# Bell Laboratories Record

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## "Signal Shaping" for Submarine Cables


By A. M. CURTIS
*Research Department*


THE problem of signal shaping, more familiarly known as attenuation equalization, is one of the oldest in electrical engineering. In 1854 certain pioneers were discussing the possibility of a transatlantic submarine cable and there was a general opinion that the current would all leak out before it reached the receiver. Partly to settle this matter, E. O. W. Whitehouse and Professor S. F. B. Morse conducted some experiments in which signals were transmitted over 2,000 miles of British telegraph lines looped to form a continuous circuit. In these experiments it was found necessary to use a type of transmission in which "signal shaping" was accomplished by having each positive signal followed by a weaker negative signal and thus partly neutralizing the effect of the capacity of the line.

In 1858, following the laying of the first Atlantic cable, attempts were made to increase its speed of about ten letters per minute by sending through a huge induction coil. This was a step in the right direction, but unfortunately the coil did not match the impedance of its circuits very well and the excessive voltage applied to the cable ruined it in a few days. These experiments now seem childish in view of our present knowledge, but it should be remembered that this all took place even before a system of electrical units had been devised, when Ohm's law was still a novelty and the very existence of inductance, as we understand it, was disputed. Before the cable failed it was established that the speed of transmission, using a mirror galvanometer as a receiver, was fifty per cent higher than that when ordinary telegraph instruments were used. The fact appears to have been overlooked that the galvanometer constituted a mechanical resonant system which when properly adjusted improved the shape of the signals.

In 1866 two successful Atlantic cables were completed. In them, use of a series condenser as an additional shaping element with the galvanometer permitted the very satisfactory speed of seventy-five letters per minute to be reached and allowed the rate per word to be reduced to one pound sterling.

In 1867 Kelvin's siphon recorder was introduced and still another shaping element, a condenser in series with the sending end of the cable, was added. Development of signal shaping methods appears to have rested here for about thirty years although the introduction of duplex operation and automatic transmission still further increased the speed to about two hundred letters per minute in each direction.

About 1898 shunt inductance elements were added to the shaping networks which then began to resemble our simpler attenuation equalizers. The improved shaping and later the use of mechanical amplifiers permitted the speed on the newer North Atlantic cables to be increased to 250 letters per minute in each direction, and here it stayed until the advent of permalloy loaded cables.

A simplex speed of 2,500 letters per minute in cable code with recorded reception has been demonstrated on the latest permalloy loaded cable laid between Newfoundland and England. At this speed vacuum tube amplifiers and complicated shaping networks are required. As the cable attenuates the higher frequencies contained in the signal much more than the lower ones, the sending networks and the receiving apparatus are designed to reverse the process and equalize the attenuation of the cable. In the final result, the overall attenuation of the system is practically constant between about one-half and fifty-five cycles per second but then increases rather rapidly until the voltage received at 111 cycles is about one-twelfth that at fifty-five cycles. The lower frequencies, which would otherwise be transmitted in excessive amounts. are penalized by series condensers, shunt inductances, and other devices which reduce the sensitivity of the receiving amplifier to the lower frequencies while making it more sensitive to the higher frequencies.

As very few engineers realize how enormous is the improvement in cable signals produced by the modern shaping systems, it will be of interest to

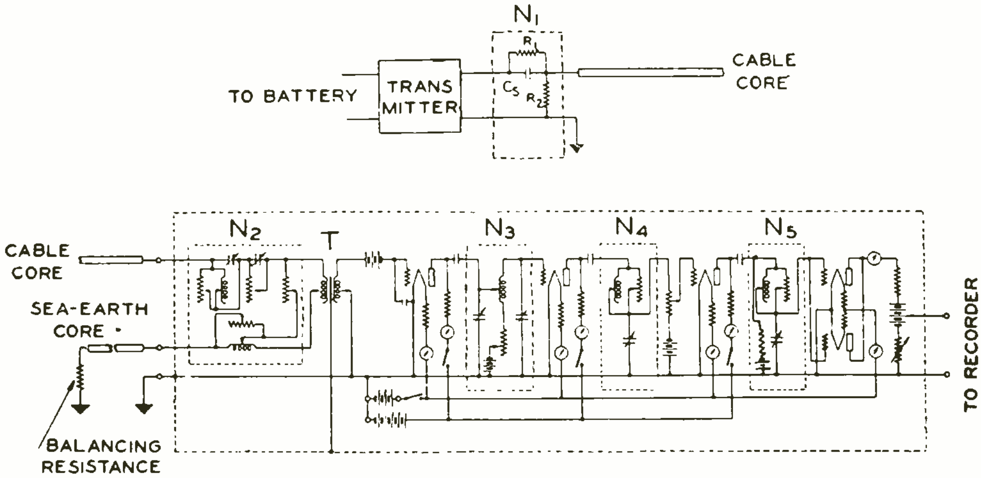



*Figure One*

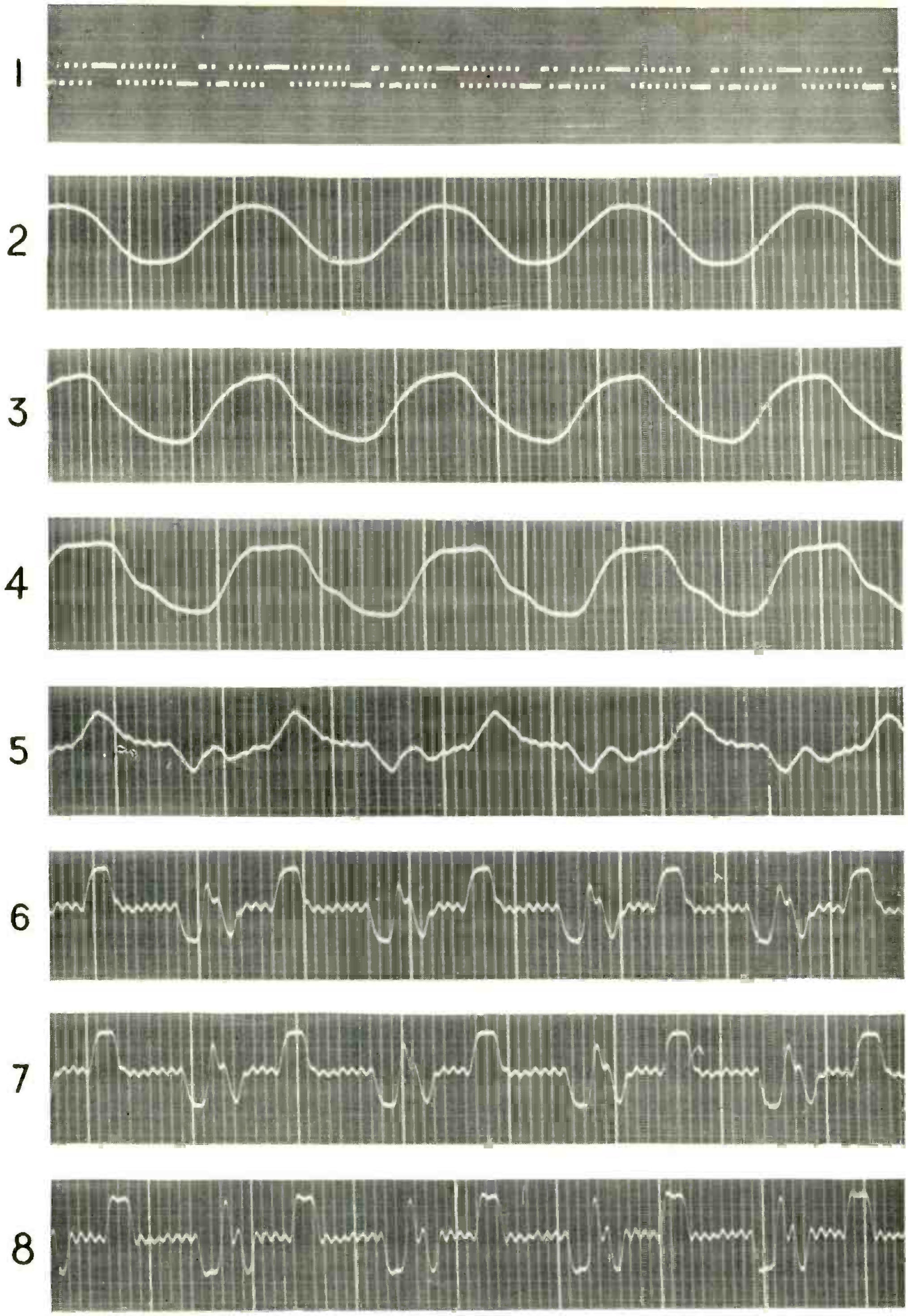



*Figure Two*

demonstrate this by a series of oscillograms made in the laboratory on an artificial line representing the cable mentioned above. The speed at which these signals were transmitted was 2,640 letters per minute. The shaping of the signals was done with the intention that the highest reversal frequency (111 cycles) would not be received from the cable but supplied by a synchronous vibrating relay which forms part of the receiving apparatus.* Oscillograms of the transmitted signals and the corresponding received signals were taken with the string oscillograph. The time lines on the oscillograms are one hundredth of a second apart. These were omitted in the case of the transmitted signals as they would have obscured the trace considerably. The cable and amplifier system used in these experiments is shown in Figure 1. Since the strong lower frequencies of the signal are suppressed in favor of the much weaker high frequencies, it is of course necessary to increase the gain of the amplifier in order to keep the received signal at a value which will operate the receiving device, which in this case is the oscillograph.

As the first step in the experiment all the shaping networks were removed from the sending and receiving terminals of the artificial line and also from the amplifier. Oscillogram No. 1 shows the voltage applied to the cable by the transmitter. It consists of a group of forty pulses forming eight printing telegraph code characters repeated continuously.

Oscillogram No. 2 shows what is received without any shaping, a slightly distorted sine wave of about five and a half cycles frequency. The amplifier gain required for this signal will be called unity and the gains corresponding to other stages in the shaping will be expressed very approximately as multiples of this initial gain merely to give a rough idea of how much of the signal must be discarded before it is intelligible.

Oscillogram No. 3 shows what happened when the sending end network was added. In this particular experiment the latter was adjusted so that its effect was not very marked, but it will be noted that the wave which was originally smooth is now quite rough and distinctly unsymmetrical. The amplifier gain was twice the initial gain.

No. 4 shows the effect of adding the shunted receiving condenser of the receiving network, N2. The gain is eight times the initial gain. A distinct inflection is now observable in the wave and it is decidedly flat on top.

No. 5 shows the effect of adding the entire receiving end network, N2, the gain being increased to seventy-five. A marked increase in definition is noted and distinct signs of the 111 cycle component appear.

No. 6 shows the effect of adding the first amplifier interstage network, N3, the gain being increased to 150. A sort of family resemblance between the received signal and the transmitted voltage can now be detected.

No. 7 and No. 8 show the increase in definition caused by adding the amplifier networks N4 and N5, respectively, the gain being approximately the same as for No. 6.

If No. 8 is now compared with No. 1, every characteristic of the transmitted signal will be recognized although the exactness of the repro-

*See *A. A. Clokey, Bell System Technical Journal, July, 1927, page 402.*

duction varies. The string of six pulses is reasonably like that transmitted. The double and triple signals are rounded off to resemble sine waves and the groups of single pulse reversals, while perfectly recognizable, are too small in proportion to the rest of the signal to be used to operate a receiving relay satisfactorily. The shaping process might have been continued until the 111 cycle component had been brought to an amplitude equal to that of the other signal components, although it could never be made an exact duplicate of the transmitted wave, as this would require the transmission of frequencies much higher than any cable will pass. It is, however, possible to apply the signal of No. 8 to the synchronous vibrating relay system and restore it to exactly the wave form transmitted. This is the plan followed in our cable printing telegraph system, as it permits a considerably higher speed of operation than is possible if the highest frequency is received in full amplitude from the cable.

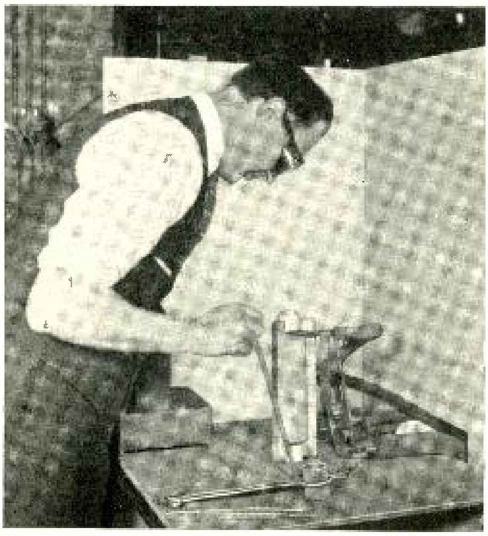
## *Bell System Plant Additions*

*Additions to plant and telephone equipment of the Bell System during* 1928 *call for an expenditure of* $420,000,000, *a sum almost half as great as the national debt at the time the United States entered the war, and considerably larger than the cost of constructing the Panama Canal. The magnitude of the operations is indicated by the facts that* 950,000 *poles are to be used, duct is to be placed for* 3600 *miles of underground cable, and circuits with a length of* 3,340,000 *miles are to be installed in aerial and underground cable. Prominent among the year's accomplishments will be completion of the second cable route between New York and Chicago.*

# Platinum Alloys for Vacuum Tube Filaments

By J. E. HARRIS
*Research Department*

THE filaments of vacuum tubes used by the Bell System consist of ribbons of carefully prepared platinum alloy coated with the oxides of barium and strontium to give a higher electron emission. It is often asked why platinum is used instead of some less expensive metal such as tungsten, molybdenum, chromium, or iron. The answer is that the material of the filament core must be of such a nature that either there



*H. L. J. Siedentop watching "melt" of platinum in high frequency induction furnace*

will be no chemical reaction between it and the barium and strontium oxides during the coating process, or in case some such a reaction is unavoidable that it will not destroy the thermionic activity of the coating.

This requirement rules out the base metals mentioned above. Tungsten, for example, when heated in air in contact with barium and strontium oxides unites with them and destroys their property of emitting electrons copiously at a low temperature. It is true that platinum may form compounds with barium and strontium oxides but these, unlike those formed with tungsten, are of such a nature that they are destroyed when heated in vacuo in the process of evacuating the tubes, the barium and strontium oxides being reformed on the surface of the filament.

The filament alloy must consist of metals which may be purified to a high degree since it is known that the presence of small amounts of impurities in the filament may have an effect on the thermionic activity out of all proportion to the amount of impurities present. This prevents the use of certain metals of the platinum group, such as iridium, ruthenium, osmium, and rhodium, which can be purified only with the greatest difficulty.

The alloys of platinum which we need are not commercially produced and this fact together with the need for exceedingly pure materials has made it necessary to purify the metals and to produce the filament cores in the Laboratories. For this purpose, the best grades of commercial materials are purchased, dissolved in acids, and carefully purified, after

*Fusing a platinum rod with oxyhydrogen torch to remove bubbles and air pockets*

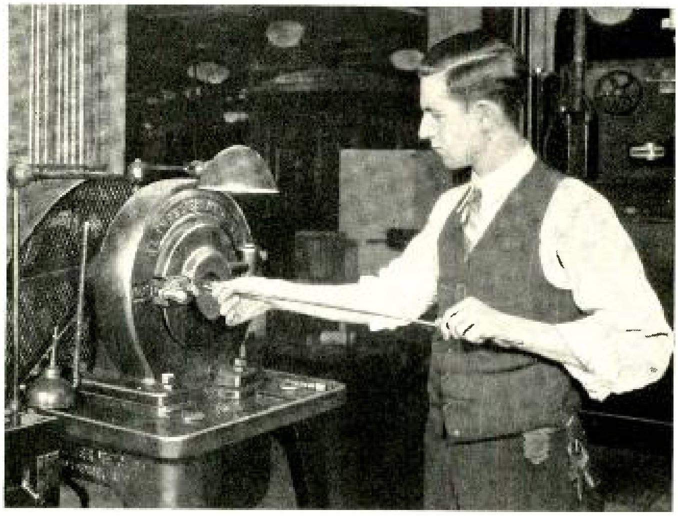
which they are reduced again to the metallic state.

The platinum comes to us in the form of platinum sponge: a gray, amorphous, powdery material not at all similar in appearance to the platinum we see in the form of jewelry. This platinum is from 98 to 99 per cent pure, the impurities consisting for the most part of rhodium, iridium, and palladium, metals which are closely related in their properties to platinum and which are separated from it with considerable difficulty. These are carefully removed by methods which we have worked out in these Laboratories so that the platinum when ready to use has a purity of at least 99.98%. The purity of the metal is readily determined by a thermoelectric test, the thermal e.m.f. developed between a sample of the platinum being tested and another sample of known purity giving a direct measure of the impurities present.

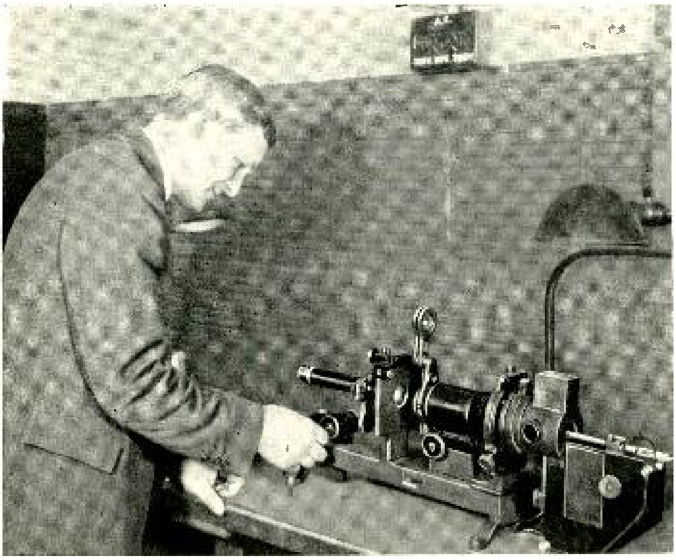
In connection with this purification frequent use is made of the spectroscope by means of which it is possible to determine what impurities are present and roughly to what exent. This information is often of great assistance in guiding the work of purification.

The platinum and the alloying metals are finally obtained in the form of sponge which is pressed together into pellets and melted in an induction furnace of a type similar to that recently described in an article in the RECORD by J. H. White. For melting the alloy a temperature of approximately 1750° C. (3400° F.) is required.

After being melted and cast, the metal is rolled and swaged until a



*C. F. Larkins swaging platinum rod as the first step in size reduction* rod ¼" in diameter and three or four feet long is obtained. At this stage, it is necessary to go over the bar carefully with an oxyhydrogen torch to work out the gas pockets and bubbles embedded in the metal. In this process all the metal in the rod is fused slightly a little at a time. If this is not done the gas pockets are drawn out with the metal in the working process which causes the wire, when the smaller sizes are reached, to break into many pieces and sometimes makes it impossible to draw the wire at all. When the rod has been sufficiently treated in this fashion to give a perfectly sound bar it is further swaged and drawn into wire of the required size and finally rolled to ribbon ready for shipment to the tube shop.



*The projector for measuring the width of platinum alloy ribbon is shown in operation by H. T. Reeve*

The final diameters of the wires from which the ribbon is to be rolled vary from one to thirteen thousandths of an inch, depending on the type of tube for which they are intended.

The filament from the one thousandth inch wire is used in a tube having a filament current of six hundredths of an ampere and that from the thirteen thousandth inch wire in a tube having a three ampere filament current. A conception of the fineness of the smallest size wire may be gained from the fact that, although the alloy is twenty times as heavy as water, it requires more than a mile and three-quarters of the wire to weigh an ounce.

The final step in the production of filament core is that of inspection. In the production of filament it is necessary, in order to insure the proper electrical characteristics for the tubes, to work to such close dimensions that even the most accurate of micrometers is not exact enough to measure the dimensions within the limits desired. For this reason the cross-section of the wire is determined by weighing samples a meter long. The width of the ribbon in the types of filament where the greatest accuracy is required is determined by projecting an image magnified a thousand times on a screen properly calibrated so that it is possible to tell by a glance at the image whether the ribbon falls within the required limits.

Improvements in the core and in the coating and pumping processes have made it possible within recent years to increase the life of repeater tubes many fold, with large resultant savings to the operating companies and improvement in service.

# Our Insurance Plan

By J. F. MORAVEC
*Commercial Manager and General Auditor*

LIFE insurance, as I view it, is a real asset to the present and future estate of any individual. It affords immediate protection to dependents in the hour of need and additionally combines with it, throughout the life of the policy, sound investment. I believe that most of us are apt to treat this matter of life insurance too lightly.

Recently we have each received a copy of the booklet concerning the Insurance Plan as adopted by the Laboratories, containing the terms and conditions under which insurance may be obtained. Perhaps some of us for one reason or another neglected to read this booklet. Others, perhaps, glanced through it superficially without much interest and have only a hazy idea of what it is all about. To all I would say, "Read it and read it carefully," for without question this Plan offers real advantages which many of us may not appreciate. The necessity for life insurance is very generally admitted but only too often the provision for such protection is delayed so long that when disaster overtakes us we find ourselves without adequate insurance and in some cases no insurance at all. Our intentions were good, but have you heard of anyone who protected his family or dependents with good intentions only? Delay is costly and one sure thing about insurance is that the price increases the longer we wait to do what in most instances we are eventually going to do.

The first question which, I take it, comes to the minds of most of us concerning the Plan is: "How much cheaper can I purchase protection under the new arrangement?" And when told that there is no premium saving under the Plan except for those who are engaged in so-called "hazardous occupations," we are quite likely to decide once and for all that the Plan offers little or no reason for us to participate. If it had not been for the fact that I, as a member of the Committee which considered the advisability of adopting the payroll deduction insurance idea in the Laboratories, was afforded the opportunity to investigate the matter from all angles, I too might have decided similarly. As it was, I studied the Plan fully, considering it in the light of past experience and in its relation to the other employee plans of the Laboratories, and came to the conclusion that it offers a real service to all of us who desire to participate. Accordingly, it seems to me that the salient features of the Plan are worthy of fuller discussion than can be given in the Plan Booklet.

First there is the payroll deduction feature. Experience has taught all of us that it is better to save first and spend afterward than to spend first and then save what there is left. The recognition of this fact underlies the

Savings and Stock Plans and is now incorporated in the Insurance Plan as well. To achieve financial independence, one of the most practical ways for most of us is to fix our saving at a certain point by arranging that we receive that portion of our income that we plan to spend and have the rest automatically accumulated for us in the form of savings, stock or insurance. This arrangement is accomplished through the payroll deduction scheme.

Even for those who can readily provide in advance for their financial obligations the payment of life insurance premiums through salary deductions may prove an advantage in that it relieves them of the necessity of paying premiums personally to the insurance company. This is particularly true because arrangements have been completed with the insurance company since the inauguration of the Plan which make it possible to derive the advantage of the lower premium rate for *annual* payments and at the same time pay premiums through deductions from pay. This may be accomplished in one of two ways: (1) You may, at the time of taking out your policy, pay the first annual premium in full to the insurance company. Then you may authorize deductions from pay to be held by the insurance company and used to meet, annually, succeeding years' premiums when they fall due. (2) You may, at the time of taking out your policy, authorize deductions from pay in such amounts as will meet payments on the current year's premium and will in addition accumulate in advance funds sufficient to pay in full the succeeding year's premium when it becomes due. This is in effect a double deduction, partly for current year's premium requirements and partly to enable you in the succeeding year to operate your insurance payments on the basis described under option 1 above. Both of these options utilize the deduction scheme as applied to insurance very much as you might use the Savings Plan to accumulate funds to meet your premiums for the succeeding year. In this connection the insurance company agrees to credit you with interest at the prevailing rate (which at the present time is 4¾%) on all amounts accumulated in advance until the time these amounts are applied in payment of annual premiums.

I feel, furthermore, that the payroll deduction feature may appeal to those who hold policies of the Equitable Life Assurance Society taken out prior to the inauguration of the Plan, since that company has extended to them the privilege of authorizing payroll deductions for the payment of premiums on such insurance, regardless of whether or not they take out new insurance under the Plan.

The omission of the customary medical examination in cases of applicants between the ages of 15 and 55 inclusive for amounts up to a total of $10,000 for any type of policy except Term is another feature of the Plan. Of course, the insurance company reserves the right to call for an examination when the physical condition of any employee would seem to indicate that this is necessary; but as most of us in the Laboratories are good risks from a health standpoint, this right will probably not be exercised very frequently.

In all of this it is well to keep in mind that under the payroll deduction plan your insurance is not dependent upon your continued employment with the Laboratories. You take out your insurance as an individual but your premiums are automatically cared for through payroll deductions. If at any time you sever your relations with the Laboratories, the protection you have bought stays with you. The only change would be that premiums on a quarterly, semi-annual or annual basis would be paid direct to the insurance company by you. The essential factor — protection — would not be affected in any way. Furthermore, when you take out insurance under the Plan, you have all the rights and privileges of a policy holder not under the Plan. As a matter of fact you are in a preferred position by reason of the advantages which I have mentioned.

Finally, in the Equitable Life Assurance Society of the United States, the Company selected to operate under the Plan, we have one of the strongest, oldest and most progressive institutions in the insurance field.

The selection of the proper life insurance is frequently an intricate matter and there is now available to all members of the Laboratories the service of an insurance expert, Mr. L. H. Bunting, who is the local representative of the Equitable, and who is now located in Room 144. He is ready to extend to anyone who may call upon him assistance in changing provisions of payments or beneficiary, and in all other life insurance matters, whether for policies of the Equitable or of other companies. The service, in short, will be that generally offered to only the largest policyholders of a life insurance company. Those who desire Mr. Bunting's advice may feel free to discuss their insurance matters with him. He may be reached by telephone on Ext. 264.

In conclusion may I emphasize that life insurance is something which all of us should consider seriously and which most of us should make a part of our financial scheme, particularly if we have others dependent upon us.

# Carrier Telegraph in Canada

By J. C. BURKHOLDER*

SPANNING the entire continent through the territory of our northern neighbor lies the Canadian National Railways System. A journey over its lines discloses scenery that warrants the almost unlimited use of superlatives. Jasper National Park, the largest national playground in the world, occupies but one small section of an almost continuous panorama of natural beauty and grandeur. Although its twenty-two thousand miles of track thread many large cities, much of its right-of-way is through a lonely country which the rapid growth of Canada has not yet compassed. From some of its station platforms bears are not uncommon sights and for the entertainment of the few inhabitants the howling of wolves is a frequent accompaniment of the northern lights which so frequently illumine the long winter nights, adding beauty to the scenery but severely hampering the operation of the telegraphs.

One of the major departments of this railroad system is the Canadian National Telegraphs whose lines connect with those of the Western Union Telegraph Company in this country. Canada has been growing rapidly and it was realized some time ago that the telegraph facilities had become inadequate and that extensive additions were necessary. One and a half million dollars was the estimated cost of providing the required channels by adding new wire circuits. The same facilities could be procured, however, by the use of multiplex carrier circuits at an estimated cost of only half a million. The proper step to take was obvious.

Orders were placed with the Northern Electric Company for a complete carrier system consisting of five terminal stations, twelve repeater stations, and a repeatered telephone circuit between Montreal and Winnipeg by way of Toronto, all to operate on the same pair of wires. For this work the system was divided into four sections: Montreal to Toronto, Toronto to Winnipeg, Winnipeg to Saskatoon, and Saskatoon to Vancouver.

The installation involved no small undertaking. Carrier current telegraphy was entirely new to Canada and there was therefore no one familiar with the details of the system. In addition the distances spanned are enormous; the link from Toronto to Winnipeg—over thirteen hundred miles and requiring seven repeater stations—is the longest in existence. Compared to carrier circuits in this country, the actual electrical length of this link is much greater than that indicated by the number of miles because the wire used has double the resistance of that ordinarily used by the American Telephone and Telegraph Company.

**Mr. Burkholder, formerly a member of the Systems Development Department, was the representative of the Laboratories in the engineering and installation of the system he describes. He has since become Chief Engineer of the Canadian National Telegraphs.*

Canada in some respects is particularly suitable for carrier installations. The fact that the distances are great between the large cities and that there are very few towns of any size intervening makes a carrier system very attractive economically. Of even greater importance, however, is the freedom from interruption that the carrier will bring. The effect of the aurora on grounded telegraph systems over the territory covered by the Canadian National Telegraphs is often calamitous. At times service is impaired for days at a time. The carrier, bringing almost complete immunity from auroral disturbances, due to its being an ungrounded system operating through transformers, will be worth much more to Canadian industry than the million saved by its original installation.

Having been asked by Northern Electric for technical advice and assistance, the Laboratories pointed out that the operation of paralleling telegraph circuits at 240 volts might seriously affect the carrier system. It was decided, therefore, to complete first a portable single carrier channel which could be used as a test circuit to determine what changes in the line would be necessary for the successful operation of the complete transcontinental carrier telegraph system.

While making tests in the fall of 1926, electrical disturbances were reported east and west of Capreol which lies just north of the western end of Georgian Bay. All this territory north of Lakes Huron and Superior is wild and very sparsely settled. Almost the entire population is in townships of two or three hundred people at the railroad division points. No roads exist; the railroad and its telegraph lines are the only links connecting these remote centers with the rest of the country. As the line had been reported in good condition and further as line inspection and maintenance in such a country is difficult, elaborate tests were made to locate the trouble and to discover its cause. While the tests were under way, the trouble disappeared, but not for long.

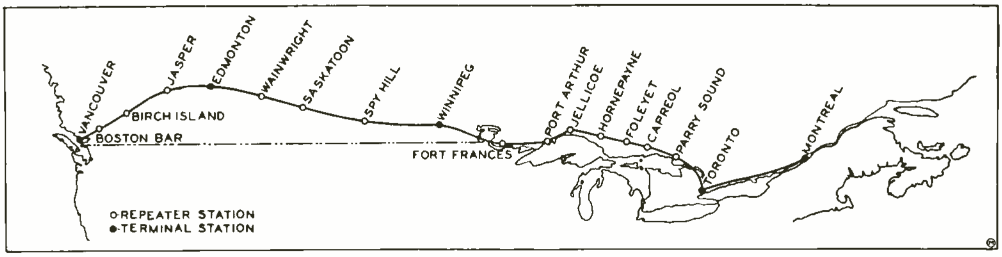



*Fig. 1—Map of Canadian National Railway System showing carrier terminal and repeater stations*

During 1927 installation of the equipment went steadily along. Buildings had to be designed and erected to house the equipment at several of the repeater stations. The accompanying photograph at Foleyet shows a typical repeater station in the foreground, built on to the old station with the higher gable just behind it. When testing was resumed on the Toronto-Winnipeg section in the late

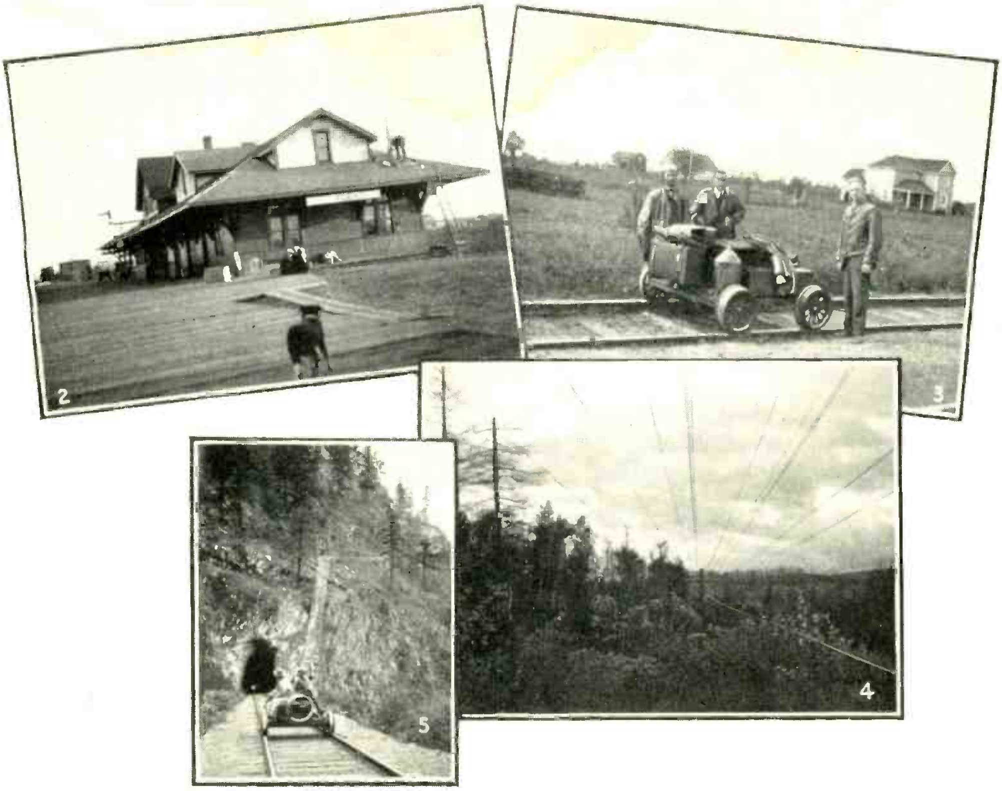



*Fig. 2—Repeater Station at Foleyet; (3) gas car ready for inspection trip; (4) tangle of brush and wire; (5) the Yale Tunnel*

summer of 1927 the same peculiar disturbances that had caused so much trouble the year before reappeared.

In view of the elusive nature of the disturbances, which indicated slack wires as a possible cause, it seemed wise to make a personal inspection of the entire line west of Toronto. For this purpose the small gas car shown in Figure 3 was used. Linemen were taken along to repair bad sections as they were found. In general, conditions were far from being as good as had been at first reported. In some places the brush had grown up into the sagging wires, as is shown in Figure 4. At night tests were made both ways from that night's stopping place. As the inspection party proceeded the interference became less and less till when Foleyet was reached the trouble had almost entirely disappeared. The line while satisfactory for ordinary direct current telegraphy was evidently not in sufficiently good condition for carrier circuits.

Still the line was noisy in some sections so that tests were continued and further line inspections made, in the course of which the poles between transpositions were counted. Where irregularities were found additional transpositions were inserted. In one place where a 110,000 volt power line paralleled the telegraph circuit for about two miles it was necessary to put transpositions at every pole.

Day by day and night by night the repairing and testing went on. Much of the country is rough, requiring considerable detours from the track as may be understood by reference to Figure 5. Also the work was not without its hazards. Except for the section from Montreal to Toronto the system is single track and constant watch had to be kept for trains. At one time we came suddenly upon a freight train and had just time to jump as the gas car rolled into the rear end of the train. On another occasion while we were traveling along at about forty-five miles an hour with our eyes fixed on the telegraph line the car ran into a derailing switch. Smashed equipment, an overturned car, and rather bruised observers were the result.

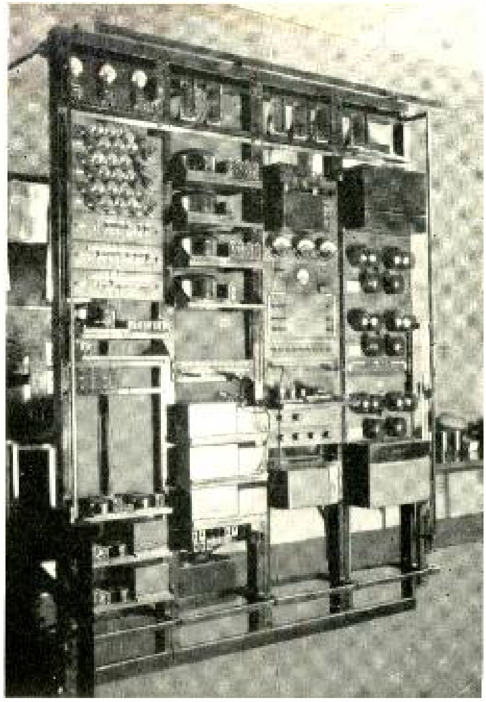


*Fig. 6—Carrier panels in typical repeater station*

The Toronto-Montreal section was opened to commercial service on April 26, 1927. On this day W. G. Barber, General Manager of Telegraphs, sent the following telegram from Toronto to Vice-President Robb in Montreal: "The carrier telegraph installation Montreal-Toronto has been completed and is working successfully. This message goes to you as the first message over a four channel multiplex operating at fifty words per minute on one of the telegraph carrier channels. This is the first time in telegraph history that a telegraph system has operated successfully carrying both multiplex printer and Morse telegraph messages over its various channels at such high speed."

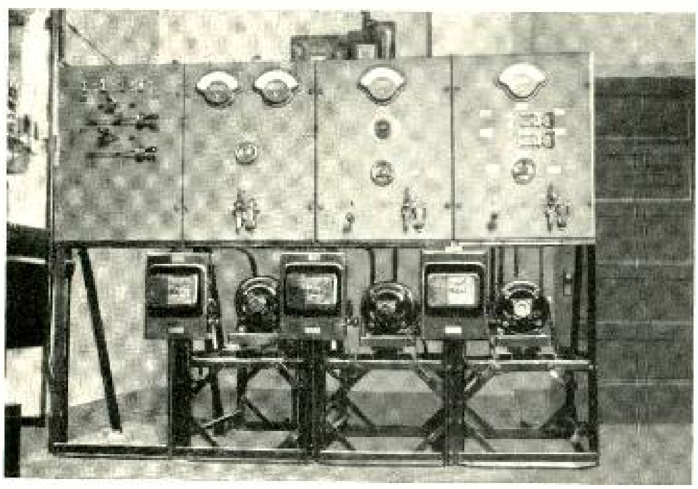


*Fig. 7—Power plant for repeater station*

A little over six months after this, on November ninth, the section from Toronto to Winnipeg was opened with a public demonstration at each terminal. This marked the completion of more than half of the total distance of over thirty-two hundred miles. While only six carrier channels had been planned originally for this section, traffic had grown to such extent that it was necessary to take equipment built for one of the western sections to increase the Toronto-Winnipeg sections from the six carrier channels originally planned to ten. In addition it had been decided to install an additional terminal station at Edmonton and to relocate the repeater stations originally planned for these western sections.

With this considerable accomplishment behind them the Canadian National Telegraphs is going on with the installation of the remaining sections which will complete its continental span from Montreal to Vancouver and insure that during the long winter months the aurora will no longer be a menace to telegraphy.

## *A Treatise on Probability*

*"Probability and Its Engineering Uses," by Thornton C. Fry, has just been published by D. Van Nostrand Company as part of its series of books by the staff of Bell Laboratories. An outgrowth of notes for the course given here and at a subsequent course of lectures at Massachusetts Institute of Technology, the book deals with many aspects of the interpretation of engineering and other data.*

*Considerations of probability have been used so effectively in correlating telephone facilities to traffic, necessarily irregular in flow, that the formulae and principles involved are of especial interest. More recently the same procedure has been applied to determine the stocks of materials and supplies needed at Hawthorne and Kearny, and to provide a rational means of inspection and control of the quality of manufactured products there.*

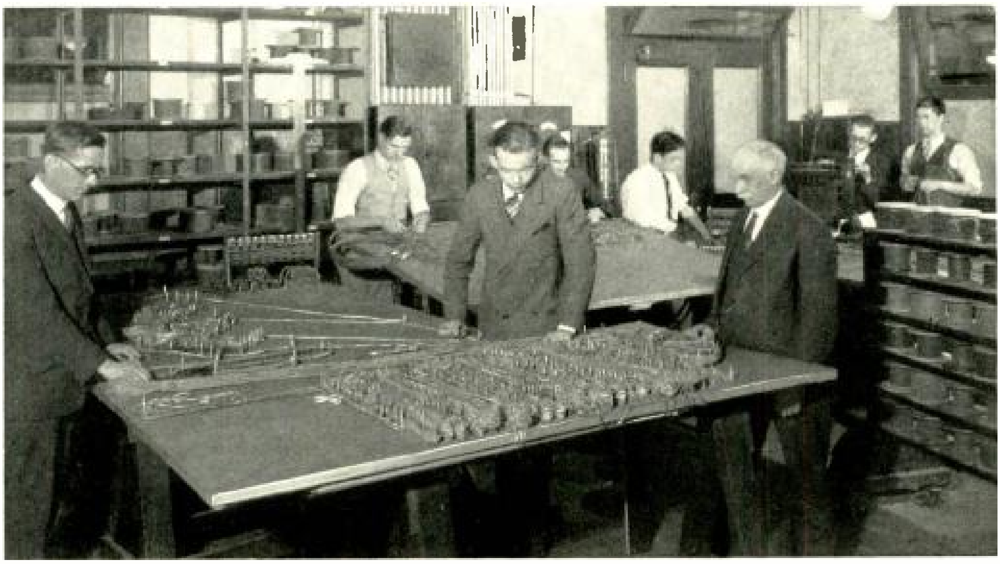
# The Local Circuit Development Laboratory

By J. L. DOW
*Systems Development Department*

IN the development of circuits for local service both a design and a laboratory group participate. Although not taking a direct part in their creation the laboratory yet shares responsibility equally with the design group for the circuits which proceed to the field. Its function is to check all arrangements which may be proposed and issued; its responsibility is to see that not the smallest item is overlooked which might lead to possible failure. To insure success in every way humanly possible the laboratory group must therefore verify in actual operation all circuits proposed by the design group.

In carrying out this function each detail of every scheme is given careful scrutiny, a work requiring a staff of 128 trained engineers and some 46 assistants. The department is subdivided into groups, each containing specialists in one particular field. Relays, panel-type equipment, manual equipment, step-by-step equipment, special development problems, and field study and installation requirements, has each its own group of engineers who not only carefully analyze but test each new circuit that falls within its function.

Last year over eight hundred new circuits were issued and over two thousand reissued. Some new circuits involve such well known principles and schemes that they may be approved without test but most of them



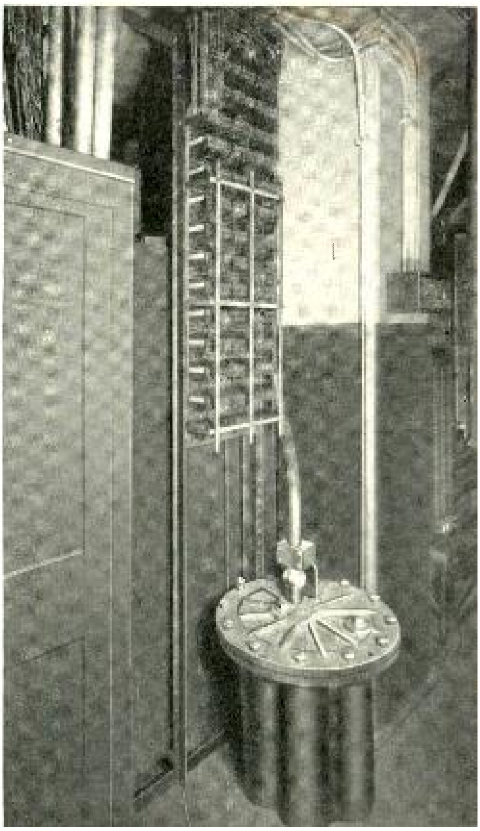
*F. L. Cox examining local cable form of a cordless tandem circuit being wired by W. S. Hane and C. E. Blumenaur* must be carefully tested before they can be approved. To accomplish this each must be set up on benches in the laboratory; adjusted under the most adverse conditions that it may ever meet; and tested, not only by itself, but in conjunction with every other circuit to which it may be connected at any time. When the circuit with its associated equipment occupies too much space to be mounted on benches, as would be the case with panel type senders for instance, it is set up on standard telephone frames in the machine switching section of the laboratory.

Making the local cable forms for these tests and cutting-in the apparatus on the frames or benches keeps a group of twenty-six men busy. Each group of circuits is delivered as though it were to be placed in a central office for the service of the subscriber.

Probably the most used single piece of apparatus in the laboratories—as in the telephone plant in general—is the relay. Twelve thousand of them were used in tests last year by the Circuit Development Laboratory. A large number were special or newly-designed relays which were made in the Model Shop solely for the purpose of being tested in the circuits under investigation. Each must be tested and adjusted both electrically and mechanically before it is placed on the frame and sometimes readjusted later during the testing of the circuit. Fifteen thousand relay adjustments were made last year. In many cases they are delicate and demand skill and care to secure their satisfactory accomplishment.

*A. Bregartner adjusting a series of "E" type relays*

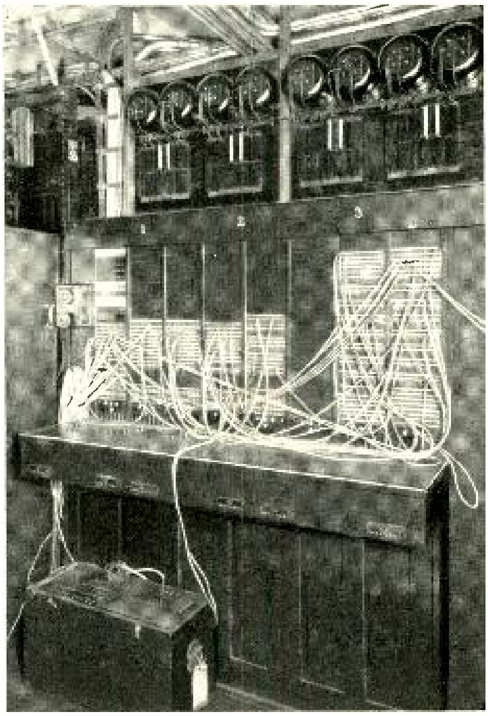
Many interesting types of equipment are used by the engineers in the course of their work. Besides the usual instruments for measuring voltages, currents, and power of all magnitudes there are many special types of apparatus, among which is the pulse varying machine which was made necessary by the advent of dial systems and the resulting studies involving pulsing. This device, of which there are four in the labo-



*Loading coil pot with condensers and resistances used in making up the 40 sections of loaded No. 19 gauge cable. These sections are terminated in jacks in the left hand end of the patching section shown in the adjoining column*

ratory, provides means of sending a group of short electrical impulses such as are produced when the subscriber dials. These machines will produce either a continuous chain of pulses of any frequency from five to thirty per second or groups of any number of pulses separated by open periods. The duration of both the pulses and the open periods is adjustable. This makes it possible to determine the type of pulsing necessary to accomplish any particular result and also to determine the performance of relays under different pulsing conditions and lengths of circuit.

To determine limiting distances, or length of loop, for different circuit functions, artificial lines are provided: electrical networks simulating very closely the characteristics of the various types of cable and open wire lines. These are built up in unit sections so that any desired length of line may be readily selected. Particularly interesting is the artificial duplication of forty sections, each equivalent to 1.66 miles of loaded nineteen gauge cable. This is built up of condensers, resistances, and loading coils in proper combinations and the sections terminate in jacks mounted in the laboratory patching section.

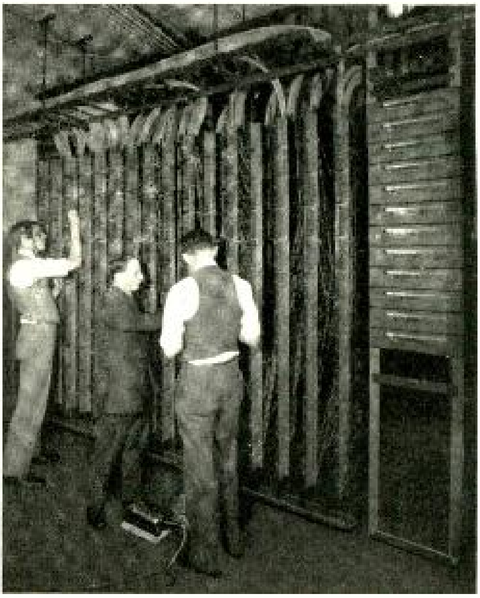


*Main patching section which gives each engineer access to the common equipment of the laboratory*

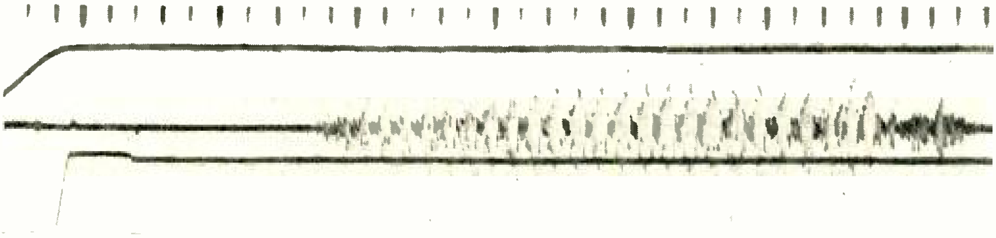
This patching section enables any engineer to have access to all the artificial lines described above and to all other circuits in the laboratory. Trunks running to various parts of the laboratory and to other laboratories in the building terminate in jacks mounted in the patching sections and the desired connections are made by plug-terminated cords. Each new circuit must be tested with the circuits with which it is to be associated so it is necessary to provide and maintain all the equipment which is found in standard central offices, not only manual but panel and step-by-step, as well as equipment for all forms of private branch exchanges. All these circuits terminate on a distributing frame and most of them are connected to the patching section.

Should any special circuits be required for a particular test which are not wired to this section it is necessary only to change some of the cross-connections in the distributing frame to make them available. The patching section thus gives access to all the circuits which are commonly required and to other parts of the laboratory or building while the distributing frame multiplies and extends this function so that even the special equipment becomes readily available.

Many studies are made which involve the measurement of periods of time of the order of a thousandth of a second, such as the operating or releasing time of relays, or surges due to condenser discharge or to the breaking of inductive circuits. This is most conveniently done with the oscillograph, of which two are kept continuously in use and a third is available for studies of trouble in the field or to carry peak loads in the laboratory. In 1927 over twelve thousand separate oscillograms averaging seven feet long were taken and analyzed by the engineers. This represents the application of the oscillograph to nearly seven hundred specific circuit



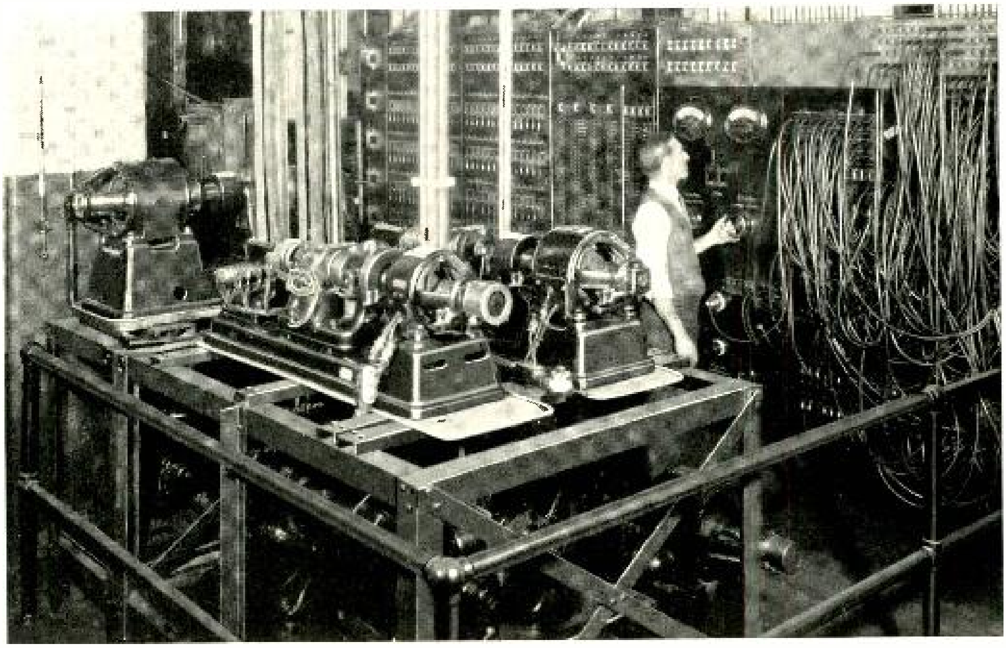
*J. E. Devany supervising the work on an intermediate distributing frame*



*Oscillogram showing amplified speech and noise* problems. Many of these were made to determine time intervals, but others made use of the instrument as a voltmeter, ammeter, or in some cases as a wattmeter, as in the current-drain studies which were described in the January issue of the Record.

As it is impossible to secure accurately readable deflections on the oscillograph with currents less than about a hundredth of an ampere and as it is frequently necessary to study circuit conditions involving currents as low as a thousandth of an ampere or less, there is provided a three stage resistance-coupled amplifier which amplifies any frequency within the range of the vibrating-mirror oscillograph itself. This extends the use of the instrument to the study of currents of the order of those ordinarily produced by speech. The accompanying illustration shows how the oscillograph was used to determine the relative voltages produced by speech and by a disturbance on a subscriber's line. The peak at the right represents the disturbance while the rest of the trace was produced by speech in a normal tone over the same line.

A flexible and adequate power supply is, of course, a necessary adjunct to the circuit laboratory. For various alternating current requirements the laboratory is equipped with three standard central office ringing machines which supply both the ringing current and the familiar tones, and also with one of the latest types of direct connected ringing machines. Beside these there are three ringing machines for special studies, the frequencies and voltages from which are independently variable throughout the entire range of standard values. Various other special machines are available also such as inductor alternators for low frequency tone studies,



*Power equipment showing ringing machines, interrupters, and power distributing board, with a few of the 250 cords up* and a vacuum-tube oscillator for frequencies from thirty-five to 75,000 cycles per second.

Except in special cases the laboratory depends on the central power room for its direct current supply. Fifty trunks are run from the power room to the multiple jacks on the Laboratories' power board, and these are cross-connected as desired. Switches are arranged so that any potential from one to fifty-six volts may be obtained as desired and higher voltages may be obtained if necessary by special connections. To make the power supply flexible one hundred and thirty circuits run from the power board jacks to the various benches and frames. These jacks may be connected by patching cords to the multiples which are supplied from the power room.

It is such facilities as these that make it possible for the Circuit Development Laboratory to carry on its work in the best fashion possible and to see that the standards of the Bell System are maintained in all new circuits issued.

Thus our tests carefully prepare the way for the field or trial installation. This is a subject worthy of a separate article in the RECORD; it is mentioned now only to bring out the fact that the trial installation does not, as the term might imply, serve to recheck the work of the Local Circuit Development Laboratory. The field trial places the new equipment or system in what is to be, as it were, its habitat by adoption, where its operation may be studied in conjunction with other equipment and with a flow of traffic and under conditions which it would be impossible to simulate within our laboratory.

## *Recognition of Achievements*

*Discussing the eight scientific achievements he considered outstanding in 1927, Sumner N. Blossom, editor of "Popular Science Monthly," named developments of the Laboratories for the first, second and eighth places, in an interview widely quoted in newspapers. In his opinion the gains in public convenience would be greatest from the year's advances in the field of communication. Television transferred from the field of conjecture to that of accomplishment, he placed first in value. Establishment of reliable two-way telephone service across the Atlantic ranked second. The remaining Laboratories achievement in the group was talking motion-pictures, whose use multiplied so greatly during the year.*

# Permalloy in Audio Transformers

By E. L. SCHWARTZ
*Apparatus Development Department*

THE use of permalloy for transformer cores has been a highly important contribution toward the high quality of the transmission now obtained in audio frequency transformers, both input and output. Although available for only a few years, this material has been used to a rapidly increasing degree. Since manufacturing information was issued on the first coded transformer using a permalloy core, other designs have been added continually so that now there are available manufacturing specifications for dozens of audio frequency transformers of that type, for use under different conditions. Several hundred special designs have been developed as well, for use in the Laboratories in circuits and apparatus where transmission of high quality is desired.

So rapidly has its use grown that permalloy is the core material in a large majority of the audio frequency transformers designed today. There are two principal reasons for its choice—desire for the best available transmission characteristic, and for reduction in size. Improvement of transmission quality has been the more influential of the two, but there have been a number of occasions where extreme compactness, such as could not be attained with a core of silicon steel, has been the primary consideration. Due to the high nickel content, however, permalloy costs considerably more than silicon steel.

The first commercially important demand for audio-frequency transformers whose frequency range exceeded the ordinary talking range of about 200 to 3000 cycles came in connection with the design of amplifiers for the Western Electric Public Address System a number of years ago. Although transmission requirements were not unusually severe according to present standards, the occasion marked the beginning of a rapidly increasing demand for many types of audio-frquency transformers possessing transmission qualities higher than had previously been necessary. Since then, the rapid increase in the development of loud speaking equipment, radio circuits and special amplifiers has made the electrical requirements for transformers constantly more rigorous with respect to the frequency range to be transmitted and to the uniformity of transmission over that range. One of the most exacting commercial demands has been met in transformers used in amplifiers for talking moving pictures apparatus, where there is demanded as nearly uniform transmission as possible between the frequencies of 40 and 6000 cycles. In addition there have been numerous special developments for which it has been necessary to design transformers giving uniform transmission over an even wider range; notable among these is the television system recently demonstrated, for which transformers were required to transmit currents whose freqencies ranged from 10 to 20,000 cycles.

Importance of the core material in improving transmission at the lower frequencies is shown by the diagram of an input transformer the secondary of which is connected to a vacuum tube. Figure 1 is a schematic diagram, and Figure 2 the equivalent "T" network, where the condenser represents the input capacity of the tube and the distributed capacity of the transformer. The series arms a and b represent the primary and secondary resistances and leakage reactances, and M the mutual impedance between the windings. At low frequencies b can be neglected, and only the resistance component of a need be considered; this may be added to R, the resistance from which the transformer is working. It can readily be seen from this circuit that for the applied voltage to be transmitted without serious loss in the resistance R, the mutual impedance M must be large with respect to R. The value of M depends in turn principally on its reactive component, $2\pi fL$, where L is the mutual inductance of the transformer and f the frequency. As the frequency decreases, the impedance M obviously decreases as well; if it is to be kept high with respect to R, the important consideration is that L be made high. Thus the change from silicon steel to permalloy, by giving a core of higher permeability, raises L and M and so maintains the voltage amplification at frequencies where otherwise it would fall off badly. This merit of considerably higher permeability than that of silicon steel is confined however to low flux densities such as are ordinarily present in audio-frequency transformers.

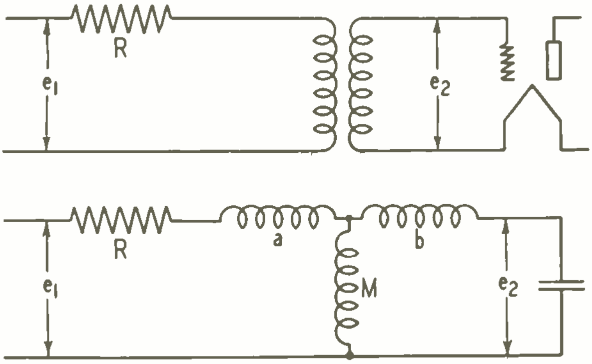



*Figure 1, above, and 2, below*

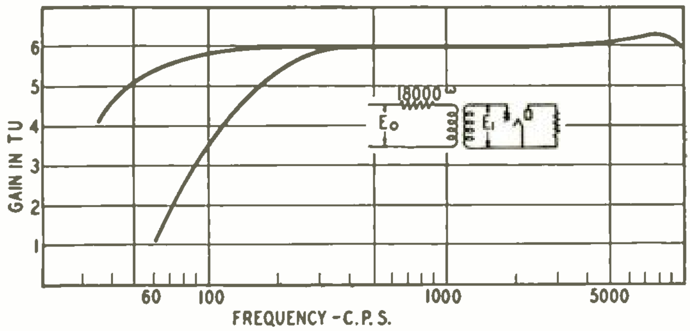
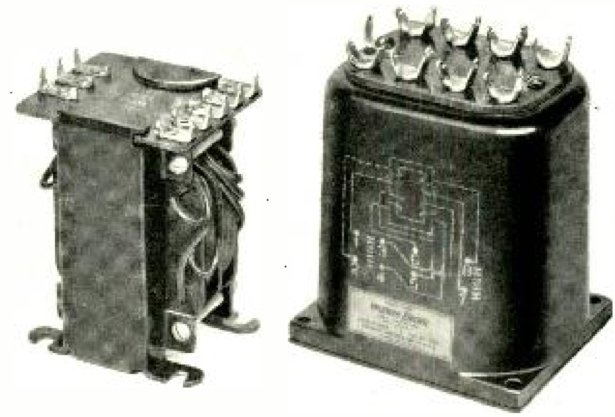


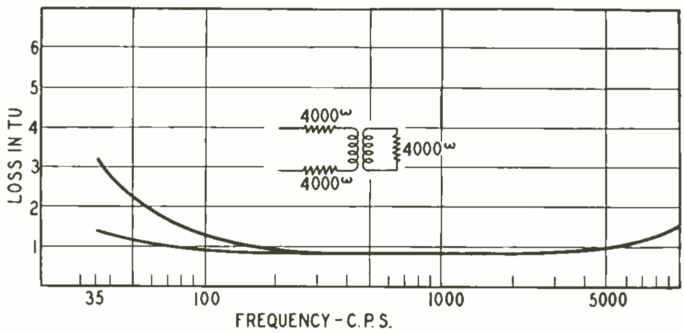

*Fig. 3 — Effect of the core material on the voltage amplification characteristics of two input transformers. Upper curve, permalloy core; lower, silicon steel core. These curves, and those of Figs. 4 and 5, were taken with a superimposed direct current of 0.002 amperes through the primary winding*

The marked improvement in transmission quality of audio-frequency transformers which comes from the use of permalloy is readily seen from comparison of the voltage-amplification characteristics of two input transformers differing only in the magnetic materials used for their cores. These characteristics are recorded on the curves of Figure 3. It should be borne in mind that the transformer used does not embody the highest amplification quality available, but was chosen rather to indicate the improvement which can be made in the amplification of the lower frequencies by a change of core material. The same windings were used for both curves, and the cores themselves, the same in dimensions and construction, differed only in material; one was of silicon steel, and the other of permalloy. Each core was separable, and so after measurements had been made using one core it was removed from the windings and replaced by the other. In Figure 3, the lower curve represents measurements taken when the core laminations were of silicon steel, the material formerly used almost universally, and the upper curve represents data with laminations of permalloy. At frequencies as high as 300 the improvement from change of core material is noticeable, and at 60 cycles it is more than 4 TU. It will be noted that there is no noticeable change in amplification at the higher frequencies. Above 3000 or 4000 cycles the voltage-amplification characteristic is determined principally by design of the windings and is affected by change of the core material only to the extent that such a change permits modification of the winding design.

In the design of output transformers marked improvement in transmission at the lower frequencies, comparable to that for input transformers, can also be made under most conditions by the use of permalloy cores. Consideration must usually be given, however, to the necessity of carrying direct current of relatively large value from the plate circuit of the vacuum tube. Susceptibility of permalloy to the magnetizing effect of direct current is far greater than that of silicon steel. With input transformers, ordinarily, direct current is so small that if it cannot be neglected the design can be arranged to take care of its presence, but for output transformers the direct current usually must be kept out of the transformer windings or its effect must be balanced out by some such circuit arrangement as push-pull con-



*Typical permalloy-core input transformers, potted and unpotted, weighing 2 and 3¾ pounds. Departure from this type has been mainly for output transformers required to transmit relatively large power and presenting correspondingly severe insulation problems; a few of these weigh as much as fifty pounds* nection of the vacuum tubes. Fortunately in many of the recent amplifier designs the tubes in the last stage are connected in push-pull to give the necessary power output; with this arrangement the direct currents from the two tubes pass through the windings in opposite directions, and so their magnetizing effects tend to neutralize each other. Of course perfect balance seldom results, but with tubes of average commercial quality the neutralizing effect is usually sufficient to assure a considerable part of the improved transmission characteristics made possible by the use of permalloy. In Figure 4, characteristics of output transformers are compared when the cores are of permalloy and of silicon steel. As before, there is no change in the windings, and the two cores are the same in size and shape, differing only in material. At the higher frequencies amplification is not changed, though an improvement could have been secured by change in design; the improvement would however have been at the expense of part of the gain at the lower frequencies.



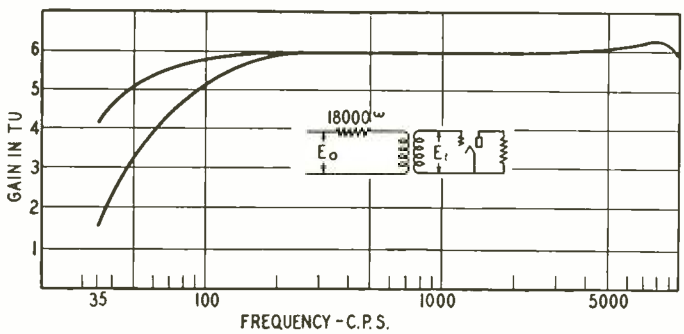




*Fig. 4, above—Transmission loss characteristics of two output transformers. Lower curve, permalloy core; upper, silicon steel*

*Fig. 5, below—Voltage-amplification characteristics of input transformers with permalloy cores. Upper, core assembled with butt joints; lower, with interleaved construction*

Use of a permalloy core is not of itself assurance of high-quality transmission at the lower frequencies; a substantial part of the improvement can be lost by use of a type of core assembly unsuitable for the conditions under which the transformer is to be operated. An example is illustrated in Figure 5. Two input transformers were used, with identical windings, and each with a permalloy core. The two cores in turn were made up of identical parts, but were assembled somewhat differently. In the first case, the laminations were assembled into two core units in the form of an E and I respectively. These were then placed together, with butt joints where they touched, imparting the effect of an extremely small air-gap. This gave the core sufficient stability to withstand the magnetizing effect of a small direct current in the windings. In the case of the other transformer, the same laminations were assembled individually into a complete core, with the E and I pieces interleaved. The joints were thus alternated from side to side, and the effect of the air gap eliminated as far as possible. The result was an unstable magnetic circuit, with inductance higher than given by butt joint construction when there was no direct current but much smaller under actual circuit conditions, when a relatively small direct current flowed through the windings. Change to interleaved construction increased the loss at 60 cycles from 0.5 TU to 2.0 TU; such a loss in each input transformer of a Public Address System or an amplifier for talking moving pictures would of course be most objectionable. In output transformers, where appreciable direct current is usually present, selection of proper core design is even more important. Use of any transformer with permalloy core should be restricted to circuit conditions for which it is suited, since presence of an unsuitable condition such as is illustrated above when direct current is present may counteract in large part the benefits which the core material would otherwise bring, and render its use of little value.

## *A French Appreciation of the Bell System*

*Monsieur Drouët, Inspector General of Posts and Telegraphs of France, in his preface to E. M. Deloraine's French translation of K. S. Johnson's "Transmission Circuits for Telephonic Communication," gracefully acknowledges the indebtedness of the world to the United States and particularly to the American Telephone and Telegraph Company for the development of telephonic communication.*

*"Un groupement industriel et financier très puissant s'y est progressivement constitué autour de l'American Telegraph and Telephone Co., qui exploite aux Etats-Unis les communications à grande distance. Ses services techniques, et ceux des Sociétés qui lui sont affiliées, comprennent un état-major d'ingénieurs de premier ordre, et certains d'entre eux sont des savants dont l'autorité s'est imposée dans tous les pays.*

*"De ce groupement d'hommes de valeur, qui mettent en commun leurs efforts pour le perfectionnement d'une même technique, on pourrait dire qu'il constitue une véritale confrérie intellectuelle qui développe et propage, en matière de communications électriques, une doctrine dont la valeur est hautement apprécipée par tous les spécialistes."*

*He speaks of their technical staff, in which he includes Bell Telephone Laboratories, as engineers of the first order who constitute an intellectual brotherhood for the development of matters pertaining to electrical communication.*

# Recent Technical Papers

*During the past year, a large number of papers by members of Bell Telephone Laboratories presented before professional societies have been published in their journals. Those listed below have not been noted currently in the* RECORD.

Diffraction of Electrons by a Crystal of Nickel—C. J. DAVISSON AND L. H. GERMER. *Physical Review, December,* 1927.

A Note on the Thermionic Work Function of Tungsten—C. J. DAVISSON AND L. H. GERMER. *Physical Review, November,* 1927.

The Scattering of Electrons by a Single Crystal of Nickel—C. J. DAVISSON AND L. H. GERMER. *Nature, April* 16, 1927.

The Thickness of Spontaneously Deposited Photoelectrically Active Rubidium Films, Measured Optically—H. E. IVES AND A. L. JOHNSRUD. *Journal of the Optical Society of America, December,* 1927.

A Photoelectric Process of Halftone Negative Making Applicable over Telephone Lines—H. E. IVES. *Journal of the Optical Society of America, August,* 1927.

Plane Waves of Light—I—Electromagnetic Behavior—THORNTON C. FRY. *Journal of the Optical Society of America, September,* 1927.

Plane Waves of Light—II—Reflection and Refraction—THORNTON C. FRY. *Journal of the Optical Society of America, January,* 1928.

On Electrical Fields and Metallic Surfaces—J. A. BECKER AND D. W. MUELLER. *Physical Review, February,* 1928.

Precision Determination of Frequency—J. W. HORTON AND W. A. MARRISON. *Proceedings of the Institute of Radio Engineers, February,* 1928.

Frequency Measurements with the Cathode Ray Oscillograph—F. J. RASMUSSEN. *Journal of the American Institute of Electrical Engineers, January,* 1927.

The Short Wave Limit of Vacuum Tube Oscillators—C. R. ENGLUND. *Proceedings of the Institute of Radio Engineers, November,* 1927.

The Propogation Characteristics of Sound Tubes and Acoustic Filters—W. P. MASON. *Physical Review, February,* 1928.

A Direct Comparison of the Loudness of Pure Tones—B. A. KINGSBURY. *Physical Review, April,* 1927.

Observation of the Microstructure of the Path of Fatigue Failure in a Specimen of Armco Iron—F. F. LUCAS. *American Society for Steel Treating, Transactions, April,* 1927.

Submarine Cable Insulation with Special Reference to the Use of Rubber—R. R. WILLIAMS AND A. R. KEMP. *Journal of the Franklin Institute, January,* 1927.

Direct Determination of Hydrocarbon in Raw Rubber, Gutta Percha and Related Substances—A. R. KEMP. *Industrial and Engineering Chemistry, April*, 1927.

The Significance of the Dielectric Constant of a Mixture. H. H. LOWRY—*Journal of the Franklin Institute, March*, 1927.

The Densities of Coexisting Liquid and Gaseous Carbon Dioxide and the Solubility of Water in Liquid Carbon Dioxide—H. H. LOWRY AND W. R. ERICKSON. *Journal of the American Chemical Society, November*, 1927.

Absorption of Water by Rubber—H. H. LOWRY AND G. T. KOHMAN. *Journal of Physical Chemistry, January*, 1927.

The Adsorption of Gases by Solids with Special Reference to the Adsorption of Carbon Dioxide by Charcoal—H. H. LOWRY AND P. S. OLMSTEAD. *Journal of Physical Chemistry, November*, 1927.

Effect of Moisture on Electrical Properties of Insulating Waxes, Resins and Bitumens—J. A. LEE AND H. H. LOWRY. *Industrial and Engineering Chemistry, February*, 1927.

Brittleness Tests for Rubber and Gutta-Percha Compounds—G. T. KOHMAN AND R. L. PEEK, JR. *Industrial and Engineering Chemistry, January*, 1928.

Structure of a Protective Coating of Iron Oxide—R. M. BOZORTH. *Journal of the American Chemical Society, April*, 1927.

The Solid Solubility of Antimony in Lead as Determined by Conductivity Measurements on Cold-Worked Alloys—E. E. SCHUMACHER AND G. M. BOUTON. *Journal of the American Chemical Society, July*, 1927.

An Efficient Apparatus for Measuring the Diffusion of Gases and Vapors through Membranes—E. E. SCHUMACHER AND L. FERGUSON. *Journal of the American Chemical Society, February*, 1927.

The Electric Moments of Substituted Benzene Molecules and the Structure of the Benzene Ring—C. P. SMYTH AND S. O. MORGAN. *Journal of the American Chemical Society, April*, 1927.

# News Notes

The Address which Dr. Jewett delivered before the Alumni Dinner of Massachusetts Institute of Technology is published in the March issue of *The Technology Review* under the title "Scientific Education." On February 28 Dr. Jewett spoke on "Some Facts and Fallacies about Industrial Research" before a Luncheon Meeting of the Philadelphia Engineers Club.

J. C. Hunsaker was the host of Col. Stedman S. Hanks, President of the American Airports Corporation, when the latter visited the Laboratories on March 9.

## Systems Development

L. F. Porter made tests on No. 3 toll circuits at Reading, Pennsylvania.

H. J. Fisher is in London, England, conducting tests on new improvements on the transatlantic circuits.

G. W. Ames left on February 20 for Denver, Colorado, to study field conditions on broadcasting circuits routed over transcontinental telephone lines.

C. D. Walker was in Chicago, discussing plans for the installation of a new power plant for the enlarged Chicago Toll Office with engineers of the Illinois Bell Telephone Company.

H. M. Spicer spent two days in Waltham, Massachusetts, discussing voltage control equipment with the Palmer Electric and Manufacturing Company.

T. C. Campbell spent the first week in February studying trouble conditions on panel selector frames in the Chicago dial offices.

R. P. Jutson visited Kane and Erie, Pennsylvania, and Newark, Ohio, where he studied the use of small automatic power plants in various types of power service.

H. D. Bruhn visited the first No. 701-A P. B. X. to be installed in Chicago on February 13.

V. T. Callahan investigated emergency gas engines in Schenectady and Utica, New York.

F. R. Dickinson arranged for the new grouping of transmission measuring equipment in the new Cleveland Toll Office.

C. W. Van Duyne visited the Westinghouse Electric and Manufacturing Company at Pittsburgh to discuss development features of an emergency charging set driven by kerosene engines.

## General Staff

During Schoolmen's Week at the University of Pennsylvania, John Mills addressed the science sections on "Physics and Chemistry of Television."

S. P. Grace spoke before the New York Electrical Society on recent developments in the Laboratories, on March 9.

R. W. King lectured before the Wednesday Club of St. Louis on March 14, on the subject "Research and Development at Bell Telephone Laboratories."

### Patent

During October, November, December, January and February patents were issued to the following members of the Laboratories staff:

| | |
|---|---|
| H. D. Arnold | F. A. Kuntz |
| E. P. Bancroft | A. G. Landeen |
| E. L. Baulch | W. G. Laskey |
| F. S. Bernhard | V. E. Legg (2) |
| C. H. Berry | M. B. Long |
| W. L. Betts | G. T. Lorance |
| H. S. Black (2) | H. H. Lowry (2) |
| D. G. Blattner (2) | G. R. Lum |
| O. E. Buckley (2) | D. MacKenzie |
| R. M. Burns | W. H. Manthorne |
| E. T. Burton | W. A. Marrison |
| W. W. Carpenter | G. R. Martin |
| R. W. Chesnut | R. C. Mathes (3) |
| E. H. Clark | D. T. May |
| A. M. Curtis | E. D. Mead |
| J. W. Dehn | D. D. Miller (2) |
| R. W. DeMonte (2) | John Mills (2) |
| H. F. Dodge (2) | C. E. Mitchell |
| A. D. Dowd | C. R. Moore (3) |
| T. J. Engel | E. R. Morton |
| J. F. Farrington (5) | R. Nordenswan |
| J. C. Field (2) | A. A. Oswald |
| H. J. Fisher | R. E. Peoples |
| J. W. Foley (2) | H. Pfannenstiehl |
| W. Fondiller | W. A. Phelps |
| C. B. Fowler | R. L. Quass |
| H. A. Frederick | H. T. Reeve |
| H. T. Friis | G. Riggs |
| J. O. Gargan (2) | J. G. Roberts |
| J. S. Garvin | F. M. Ryan (2) |
| E. W. Gent (2) | J. P. Schafer |
| J. J. Gilbert | J. C. Schelleng |
| A. F. Gilson | P. Schwerin |
| H. W. Goff (2) | W. J. Shackleton (2) |
| J. W. Gooderham | O. A. Shann |
| C. L. Goodrum | T. E. Shea (2) |
| W. S. Gorton | J. B. Shiel |
| Frank Gray | H. O. Siegmund (2) |
| C. W. Green | L. J. Sivian |
| T. R. Griffith | A. B. Sperry |
| A. Haddock | C. A. Sprague |
| A. E. Hague | F. A. Stearn (2) |
| L. N. Hampton | C. W. Stevens |
| H. C. Harrison (3) | R. L. Stokely (2) |
| R. V. L. Hartley (2) | W. J. Thayer |
| R. A. Heising (3) | H. W. Ulrich (2) |
| E. E. Hinrichsen (2) | H. Vadersen |
| J. W. Horton | C. G. Von Zastrow |
| H. Hovland | F. A. Voos |
| F. A. Hubbard | E. Vroom |
| H. E. Ives (5) | R. L. Wegel |
| K. S. Johnson | E. C. Wente |
| W. C. Jordan | E. B. Wheeler |
| A. R. Kemp (2) | R. S. Wilbur |
| D. H. King | F. C. Willis |
| J. J. Kuhn | I. G. Wilson |

G. H. Heydt, G. T. Morris, T. P. Neville, J. C. R. Palmer, P. C. Smith and E. Woodbury were in Washington, D. C. from February 8 to March 13 in connection with the prosecution of applications for patent. During the same period G. H. Stevenson and W. G. Crawford visited Philadelphia and Camden, respectively.

### Inspection Engineering

W. C. Miller and R. M. Moody attended regular Survey Conferences at Hawthorne during the early part of March. H. F. Kortheuer and T. Mellors attended a similar conference at Kearny.

G. D. Edwards and R. J. Nossaman visited the Cleveland, Detroit and Chicago field territories during the first two weeks in March, and discussed general field activities with Telephone Company engineers and Western Electric Distributing House men in Detroit, Indianapolis, and Columbus. Mr. Nossaman also visited field headquarters at St. Louis and Cleveland.

A. I. Rivenes, formerly Local Engineer in the Chicago field territory, has resigned to become Division Traffic Engineer of the Chicago Area for the Illinois Bell Telephone Company.

I. W. Whiteside, formerly Field Engineer at Detroit, has been appointed Field Engineer in the territories of the Illinois Bell Telephone Company and the Wisconsin Telephone Company, replacing A. I. Rivenes. Mr. Whiteside's headquarters will be in Chicago.

R. C. Kamphausen has been appointed Field Engineer in the territories of the Michigan Bell Telephone Company and the Indiana Bell Telephone Company, replacing I. W. Whiteside. Mr. Kamphausen's headquarters will be in Detroit.

### Outside Plant Development

R. L. Jones, C. D. Hocker, and V. B. Pike, with G. A. Anderegg and E. E. Schumacher were in Philadelphia on February 28 to observe a demonstration of a proposed new method of joining cable sheath.

E. M. Honan and A. R. Kemp visited New Haven and Bridgeport on March 1 and 2 to study development of rubber covered wire.

I. C. Shafer was in New Haven on February 29 in connection with development problems involving drop wire attachments.

J. M. Hardesty attended the annual meeting of the American Concrete Institute in Philadelphia, from February 28 to March 1.

L. W. Kelsay and W. W. Werring were in Bridgeport on March 1, studying proposed improvements in connecting blocks.

E. M. Honan and A. R. Kemp attended a meeting of the Rubber Committee of the American Society for Testing Materials on March 15 and 16.

C. D. Hocker attended a committee meeting of the American Society for Testing Materials in Philadelphia on March 9.

### Apparatus Development

H. W. Goff and J. F. Hearn recently visited the American Brass Company plant at Waterbury, Connecticut to observe new methods of arc welding.

C. G. McCormick was in Chicago during the second week of February to discuss questions on step-by-step apparatus with representatives of the Automatic Electric Company and to obtain information on apparatus at Western Electric, Hawthorne.

James Abbott and C. J. Hendrickson visited Philadelphia on February 20 to confer with engineers of the Western Electric Installation Department at the Baring office on dial testers installed there.

H. S. Price supervised the installation of a master oscillator unit in the five-kilowatt broadcasting equipment of the U. S. Playing Card Company in Cincinnati. He also inspected the five-kilowatt broadcasting station of the Stromberg-Carlson Telephone Manufacturing Company at Rochester.

H. M. Stoller lectured on Television before the Rochester section of the A. I. E. E. on March 2.

J. C. Field spent several weeks in North Dakota working on the train dispatching system of the Minneapolis, St. Paul & Sault Ste. Marie Railroad Company. On his way east he made an investigation of the selector supervisory system used by the Illinois Central Railroad Company.

P. H. Pierce was the author of an article on "Some Applications of Vacuum Tube Amplifiers" which appeared in the February issue of *The Nebraska Blue Print.*

T. E. Shea is spending the first half of each week lecturing before a class on "Transmission Networks" at Massachusetts Institute of Technology. The class includes over thirty students and is also attended by about twelve members of the faculty.

W. W. Werring has been appointed to the Committee on Standardization of Impact Testing Methods of the American Society for Testing Materials.

H. O. Siegmund visited Hawthorne on March 14 to confer on contact design.

W. Fondiller, F. F. Lucas, H. N. Van Deusen and J. E. Harris visited Kearny on March 14 to inspect developments in the extrusion of lead cable sheath, and thermal-control of the lead presses.

### RESEARCH

L. J. COBB visited Hawthorne on March 11 to set up equipment for testing No. 4-A electrical reproducers. W. C. Jones and L. A. Morrison later went to Hawthorne to observe the manufacture of these reproducers.

E. G. SHOWER visited the Johns Hopkins Hospital at Baltimore to inspect apparatus used in various phases of work on audition.

C. R. MOORE was at Hawthorne from March 3 to 11 in connection with work on broadcast transmitters.

R. M. BURNS attended a conference on electroplating at the Bureau of Standards in Washington, on March 2.

W. G. KNOX witnessed trials of the application of sprayed lacquer in refinishing housings of subscriber sets in Philadelphia on February 27.

F. F. FARNSWORTH AND C. L. HIPPENSTEEL attended meetings of the metal section of the American Society for Testing Materials in Washington on March 21 and 22.

R. M. BURNS AND F. F. FARNSWORTH with H. N. Van Deusen of Apparatus Development studied the effect of corrosion on central office equipment in Altoona, Pennsylvania, and Atlantic City, New Jersey.

H. E. IVES lectured on television before the Naval Post-Graduate School at Annapolis on March 2, at the University of Kansas on March 5, and before the St. Louis section of the A. I. E. E. on March 8. On March 20 and 21 he spoke before the students and faculty of Yale.

H. D. ARNOLD lectured on "Recent Researches in Communication" before a joint meeting of the Middletown Science Society and the Physics Department of Wesleyan University in Middletown, Connecticut, on March 13.

E. F. KINGSBURY gave a short talk on television before the Women's Reading Club of Rutherford, New Jersey, on March 30.

C. J. DAVISSON spoke on "Diffraction of Electrons by a Crystal of Nickel" before the Philosophical Society of Washington, D. C., on March 31.

F. GRAY spoke on television before a joint meeting of the Exchange Clubs of Scranton and Wilkes-Barre in the latter city on March 20.

ON FEBRUARY 29, C. T. Wood addressed the Men's Club of the Broadway Tabernacle on "The Dance of the Electrons."

E. M. NOLL visited the Henry L. Scott Company at Providence on February 14 to discuss operational details of the rubber compression machine which is being built there for the Laboratories.

M. J. KELLY addressed the Colloquium at Massachusetts Institute of Technology on March 5 and 6, on "Thermionic Filaments of Vacuum Tubes Used in Wire Telephony."

FRANK GRAY lectured on "Television and the Electrical Transmission of Pictures" at the Brooklyn Academy of Music on March 31, under the auspices of the Alfred Waters Proctor Foundation.

R. R. WILLIAMS spoke at the Colloquium on March 5, on "Conduction of Electricity in Textile Insulations"; and on March 19, J. C. Schelling spoke on "Recent Developments in Radio Transmission."

# Club Notes

The 1927-28 basketball season was completed on Tuesday evening, February 28, when the team representing the Equipment Branch of the Systems Development Department and that of the Commercial Department played for the Club Championship. This year the league season was divided into halves, of which the Equipment Department won the first and the Commercial Department the second. Equipment won the deciding game by a score of 28 to 18 before a large and enthusiastic gathering, and now has two legs on the trophy. To the Equipment men also went the individual prizes. The final standing in the league was as follows:

| | *Won* | *Lost* |
|---|---|---|
| Equipment | 11 | 1 |
| Tube Shop | 9 | 3 |
| Commercial | 8 | 4 |
| Research | 5 | 7 |
| Toll and Circuit | 4 | 8 |
| Apparatus Development | 3 | 9 |
| Junior Assistants | 2 | 10 |

*First Ten Individual High Scorers*

| | Field Goals | Foul Pts. | Total Pts. |
|---|---|---|---|
| MacCullough—(Toll and Circuit) | 13 | 18 | 44 |
| Nichols—(Commercial) | 49 | 14 | 112 |
| Kontis—(Tube Shop) | 47 | 12 | 106 |
| Smith—(Apparatus) | 33 | 2 | 68 |
| De Angelis—(Research) | 31 | 5 | 67 |
| Lohmeyer—(Apparatus) | 29 | 5 | 63 |
| Elliot—(Research) | 26 | 10 | 62 |
| Smith—(Tube Shop) | 27 | 6 | 60 |
| Ottoman—(Equipment) | 19 | 14 | 52 |
| Bodtlander—(Jr. Assistants) | 22 | 7 | 51 |

## Hiking

For those who have shared the joy of following trails through wood and meadow to a blazing campfire and a supper beneath the stars, there is no need of a pressing invitation to join the hiking club. Others who are interested will find a warm welcome, and friends of members are invited to come.

Some of our hikers anticipated the opening of the official season and, under the leadership of Bob Bogumil, spent Washington's Birthday at Bear Mountain, where skiing, tobagganing, and ice-skating were in order. On the same day, another group hiked to Silver Lake, White Plains, where W. C. Buckland and F. R. Stansel prepared an old-fashioned clam chowder.

Though hiking is its own reward, a splendid trophy is to be awarded this year to the best hiker among the men and another to the women. Choice will be made from those hiking the greatest distance in the season, by vote of those covering fifty miles on Club hikes. All who hike one hundred and twenty-five miles are to be the guests of the Club on a special hike at the end of the season.

The spring program will begin on Saturday, April 14, with a ten mile hike from Piermont to Alpine, the objective being a campfire supper with Phyllis Barton as hostess. The cost of transportation and supper will be about one dollar and fifty cents. On Sunday, April 22, the group will hike by trail under the leadership of Trevor Temple from Suffern to Tuxedo through the picturesque Ramapo Mountains. The cost of transportation will be about two dollars. Please call Phyllis Barton or A. Grendon if you wish to attend either.

Printed copies of the complete hiking schedule for the spring may be obtained on request.

### Baseball

The Bell System Baseball League will open the 1928 season on Monday evening, April 30, at Erasmus Field, Brooklyn. This year the league is composed of fourteen teams and is divided into two groups of seven teams each. Games will be played each week on Monday, Tuesday, Thursday and Friday evenings starting promptly at 6 P. M. All members of the Laboratories are invited to attend these games.

### Track and Field

The Bell System Baseball League will promote an intercompany track and field meet at Erasmus Field on Saturday afternoon, June 16.

## WOMEN'S ACTIVITIES

### Dancing

The dancing class continues every Monday night at the Vecchio Studio, where the "Varsity Drag" is the latest subject for study.

### Swimming

The new term for Women's Swimming Classes will start Monday, April 4. There will be two classes a week, and the course, which will extend over a period of ten weeks, will afford a splendid opportunity to put in some intensive training for the summer vacation. For application blanks see Miss Steel, Section 1-G.

### Bowling

The women bowlers of the Laboratories are most enthusiastic about the arrangements made for them by the Bell Laboratories Bowling League. Four teams selected in a contest held on February 24 have been scheduled to bowl at Dwyers on Friday evenings for six weeks ending April 6. A member of the Bowling League has been present to instruct the beginners, and there has been marked improvement in the scores since the first games. The women's teams are represented on the executive committee of the Bowling League by Helen Cruger and Marie Boman.

### Basketball

With a record of having won six games out of nine, the Women's Basketball Team has completed the 1927-28 season with a success hitherto unattained. This season, which has meant the first real attempt at outside competition, has opened up an avenue leading to future attractive and spirited programs in women's basketball. The first five games were successive victories for the Laboratories Club Team, which defeated teams of the Southern Division of the New York Telephone Company, the Vacuum Oil Company, the Seaboard National Bank, Hudson Street branch of Western Electric, and the Union Carbide and Carbon Corporation. Then followed defeats by the People's Palace and the Federal Reserve Bank. In a return game with the Southern Division of the New York Telephone Company the Laboratories Team was again victorious. In the final game, Hempstead High School Alumnae were winners; they exemplify the type of team we are preparing to meet next season.

Gold basketballs were awarded to eleven members of the squad.

## *The St. Francis Dam Disaster*

*The prompt handling of a terrific rush of urgent calls was instrumental in saving the lives of hundreds of people trapped in the valley of the Santa Clara River during the recent flood. Though the telephone offices were in imminent danger of being swept away by the deluge, the operators stayed at switchboards, transmitting warnings, and notifying the local constables to spread the general alarm.*

*Lines and equipment suffered badly, and orders were given to spare nothing in the effort to restore service. The first line went down at* 12:45 *Tuesday morning. By noon one hundred repairmen were on the job, and fifteen truckloads of insulated wire for temporary use had arrived in the flood area. As part of the day's work, two telephone men swam across a fifty-foot torrent of water to start repair of the San Francisco-Los Angeles circuits. By six o'clock in the evening all of the circuits on the inland route, which carry a great part of the telephone and telegraph load from southern California to the north, were restored by the use of temporary insulated wires laid on the ground and through water. Special telephone and telegraph circuits were installed to take care of the Red Cross, news agencies, and the Governor and his staff.*