BELL LABORATORIES RECORD

TEST AND CONTROL BOARD
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JOINTS IN SUBMARINE CABLE
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DRY BATTERIES FOR THE BELL SYSTEM
J. C. WRIGHT

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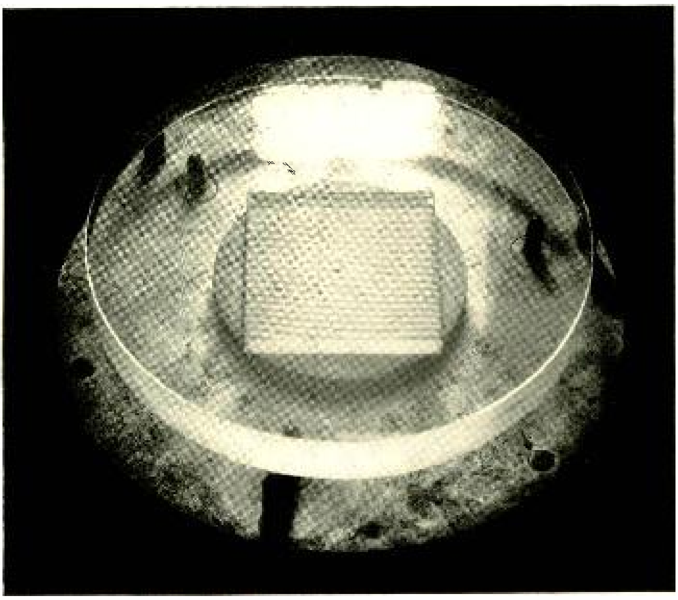

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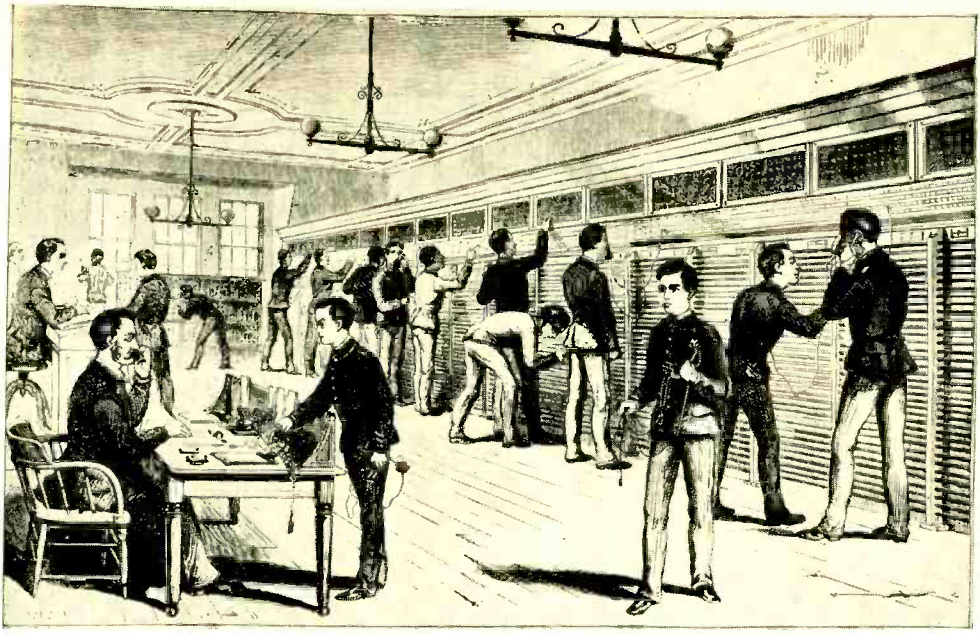


Early Handsets

By H. A. FREDERICK
Transmission Instruments Director

THE first telephone, invented and patented by Alexander Graham Bell in 1876, was a very simple device. In principle it resembled the telephone receiver of today, but was used for both speaking and listening. Although thoroughly adequate for the demonstration of a principle, such an arrangement was decidedly inconvenient for practical use. New fields for the exercise of human ingenuity were opened, however, by this brilliant invention, and the next five years witnessed an extraordinary activity all over the world in the invention of modifications and applications of Bell's fundamental discovery. As we look back on them, however, all these ideas and inventions did not appear in what we would now consider their logical order. Some of them could not be successfully applied until later improvements had rendered them practical.

An understanding and appreciation of Bell's invention was extended to England by his demonstration lecture before the Society of Telegraph Engineers in London in October 1877. The inconvenience of first listening with an instrument and then talking into it seems immediately to have impressed two Englishmen. Charles A. McEvoy, an employee of the London ordnance works, apparently the first to act, patented the two arrangements shown in Figure 1. One consisted simply of a speaking tube connecting the air space back of the receiver with the mouth, so that the receiver could be held continuously to the ear. The other was a clumsy but effective device for holding two of the early hand receivers: one in position for talking and the other for listening. These proposals disclosed the first handsets. Only six weeks later, G. E. Pritchett, an architect, obtained a patent somewhat extending the ideas disclosed by McEvoy. Pritchett also shows both a speaking tube connection around to the mouth from a receiver held to the ear, and two instruments on a curved and adjustable handle—one to be used as a transmitter and the other as a receiver. In addition he shows a considerable variety of branched arrangements of speaking tubes connecting into the instruments so that several people could use them simultaneously. He stressed the importance of so arranging the apparatus that it could be mounted on the head and shoulders of the users, thus leaving the hands free. None of these devices appear to have been used commercially by their inventors, partly because of the absence of practical telephone systems, and partly because any of the devices would have been somewhat too inefficient for satisfactory use.

In the following year—1878—the Gold and Stock Telegraph Company, a subsidiary of the Western Union Telegraph Company, proceeded to establish telephone-exchange service in the New York district. Rights were acquired to the Gray receiver and the Edison transmitter patents. Many novel devices had to be originated to provide telephone service, but in the light of our present switchboard practices, this early system seems very crude and elemental. A view of the exchange is shown in the photograph at the head of this article. It required the operator or switchman to move from one switchboard to another to complete a call. Since he had to carry the telephone instrument with him, the most portable form possible was desirable. Robert G. Brown, the chief operator of the first Gold and Stock exchange, was responsible for a number of the original features which were used there. Not the least important of these was the arrangement he developed and introduced in 1878 of a combined receiver and transmitter. This combination was dictated entirely by the practical needs of the situation and appears to have been developed without knowledge of either of the inventions mentioned above. Unlike McEvoy or Pritchett, Brown used an Edison carbon transmitter. Since Edison's first transmitter was patented in 1877, it seems quite possible that neither McEvoy nor Pritchett were familiar with it at the time their patents were filed.

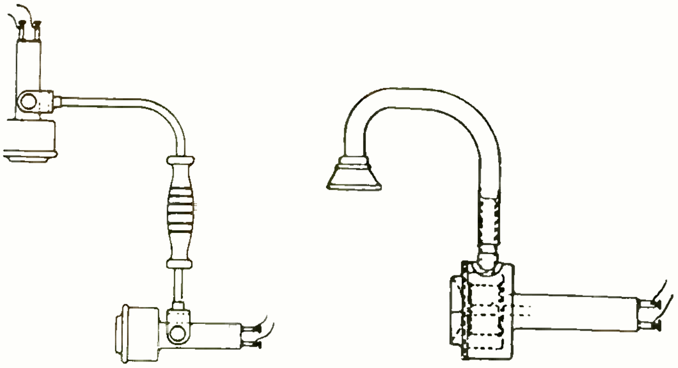


Fig. 1—The first suggestions for avoiding the necessity of moving the Bell telephone back and forth from mouth and ear were made in England

The handle of the Brown handset, shown in Figure 3, consisted of a curved iron bar which formed part of the magnetic system of the receiver. Connections from the transmitter and receiver were brought out through flexible cords which terminated in plugs. A switchman could carry this apparatus to any section of the room and plug it into the switchboard to which he had been assigned to answer or complete a subscriber's call. At the time these first handsets were made and put in use, Brown was apparently more interested in getting the new switchboard into operation than in protecting his ideas by patent, so that it was not until September 1879 that he realized the novelty of his device and filed patent application. His first broad claims to the combination of a receiver and transmitter on a handle were rejected on the grounds that the idea had been anticipated by Pritchett. Brown therefore amended his application, and in 1880 a patent was granted covering the specific arrangement of instruments as they were used at the Gold and Stock exchange. The "universal switch", one of the Western Electric Company's early switchboards, was also used there, and for some time after these two devices seem to have been associated.

The performance of these first exchanges in New York was considered so successful that both the devices used there and some of the men associated with their development found their way abroad. In 1880, La Societé General des Telephones was formed in Paris by the union of three companies which had been organized and granted concessions the year preceding. Brown was drafted from the Gold and Stock Company in New York to serve as electrical engineer of the Societé General in Paris. The exchange which he helped to establish used his handset which still employed the Edison variable-resistance, carbon-block transmitter. This appears to have been the first use of the handset in Europe. These first Paris exchanges employed women as operators, instead of men as the New York exchanges had done, and the Brown handset was found undesirably heavy. As a result there was an active demand for the development and improvement of the handset, particularly

Fig. 2—The early English patents suggested the handset in appearance, but were never given practical application

Fig. 3—The first commercial handset was invented by R. G. Brown, and used by the Gold and Stock Telegraph Company of New York

ever, could be used only in a vertical position, and thus was not suitable for handset use. For switchboard use the transmitters were mounted vertically in a convenient position in front of the operators, and the receiver of the handset was replaced by the head receiver invented by W. L. Richards in 1884. For subscribers' use, the better performance of the Blake transmitter and that it be made lighter and more convenient.

A simpler and lighter set was designed by M. Berthon, chief engineer of the Societé General in Paris, which used a Berthon transmitter and an Ader receiver. This set performed sufficiently well so that its use spread through the provinces of France, not only for operator's use, Figure 4, but for subscribers' intercommunication service, for which there was an increasing demand. This form of service was extended to include communication with other houses in the district. The earliest use of the handset by subscribers was probably at this time which was about 1882. From this time on the handset saw considerable development, and was improved in appearance, size, and convenience. It was used in Europe both for ordinary telephone systems and for PBX service, and has been known as the "Microtelephone".

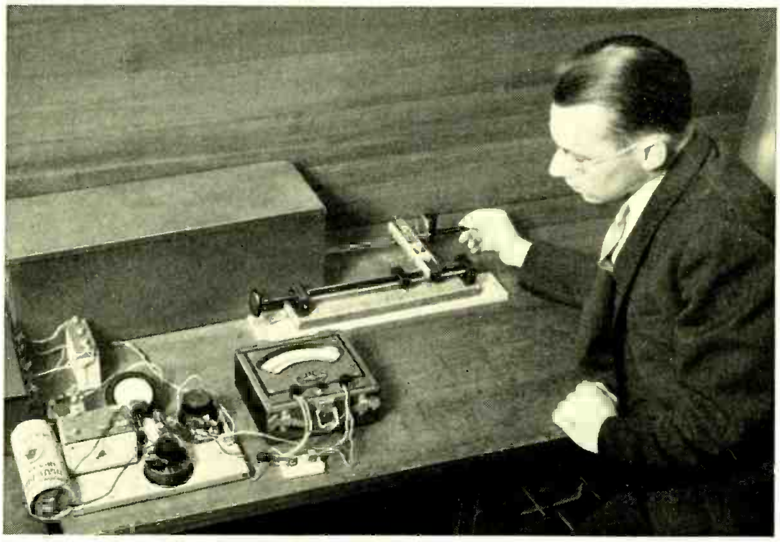
In America the operator's handset was used only until about 1884, and its use was not extended to subscribers. In this period the relatively insensitive Edison transmitter was replaced by the more efficient Blake transmitter. This transmitter, how-

Fig. 4—Brown took his early handset to France, where it was used in the early Paris exchanges

the subsequent granular carbon types, led to the development of a telephone system along the line of wall sets and desk-stand sets which permitted the application of these transmitters to best advantage. Such use of these transmitters made it feasible to work to higher standards of transmission service, than in those countries where the less efficient handset was employed for regular service.

As the years passed, foreign manufacturers were active in pushing the sale of their various handsets in this country, but as already pointed out, their use was necessarily restricted to limited classes of service and for intercommunication systems. The available types of handsets were not adequate for general use in the Bell System with its better transmission standards.

The convenience of the handset was recognized by the engineers of the Bell System, however, and laboratory studies were carried on for years with the object of so improving its performance as to make its more general use possible. A few years ago these developments reached the stage of suitable performance, and commercial production was at once started. By this time, the handset had acquired the reputation of being an European product. It is interesting to remember, however, that the first practical handset was made in this country, and that although it was taken abroad, and there somewhat improved, its development to a stage where it was suitable for use under the service conditions in this country is an American achievement.



Set-up for measuring the "q" of circuits tuned for wavelengths in the neighborhood of 60 centimeters. W. E. Kirkpatrick of the Research Department is adjusting the microscopic condenser of the tuned circuit

Joints in the Insulation of Submarine Cable

By F. S. MALM
Chemical Laboratories

THE conductor for submarine cables of the gutta percha or paragutta types is generally insulated in lengths of one or two miles.* After careful testing, these lengths are joined together in the factory prior to application of jute and armor wire. While the cable is being laid, or before, the longer deep sea sections are finally spliced on ship board to the intermediate and shore-end types. Thus a single-core cable of the heavier type may involve about as many joints as the length of the cable in miles. A serious defect in any joint would sooner or later result in operating difficulties requiring prompt repair.

Interesting testimony to the many problems and large expense involved in locating, grappling, lifting and repairing a defective cable has been given by a veteran cable-ship captain as follows.** "On one repair we hooked our cable twenty-six times in depths ranging from 2000 to 2600 fathoms, or about 15,000 feet. In each instance, we lifted the cable almost to the bow, only to see it snap under its own weight, and disappear into the sea. We stayed on that job from June to the middle of August. Finally we found a section strong enough to stand lifting, but we had to splice in two hundred and fifty miles of new cable to replace what we had broken. Sometimes, in heavy weather, we lose grapnels and rope; buoys drift and founder, or they get fouled in cables and do serious damage. Grapnel rope costs $1200 a mile; a deep sea buoy, which carries six tons, costs over $2000, and a mark buoy of three tons, $900. So you see, when we lose twenty-eight miles of rope and half a dozen buoys, as we did on one repair, our expense* in these two items

In addition there is the expense of cable ship hire, which may be of the order of $2000 per day.

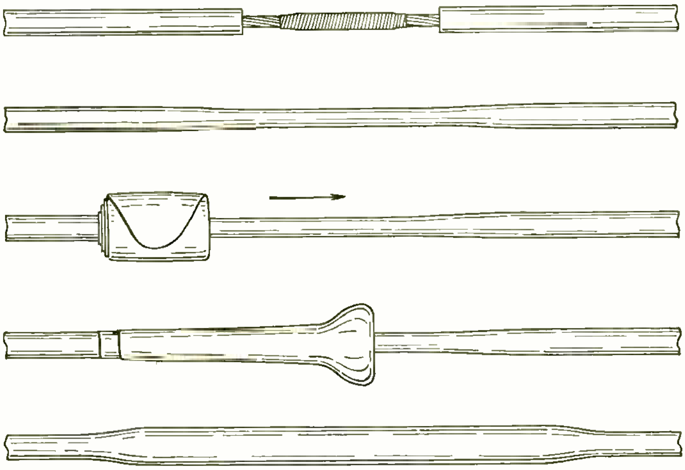


Fig. 1—In splicing the gutta-percha insulation of a submarine cable by hand, the insulation at the two ends of the splice is drawn together, and a sheet of gutta-percha is wrapped around the cable and worked over the joint until it adheres at the seam and has a smooth outer surface

*Record, *May*, 1931, *p.* 412.
***The American Magazine, January* 1925, *p.* 48, *an interview by George W. Gray with Captain W.G.S. de Carteret, marine superintendent of the Western Union Cable depot at Halifax.*

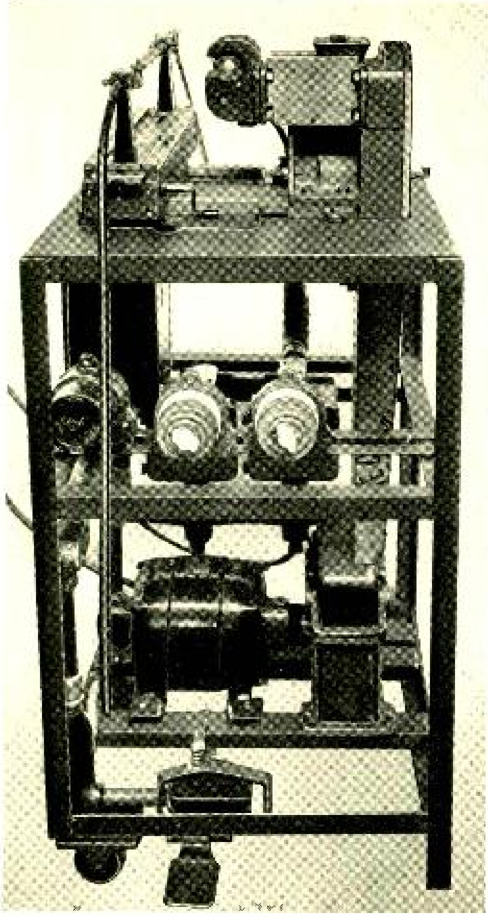


Fig. 2—The machine for completing paragutta joints applies the plastic material at the rate of about an inch per minute

alone is considerable. But the expense is not the worst of it; if supplies give out, we must lose valuable time putting back to port for a fresh stock."

In consequence of such experiences as these, extraordinary pains are taken to insure as nearly as possible that every joint will preserve throughout the useful life of the cables as good insulating characteristics as a corresponding length of insulated conductor. In the past, gutta percha has been the standard insulation for deep sea cables, and the joining has been done manually by experienced splicers. Their methods have varied; a typical one is illustrated in Figure 1.

When paragutta* was developed in these Laboratories, experimental joints were first made by standard manual methods using the new material, and it was found that perfect adhesion could not be obtained at the seam between the joining material and the core. It was also found that the conventional accumulation method of electrically testing the soundness of joints was not only unsatisfactory for detecting flaws but was misleading and gave a false impression of security. Joints with poor adhesion at the seam may appear to be satisfactory according to this method of test for periods varying from a few months up to two years of immersion in water and may fail later. Indeed in the past the principal assurance of the soundness of joints rested on the individual ability and skill of the jointer himself.

In view of these uncertainties, it was decided to develop mechanical methods for forming paragutta joints according to a more rigidly controlled procedure than had been customary. After considerable experiment, a machine (Figures 2 and 3) was developed which extrudes the plastic joining material over the conductor joint at a uniform rate and at a constant temperature and pressure, and thus performs in an improved way the last and most critical operation in joining the insulation. The original machine was designed by Mr. B. T. Trebes of the Western Electric Company and built at Hawthorne. Both the machine and the process underwent further refinement at the plant of the Norddeutsche Seekabelwerke at Nordenham. Mr. Ernst Studt of the Seekabelwerke staff actively cooperated with these Laboratories in that devel-

*Record, *May* 1931, *p.* 422.

opment. The jointer is now given detailed and complete instructions covering every operation in the process of making a paragutta joint.

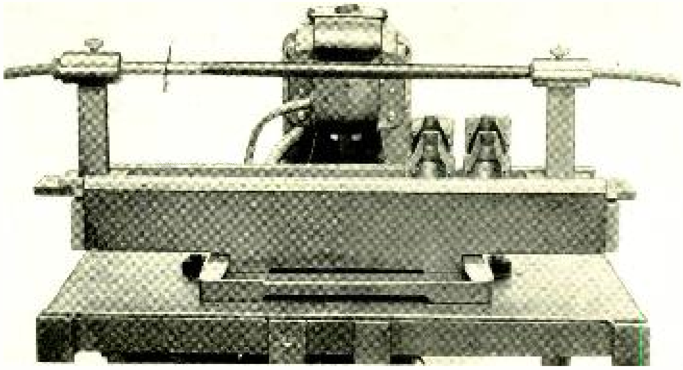


Fig. 3—The two parts of the extrusion die which apply paragutta to a cable joint can be seen resting on top of the machine

The application of this method to the 1930 Key West-Havana Cable* is illustrated in Figure 4. Over the conductor joint (a) the insulation at one side is heated by steam and drawn down by hand (b), and is overlapped by insulation drawn down from the other side (c). The overlap is molded under heat and pressure, while wrapped in tinfoil (d) to prevent the insulation from sticking to the heated mold.

*Record, *May* 1931, *p.* 412.

After chilling with ice water, the tinfoil is removed, the surface is filed to a symmetrical smooth contour, and the molded joint (e) is placed in the extruding machine. The two parts of the extrusion die are clamped around the molded joint and the plastic paragutta is forced into the die while the joint is carried through the die at the rate of about one inch per minute. The resulting joint (f), which is about ten inches long, is hand polished and cooled, and the jointer's identification number is stamped thereon.

Tests on hundreds of experimental and manufactured joints so made have shown that the adhesion at the seam is equivalent in tensile strength and elongation to the homogeneous core material. A most rigorous test for establishing this fact involves cutting thin cross-sections

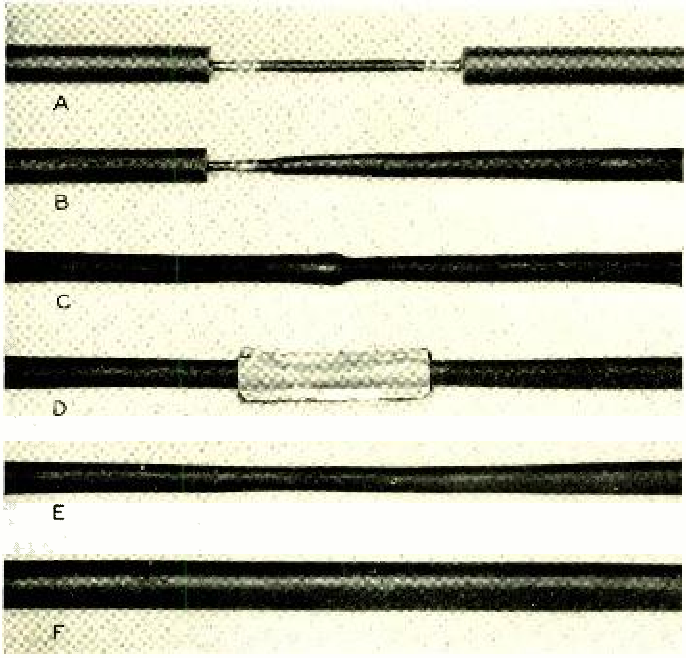


Fig. 4—Steps in splicing paragutta insulation with the aid of the machine

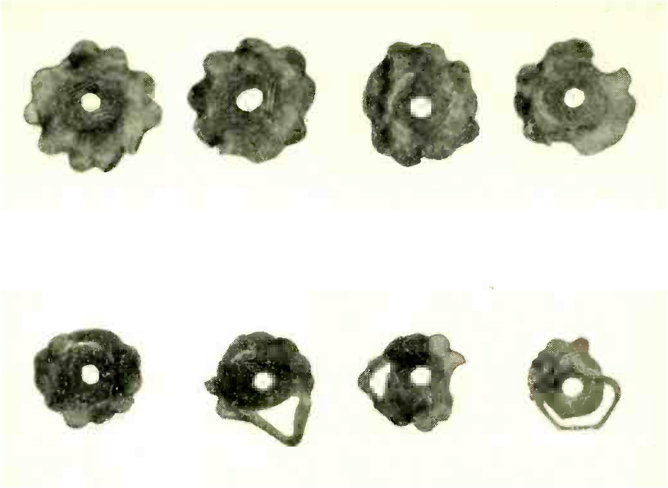


Fig. 5—Machine made joints in paragutta insulation (above) cannot be pulled apart at the seam, as can some manually made joints (below)

at various places along a joint and stretching the material from opposite sides of the seam to a point approaching the ultimate tensile strength of the insulation (Figure 5). A large number of specimen joints made in the new way were tested by this method, and all proved perfect.

Additional rigorous tests to bring to light mechanical or electrical defects in paragutta joints have involved low temperature flexing and stretching, followed by subjection to hydrostatic pressures simulating sea-bottom conditions. To perform the latter test, special high pressure testing equipment similar to that shown in Figure 6 was used. This high-pressure tank is a cylindrical steel forging weighing about 145,000 pounds, with walls about thirteen inches thick,

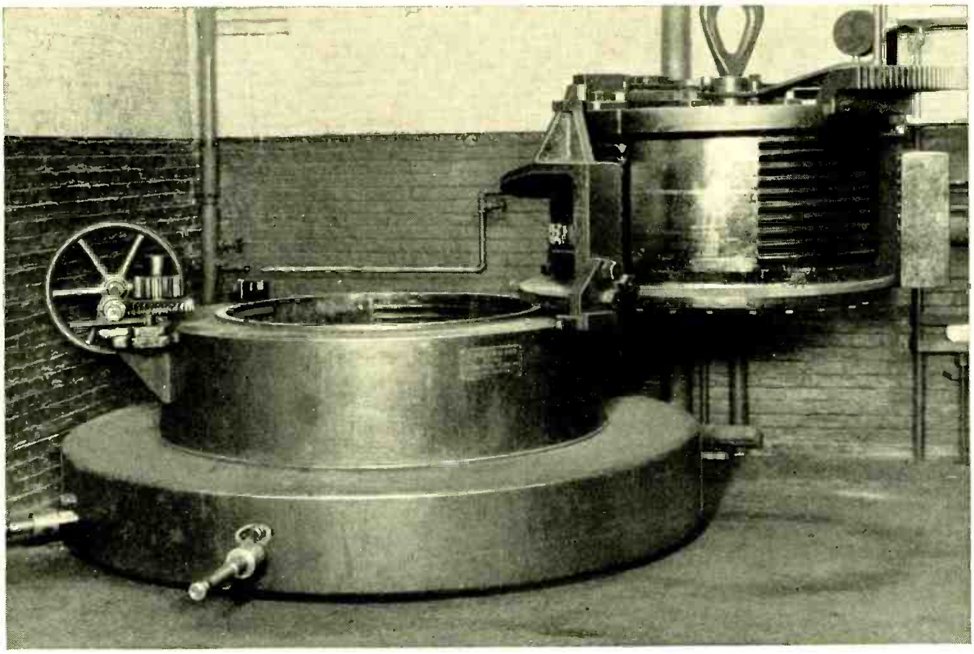


Fig. 6—Equipment of this type was used at Norddeutsche Seekabelwerke for subjecting submarine cable cores to sea-bottom pressures and temperatures

an inside diameter of forty-six inches and a depth of seventy-six inches. The equipment will accommodate a reel containing one to three miles of core depending on the particular type. The upper plug, weighing about 16,000 pounds, has to be raised and lowered into position by a ten-ton crane.

The safe operating pressure of this tank is 12,000 pounds per square inch, equivalent to the pressure existing about five miles below the surface of the sea. Pressure tests on submarine cable cores are ordinarily conducted at about 6000 lbs. per square inch and 34° F. which correspond approximately to the average conditions obtaining for the greater part of the length of a transoceanic cable.

A joining machine such as that described in this article was used to make the joints in the 1930 Key West-Havana Cable by the Norddeutsche Seekabelwerke, both in their factory at Nordenham, Germany and on their cable ship *Neptun* from which the cable was laid. The cable was manufactured under these Laboratories' supervision. The extremely high level of insulation which this cable still exhibits after more than three years at sea bottom furnishes good evidence of the excellence of the type of joint made by this machine.

This machine automatically tests the life of the switchhook contacts in eighteen telephone bases. It switches from one circuit condition for the break of the contacts to another for the make, and stops operating and lights a lamp when the resistance of any pair of contacts becomes objectionably high

Maintaining Quality in Bell System Dry Batteries

By J. C. WRIGHT
Telephone Apparatus Development

ALTHOUGH large storage batteries are used to supply current for the operation of telephone central offices, the dry cell still serves as the most economical source of power for many purposes in the telephone plant. Dry cells in considerable numbers are used in telephone sets on rural lines, for ringing-voltage and coin-collect batteries in small central offices, for various test purposes, and for grid bias for certain repeaters as well as for the flashlights used in installation and maintenance work. To insure that only dependable and high-quality cells are used in the telephone plant, Bell Telephone Laboratories has for many years conducted investigations and tests to determine the most economical and satisfactory types. In connection with this dry-cell work, representatives of the Bell System have participated actively in the work of the American Standards Association Committee on dry cells which formulates specifications for the dry-cell industry.

Fig. 1—Recording voltages of batteries on test in the battery testing laboratory

Originally tests by the Laboratories were made only on the No. 6 dry cells under conditions duplicating those of local-battery stations and of typical central-office service. In more recent years, however, the work has been extended to cover flashlight cells and various sizes and types of plate and grid batteries which find use in the System for a wide

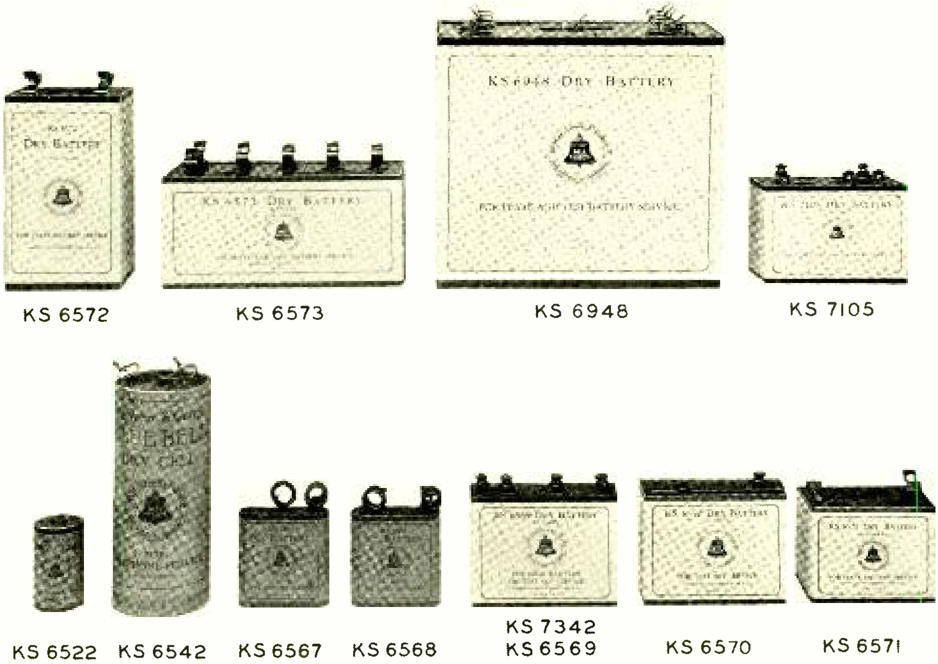


Fig. 2—Twelve types of dry batteries supply the major part of the Bell System demand. The KS-7342 battery, not shown in the photograph, is the same as KS-6569 except for its terminals

variety of purposes. The conditions of test for the latter types, are such as to duplicate the particular conditions of use of these batteries in the telephone field rather than for the usual radio service.

The Laboratories' work on dry cells and batteries may be classified under three important heads. First, are the tests necessary to insure the maintenance of satisfactory quality of the cells and batteries purchased for Bell System use. The greater part of the demand for batteries in the System has been concentrated on twelve types which are now supplied under Bell System designations as shown in Figure 2, and which are specified by the numbers of specifications under which they are purchased. In these specifications are outlined definite conditions for life tests under which guarantees are required from the suppliers. These guarantees cover the average performance to be given by samples of the commercial output for a stated period, usually one year. Samples representing the commercial output of each of these types are obtained periodically from the manufacturers for the specified life tests and the results are checked with the guarantees. This part of the Laboratories' testing of dry cells is mandatory under the purchasing specifications and eliminates the necessity for any other inspection before the cells are placed in service by the telephone companies.

Supplementing these tests the Laboratories maintains a constant study of the dry battery art as exemplified by all the commercial brands of dry cells on the market. Samples for these studies are obtained in such a manner that they represent the regular commercial output of the manufacturer. This insures that at all times the Bell System batteries are of the highest quality.

The third part of the Laboratories' dry-cell work consists of investigations of experimental cells that are undertaken from time to time when new types of construction not yet in commercial production offer promise of greater economy or improved characteristics under telephone service conditions. This work is conducted through cooperation with the different dry-cell manufacturers interested in obtaining Bell System business.

All of this dry-cell work involves testing under a wide variety of conditions. Experience has shown that the only way to compare the relative merits of different types or brands of cells for any particular service condition is by laboratory life tests under controlled conditions approximating this service. Thus for dry cells for station use, the results of observations of traffic at a large number of local battery stations had shown that the average conditions might be satisfactorily represented by a test in which the cells are discharged four minutes per hour, ten hours per day for six days per week with a discharge period every two hours on the seventh day, a total of sixty-five four-minute discharges per week. In this test three cells in series are discharged through a resistance of fifty ohms, which represents the average resistance of the transmitter circuit in the station set. The life is taken as the duration of the test to a value of closed circuit emf representing that at which battery replacements should be made to insure satisfactory service. Cells for this test are kept until they reach a uniform age of three months to make allowance for the average age when the cells are actually placed in service. For cells of the present types, as much as two years may be required for the completion of tests under these conditions.

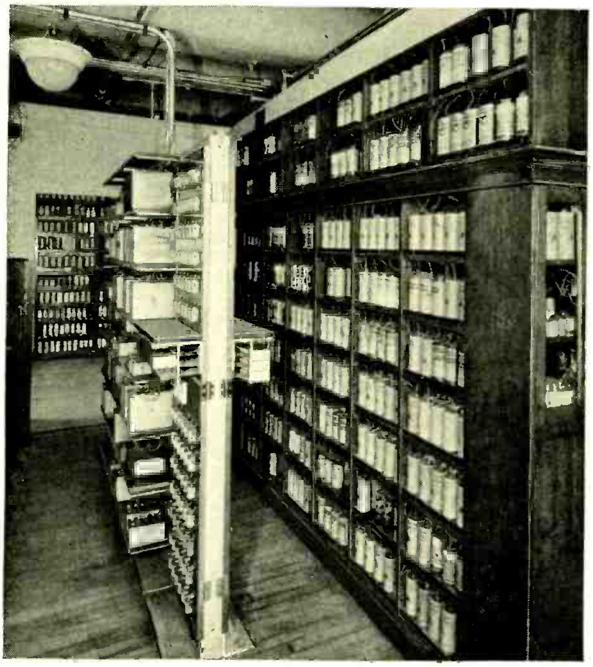


Fig. 3—Part of the battery testing laboratory showing the methods of mounting the batteries on test

Since many of the standard types of batteries are used in several kinds of service, it is necessary to make tests simulating these conditions of service, and to give each type of test due weight in determining the relative merits of different brands of cells. Thus for flashlight cells, for example, a field survey showed them to be used under widely varying conditions, and hence, to select the most economical types for use in the System, it is necessary to make two tests

Fig. 4—One group of program machines and recording meters used for dry cell testing

corresponding to light and to heavy industrial service, the latter having four times as many discharge periods as the former.

The present facilities of the Laboratories are sufficient to permit the testing simultaneously of over 3500 No. 6 cells, 300 radio-type plate batteries, 10,000 grid batteries and 150 flashlight cells. The testing equipment and procedure have been so planned that almost completely automatic operation of the equipment has been obtained. A view of part of the dry-cell laboratory is shown in Figure 3.

The timing of all of the discharge periods for the various life tests is controlled automatically by a number of commercial program machines operated from a high-grade master clock. The closed-circuit voltages of all cells and batteries on test are read periodically, and for tests of short duration where frequent readings are required, multi-point automatic voltage recorders have been adapted to record the voltage of each cell at frequent intervals. For flashlight cell tests, arrangements can be made to have the voltmeter automatically record the voltage during the discharge periods for as many as 180 cells. The use of voltage recorders makes it possible to run the tests independently of the working hours of the Laboratories, and to obtain the desired readings even when no one is in attendance.

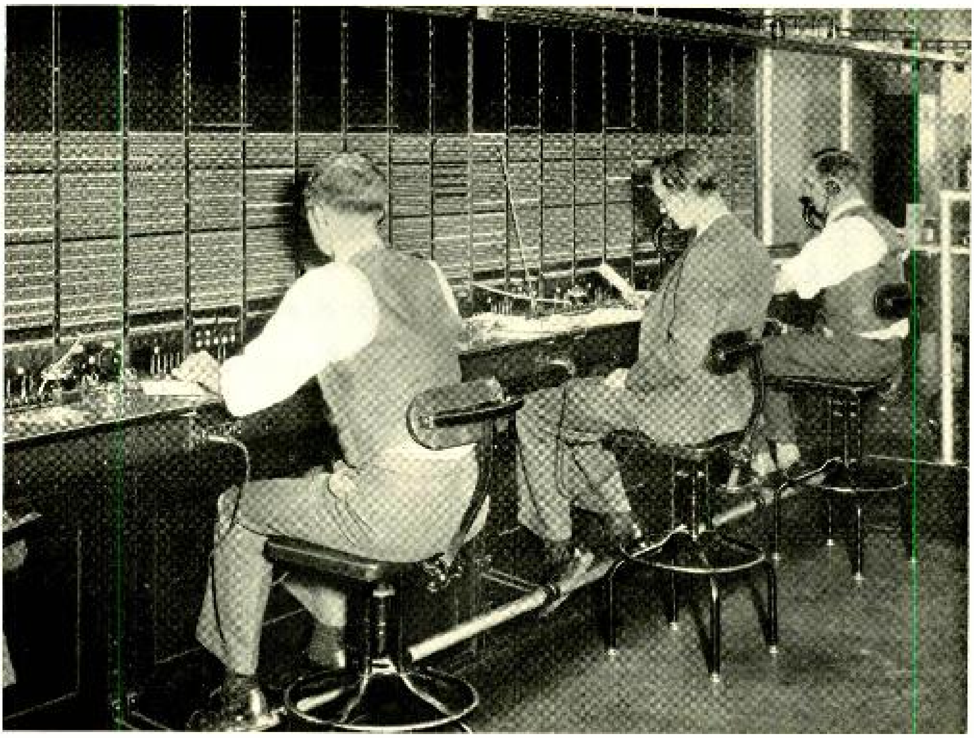
As the reactions in a dry cell are essentially of a chemical nature, its performance is considerably affected by its temperature while in use. To get consistent comparisons between results at different periods, therefore, particularly in the case of small cells, it is necessary to make all tests at the same temperature. Also, since there may be appreciable variation between different lots of cells of the same type and make, correct conclusions can be reached only after tests have been made on a number of lots representing an extended period of manufacture such as a year.

As it is necessary to make the tests at a constant temperature all the dry-cell testing equipment is housed in a room equipped for temperature control. In the winter, temperature regulation is obtained by thermostatic control of the radiators connected to the building heating system. For cooling the room, a circulating system passes air through fin-type radiators, through which cold water is pumped. The operation of the cooling system is on an intermittent basis by electrical control from contacts on an automatic temperature recorder. With this arrangement the temperature of the room is maintained constantly between 69 and 71 degrees Fahrenheit.

The scope of the dry-cell work by the Laboratories is indicated by the regularly scheduled tests as follows: 20-ohm station service; 50-ohm station service; pole-changer service; light flashlight service; heavy flashlight service; repeater grid-battery service; and radio plate-battery service under four conditions of test.

Estimates of life for other conditions are required frequently in connection with the design of apparatus and equipment and the preparation of maintenance and operating instructions. These estimates often require that special tests be made in addition to the standard tests noted above. These special tests cover conditions of continuous and intermittent discharge, both at constant current and through fixed resistance. In such tests the discharge periods may vary from a few seconds to several hours with the intervening open-circuit periods also varying over a wide range.

The demand of large dry-cell users for the best possible product has led to the development of a widespread interest in dry-cell life tests such as those carried on by the Laboratories, and the general increase in life testing that has taken place among manufacturers and users of dry cells has brought about a marked advance in manufacturing methods and a decided improvement in the quality of dry cells in general. In the case of the six-inch Bell System telephone cell, for example, study of the relative merits of various brands, by means of the tests described above, has made it possible to obtain a gradual improvement in life during the past ten years which now amounts to nearly 100 per cent. There has been a corresponding improvement also in the other types of cells and batteries used in the plant, and as a result substantial economies in the cost of dry-cell service in the telephone system have been realized.



No. 8 Test and Control Board

By G. E. BAILEY
Equipment Development

PREVENTIVE maintenance, in the form of routine tests, has been very successful in the toll plant in locating actual or potential circuit troubles so that they can be cleared in periods of light load. By thus reducing the number of troubles which occur during the busy hours, the circuits are kept available for traffic, and it is possible to combine prompt service to subscribers with an economical amount of plant. But busy-hour troubles will still occur and the minutes which elapse between the detecting of a trouble by an operator and the attack on it by a testboard man must be deducted from the few hours in which that circuit must earn one day's share of its annual charges.

When something goes wrong with a toll circuit in service, it usually comes first to the attention of an operator. The practice was formerly to refer the case to a supervisor for verification, and preparation of a ticket which was forwarded to the testboard for attention. The handling of this ticket and the incidental clerical work took costly minutes of circuit time, and if the trouble were of the intermittently recurring kind it might be gone when the tester reached it only to reappear after his report of "OK on test".

In order to speed up the reporting of toll line trouble in service the No. 8 Test and Control Board was developed and installations are now in satisfactory service in Detroit, Los Angeles, New York, and some sixty other places. This board serves to group all toll circuits at one point to which troubles are reported direct from each position of the toll switchboard, and at which facilities are arranged to test the toll circuits under the same conditions in which these circuits are used for commercial service. These tests at the No. 8 board are in the nature of rough diagnoses, in order to route the case to the proper group for attention.

The face of the No. 8 board is equipped with a complete multiple of all toll lines. Adjacent to each line jack is an "out-of-service" jack; insertion of a dummy plug into the latter gives a busy indication on the line. These two jacks give the test man complete control of the line either for observation while it is in use or for testing after it has been taken out of service. In addition, when the office toll-line multiple is equipped with idle line indicating lamps, these lamps also appear in one position of the No. 8 board to permit tests of the indicating circuit to be made here instead of at the switchboard. In the face of the board are also placed lamps and jacks for trunks: from the line positions, and to and from testing points in the same and other toll offices.

Keyshelf equipment includes three cords which give access to the testing circuit. This is equipped for ringing, talking and monitoring; for talking tests with and without attenuation pads; for ringing and voltmeter tests, and for 1000-cycle transmission measurements. In addition, there is a pair of connecting cords, on which the test man can talk or monitor; and several cords to hold circuits when test cords are busy. Trunks are provided for connecting to other equipment for more extensive tests or measurements when required, and also for bringing the case to the attention of the proper test man who will make the actual test at some other point. Some of the equipment associated with these circuits is located in the sections, while the rest of it is located on relay racks.

When a case of trouble comes to the attention of an operator, she will plug

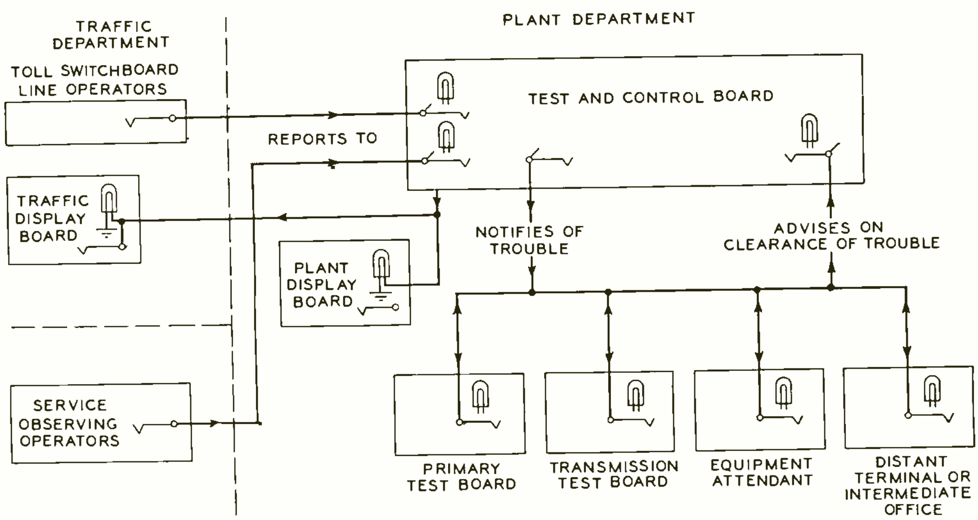


Fig. 1—How information regarding circuit conditions passes to and from the test and control board

into a trunk leading to the No. 8 board. Answering jacks are multipled throughout the board so that any available test man can take her report. Should he wish to take the line out of service, he will insert a plug into the "out of service" jack; while this will not interfere with a current conversation, it will cause the line to test "busy" afterward. If and when the line is free, he can ring the distant terminal. Should he desire the co-operation of the test board in a distant office, he can reach it either by taking an available toll line in the multiple before him, or over a telephone or telegraph order-wire. As soon as he determines the general nature and probable location of the trouble, he reports it to the group responsible for clearing it.

Since this arrangement no longer requires the initiating of trouble report tickets which were recorded in the past by the Traffic Department, it is in some cases desirable that they have other records which will give a clear picture at all times of the toll lines which are not available for use. A part of the test and control board equipment provides for this in the form of a traffic circuit display board which may be located at some suitable point in the operating room. Each toll line appears in this board as a lamp and jack. When a test man at the test and control board takes a toll line out of service by means of the out-of-service plug, for the purpose of observation or testing, the lamp in the display board associated with that toll line will be lighted. This display board will be attended by operators or clerks; and signals, indicating that a toll line has been taken out of service, can be recorded with any essential data secured from the test board.

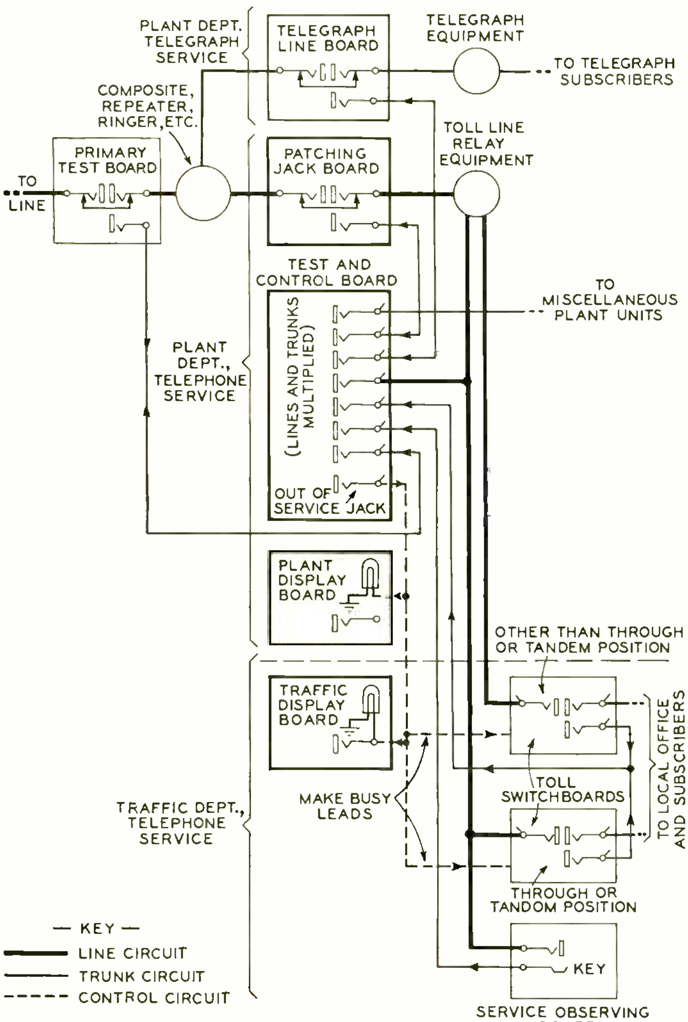


Fig. 2—How the test and control board is associated with other toll office units

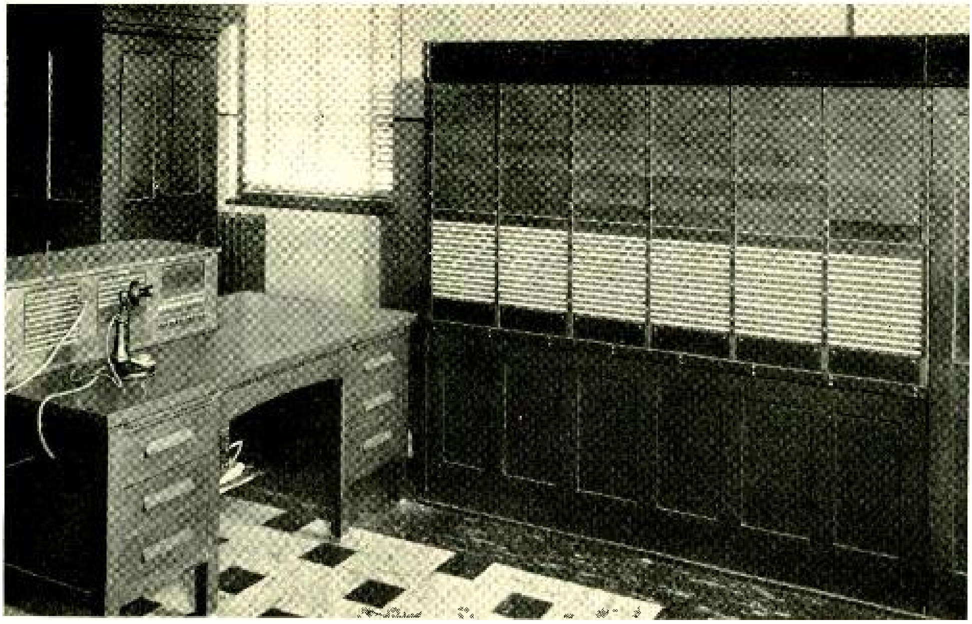


Fig. 3—Circuit display board which keeps the Traffic Department advised of circuit conditions

When the signal indicating a line out of service appears at this board, a dummy plug will be placed in the jack associated with the lamp, and the lamp will be extinguished. The nature of the trouble and a preliminary estimate as to the length of time the toll line will be out of service can be obtained when required from the Plant Department. If it becomes evident that a toll line will be out of service for an extended period, the type of trouble and its probable duration may be indicated on the display board by the use of appropriate colors on the dummy plugs. As subsequent reports are received on particular cases, the color of the plug marking the line can be changed as required. When a test man at the test and control board completes his work on the toll line, finds it ready for service, and restores it by removing the out-of-service plug, the lamp associated with this line at the traffic circuit display board will again be lighted. The presence of a lighted lamp in a line having a dummy plug in the jack indicates that the line is back in service, and the plug is removed, extinguishing the light. In smaller offices this board is sometimes in the form of a cabinet located on a wall or column.

When a toll tandem switchboard* is provided in an office the traffic circuit display board permits the circuits to be arranged in the same order as they appear at the toll tandem switchboard. Consequently, there will be an appearance of the overflow circuit in the same relative location in the traffic display board as in the toll tandem board. Since there is no toll line connected to the lamp and jack circuit occupying the overflow position in the traffic display board, it is possible to connect this circuit through to the toll tandem overflow circuit in order to provide a control

*Record, *June* 1930, *p.* 473.

and an indication of posted* delays. The toll tandem overflow circuit normally functions to light a lamp at the toll tandem board when all circuits of a group are busy. If it is desired to indicate a posted delay, a plug may be inserted in the jack occupying the overflow position in the traffic display board. This causes the associated lamp in the display board to light steadily and the overflow lamp in the toll tandem board to flash, thus indicating a posted delay as against an all-circuits busy condition. Since the lamp in the traffic display board remains lighted during the time the plug is in the overflow jack, it indicates to the Traffic Department a different condition from that for a normal circuit appearance.

In large-capacity offices a plant display board may be located near the desk of the man in charge of the control board. This board consists of a

*A posted delay is one of such duration that it is desirable to advise the calling subscriber when the call is placed.

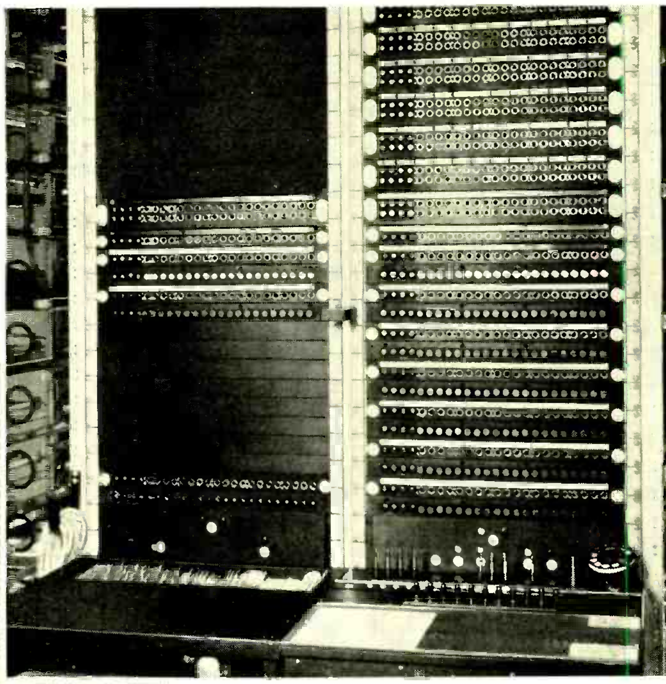


Fig. 5—A non-multiple test and control board at Aurora, Illinois, typical of equipment for the smaller office. Toll lines are made busy by operating the keys seen below the jacks in the lower part of the right-hand panel

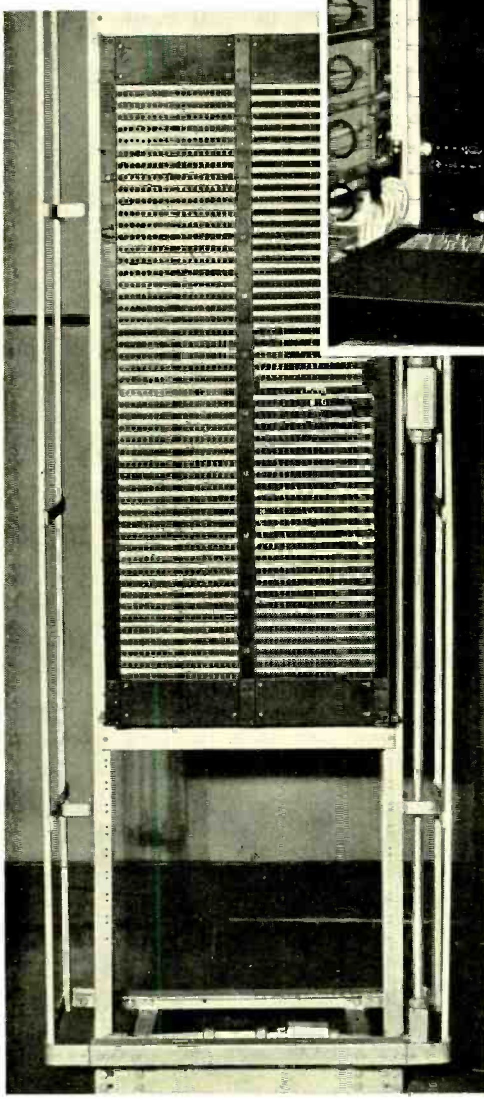


Fig. 4—A similar display board gives to the plant man in charge a picture of the line situation

single relay rack bay arranged with one appearance of the toll lines similar to the traffic circuit display board. A lamp remains lighted behind the designation strip of each line as long as it is out of service. This board provides a compact picture of the number and distribution of lines out of service and aids in the supervision of the testing.

In offices with an insufficient number of lines to warrant the use of a switchboard type of control board, a relay-rack type may be used. This board has the same testing facilities as the large board and is operated in a similar manner, except that it will normally have only one appearance of the lines. It also provides space for the patching jacks for each line, which, in the case of the large capacity board, are located in separate relay-rack bays.

EARTH, RADIO AND THE STARS

Testimony to the many valuable contributions of these Laboratories to cosmology is given by the numerous references to papers by members of the technical staff in a book, EARTH, RADIO AND THE STARS, *by Dr. Harlan T. Stetson, Research Associate in Geophysics at Harvard University, recently published by McGraw-Hill. In this excellent and readable summary of present-day knowledge of what its author calls "cosmecology", notice is given to the papers of L. Espenschied, C. N. Anderson, R. S. Bailey and C. R. Burrows on radio transmission, of R. A. Heising on ionized regions of the atmosphere, of E. T. Burton and E. M. Boardman on the electrical effects of solar eclipses, of A. M. Skellet, J. P. Schafer and W. M. Goodall on the ionizing effects of meteors, of K. G. Jansky on galactic radio waves, and of K. K. Darrow on cosmic rays. Since reference is made to astronomical methods for the accurate measurement of time, the failure to mention the non-astronomical methods developed in these Laboratories by W. A. Marrison seems a singular omission.*

Jacks and Plugs for Portable Telephones

By H. K. KRANTZ
Telephone Apparatus Development

PORTABLE telephones for subscribers were first made available by the Bell System in restaurants, hotels, and hospitals to permit patrons to receive or initiate telephone calls without having to go to a central location. To provide this service, jacks were installed at designated locations on the premises, and telephones were provided with plugs attached to the cords. A survey had indicated that more three-wire than two-wire circuits would be required, and that there would be a demand for flush jacks as well as for the non-flush type. Three-wire plugs and jacks were therefore used for both types of circuits, the jack being a non-flush type which could be arranged when required for flush mounting.

The contact portion of the plug provided was similar to the ordinary switchboard plug: one conductor terminating in the tip section of the plug, one in a metal ring just back of the tip, and the third in the sleeve or stem of the plug. The body section, however, was of greater diameter, and was provided with a hard rubber shell, enlarged at the cord end to make it easy to pull the plug out of the jack. It was subsequently found that the plug received such severe treatment in service that the hard rubber shell was frequently broken. As a result the design was changed to provide a sturdier shell uniform in diameter throughout its length. This plug, known as the No. 148, is shown in Figure 1. The cord entered through

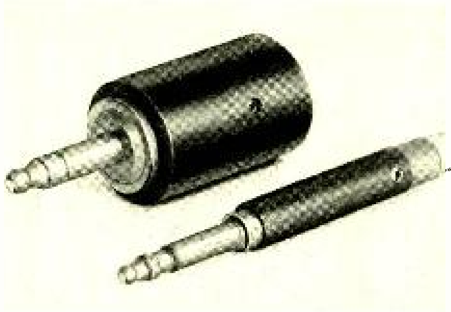


Fig. 1—The No. 148 plug differs from the ordinary switchboard plug in having a large hard rubber body, but the contact portion is of the same general type of construction

a hole in the end of the shell, and adequate space was provided for the connections, and for staying to take the strain off the conductors should the plug be pulled out by the cord.

The jack for use with this plug had a stamped metal base on which were mounted spring contacts for the tip and ring conductors. Contact to the sleeve of the plug was made by a bushing held out from the base on a punched metal support. All of these parts were insulated from each other, and were equipped with binding screws for wire connections. A square drawn-metal shell, finished in black, fitted over the jack and had a hole in the front somewhat larger than the sleeve bushing. In this opening was sprung a hard rubber ring to insulate the shell from the bushing. There were holes in the punched metal base through which concealed wiring could be brought, and slots in the bottom edges of the shell for surface wiring to enter.

When it was necessary to mount the jack flush with the wall, the shell was not used. A blank plate such as is used with commercial flush outlet boxes was employed instead. This plate would be drilled for screws to fasten it to the jack, and with a hole at the center large enough to take the hard rubber ring surrounding the sleeve bushing. It would then be fastened over the outlet box into which the wiring had been run in the usual way.

Increased requirements for flush jacks later made it desirable to design

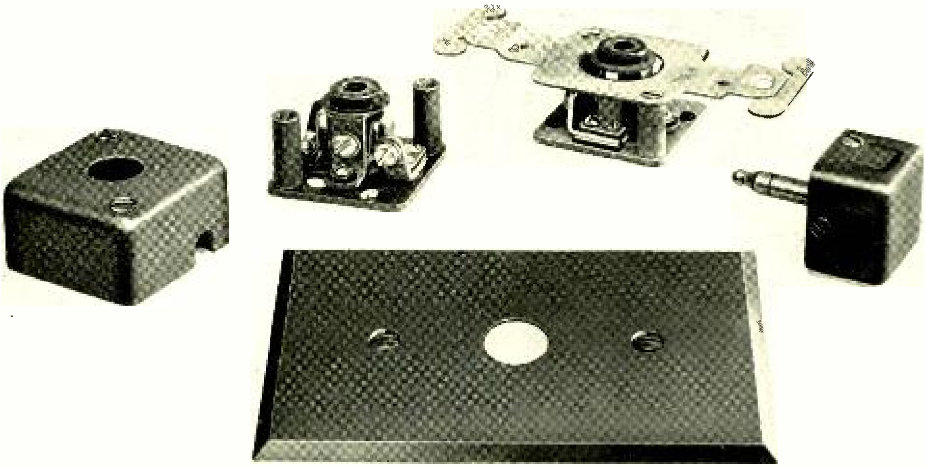


Fig. 2—An ordinary switchboard jack is too long to be used conveniently for surface mounting, and so a shorter construction was provided. The body of the plug was shortened also

a jack especially for this service so as to avoid the necessity of preparing the plates for each installation. In the first flush jack the use of separate insulators for the sleeves had proven particularly objectionable. They were not only difficult to manufacture but were frequently broken while being sprung into place or when hit by the plugs. In the design of the new jacks, therefore, the insulation was made an integral part of the sleeve bushing. With this change in construction it was, of course, necessary to design the jack to fit standard outlet boxes and plates, which might be used with it, and at the same time to keep the manufacturing costs low by using as many of the existing parts as possible. This new design is shown in Figure 2.

While the original portable telephone installations were in restaurants and hotels, the general popularity of this type of telephone has extended in recent years to offices and residences. This has involved the provision of wiring plans* and PBX services** which permit the portable telephone to be employed for many more purposes than simply answering and placing outside calls. Many of these new wiring plans require more than three conductors at the stations, and as a result plugs and jacks of more than three conductors would have to be provided for this type of service. Considering the probable demand for various numbers of contacts, it was decided to provide plugs and jacks of 3, 4, and 8 contacts: the 3-contact equipment serving when there were 2 or 3 conductors, and the 8, when there were from 5 to 8 conductors. Both flush and non-flush jacks had to be provided. The plugs and the non-flush jacks were finished in either black or old brass, and the flush jacks in old brass or brush brass.

For three conductor service, the jacks already available were in general satisfactory but the non-flush type was changed to employ the new sleeve construction already employed with the flush type. For this new service plates were included with the flush jacks to facilitate installations and to assure finishes which would harmonize with associated apparatus.

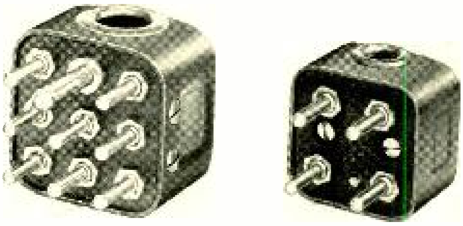


Fig. 3—With the four- and eight-contact plugs each contact is a smooth prong and provision is made to insure that the plug will always be inserted in the jack in the same way

To improve its appearance, the three-conductor plug was redesigned in the form shown in Figure 2. A shallow rectangular metal shell, instead of the cylindrical shell, was used to cover the cord connections. Considerable study was required to reduce the body elements to the small space allowed by the new cover. The cord enters through a bushed hole in the side of the cover, instead of through the face of the cover. This smaller plug, with the cord entering through the side, greatly reduced the effective projection from the wall.

For four- and eight-contact service, the type of plug and jack used for the three-contact circuits was not particularly suitable. Much laboratory study and ingenuity was necessary to design four-and eight-contact plugs and jacks

*Record, *April* 1932, *p.* 1.

**Record, *April* 1933, *p.* 244.

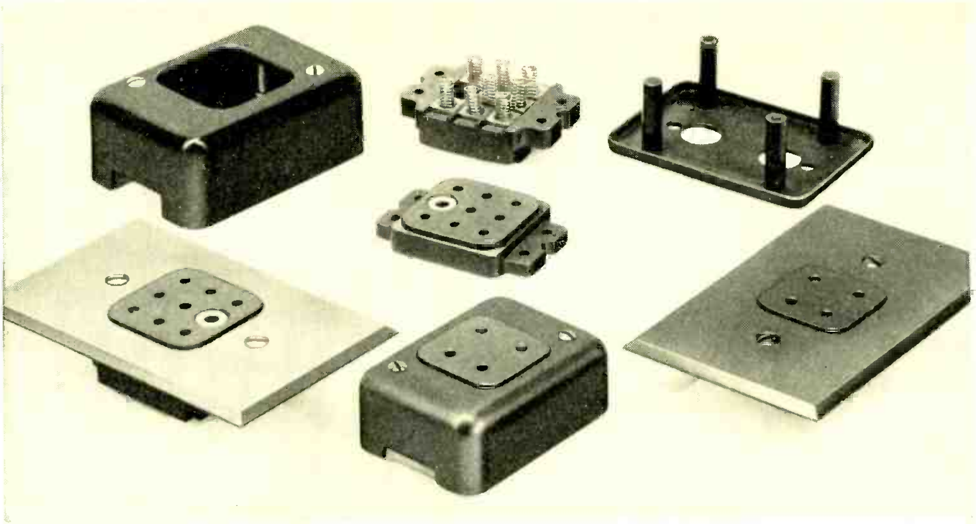
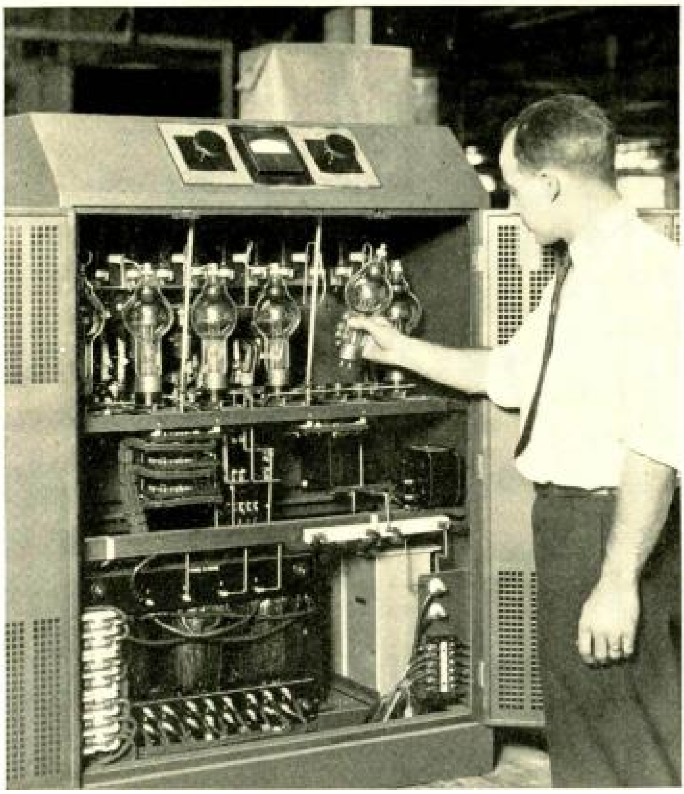


Fig. 4—The four- and eight-contact jacks have intermeshing spring contacts instead of the flat spring contacts of the three-contact type

which would meet the severe contact requirements, provide space for cord connections with terminals attached and for their staying, and at the same time occupy a small space. After a careful investigation it was determined that intermeshed helical springs in the jack engaging smooth cylindrical prongs on the plug would give most satisfactory contact. It is essential, of course, that any one prong of the plug should always connect to the same terminal in the jacks, and to insure this with the four-contact plug, the four prongs are not equally spaced but are located at the corners of a trapezoid. To secure the same result with the eight-contact plug an extra prong is employed which is much larger than the others. This arrangment has the additional advantages of making the union between plug and jack more rigid. These plugs are shown in Figure 3.

The jack construction is shown in Figure 4, where the arrangement of the interlocking springs may plainly be seen. The same body is used for both flush and non-flush types. Although this is economically desirable, it made the design more difficult since with the non-flush type, the body is fastened to the jack covers, while with the flush type, the body is fastened to the yoke, the plate being screwed to the yoke after it has been installed in the outlet box.

With these various forms of plugs and jacks all the more usual needs for portable telephones may be readily met. The jacks are small enough to be installed in almost any location and the variety of finishes provided make them inconspicuous. The plugs lie flat against the jacks where they are not likely to be in the way and are rugged enough to give long life under any ordinary conditions.



A 5000-Volt Mercury-Vapor Rectifier for the 6B Radio Broadcasting Transmitter

By H. A. REISE
Radio Development

IN the early years of broadcasting, the plate power for most transmitters was obtained from high-voltage motor-generator sets. This was a very satisfactory and economical arrangement since the power requirements were small and the motor-generator sets could readily be arranged to operate from any available type of power supply. This practice was followed in the design of the Western Electric 6A and 6B (1 kilowatt) Radio Broadcasting Transmitters on account of its obvious advantages. The plate voltage made available, however, was limited to 4000 volts since this was, at that time, the practical limit with two conventionally insulated armatures connected in series.

The trend toward higher-powered broadcasting transmitters resulted in a demand for sources of plate power at higher voltages, and gave rise to the development of thermionic rectifiers, which have been extensively employed for some time in the larger transmitters, such as the Western Electric 5 kilowatt transmitter and the Western Electric 50 kilowatt equipment already described in the Record.*

Recently there has been some desire for increasing the modulation capability of the 6B transmitters from an average of approximately 85% to a full symmetrical 100%, which is not possible with the plate voltage limited to 4000 volts as it is by the motor-generators originally supplied with this equipment. It has thus appeared desirable to make available for use with this transmitter apparatus capable of supplying plate power at a voltage of 5000, which can be used to replace the high voltage motor-generator sets (many of which have been in service for several years and may be in a condition where proper maintenance is difficult), and will at the same time give the advantages of symmetrical 100% modulation.

This undertaking was much simplified by the development during the last few years of the high-voltage gas-filled rectifier tubes. The gas in the tubes is mercury vapor obtained from a small amount of mercury incorporated in the tubes during manufacture. These tubes have very high efficiency, good regulation, and even in the larger sizes do not require water cooling.

The complete new plate power supply for the 6-type transmitter, including six tubes, transformers, controls, and auxiliary equipment, is housed in an attractive metal cabinet only four feet high and three wide. It is shown in the photograph at the head of this article with the two front doors open.

*Record, *November* 1927, *p.* 71.

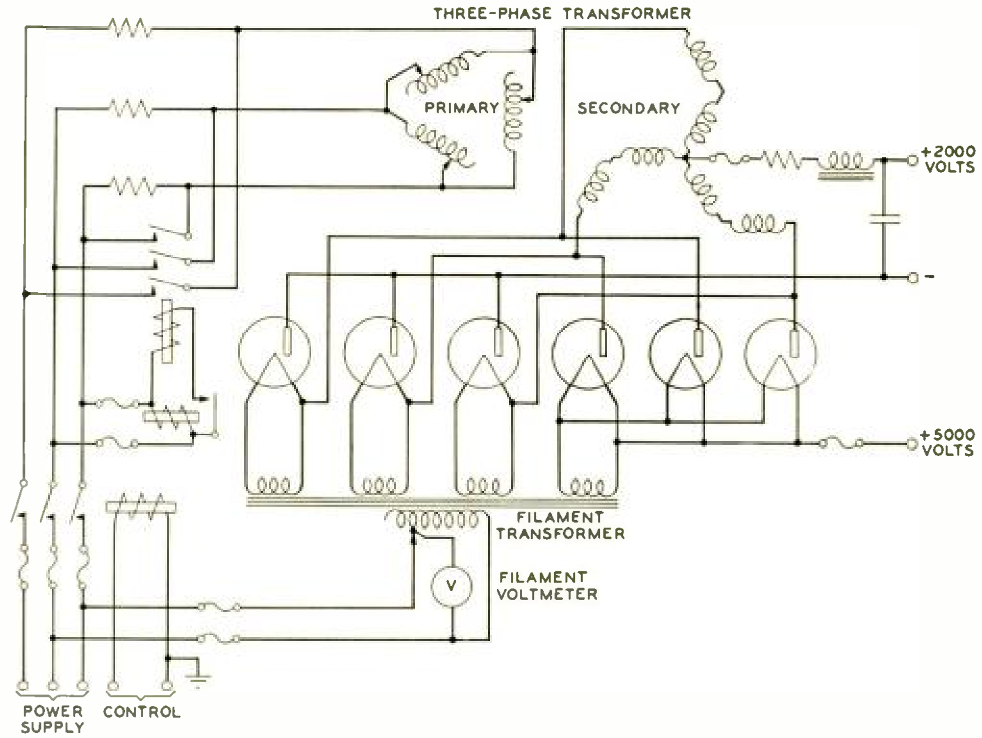


Fig. 1—*Simplified schematic of mercury rectifier for the No. 6 type broadcast transmitter*

A sloping panel across the front of the top provides a convenient mounting for a filament voltage meter and two voltage controls.

The electrical circuit comprises essentially a three-phase transformer and six mercury vapor tubes—the 267A—connected in a three-phase full-wave circuit as shown in Figure 1. The primary windings of the main transformer are provided with five and ten per cent voltage taps both above and below normal. Three tap-changing switches, mechanically coupled together and controlled from a dial on the sloping panel, permit adjustments for the line voltage to be made under load. The second dial on the sloping panel controls a tap-changing switch associated with the filament transformer. The filament voltage is indicated by a meter mounted between the two control dials. Plate voltage is read on a meter mounted on the transmitter rather than on the rectifier unit.

The normal output voltage for plate supply is 5000 volts but a potential of 2500 volts is obtained from the common point of the secondary windings of the transformer, and reduced by resistances to 2000 volts for use as a plate supply for the early stages of the transmitter. Sufficient filter sections are located in the rectifier unit and in the associated transmitter to reduce the ripple voltage of the rectifier output to a satisfactory level.

To reduce the starting current to a safe value when the rectifier is connected across the line, resistors are connected in the primary leads to the three-phase transformer. These resistors are automatically short circuited after a short time delay.

The control circuits of the transmitter and rectifier unit are electrically interconnected to maintain the same operating sequence as that used with the motor-generator set. Door switches in the rectifier unit, interconnected with those in the transmitter, cause the high voltage to be removed whenever the doors on either the transmitter or the rectifier are opened. In this way the operating personnel is protected from accidentally coming in contact with dangerous potentials.

In the design of this unit every effort has been made to minimize the work necessary in changing over from motor-generator set to mercury rectifier. The installation of this new equipment does not require that the station be off the air if it is not operated on a schedule of more than about 17 hours per day. Under these conditions the complete conversion can be made within three days without difficulty.

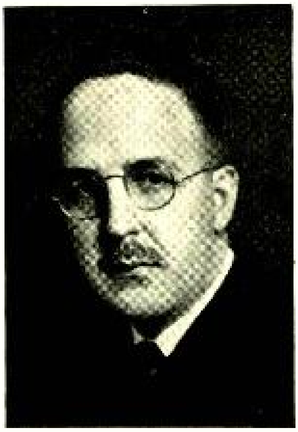
Contributors to this Issue

F. S. Malm entered the Students' Course in the Western Electric Company's Hawthorne Works in 1906, and engaged first in installation work and later in switchboard cable design, meanwhile pursuing evening studies in chemical engineering at Armour Institute and later at Lewis Institute. In 1908 he entered the rubber division where he later took charge of the chemical engineering and development work on soft and hard rubber. In 1920 he transferred to the Submarine Cable Development Branch, and in 1929 his long experience with rubber and allied materials led to his transfer to the Submarine Cable group of the Laboratories, as a member of which he went to Europe in 1929 in connection with telephone cable projects. Three years later he returned to join the Chemical Laboratories where he is now engaged in research on submarine insulation and in special rubber studies.

After receiving the degree of B. S. from Princeton in 1910 and E. E. in 1912, Halsey A. Frederick joined the Engineering Department of the Western Electric Company. He has remained with this organization, now Bell Telephone Laboratories, ever since. At the present time, he is in charge of the research and engineering work on telephone transmission instruments. As such, he has supervised the development of the telephone handset and the design and development of loudspeakers for the sound picture and public address systems, together with considerable apparatus of a similar nature.

When the Equipment Development group of the Laboratories was organized in 1919, G. E. Bailey was one of the engineers transferred from Hawthorne. Six years of current engineering, following his graduation by Norwich University in 1913, had familiarized him with Bell System equipment practice. His first assignment was to panel dial development; in 1923 he returned to manual equipment and until 1929 he was engaged in call indicator, straightforward trunking, and No. 11 switchboard development. Transferring in 1929 to toll equipment work, he has played a part not only in the equipment engineering of the No. 8 test and control board, but also in the redesign of toll switchboards for increased capacity;

F. S. Malm



H. A. Frederick

G. E. Bailey

H. A. Reise

H. K. Krantz

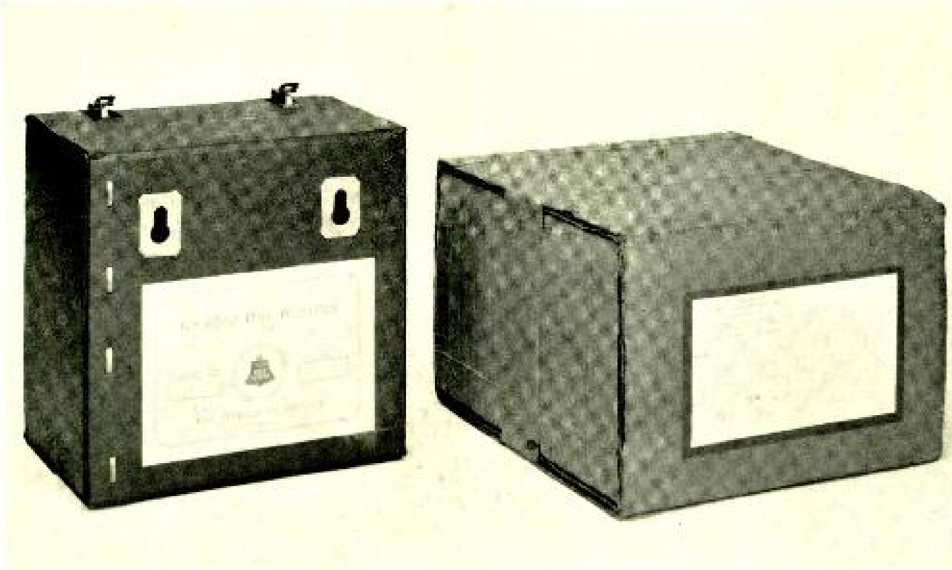
J. C. Wright

the introduction of lamps for busy and idle line indication; and the simplification and improvement of pneumatic ticket-distributing systems.

After receiving a B.S. degree in Electrical Engineering from the University of Washington in 1928, H. A. Reise worked for the Seattle Broadcasting Company for one year. In 1929, while in Seattle, he obtained a position with Bell Telephone Laboratories and came East to join the Radio Development group. Since then he has engaged in the development of radio broadcast transmitting equipment at both Whippany and New York.

After obtaining M.E. and E.E. training at Stevens and Massachusetts Institutes of Technology and serving in the U. S. Navy, H. K. Krantz was employed for six years with the Westinghouse Electric and Manufacturing Company in the design of domestic and industrial safety switches, panelboards, and allied apparatus. As engineer in charge of safety switch and panelboard development, he evolved many innovations in this field and was granted more than 30 patents. This position was relinquished to conduct private research for a number of years. In 1928 he joined the Technical Staff of the Laboratories' Apparatus Development Department where he has since been engaged with maintenance apparatus for central offices, and in the design of plugs, jacks, and other instrumentalities for subscribers' use.

After receiving an M.E. degree from Cornell University in 1909, J. C. Wright joined the Western Electric Company at Hawthorne where he took the Student Training Course. The following year he transferred to the Physical Laboratory in New York and undertook development work on dry cells and portable storage batteries. In addition he has been engaged in the development of carbon and tungsten switchboard lamps, of lamp caps, of resistance lamps, and of improved types of wire insulation. He also handled the development and construction of the special air-conditioning equipment used in the Laboratories for duplicating various atmospheric conditions to which telephone apparatus is subjected in service.



To simplify the handling of dry cells for use at local-battery subscribers' stations, a new unit battery has been developed. A rugged black pulp board container shown above at the left, encloses three standard Blue Bell cells. The connections between cells of the battery are soldered and two spring terminals are provided so that connection may readily be made.

The battery is of such size that it will fit in the standard No. 317 magneto sets. Two inverted keyhole grommets similar to the mounting holes in the standard metal battery box are provided in the back of the battery in order that it can be hung on a wall or other mounting surface with two No. 8 screws in the same manner as a battery box. Care has been taken in the design so that in many places economies can be realized by installing it without using a battery box. A label giving the specification number, the date of manufacture and a place for the date of installation is pasted on the back of the battery.

The battery is packed in a corrugated shipping carton shown at the right. This bears a label for conveniently applying the address of the station when it is desired to ship the battery to the station by parcel post.