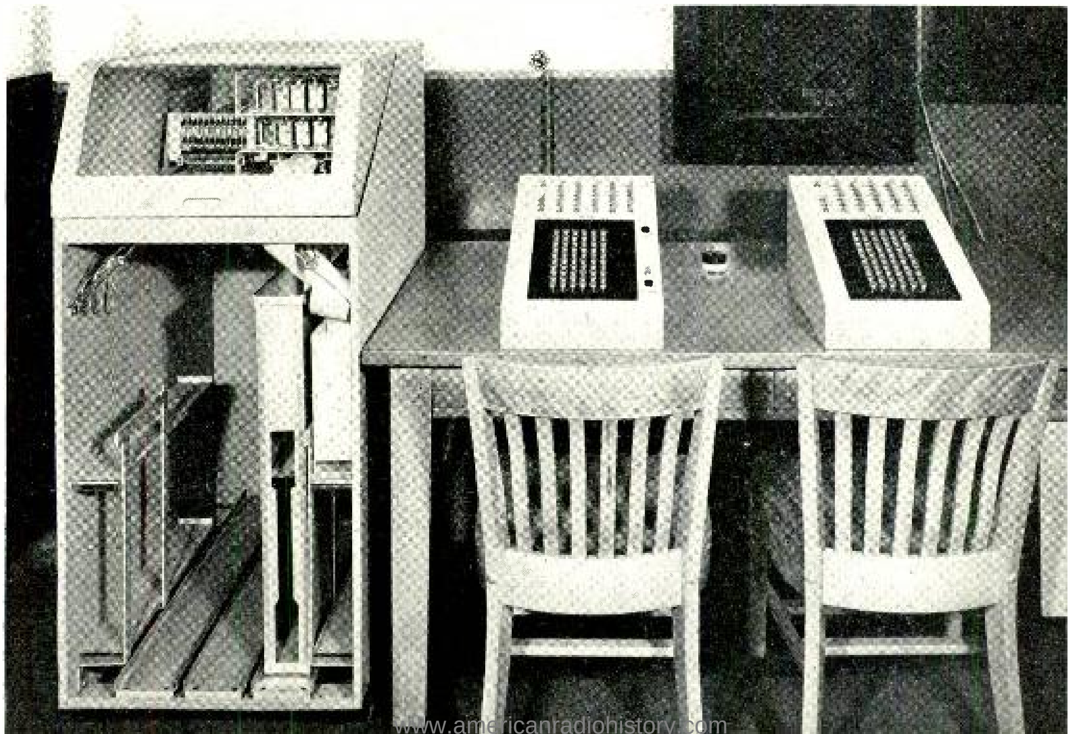
Machines of the automatic message accounting center*—assemblers, computers, sorters, summarizes, and printers—are of a type unique in telephone systems in that they function without benefit of interconnecting leads to pass intelligence from one to another. In place of the more usual wire connections, these machines read holes which have been perforated in paper tapes to gain the information necessary to their jobs, and all of them provide a physical output in the form of other punched tapes, printed call tickets, or summary sheets.

Four of the machines, the assembler, computer, sorter, and summarizer, perforate other tapes to furnish information to subsequent machines in the processing series, while the printer makes its output in the form of typed records. In all cases, all operations of each machine are fully determined by the punched hole information on the tape which is fed into it. Similarly, for every punched paper tape fed into a machine, there can be only one correct output whether in the form of tapes or printed matter. Such machines can best be tested by means of specially prepared test-tape inputs and by checking the machine's output against master output tapes or lists, provided this checking or comparing process can be carried out with sufficient speed and accuracy.

Since each line of an AMA tape is in the form of coded six-digit numerals, the tapes used to feed the test information to each machine, and also those used for comparison with the machine's output, are designed by preparing lists of numbers to

* RECORD, *February*, 1952, *page* 70; *June*, 1952, *page* 237; *May*, 1952, *page* 227; *July*, 1952, *page* 289; *July*, 1952, *page* 299; *and August*, 1952, *page* 321.

Fig. 1—The test tape perforator includes a reader, two key sets on a table, and a small relay cabinet evident just below the table top at the right.



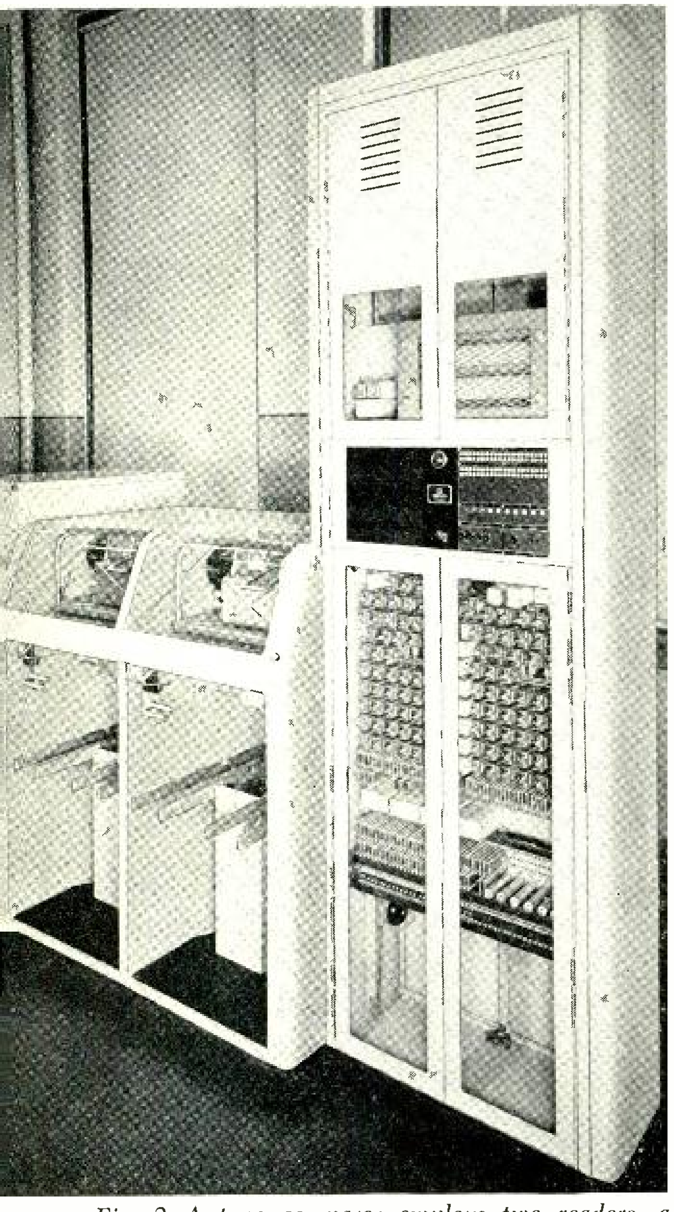


Fig. 2—A tape comparer employs two readers, a large cabinet of relays and other control apparatus.

represent the information to be punched into the tapes. These numbers are tailored to the operating peculiarities of each machine so as to provide as complete testing as possible with a minimum number of entries. The number lists also carry information for key manipulations and some other special operations required of the test man.

Copies of these number lists are also used by the test man in locating trouble when the machine stops during testing. For this reason the lists are also made to carry as many "sign posts" as possible to facilitate analysis of troubles when they occur. Several expedients are used for this purpose: digits that do not affect the operation of the machine on particular tests are arranged in ascending numerical order; deliberate errors are introduced into the tape to cause machine stoppages at predetermined points; and meaningless repetitive entries are used to mark certain positions on the tape by producing visually recognizable punched hole patterns.

After the number lists have been designed, the test tapes represented by these number lists must be manufactured. To facilitate this operation, a test tape perforator was developed. As shown in Figure 1, this consists of two key sets mounted on a table on which is also mounted a small cabinet for the register and relays that control the operation of a perforator of the type used in other AMA machines.* In perforating a test tape, two operators are used, and each is furnished a copy of the test tape number list. Each operator writes the entries on her list on her own key set. Since the lists are identical, the operators should be writing the same number at each writing. The associated relay circuits monitor the results of the two operators' keying for each line of six numbers by a match check similar to that described later in this article for the tape comparer. If the numbers match, the relay circuit causes the associated perforator to perforate the number corresponding to the identical key setups. The keys of both operators are then automatically restored, and the operators proceed to write the next line. If any lack of agreement in the key settings is found, the circuit refuses to perforate the line until the operator at fault corrects the error.

In addition to the design and manufacture of the test tapes and test tape lists, there still remains the problem of making the comparison with the machines' outputs sufficiently rapid and accurate. In the case of the printer, a visual check of the output is unavoidable. This check, however, has been made as convenient as possible by showing the expected output in printed

* Record, *November*, 1951, *page* 504.

form on the input test-tape number lists alongside the entry line numbers.

A different sort of problem is posed by the assembler, computer, sorter, and summarizer. The output tapes from these machines contain thousands of lines of punched holes which must be compared with previously prepared output test tapes to determine if they are exact hole-for-hole duplicates. To provide a speedy and accurate means of tape comparison, a tape comparer was developed. It is used also for comparing new test tapes with the originals. Since the test tapes are paper, their life is limited. Thus new tapes must be made rather frequently, and these reproduced test tapes must also be compared line-for-line before the worn originals may safely be discarded.

The tape comparer, shown in Figure 2, employs two standard tape readers, and the tapes to be compared are fed into them. Relays in the comparer so control the line stepping of the two readers that the tapes are compared for identity line-for-line; the machine stops and sounds an alarm whenever any lack of identity is noted or whenever either tape violates the code system used by having too many or too few holes on either tape.

Included in the relay cabinet at the right of the two readers are two relay registers, one for each reader. As each line is read, the six-digit number is recorded on the associated register. A circuit is wired through the contacts of the register relays in such a way that unless the same numbers are recorded on both registers, and unless, for each 2-out-of-5 digit, two and only two of the five relays are operated, the circuit will not be closed and the two readers will not be stepped to the next line. The portion of this circuit for the last digit of the line is shown in Figure 3.

To obtain the highest speed of operation and to provide reliability, it was found necessary to operate the two readers in synchronism with each other. In view of the fact that the readers are driven by induction motors and fixed gear trains, this provided an interesting problem. The solution was found by taking advantage of the fact that, with a fixed load, induction motor slippage can be made to vary slightly with the applied voltage. The reader motors are required to drive only a relatively light and fairly constant load consisting of the reader gear train and tape reading and moving mechanism. It was found that the insertion of a fixed resistor into the power feed of one reader motor after it had reached running speed was sufficient to guarantee that it would run somewhat slower than the other reader motor and still leave sufficient reserve power for all reader operations. Control over the other reader for synchronizing purposes was obtained by periodically cutting in and out a resistance in series with its power circuit. The control arrangement used is shown in the simplified diagram, Figure 4.

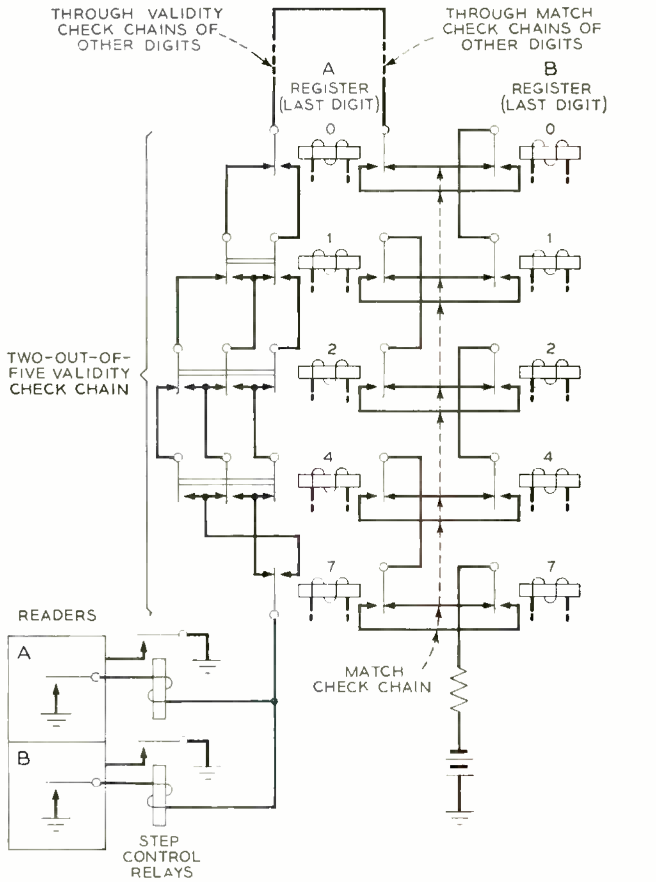


Fig. 3—A simplified schematic of the comparer circuit for one digit. Only if the same digit is read on both, will the two readers be allowed to step.

To understand the operation of this circuit arrangement, assume that readers A

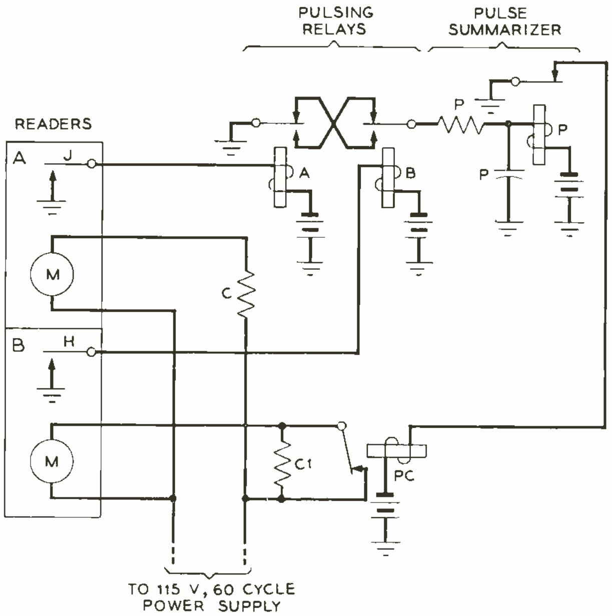


Fig. 4—Simplified schematic of control circuit that keeps the two readers operating in synchronism.

and B are running with their respective cam contacts J and H momentarily in synchronism. Relays A and B operating from these contacts will also be in synchronism and there will be no tendency for relay P, which is in series with the reversed transfer contacts, to operate. Reader B however, is running faster than reader A because of resistor C in series with the reader A motor. Contact H and its relay B, will, therefore, become slightly out of phase with contact J and its relay A. With relays A and B slightly out of phase, ground pulses are delivered to the 8-mf condenser P through resistor P at the beginning and end of each reader cam cycle. As the out of phase relationship increases, these ground pulses discharge condenser P to the point where the difference between the potential on condenser P and the 50-volt supply becomes sufficient to operate relay P. The operation of relay P causes the release of the power control relay PC which in turn introduces resistor C1 into the power leads to the reader B motor. This relatively high resistance in its power leads causes the motor of reader B to lose speed, thus bringing contact H back into phase with contact J. This brings relays A and B also back into phase with each other, thus ending the ground pulses to the pulse summarizing condenser P.

The ending of these ground pulses permits the potential to build up on condenser P to the point where relay P releases, reoperating relay PC. With the re-operation of relay PC, the speed of reader B is once more increased because of the removal of resistor C1 from its power leads, and the speed control cycle, just described, repeats itself. This arrangement provides a degree of syn-

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chronization sufficient to keep both readers stepping reliably on each line read and to avoid the loss of time which would otherwise result from each reader waiting for the other when out of synchronism.

Because of the flexibility of the test tape method of testing, it has been possible to impose upon each machine a much greater number of testing conditions than would have been practicable with specially designed test sets or manual testing. Also, since test tapes are made to conform in general with the requirements for the regular processing tapes, their use permits some of the routine testing to be done, if desired, by the regular operating forces.

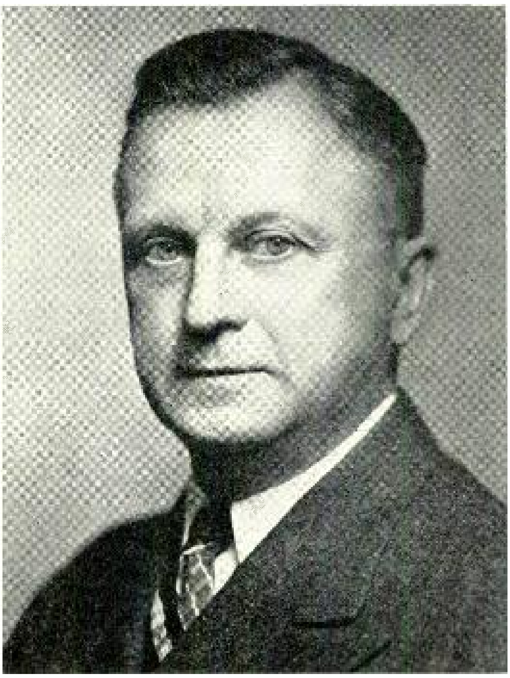
A T & T Chief Engineer Retires

On July 31, Harold S. Osborne, Chief Engineer of A T & T and an internationally known communications engineer, retired after 42 years of work with the Bell System. After earning a doctorate from M.I.T., he joined the Bell System in 1910 and began work on problems of transmission and protection. In 1940 he was appointed Plant Engineer and in 1943 Chief Engineer of A T & T. During World War II he served as consultant to several government agencies and since 1951 has been a member of the Domestic Communication Industry Advisory Committee to the National Production Authority.

Dr. Osborne has been an active member of many organizations, serving as President of A.I.E.E., Vice President of the American Standards Association, and President of the United States National Committee of the International Electrotechnical Commission. He has written extensively on telephone engineering and other communication services. In addition, he has published several works on city planning, a subject with which he became familiar through organizing the town planning board and by serving as Commissioner of Public Works of Montclair, New Jersey.

Dr. Osborne will be succeeded by H. I. Romnes, who joined the Bell System in 1927. A graduate of the University of Wisconsin and a former member of the Laboratories, Mr. Romnes worked in the Engineering Department of A T & T until 1950, when he was appointed Director of Operations for Long Lines Department.

As Mr. Romnes takes over Dr. Osborne's duties, A. F. Jacobson, Vice President in charge of operations for the Illinois Bell Telephone Company, will become Director of Operations for Long Lines. Prior to his term in Illinois Bell, Mr. Jacobson was a member of the Northwestern Bell Telephone Company in Nebraska and Minnesota, and in 1949 became Vice President in charge of operations for the Northwestern Bell.



Harold S. Osborne

Solid Sound

L. G. KERSTA
Transmission Research

Ever since Descartes devised analytic geometry, people have been preparing graphs to bring in the visual sense of form as an aid to evaluating the nature of physical, economic, and other problems. Most of these graphs are line patterns in two dimensions on a plane but they may also be produced as curves or surfaces in space, that is, in three dimensions. In studies being made on the information-bearing characteristics of speech we have produced such forms for determining the nature of movements in specific sounds, such as the digits. They enable us to "see" the sound in space as well as hear it. The three dimensions used are time, frequency, and energy, and we have dubbed the resulting spatial representation "solid sound."

A primary tool for providing a visual display of sound on a flat recording surface is the sound spectrograph*. Figure 1 shows two sound spectrograph patterns of the repeated sound, "la-la." At the left is a portion of a standard spectrogram which adequately portrays time, along its length, and frequency, across its width. The third dimension, amplitude, is inadequately portrayed because of inherent limitations of the tracing medium. The only clue to amplitude is the small range of variation in the density of the tracing which the eye has difficulty in interpreting. At the right of Figure 1 are patterns made when an auxiliary device is used that is able to portray an amplitude range not limited by the characteristics of the tracing medium. This increased the measurable amplitude range from about 12 db to 40 db.

This improved amplitude portrayal is made, however, at only one instant in time, and since the definition of a sound requires the study of many successive instants in time, a series of these portrayals or "sections" becomes necessary. Figure 2 shows such a series, with each spectrogram section representing a time slice of 1/72 sec., taken from a recording of the word "five" spoken by a male voice. It is from such a series of spectrographic sections that the original "solid sound" model shown above was constructed.

The raw material "slices" or "sections" illustrated in Figure 2 were automatically recorded by a sound spectrograph on a special facsimile paper. These, however, did not lend themselves readily to the construction of solid sound models. This was because of their small size, and because the paper was not a very good construction medium. Each slice was therefore enlarged by a factor of four, using pantographic means to inscribe the slice pattern directly upon sheets of plastic. These sheets were then cut out and stacked to form the "loaf," of the entire word (Figure 3). The plastic models were used to make molds from

* Record, *January*, 1946, *page* 7.

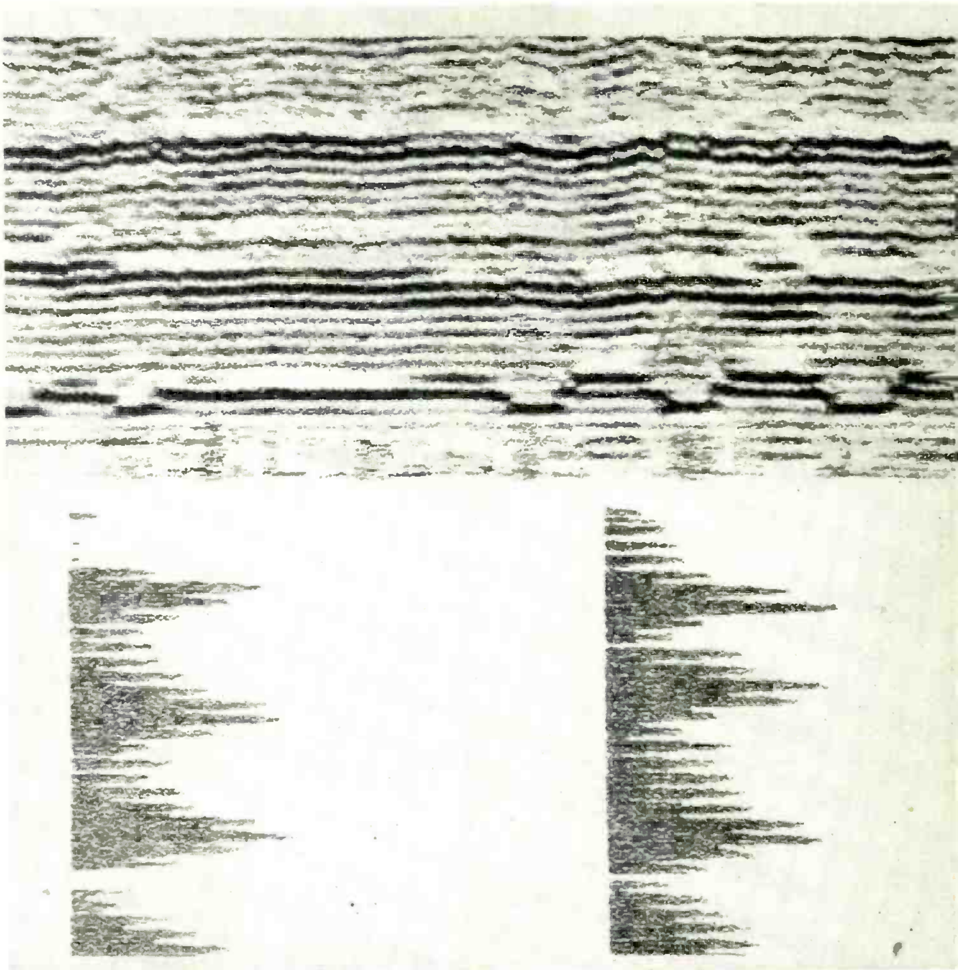


Fig. 1—Conventional spectrogram and amplitude section of the repeated sound la-la.

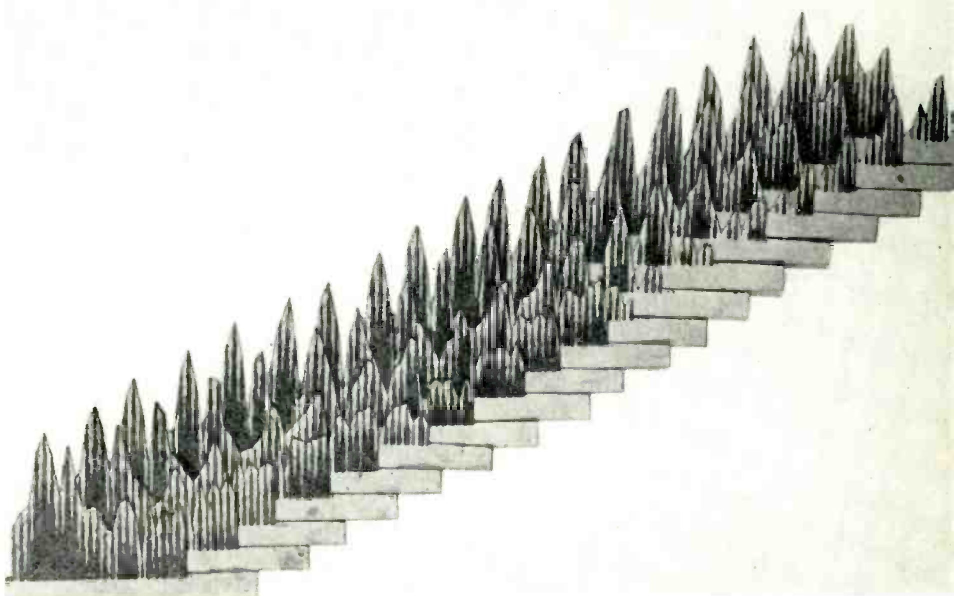


Fig. 2 — Exploded view of digit 5.

which the final plaster of paris models were cast. It was by this process that the models shown on page 354 and in Figures 4 and 5 were made. The two solid sound models represented in these illustrations are of a male voice uttering the digits "five" and "nine" respectively.

Now that it is possible to see in one three-dimensional piece a word that was heard in one piece, what can be learned that is not evident from other means of analysis? We have the word before us in the form of a relief map showing "mountain ranges," deep "valleys," and lesser "foot hills." Our standard three-dimensional spectrogram lets us follow the location of the ranges in frequency as a function of time but gives a poor idea of the steepness of the slopes, that is, the selectivity of the vocal resonances. The two-dimensional spectogram, or section, gives us a good measure of the last quality but only at one instant of time. Putting both together to get the solid sound model gives us a useful supplement to these more usually employed procedures which provides a better visualization and a check on possibly overlooked features in the dynamics of a sound.

By seeing simultaneously the full dimensions of time, frequency and energy of the spoken digit "five", for example, we determine that there are two very high ranges and a third, smaller range, joining the high ranges from a group of what might be termed "foothills". Since the frequency increases from left to right and time progresses toward the back of the model, we note that when "five" is spoken the initial, moderately high ranges signify loud energies at two low frequency areas. These areas are close, fairly well merged and broad at the beginning where the "f" of the "five" is being generated and separated into two well-defined and distinct peaks through the voicing of the "ive" part. It is generally significant that consonants are represented by very broad frequency energy and that voiced sounds such as those for vowels result in sharply peaked ranges with deep valleys. This may be seen in the latter part of the model for the digit "five".

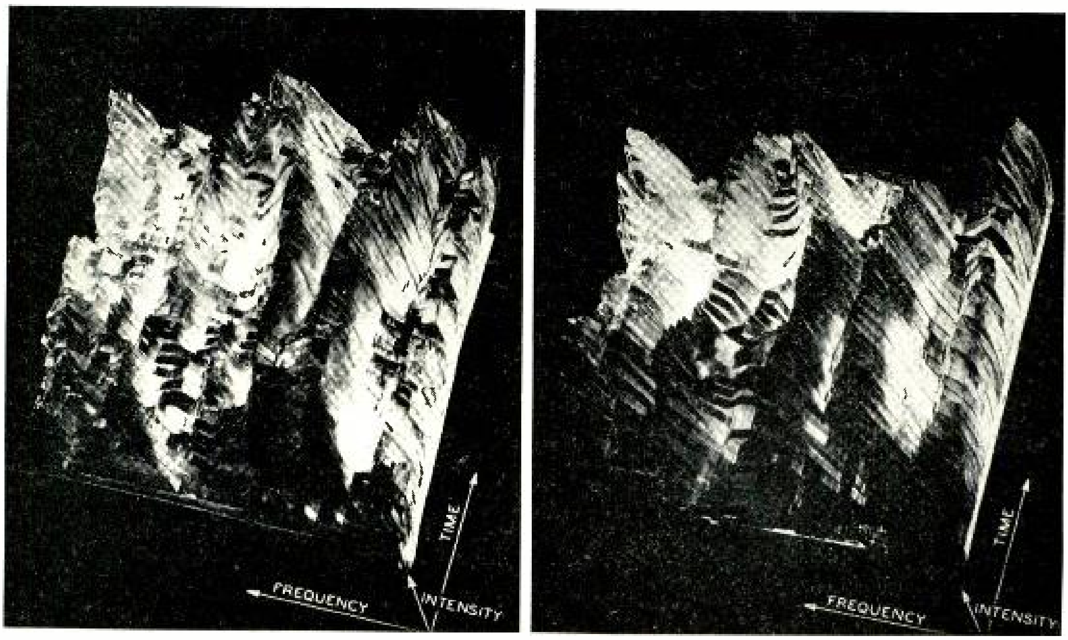


Fig. 3—Plastic "loaf" models of digits 5 (*left*) *and* 9.

Means are available which allow us, by the use of selective filters and various electronic techniques to vary transmission conditions in terms of time, frequency, and energy to determine the corresponding influence on our interpretation of what we hear. We find that the identity of vowels

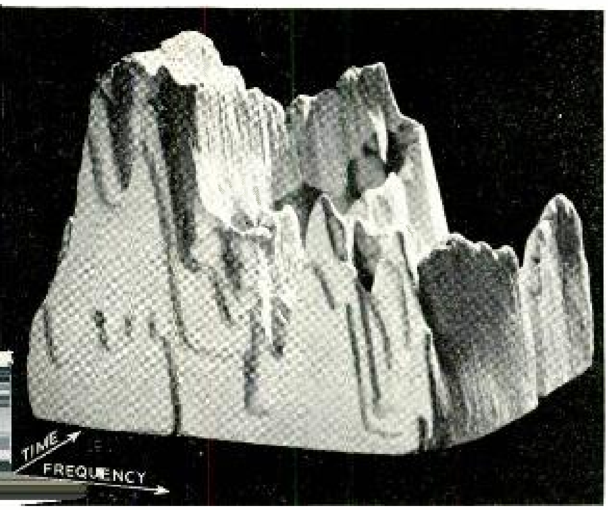
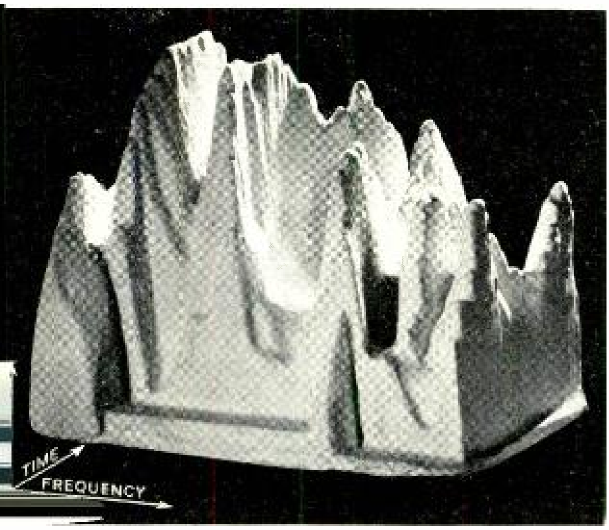


Fig. 4—Solid sound model of digit 5.

Fig. 5—Solid sound model of digit 9.



is contained almost entirely in their two major peaks. The identity of consonants depends upon their starting and stopping characteristics, and upon the areas of energy concentration. Although the major ranges for a given phonetic pattern look very similar for a variety of speakers the smaller ridges or "foothills" in the valleys may vary. These are believed to depend on emphasis, inflection, and on speaker identity.

The solid sound model for the digit "nine" (Figure 5) conforms in a general way to the "five" model in that it has two major peaks at its low frequency end. Here, however, the similarity ceases since the course of the ranges is different and the "foothills" bear no resemblance to each other. At the beginning of "five" we saw evidence of broad frequency energy, but in "nine" we see two widely spaced peaks—a characteristic of the sound of "n". Thus as we proceed through models of the other digits we find each defined by a different and distinctive "mountain range".

The significant fact to be derived from studying solid sound models is the individuality of the principal ranges for sounds, and the similarity of these ranges for any given sound regardless of the speaker. The solid sound technique allows us to observe all the speech sounds of the language, and to classify them by observing their individual characteristics. Knowledge of such fundamental factors of speech is applicable not only to present transmission problems, but is expected to further our understanding of such problems as the design of voice-operated devices.

THE AUTHOR: L. G. KERSTA entered the Laboratories in the summer of 1925 as a Technical Assistant. After three years, during which he attended the Technical Assistant School, he left temporarily to continue his studies at Columbia University. Returning to the Laboratories in 1930, Mr. Kersta worked in the Research Department on linear circuit problems, including modulation studies on transatlantic radio circuits, coaxial terminal systems, multiplex and privacy systems, and harmonic producers. From 1940 to 1945 he was at Whippany, where he was engaged in radar research. After 1945 he was with the Transmission Research Department, conducting research on selective voice control devices. Since 1951 he has been with the group studying user preference.

Bardeen and Brattain Honored

John Bardeen and Walter H. Brattain will be awarded Stuart Ballantine Medals by the Franklin Institute on the fifteenth of October. The presentation will be a part of the Medal Day ceremonies in the Institute's Franklin Hall in Philadelphia. The citation accompanying the medals reads in part "in recognition of their contributions to the theory of surface states in semi-conductors and of their invention of the Point Contact Transistor, a device foreshadowing a notable advance in the means of electromagnetic communication."

A transistor is a simple device which may eventually replace the vacuum tube in many applications. Its operation depends on the electrical transmission characteristics of the relatively rare element germanium. Research on the characteristics of germanium and other semi-conductors led Dr. Bardeen and Dr. Brattain to the invention of the transistor. Already in use in certain telephone equipment, it holds great promise for military as well as commercial applications.

Since his work on semi-conductors and the transistor at the Laboratories, Dr. Bardeen has joined the faculty of the University of Illinois and is now teaching there as a Professor of Physics. Harvard University will have Dr. Brattain as a visiting lecturer during the fall term of the forthcoming academic year. He and two assistants will conduct a graduate course on the use of transistors and he will share with Professor Harvey Brooks of the Division of Applied Science in conducting a seminar on solid state physics underlying transistor behavior.

U. S. A. F. Technical Advisory Group on Armaments

A Technical Advisory Group for the Air Force Armament Center at Eglin Air Force Base, Florida, has recently been established. This group of outstanding scientists, educators, and engineers will give individual and collective assistance toward solving the complex problems involved in development testing of new armament. H. H. Bailey of the Military Electronics Department at Whippany represents the Laboratories among the group.

The Armament Center was established December 1, 1951, as part of the Air Research and Development Command for the purposes of testing all types of aircraft armament, conducting research and development related to such tests, and providing test facilities for contractors and other governmental agencies. To date, approximately $20,000,000 has been authorized for facilities and instrumentation required at the Center.

More Overseas Service

Direct transoceanic radiotelephone service has recently been opened by A T & T to two additional foreign countries. Finland will handle its traffic to America over a new 5,600-mile direct circuit, instead of routing it as formerly through Stockholm, Sweden. In addition, five important Portuguese territories have also been linked to the United States via overseas radiotelephone by A T & T and the Portuguese Radio Marconi Company. Through Lisbon, calls to and from the Azores, Maderia, and Cape Verde Islands in the Eastern Atlantic and Angola and Mozambique in southern Africa can be completed.

Standards Organization

Announcement of an agreement among technicians of the United States, Canada, and Great Britain on unification of engineering standards was made recently. J. R. Townsend of the Laboratories, Assistant to the Director, Office of Defense Mobilization, was temporary chairman at the meeting of standardization experts from the three countries. A permanent organization has been set up with Howard Coonley, Director of Conservation, Defense Production Administration, as chairman.

General accord was reached on all major items such as drafting standards, screw threads, pipe threads, threads and fittings for gas cylinders, and fits and tolerances. Agreement on most standards is anticipated in the near future as mutual defense efforts require the maximum possible interchangeability of materials and equipment.

Finding Gas Leaks In Cable Sheaths

M. W. Bowker
Cable Methods Engineering

Had Oliver Cromwell been a telephone man, his famous admonition "—mind to keep your powder dry" might well have been "—mind to keep your paper dry." Although paper is not ordinarily highly regarded as a material of engineering, in the form of insulation on telephone cable conductors it has for more than a half century served a most important use in a very satisfactory manner. However, paper is a thirsty material, and wet paper means lowered insulation resistance and hence circuit trouble. Since any hole in the cable sheath provides a potential channel for the influx of water during the next rainstorm or inundation, the matter of finding sheath breaks so they can be repaired before trouble occurs has received much development and field attention. Aerial cable in particular is exposed to damage from a variety of man-made and natural sources, most of them inherent to its environment.

The entrance of damaging moisture may be minimized effectively by maintaining the cable under gas pressure*. Most of the toll cable is now maintained in this manner, and systems recently developed for use with exchange cable plant are attracting a growing interest. With the increased use of pressurized cable maintenance and

* RECORD, *March*, 1934, *page* 214.

the resultant reduction in moisture troubles, a shift of emphasis occurs toward the problem of developing economical methods for locating openings through which gas escapes from the sheath.

From the beginning of pressure maintenance, gas leaks have been located by the gradient method. Any cable of given size and structure has a uniform pneumatic resistance analagous to the electrical resistance of a conductor of given size and material. When a sheath break occurs, the continuing loss of gas causes the pressure to fall to some minimum value at the point of leakage and as gas flows from both directions toward the leak, the pressure along the cable is affected to a uniformly diminishing extent as the distance from the leak increases. Under these conditions, pressures are measured at valve points distributed along the cable on both sides of the leak and are plotted against the corresponding longitudinal measurements of distance. The approximate location of the leak is indicated by the point of intersection of the two falling gradients. The exact location of the leak is arrived at by careful visual inspection which includes painting all suspicious areas of sheath with a soap solution so that any escaping gas will be detected through the generation of soap bubbles.

The gradient method gives good results and reasonably accurate initial leak locations when the leaks occur singly and are large enough to cause a substantial lowering of the gas pressure. Its accuracy on aerial cable is seriously impaired by temperature differentials imposed by changing shade and sun exposures, by sudden cooling such as from a rainstorm, and by normal temperature fluctuations. Additionally, the smaller the leak, the less accurate the initial location, and multiple small leaks along a length of cable give no recognizable gradient. In these more difficult cases it may be necessary to soap a considerable amount of cable. This becomes a time-consuming procedure, and it has been a development objective to find quicker and less expensive techniques for locating aerial cable sheath breaks.

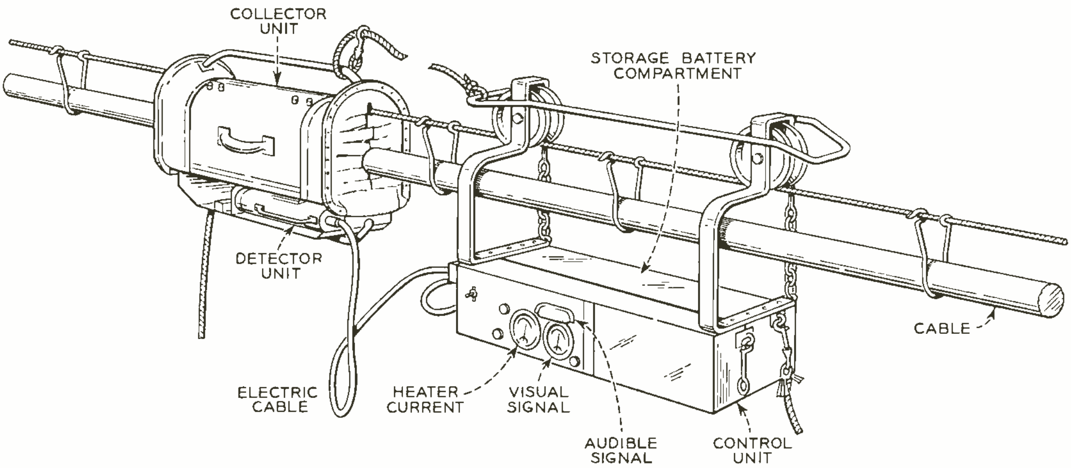


Fig. 1—A perspective drawing of the B Leak Locator.

The Laboratories has explored various methods for easier location of gas leaks and has received numerous suggestions including the placing of colored or scented gases in the cable so that one could see or smell a gas leak. These are intriguing ideas but the fact is that there are no known harmless gases which could be satisfactorily seen by the human eye or detected with the human nose. However, a sensitive electronic nose has been developed which can detect very small leaks of a special gas. Appropriately enough, this device has been nicknamed "The Sniffer."

The sensitive element of this gas detecting apparatus is a halide gas detector developed by the General Electric Company

Fig. 2—The collector opened and the detector removed.

outer cylinder at a negative potential of approximately 300 volts relative to the inner cylinder, the ion emission is collected to form an ion current, and any halogen compound striking the inner cylinder causes the ion current to increase. The element is particularly sensitive to Freon 12 (CCl_2F_2), a common refrigerant, which at normal temperatures is an inert, non-toxic gas. It was therefore reasoned that, if a telephone cable could be charged with this harmless gas, the sensitive detector could be used to locate leaks.

for locating leaks in refrigerating systems. The element operates on the principle that an incandescent electrode will normally emit positive ions, and if any compound containing a halogen (chlorine, fluorine, bromine, or iodine) strikes the heated electrode the positive ion emission will increase markedly. The element is essentially two coaxial platinum cylinders, the inner one of which is heated to incandescense by an indirect heater. Platinum is used for the electrodes because it can be operated in air at the required temperature without significant oxidation. By maintaining the

To make use of the characteristics possessed by the element it was necessary to develop apparatus that could be pulled along a Freon filled cable, take a sample of the air surrounding the cable, and pass it through the sensitive element. A schematic diagram of the complete apparatus designed to fulfill these needs is shown in Figure 1 and for discussion can be broken down into four essential components: the collector, the detector, the control unit, and the power supply. The collector which is shown open in Figure 2 is essentially an aluminum tube which surrounds the cable and acts as a combination windshield and gas collector. It is equipped with steel skids, so that it rides along the strand which supports the cable, and it has a hinged bottom so it can readily be placed over and removed from the cable. The bottom section contains a compartment which normal-

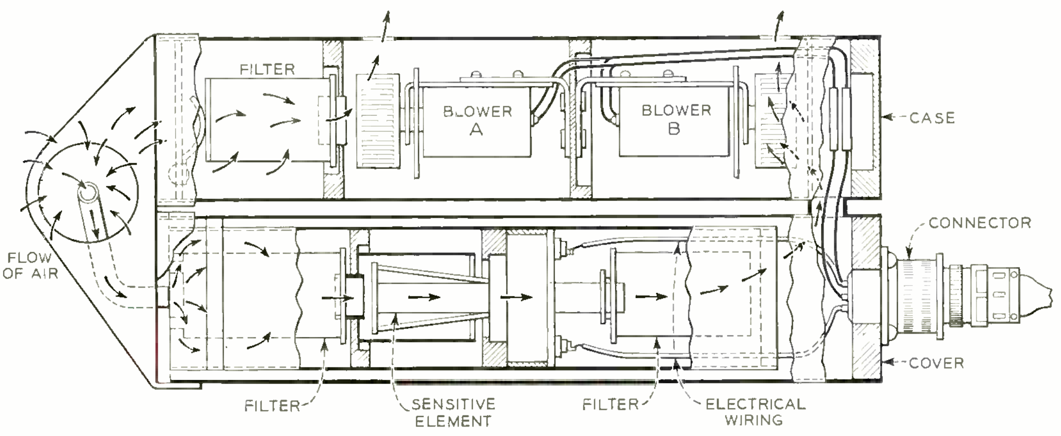


Fig. 3—Arrangement of the components of the detector. For quicker sampling of the contents of the collector, a liberal flow of air past the sampling point is maintained by blower A. Filters on both sides of the sensitive element protect it from dust.

Fig. 4—Charging the cable from a tank of Freon.

ly holds the detector. This latter unit, which is shown in the foreground of Figure 2 and a schematic of which is shown in Figure 3, is designed so that it will draw in a relatively large sample of air from the collector. A portion of this sample is continuously drawn through the small tube from which it is passed through the sensitive element. In this way the sensitive element continuously receives a representative sample of the air surrounding the cable.

The control unit and power supply have been combined into a single unit fitted with wheels so that it can ride along the suspension strand with the collector. The control circuit is essentially a dc amplifier terminated in a relay which operates a bell so that if the sensitive element receives a "sniff" of Freon, the current increase through the element will actuate the circuit to ring the bell.

The heater of the sensitive element requires a power supply of approximately 50 watts, and this is furnished from three light-weight lead-acid storage batteries. In order to maintain minimum weight, storage cells with a capacity of one-half day of operation are used. Thus under continuous operation two sets are required for each day. The vacuum tubes of the amplifier operate from dry batteries which are included in the control unit.

Field experience with the apparatus indicates that the original objective of being able to pull the entire apparatus along the cable and operating the bell whenever the locator passes over a significant gas leak has been realized. The sensitivity of the apparatus is such that it will detect leaks of 1/100 cubic foot per day when it is pulled at the rate of 120 feet (one average cable span) per minute. At a rate of 1/100

Fig. 5—The B Locator during a trial run in Westchester County, New York.

of a cubic foot per day it would require about two weeks to fill a one gallon jar. Leaks of this size, although smaller than are usually considered necessary to locate, may eventually grow to larger ones. Thus the locator makes it possible to "take a stitch in time to save nine."

In general the operating procedure has been to fill a complete gas section (up to 17 miles of cable) with Freon before starting with the locator. This is accomplished by connecting Freon tanks (see Figure 4) in the middle of each three to four miles of cable, opening valves at each end of the section and approximately at the half-way points between tanks, and letting the Freon push the air or nitrogen out of the cable. When the Freon arrives at and flows from the open valve it can be "seen" because it creates refraction effects similar to heat waves often seen on a hot day.

The normal locating procedure uses two or three men who climb the poles to transfer the apparatus from one side of the pole to the other and one man who pulls the unit along the cable from pole to pole. When the collector passes over a gas leak some of the escaping gas is drawn into the detector, the ion current increases, is amplified in the control unit, a relay operates and the bell rings. A milliameter gives a visual indication as a supplement to the audible alarm. In general, when the bell operates, the apparatus will have been pulled from one to ten feet beyond the leak which caused the signal. The normal procedure is to stop when the bell is first heard and wait for the collector and detector to clear themselves of the halogen gas after which the bell will stop ringing. The unit is then pulled backward, approximately a foot at a time, until the bell rings again. At this time the collector is usually over the gas leak. A cable man then climbs up to the cable from a ladder or rides out to the locator on a cable car, removes the detector and pushes the collector aside. He passes the inlet of the detector slowly along the cable until the bell rings again. At this time the inlet of the detector is usually within a few inches of the gas leak and careful inspection with a soap solution will reveal the fault. Since at the temperature of the flame of a soldering torch, Freon breaks down into corrosive products, the leaks are tagged as they are found with the locator and repaired after the Freon has been removed from the cable by pushing it out with nitrogen.

Fig. 6—Moving the collector past a pole.

When the cable is along roads or where the right-of-way is such that a truck can be driven along the cable route, the control unit and batteries are carried in the truck and connected to the collector-detector by means of an extension cord. In these circumstances only the collector-detector need be transferred at poles and the cable can be inspected approximately one-third faster. Figures 5 and 6 show the locator being used in Westchester County, New York. Since the cable was along the road the control unit and battery supply were carried in the truck.

The "sniffer," which has been coded "B Leak Locator," has been used as a reconditioning tool in which whole gas sections have been inspected and also as an aid in locating individual leaks which the plant people had been unable to locate by the pressure gradient method. During the development of the apparatus a model was used to "sniff" over 200 miles of operating cable and located an average of three leaks per mile at a cost of approximately one-third that of the former method.

THE AUTHOR: Since joining the Laboratories in 1940, Miles W. Bowker has been a member of the Outside Plant Development Department. He is currently concerned with the development of pressure maintenance for cable systems. This involves the development of sensitive instrument techniques for accurately locating small sheath breaks in buried and underground cable. During World War II he worked on underwater sound systems. Swarthmore College awarded him a B.S. degree with honors in 1940. He received an M.S. degree from Stevens Institute of Technology in 1951.

Patents Issued to Members of Bell Telephone Laboratories During the Month of June

2,598,677 – W. A. Depp – *Multicathode Glow Discharge Device.*

2,598,695 – H. E. Hill and D. B. Parkinson – *Impulse-Sender With Relay Distributor.*

2,598,707 – B. T. Matthias – *Electrical Device Employing Ferroelectric Substance.*

2,599,097 – F. S. Entz and R. O. Soffel – *Radiotelephone Station Identifying System.*

2,599,357 – C. E. Brooks and W. W. Carpenter – *Automatic Telephone Billing System.*

2,599,358 – H. D. Cahill, W. W. Carpenter and T. L. Dimond – *Call Data Recording Automatic Telephone System.*

2,599,368 – E. Bruce and L. Gross – *Beam Switching System.*

2,599,392 – L. A. Kille – *Recording Device.*

2,599-409 – C. O. Parks – *Sender Test Circuit.*

2,599,753 – A. G. Fox – *Waveguide Phase Shifter.*

2,599,763 – W. E. Kock – *Directive Antenna System.*

2,600,407 – L. W. Kelsay – *Protective Device.*

2,600,466 – A. E. Bowen – *Waveguide Attenuator.*

2,600,482 – R. E. Collis and J. W. Dehn – *Electric Delay Circuit.*

2,600,500 – J. R. Haynes and W. Shockley – *Semiconductor Signal Translating Device with Controlled Carrier Transit Times.*

2,600,502 – W. H. T. Holden – *Calling Line and Private Branch Exchange Line Identifier.*

2,600,560 – W. T. McMahon – *Static Frequency Changer.*

2,600,561 – L. A. Meacham – *Pulse Modulation System.*

2,601,373 – H. F. Dienel and G. K. Teal – *Method of Making Silicon Carbide Circuit Elements.*

2,601,403 – L. Y. Lacy – *Electric Circuit.*

2,601,415 – B. M. Oliver – *Vertical Sweep Synchronizing Circuit.*

2,601,444 – M. E. Mohr – *Stabilized Multivibrator Oscillator.*

Recorded Announcement of Toll Line Delays

M. E. Maloney
Switching Engineering

The time is Christmas Day and the scene is a toll crossbar office in, let us say, Kansas City. Long distance operators are hard at work on a flood of seasonal calls which on Christmas Day, 1951, reached a national total of more than 30 per cent above normal daily load. Trunks must do extra work. Operators, too, have extra work to do, not only in coping with the additional traffic but also in handling a higher percentage of personal calls, many of them to folks in out-of-the-way places. Meanwhile, orders left by distant operators for outgoing trunks are piling up; those for trunks between Kansas City and St. Louis must wait an hour or more. To keep the distant operators informed of the situation, an operator whose services can ill be spared is put on delay quote duty.

In response to each new call for St. Louis, and probably other points, she monotonously repeats, "There will be one hour delay at Kansas City." Other girls may have to be similarly employed in quoting other delay times. The job is a wearisome one; no reply is heard; it's like saying the same thing over and over into empty air. To eliminate this tedious job and release operators for other duties in periods of peak traffic and emergency, the Laboratories have developed a "delay quote" announcing machine.

Under normal overload conditions such as those of the daily busy hour, No. 4 crossbar system switches calls to a group of overflow trunks when all intertoll trunks in a desired group are busy. If one of these is vacant, the distant operator receives back a slowly flashing signal; she then turns to other work but holds this connection on her position for a prescribed time such as five minutes. If no trunk indicates its availability within this period by increasing the flash rate, or if no overflow trunks are vacant she selects a new trunk to the same point, dials 151 and gets an operator who writes an order for the desired destination. Normally, there is the expectation that a

Fig. 1—J. A. Lehans removes wheel of delay quote recorder to inspect magnetic rubber band which accommodates as many as six recordings. Three of the channel amplifiers and associated power supply appear in the tray below.

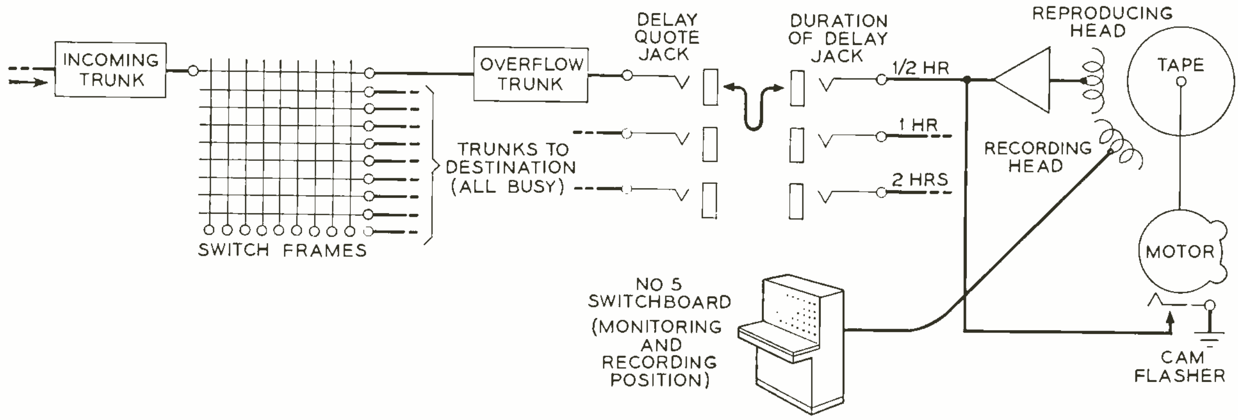


Fig. 2—Block diagram of connection to delay quote machine.

trunk will be available within, let us say, twenty minutes. When, however, the chief operator foresees delays of a half hour or more, she may arrange for calls reaching overflow trunks to be switched to the delay quote operator or, preferably, to the new announcing machine.

Mechanized announcing was first used in the Bell System switching plant in the late 20's to announce a call registered in a sender; the object was to permit an operator to leave the line and attend to other calls instead of waiting to pass the called number to a distant operator. Recordings, too, were introduced to relieve an operator of monotonously repeating weather and time announcements. For many years, however, the application of mechanized announcing in the telephone system was limited by the relatively high cost of announcing machines, and the large amount of attention needed to maintain them. With a background of the rapid progress in the recording art, the Laboratories have developed recording media and machines sufficiently economical and rugged for applications such as delay quoting.

The machine which has been applied to delay quoting is shown in Figure 1. The recording medium is an elastic surface, currently neoprene impregnated with magnetic oxide and stretched like a flat tire on the wheel. This recording surface rotates, and six pairs of record-reproducing and erasing heads provide for six different recordings. The head for each channel feeds through a channel amplifier; three of these amplifiers with their power supply are shown mounted beneath the recorder. The output of each channel amplifier is fed to a control trunk and distributing network to jacks in a traffic supervisory panel, as indicated in schematic Figure 2. When a two hour delay, for example, is posted at New York for calls to Taunton, Mass., a patching cord at the panel inserted between a "Taunton" jack and a "two hour" jack automatically steers all calls landing on Taunton overflow trunks to the "two hour" channel of the recorder.

Because an operator who has dialed a call may have to cut out to work on another line, it is necessary to attract her attention by flashing a cord lamp. For this purpose, cams on the rotating message drum generate two flashes in the control circuit ahead of the announcement. After these flashes and before the recorder puts the announcement on the wires, there is an additional interval also generated by a cam known as the "guard time" to allow certain toll line cir-

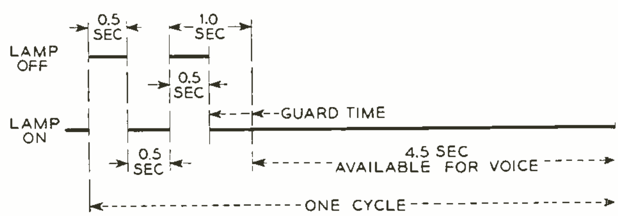


Fig. 3—Time cycle.

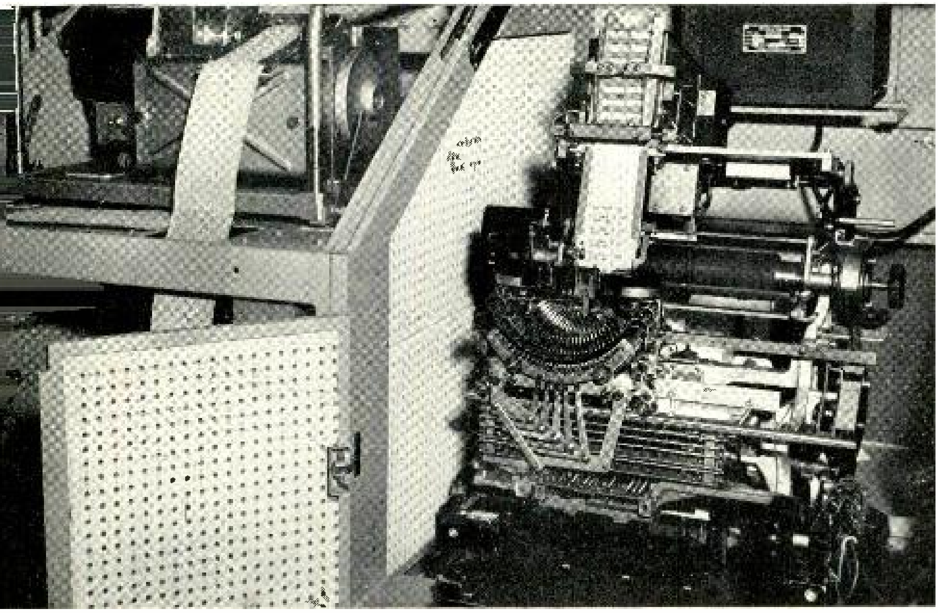
cuit relays to operate (Figure 3). The entire cycle including the flashes, guard time and the announcement occupies about 6.5 seconds. The 4.5 second interval provided for the announcement has proved adequate to date.

Control of the equipment is in the end position of the No. 5 switchboard (Figure 2). Here the machine may be started, and each channel monitored for clarity and volume. Any channel may be erased and a different announcement recorded at will by the controlling operator.

Delay quoting also permits more efficient use of trunks in overload periods at points far removed from the congested area. For example, a call from Plattsburg, New York, to Maryland may be routed through either New York or Baltimore. In the event of a delay, the Plattsburg operator would not ordinarily know whether it was occurring in New York or Baltimore. Through delay quoting she is at once informed that there is, for example, a two hour delay in New York or a one hour delay in Baltimore. Simultaneously, the same announcement may also be heard by an operator in Wichita, trying to reach Boston and another in Atlanta, trying to reach Schenectady. Thus, all interested operators know that it is futile to make further attempts through the quoted point, and so do not uselessly engage idle trunks which could be employed for good calls. The new announcing machine also renders the delay quote function more efficient by freeing not only an operator but her position on the No. 5 switchboard for other services which cannot be handled by a mechanism.

The switching control circuits were developed by a group under the supervision of F. S. Entz, of Switching Systems Development. R. A. Miller's group developed the recorder-reproducer and amplifier.

THE AUTHOR: MARTIN E. MALONEY is currently engaged in engineering work to expand the applications of crossbar tandem switching systems. He joined the Laboratories in 1927 and has since contributed to the development of PBX, crossbar, automatic ticketing, and nationwide dialing systems. During World War II he worked on communications for aircraft warning and fighter plane control. In 1923 Mr. Maloney received a B.S. degree from Georgetown University and in 1927 an E.E. degree from Cornell University.



The AMA Printer

T. A. MARSHALL *Telegraph Systems Development*

In all the automatic message accounting processes described in previous issues of the RECORD, the information is in the form of numbers perforated in "2-out-of-5" code in paper tape. The original information was recorded in this form in the central offices, and it has been assembled, computed, sorted, and summarized in the accounting center, and new tapes have been prepared in the same 2-out-of-5 code. Before the bills representing these various charges can be made out, this information must be translated from a sequence of digits in 2-out-of-5 code into the corresponding words and numbers, and then printed for use by the accounting center personnel. It is this translation and printing that is the major function of the AMA printer.

As may be seen from Figure 1, the printer consists essentially of a regular AMA reader for obtaining the information from the tape, relay circuits for interpreting and translating the tape information, and a teletypewriter for printing the call records. This equipment is mounted in six cabinets: the printer itself is in the left hand cabinet, the reader in the next cabinet, and the relay equipment, in the four taller cabinets. The printer proper, shown in greater detail in Figure 2, is a standard 15-type teletypewriter modified by the addition of arrangements for cutting the typed paper strip into toll tickets and stacking them in the ticket box, evident on the top of the machine, and by a few other changes. The reader is the standard AMA reader already described in the RECORD*, but the control circuits differ somewhat from those used with the reader in the other stages of the accounting process. Just above the middle of the first relay cabinet is the control panel on which dials are set to identify the particular tape being processed. These are shown in greater detail in Figure 3.

Although the printer is designed for processing and recording tapes of several different types, its general method of operation can be indicated by describing the processing of the two types of input tapes that comprise the main bulk of the work of an accounting center. One of these, which is prepared by the summarizer, contains all calls charged for on a message unit basis. These calls are grouped according to the central offices, and for each central office are arranged in numerical order of the call-

* RECORD, *June*, 1952, *page* 237.

ing number. For each calling number there is a two-line entry giving the calling number and the total number of message units chargeable for one accounting period. For these message unit tapes, the output of the printer takes the form shown in Figure 4. It is a strip of paper three inches wide and folded every eleven inches. At the top is printed the central office name and the date, and below, in numerical order, are the calling line numbers with the number of message units chargeable to each during that month. In all cases the printer uses a zero with a slant line through it to represent a significant zero, and a dash to represent a non-significant zero. A list including every subscriber in a 10,000 line office would require about 180 feet of paper, and would fold to form a pack eleven inches long and about 200 sheets thick.

The other of the two most important types of tape supplied to the printer includes all toll calls, which are perforated as a 5-line entry, also in order of the calling number under each central office. For these tapes, the output of the printer takes the form shown in Figure 5. These are slips of paper three inches wide and five inches long, and are thus of the same size as the slips prepared manually by operators for calls beyond the dialing range. This equality in size facilitates correlating the slips in preparing the subscriber's bills. Each such slip records the calls of only one subscriber, and may record as many as nine calls. When there are more than nine calls for a subscriber, more than one slip is required. At the top of the slip is placed the subscriber's office name and line number, and also the month. Each call is represented by two typed lines. The first gives the day of the month, the hour and minute the call was answered, the called office area index, and the called office abbreviation, while the sec-

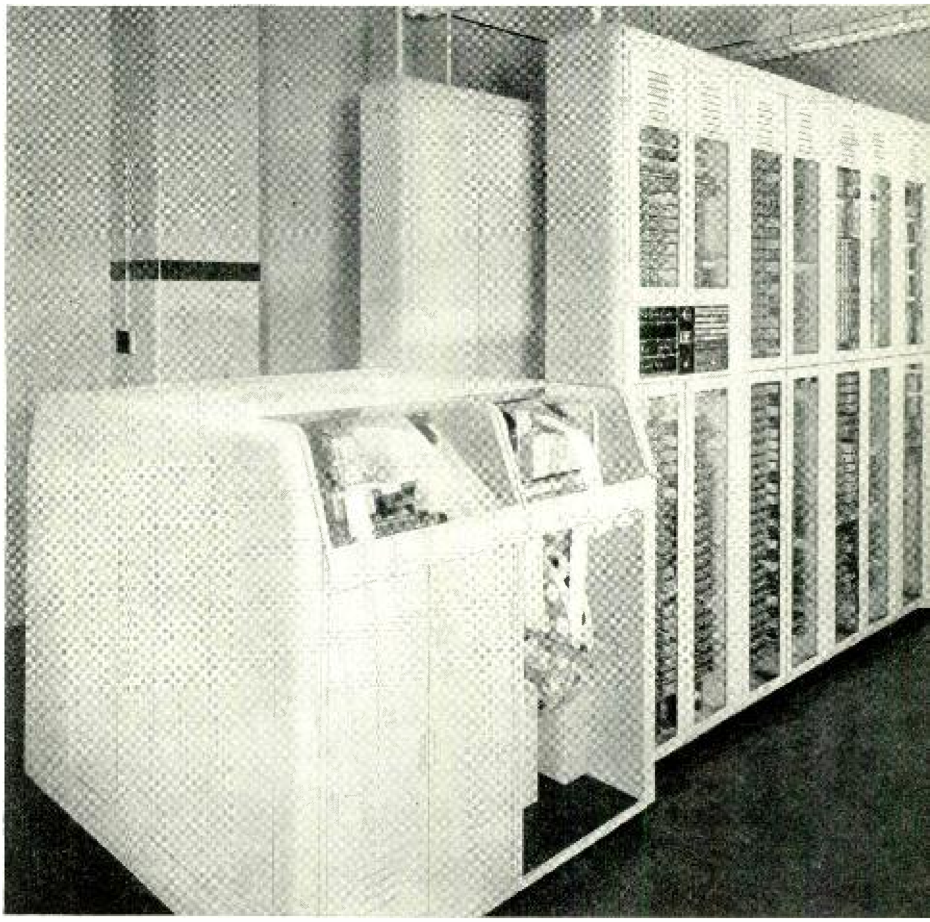


Fig. 1 — An AMA printer includes, from left to right, a printer, a reader and four bays of relay equipment.

ond line gives the called line number and the chargeable time in minutes. The time the call was answered is given on the basis of a 24-hour clock: the first two digits represent the hour, ranging from 01 to 24, and the last two digits give the minutes after the hour and range from 00 to 59.

The reader is capable of reading and advancing the input tape at the rate of sixteen lines per second, while the teletypewriter operates at a speed of 600 operations per minute, or ten characters per second. Each entry on the message unit output tape requires ten operations, including the carriage return, as may be seen from Figure 4, and thus requires about 1 second, while the corresponding input entry can be read in one-eighth of a second at the most. A similar discrepancy exists for the toll tapes. An entry on the output toll slip requires about two and one-half seconds, as may be estimated from Figure 5, while the corresponding input entry can be read in five-sixteenths of a second. For both types of tape it thus requires about eight times as long to print the output entry as to read the input entry. As a result, the reader is operated intermittently instead of continually. The circuits of the printer include a number of storage circuits, and each line of the input tape is registered in one of them as it is read. After a complete entry has been received, the reader is stopped, and is not started again until the printer is ready to begin printing the next entry.

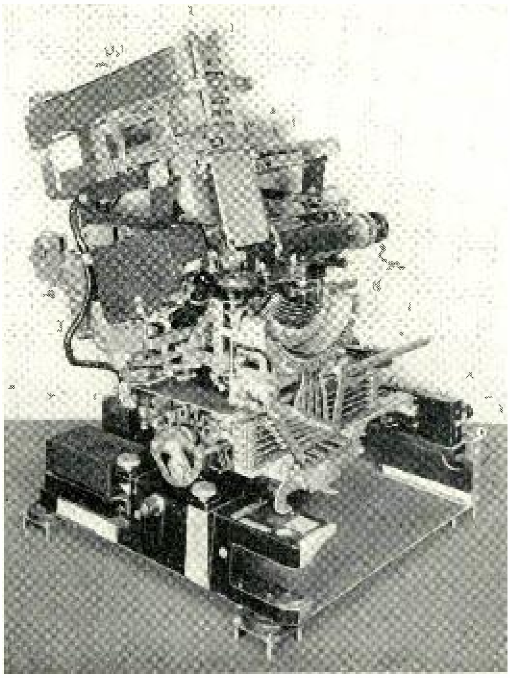


Fig. 2—For printing the output tapes and tickets, a standard 15-type teletypewriter is employed with a cutter, a stuffer, a ticket box, and a few other items added to it.

In processing a two-line message unit entry, the printing begins as soon as the first line is registered in the proper storage circuit. The second line will be immediately registered in its proper storage circuit. Then the reader will step the tape to the first line of the next entry and wait for the printer to finish the entry. Simultaneously with the return of the type basket of the teletypewriter to the left margin of the paper, the information in the line being held in readiness by the reader will be

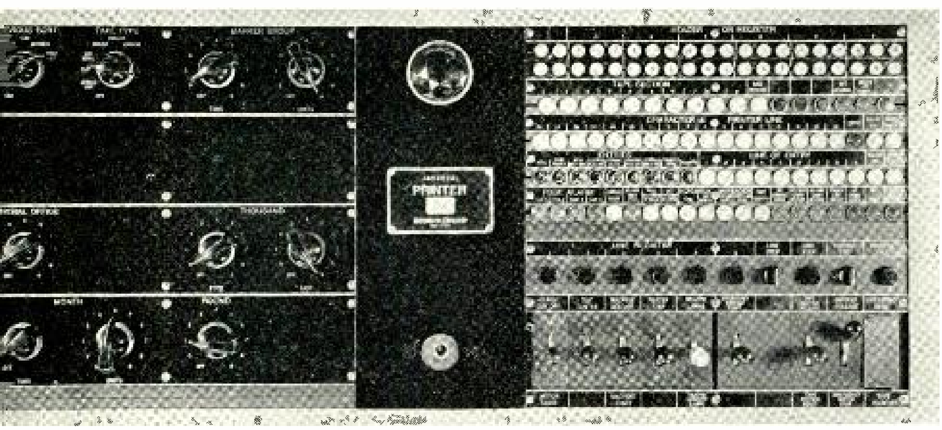


Fig. 3—The control panel for the printer includes dials for setting the type of tape, the marker group, the central office, and the month and day to which the tape applies.

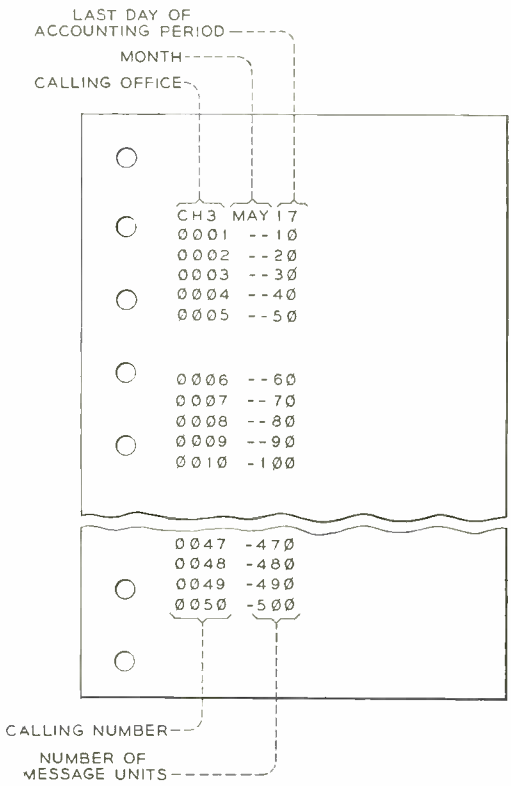


Fig. 4—An output tape for message unit calls is headed by the central office name and the date, and carries all the message unit calls made on that date as single line entries for each subscriber.

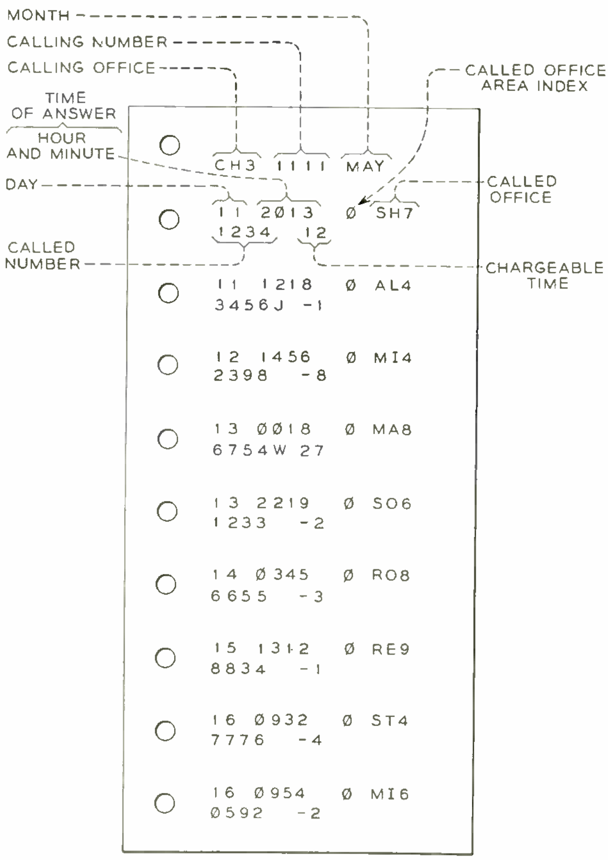


Fig. 5—Each toll ticket is five inches long and may carry as many as nine calls. It is headed by the central office name, the calling line number, and the month.

passed to its storage circuit so that the printing of the second entry may begin without hesitation.

Likewise, in processing the five-line entries of the toll ticket tapes, printing starts with the storage of the first line of the entry. The second, third, fourth, and fifth lines are immediately registered in their respective storage circuits and the reader waits, ready with the first line of the next call, for the completion of the printing of the call information.

Before a new tape is started through the reader, dials on the control panel, shown in Figure 3, are set to indicate the type of tape, the marker group that serves the calls, the central office in which the tape was prepared, and the month of the original record. Each tape carries an identification entry that was perforated in it by the computer to give this and other information. As the tape is started through the reader, the control circuit compares the tape identification entry with the information set on the dials, and gives an alarm and stops advancing if there is any irregularity.

Message unit input tapes to the printer consist of a sequence of two-line entries each like that indicated in the upper part of Figure 6. Each entry gives the total number of message units chargeable to a subscriber for one month. The printer identifies the entry by the entry index in line 1. The MU index in the B digit in line 2 has remained in the entry from previous use in the summarizer and is of no significance in the printer. Both the calling line number and the number of message units are re-

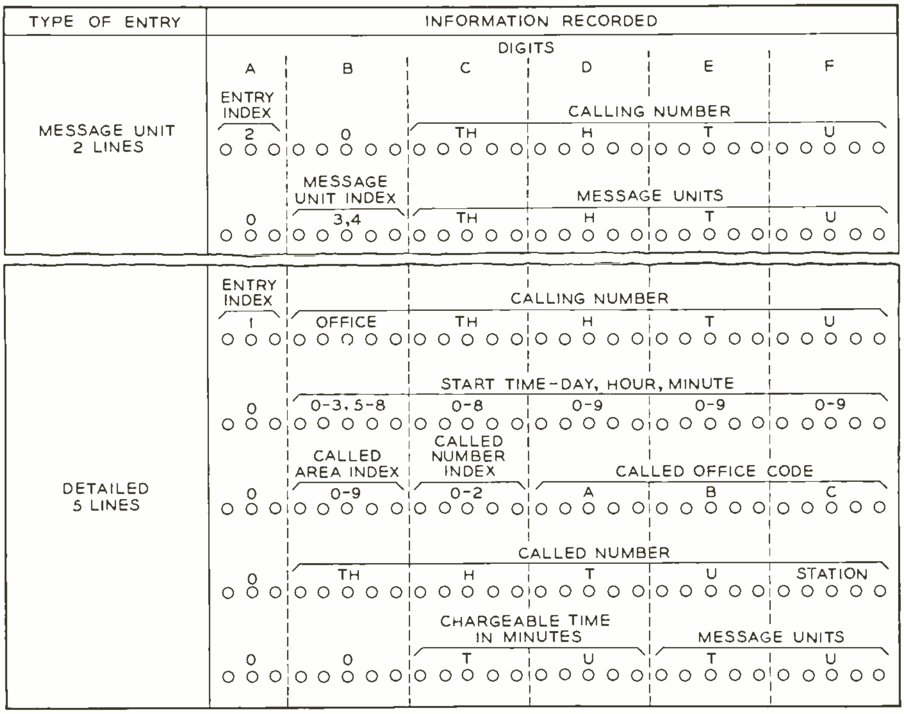


Fig. 6—Arrangement of the two types of call entries on the input tapes to the printer.

corded in the input tape in 2-out-of-5 code, but, in transferring them to the storage circuits, they are translated to decimal code. The information in the first storage circuit controls the printing of the first four characters of each line of Figure 4, while the information in the other storage circuit controls the printing of the last 4 characters of the line. Not more than 1000 message units will be recorded in one entry by the summarizer. If the number of message units chargeable to a particular subscriber is greater than 1000, the additional units will be recorded in a second entry for the same subscriber.

For these message unit tapes, the calling office and date, which appear at the top of the tape, are taken from the control dials shown in Figure 3. The name of the central office of the calling subscriber is translated from the two-digit marker group number and a single digit office designation to the familiar two letters and single numeral by the marker group translator. The three-letter month abbreviation is derived from two digits by the month translator, while the day of the month is translated from the day tens and day units dials.

For the toll tickets, the calling office number and the month, which appear at the top of each ticket, also are taken from dials on the control panel. The day of the month appears as one of the items of each entry since the calls appearing on a single ticket were not necessarily made on the same day. All the calls indicated on the toll ticket, however, are made by the same subscriber, and thus the calling line number is placed at the head of the ticket as one of the identifying marks. This is taken from the call entries on the input tape, one of which is shown in the lower part of Figure 6. These entries are grouped on the input tape according to subscriber line numbers, and successive entries will be placed on the output ticket being printed until a new number is encountered.

Each of the five lines of an input entry is read and registered in one of the storage circuits of the printer. The calling number appears in the first line, and, as soon as it has been recorded, the printer either uses it in printing the heading of a new ticket, or recognizes it as the same as the number of the ticket being printed and proceeds to print the new entry.

The first six characters of a toll entry on the output ticket are the day and answering time of the call and are translated from the five digits of the second line of the input tape. This day, hour and minute information has gone through several metamorphoses in the preceding AMA circuits. It was recorded as three separate entries in the central office tapes. The day was placed in the tape identification entry as a tens and a units digit; the hour, in the hour entry, also as a tens and a units digit; the answering time appeared in the answering time entry as three digits: minutes tens, minutes units, and minutes tenths. A total of seven digits are thus used on the central office tape to convey this information. The minute tenths digit is eliminated in the computer, and the remaining six digits are compressed by coding into five so they may be put in a single line on the output tape of the computer. This is possible because only four digits are required for the day tens digit (zero to three inclusive); only three digits for the hour tens (zero to five inclusive); and only six for the minute tens digit (zero to five inclusive). The total number of possible combinations of the three tens digits is thus 4 x 3 x 6 = 72, and since 72 things can always be represented by a two-digit number, a code has been devised by which the day tens, hour tens and minute tens digits are recorded in the output tape of the computer by a two-digit number. The day units, hour units, and message units each require one digit and thus the entire information is represented by five digits. As a result the printer must reconvert these five digits to the six digits that are actually printed on the first line of each entry of the output ticket. The four digits designating the called office area index and the called office itself, which also appear in the first line of the output ticket, are translations of the B, D, E, and F digits of the third line of the input entry. This is a more complex translation which will be described in a subsequent issue of the RECORD.

The second line of the output entry includes the called number and the elapsed time. Either four digits or four digits and a letter are required for the called line, and these are translated from the fourth line of the input entry. The elapsed time is given as one or two digits, and is translated from the C and D digits of the fifth or last line of the input entry.

Besides reading the input tape, recording the information in storage circuits, making the many translations required, and printing the output tickets, the printer carries out many checks throughout its operation. It checks the tape identification entries against the settings of the dials on the control panel, it checks every line read for complete registration in all digits, it checks many other operations, and stops operating and reports trouble on a bank of lamps whenever an irregularity is encountered. These many and varied operations call for a large and complex circuit, and, according to a *Science News Service* release of June 6, 1950, the patent* covering the printer is one of the largest on record.

* Patent No. 2,510,061 granted to D. E. Branson, G. A. Locke, and T. A. Marshall on June 6, 1950. See BELL LABORATORIES RECORD, *March*, 1950, *page* 515.

THE AUTHOR: T. A. MARSHALL joined the Laboratories in 1922, after receiving a B.S. degree in E. E. from the University of Kansas. Most of his assignments have been in the field of circuit design, and he is currently concerned with AMA printer circuits. In the past he has designed teletypewriter station and switching circuits, carrier telegraph terminal circuits, and toll development equipment such as teletypewriter switchboards and telegraph test boards. In 1934 Columbia University awarded Mr. Marshall an M.A. degree.

Oliver E. Buckley Retires

Portrait in Oil by R. P. R. Nielson, 1951.

On August 31, 1952, Oliver E. Buckley closed thirty-eight years of service in the Bell System. For half of that time he has been responsible for actively directing, encouraging, and furthering research.

Dr. Buckley's career has coincided with one of the most difficult periods in the history of industry in these United States. In 1914, as Europe went to war and America prepared to supply the Allies, Dr. Buckley entered the Engineering Department of the Western Electric Company. He came from Cornell University with a doctorate in physics and a recommendation from the well known Professor E. Merritt, "If I am not mistaken, he will go a long ways." His course has led from research physicist to Chairman of the Board of the Bell Telephone Laboratories.

Born in Sloan, Iowa, in 1887, Dr. Buckley early learned from his lawyer father the value of meticulous attention to detail so valuable to him later in responsible positions. While still in high school, he helped to install a small automatic telephone system, and took complete and detailed charge of its service and operation. In 1905, he entered Grinnell College, Iowa, where he majored in science and mathematics with such success that he was asked to assist in physics during his junior and senior years, and to teach full time the year after taking his Bachelor of Science degree. Then he moved to Cornell in 1910 as an assistant in physics, and commenced to work for his doctorate. In 1914, he was awarded the degree of Doctor of Philosophy in physics, and on July 13 became a member of the Research Branch of Western Electric Company.

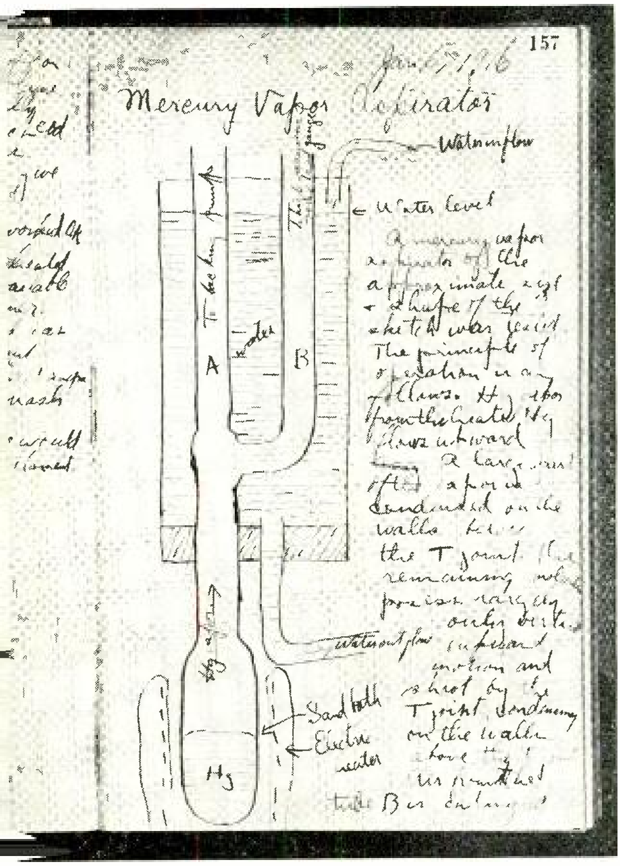
Under the direction of Dr. H. D. Arnold, Dr. Buckley commenced research into the practicability of using a mercury vapor arc as a high frequency oscillator for the projected experiments with transatlantic telephony. His thorough study convinced him that the mercury arc was not an efficient high power device. Therefore, it was decided to use the Type W vacuum tube, developed by Dr. Arnold, for the famous Arlington demonstration.*

Dr. Buckley was assigned to direct the manufacture of the large number of tubes required for the demonstration. They were evacuated with four Gaede rotary molecular pumps in a small tube shop in Rooms

* Record, *October,* 1925, *page* 43.

846-848 at West Street. The quantity was so large relative to the facilities of the shop that it was necessary to work twenty-four hours a day. Dr. Buckley religiously supervised the work, spending most of his time there during the day and calling in just before going to bed at night and just after arising in the morning. By dint of such unstinting labor, the tubes were ready in time for the demonstration. For the first time, the practicability of radio telephony was demonstrated by actual transmission between the Arlington naval antenna and the Eiffel tower in Paris, and by an accompanying transmission to Darien, San Francisco, and Honolulu.

As a result of his preparatory work for the Arlington experiment, Dr. Buckley saw the need for better tools if tubes with higher vacuum were to be made, so he developed an improved type of mercury vapor pump, and invented the ionization manometer which still remains the most efficient means for measuring extremely low gas pressures.



Page 157 of Dr. Buckley's notes on experiments with the Mercury Vapor Aspirator.

In 1917, Dr. Buckley became First Lieutenant Buckley. He had been working on Western Electric's contract with the Navy Department at Nahant, Mass., on experiments for detecting submarines, when the Army called him to active duty. His military assignment was to join the newly formed Division of Research and Inspection of the Signal Corps, with whom he sailed to France. On arrival he was promoted to Major, and was made responsible for directing all the considerable research carried out by this Division. In October, 1918, he was ordered to Washington, D. C., to assume complete responsibility for all technical matters in radio for the A. E. F. and to advise the A. E. F. on technical problems connected with wire communication.

When World War I ended, Dr. Buckley returned to Western Electric Company to commence research on improving the transmission speed of submarine cable. During the war, telegraphic messages had piled up so rapidly that transatlantic communication was choked. Some practicable and economical means for increasing operating speeds had become vitally necessary. After preliminary investigation, Dr. Buckley determined that new and better cables were required. He agreed with earlier scientists that a marked reduction in attenuation and a considerable increase in speed would be possible if the inductance of the cable were increased. Land lines had been loaded since 1900, but sea cable presented greater difficulties. However, "permalloy", a nickel-iron alloy, had just been invented in 1916 by G. W. Elmen, and Dr. Buckley envisioned the possibility of smooth continuous loading with this alloy by wrapping it around a conductor of the cable.

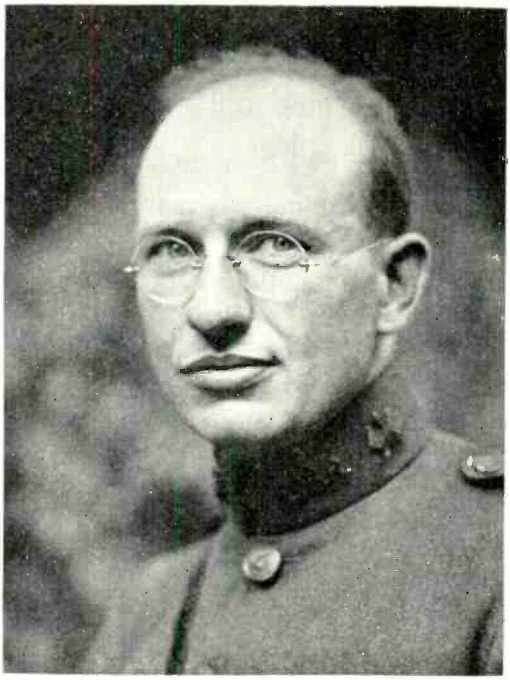
From his analyses he estimated that the speed of the transmission could be increased more than four times, and extensive research bore him out. However, production difficulties had to be overcome before the cable could be used in practical installations. For example, in the manufacture of permalloy, the heat treatment is critical. Moreover, severe mechanical strain will destroy the properties induced by the heat treating. Techniques for precisely controlling both the manufacturing and the laying of the cable had to be developed. All obstacles finally were overcome, and in 1924 the cable was laid between New York and the Azores. It performed exactly as predicted. Its message capacity was four times greater than that of previous cables, although its cost was almost the same, and attenuation was markedly lessened.

Dr. Buckley had developed a cable which has become the prototype for all subsequent high-speed telegraph cables. Today, there are in operation more than 17,354 nautical miles of permalloy loaded cable. The most striking aspect of this achievement was concretely expressed by Dr. H. D. Arnold: "The successful outcome of this work involved the most careful attention to details in a field where a mistake would involve very great loss. The Cable Company staked several million dollars on the New York-Azores cable on our engineering recommendations and our recommendation was based upon Dr. Buckley's estimates, from which we found it unnecessary to depart in any detail whatever. When one considers the magnitude and difficulty of this work it is evident that his grasp of the scientific factors underlying the project and his judgment in properly estimating the economic and business factors involved have evidenced an ability for organizing and conducting industrial research operations of an exceptionally high order."

Dr. Buckley then developed a telephone cable made of perminvar, an improved magnetic alloy, and insulated with paragutta, a more resistant insulating material, and he guided the designing of terminal apparatus adapted to the new cable. Actual deep sea trials in the Bay of Biscay proved the effectiveness of the radically new type of cable design and construction, but economic conditions at the time made a complete installation infeasible.

Bell Telephone Laboratories, which was

HISTORIC FIRST, 1924 – *Dr. Buckley, center foreground, looking at one end of the 120 nautical-mile trial-length of loaded telegraph cable at Bermuda.*



Major Oliver E. Buckley, American Expeditionary Forces, Signal Corps, 1917.

incorporated in 1925, recognized Dr. Buckley's administrative ability and, in 1930, placed him in charge of all wire transmission research. In 1933, he succeeded Dr. Arnold as Director of Research. Thereafter, the responsibility for initiating and administering broad programs occupied him fully. Under his direction and encouragement were made such advances as a type of undersea telephone repeater sturdy enough to withstand the pressure of great depths and containing vacuum tubes and other components reliable enough to operate for many years without attention. In 1950 the first of these cables was laid and operated successfully between Key West and Havana.

In 1936 Dr. Buckley became Executive Vice President; in 1940, President; in 1951, Chairman of the Board. During the period of his executive responsibilities with the Laboratories, the country has passed through the trials of its most severe depression, the throes of its greatest war, the stresses of reconversions to civilian economy, and the tensions of rearming during a "cold war". Frequent reorientation and even major reorganizations have been required within the Laboratories to enable it to meet its obligations to the Bell System and to the nation. Through these crises Dr. Buckley and the associates with whom he surrounded himself wisely made the necessary changes promptly and smoothly, raising the Laboratories to new heights of professional morale, technical skill, and productivity. Crossbar systems for local, tandem, and national dialing; completely automatic systems for message accounting; carrier systems for cable and for open wire; broadband systems over both coaxial lines and radio: all are achievements of Bell Telephone Laboratories under his direction. Some of the nation's military communication systems, a large part of its radar equipment, its most effective gun directors, and one of its most advanced forms of guided missiles have been designed during Dr. Buckley's administration. Under his leader-

MEDAL FOR MERIT *presented with Presidential citation on September 26, 1946, by Major General Harry C. Ingles, Chief Signal Officer of the Army, to Oliver E. Buckley for his contributions to the war effort.*

Professional Activities of Dr. Oliver E. Buckley

Sigma Xi, Grinnell College, 1914

Phi Beta Kappa, Grinnell College, 1914

Phi Kappa Phi, 1914

A.I.E.E., 1919-
Vice-President, 1946-48

National Research Council, 1920-1948

Franklin Institute, 1920-

American Association for the Advancement of Science, 1922-

American Physical Society, 1922-

National Academy of Sciences, 1937

Acoustical Society of America, 1937-

Engineering Foundation, 1938-1950,
Chairman, 1939-1942

Board of Education, South Orange and Maplewood, New Jersey, 1938-1950,
Vice President, 1938-1948,
President, 1948-1950

Cornell University—Engineering College Council, 1939-

American Philosophical Society, 1942

Roscoe B. Jackson Memorial Laboratory, Member of Corporation and of Board of Trustees, 1945-

National Inventors Council, 1945-

American Ordnance Association, Advisory Committee on Ordnance, 1946-1948

Atomic Energy Commission Industrial
Advisory Committee, 1947-1948
General Advisory Committee, 1948-

National Multiple Sclerosis Society, Vice-President and Director, 1949-

American Academy of Arts and Sciences, 1949

Princeton University, Advisory Council, Department of Electrical Engineering, 1950-

Harvard University, Committee to Visit Department of Physics, 1950-

Science Advisory Committee, Office of Defense Mobilization, 1951-
Chairman, 1951-1952

Thomas Alva Edison Foundation, Trustee, 1951-

Ordnance Advisory Committee, Department of Army, 1951

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ship have been produced a telephone ten times more efficient than any of its predcessors, stalpeth and alpeth cable, transistors which will markedly alter the communication systems of the future, and a theory of information which is already revolutionizing scientific thinking in many fields.

During this period, also, he made great personal contributions to the war effort, serving on advisory, investigative and research committees for the Office of the Chief of Ordnance, for the Secretary of War, for the Secretary of the Navy, and for the President. Meanwhile, he directed the Laboratories, whose 8000 members were nearly all devoting full time to war work. For all his services, Dr. Buckley was awarded in 1946 the Medal for Merit with a presidential citation.

Dr. Buckley has indefatigably supported the advancement of scientific knowledge. He has been an active member of many scientific and professional organizations. He was elected to the National Academy of Sciences in 1937, to the American Philosophical Society in 1942, and to the American Academy of Arts and Sciences in 1949. In 1948 the President of the United States appointed him to the General Advisory Committee of the Atomic Energy Commission and in 1951 to be Chairman of the Science Advisory Committee of the Office of Defense Mobilization. Several educational institutions have recognized his contributions to science by awarding him honorary degrees. Grinnell, in 1936, conferred upon him the degree of Doctor of Science; Columbia in 1948 the degree of Doctor of Science; and Case Institute of Technology in 1948, the degree of Doctor of Engineering.

Forty-three patents have been granted Dr. Buckley for his inventions. Probably his most satisfying accomplishment, however, is the completion of the Murry Hill Laboratory, one of the most ideally designed and best equipped industrial research centers in the world. As he retires, Mr. Buckley can justifiably be proud both of his personal achievements and of his ability to coordinate and direct an organization so complex as Bell Telephone Laboratories.

Orlando-Tampa Coaxial Cable

A new coaxial cable between Orlando and Tampa, Florida, is being laid by the Long Lines Department of American Telephone and Telegraph Company. When initially completed, the 101-mile addition will provide 75 telephone circuits, and when fully developed will carry hundreds of conversations as well as network radio and TV programs.

Direct Long Distance Dialing

Faster long distance service is now available in seventeen cities in the United States. A subscriber in an area equipped with the new A4A* toll switching system may give the long distance operator a number in one of 1500 other communities and the operator can dial the number directly.

The new system, developed in the Laboratories, has just been installed in Houston, Texas, by the American Telephone and Telegraph Company and the Southwestern Bell Telephone Company. By 1953, it will carry 70,000 calls, 76 per cent of Houston's long distance traffic on an average business day. In addition, it will automatically switch calls routed through Houston to other cities. Similar installations now being made in Cincinnati and New Orleans will be placed in service later this year.

TV Network

Station KFEL-TV, Denver, has been connected into the Bell System television network, the first to be admitted as a result of the Federal Communication Commission's raising of its ban on new stations. Since the "freeze" was lifted, about 600 applications for television stations have been filed with the FCC. Construction permits have been granted for 18 stations, 5 of them VHF and 13 UHF, in 12 cities: Denver; Portland, Oregon; Spokane; Austin; Flint; Youngstown; York; Bridgeport; New Britain; Holyoke; New Bedford; and Springfield, Mass.

* Record, *May*, 1951, *page*, 197.

The newly completed Denver station is served by the Bell System's transcontinental microwave radio relay system which has been carrying TV as well as telephone circuits to the West Coast since 1951. Throughout the United States, the intercity television network is now serving 108 stations in 66 cities.

O. N. R. Conference on Magnetism

The first of its kind in the United States, a conference on Magnetism was held at the University of Maryland last month. Sponsored by the Office of Naval Research, the Conference heard about fifty papers, presented by representatives of foreign countries as well as the U. S. Joint Chairmen of the Program Committee were R. M. Bozorth of the Laboratories and J. H. Van Vleck of Harvard University. Among those who presented papers were Mr. Bozorth, P. W. Anderson, J. K. Galt and W. P. Mason and, acting as discussion leaders were M. E. Fine, E. A. Nesbit and H. J. Williams, all of the Laboratories. Former members of the Laboratories, C. Kittel and Nobel Prize winner C. J. Davisson also presented papers during the conference.

S. S. *United States*

Usual ship service aboard an unusual vessel was supplied by radiotelephones on the SS *United States* during her record-breaking, round-trip maiden voyage. Ninety-six calls were completed on the outbound trip and one hundred fifty-one on her return, making a total of two hundred forty-seven. Earlier, on her test run from Norfolk to New York, she handled ninety-six oceanic messages.

This gracious lady of the seas has a telephone in every cabin, regardless of class, and carries more phones than any other ship in history. She also holds the distinction of being the only large passenger vessel afloat from which each passenger may make ship-to-shore calls directly from their cabins. Phone numbers for within-ship service are the same as location letters and cabin numbers, eliminating the necessity for a special phone book. Her main switchboard is a standard PBX three-position board and theoretically all phones aboard may be used at once. Ship-to-shore facilities are limited by the number of radio channels allocated to the ship.

A total of 750 passenger phones includes 695 in the 344 first-class cabins, 178 in the cabin-class section, and 173 in the tourist-class section. In addition, the ship's intercom system for her officers includes 130 dial phones. Three operators handle the switchboard during the day while night service requires only one. Ship-to-shore service is maintained through the U.S. Lines' main switchboard at Pier 61, New York.

Colossal Castings

Part of a military electronic unit designed by the Laboratories, two magnesium castings recently poured are presumed to be the largest in this country. On contract for Western Electric Company, the Rolle Manufacturing Company, Inc., at Lansdale, Pennsylvania, undertook the task of pouring these giant castings. The largest of the two required 4,350 pounds of magnesium to produce a piece weighing 1,630 pounds. The extra material represents that necessary to fill the sprues, gates, and risers of the mold. The smaller one used 1,900 pounds to produce a 550 pound casting. The design and development of these giants of the foundry was carried out under the direction of S. J. Stockfleth, mechanical design supervisor, and C. L. Sappet in the Military Electronics Department at the Whippany Laboratory.

Air Force Approves

The U. S. Air Force has given favorable comment on the performance of the Bell System and connecting companies in setting up operation "Skywatch." Fifty Long Lines message circuits were taken from normal service and added to existing facilities for handling aircraft warning calls. Ground observers in twenty-seven states are in communication with each other on a twenty-four hour basis. These circuits are now being used solely for Command and Air Defense Warning purposes.

Invited Paper

An invited paper was read by R. M. Bozorth at the Denver Meeting of the American Physical Society. The meeting was held from June 30 to July 3, and Dr. Bozorth gave his talk on the second day. Titled *Recent Advances in the Theory of Magnetization*, the paper was on the theory of ferrite materials and of magnetic domains. Augmenting this was a fifteen minute movie showing action pictures of the magnetic domains under discussion.

H. A. Affel to Korea

A group of leading scientists and industrialists which visited Korea recently included H. A. Affel, Assistant Vice-President of the Laboratories. They spent about three weeks in the Far East Command after leaving Washington on July 2nd. Secretary of the Army Frank Pace, in announcing the mission, said that he felt that the effectiveness of the individual soldier can be greatly enhanced by further developments in electronics. The group gathered much valuable information on the problems involved in adapting electronics to the battlefield, so that American technical and industrial know-how may more effectively improve equipment for the Armed Forces.