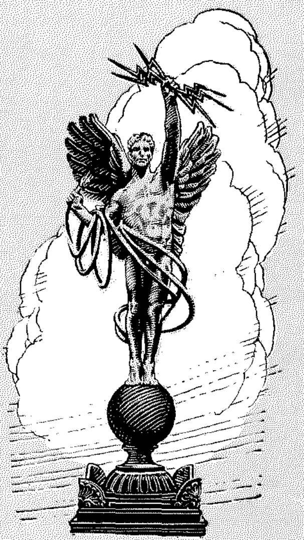
ELECTRICAL COMMUNICATION



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Headquarters Building Being Erected in Madrid by the Compañía Telefónica Nacional de España

The New Madrid Telephone Building

RISING from the highest location on the Grand Vía, Madrid's splendid new boulevard, and commanding from its tower an unequaled view of the city, the new headquarter's building of the Compañía Telefónica Nacional de España will typify strikingly the progress of the telephone art in Spain. It will, when completed, be the most imposing business structure in the capital, the tallest in Spain and among the loftiest on the European continent. Ultimately it will house the largest assembly of No. 7-A machine switching central office equipment thus far planned.

An unusual feature involved in this project was the installation and the cutting into service on December 29th of last year of 7,000 lines of 7-A machine switching equipment in a temporary building constructed for the purpose on the rear of the site of the permanent structure. When the new building is completed and automatic equipment is installed therein to take care of subscribers in the business area, the lines will be transferred from the temporary to the permanent plant, and the older equipment dismantled for use elsewhere. The temporary building will then be torn down and the new building extended to cover the site of the provisional structure. This procedure is complicated, but was necessary in order that the public might be furnished with telephone service in the shortest possible time regardless of difficulties.

Plans for the building were worked out by the Chief Architect of Compañía Telefónica Nacional de España, Don Ignacio de Cárdenas, in cooperation with Mr. Louis S. Weeks, Architect of the International Telephone and Telegraph Corporation. The structure will be a modern expression of what has become known as the Baroque style of architecture, which originated in Italy but reached its greatest development in Spain.

The new building will have a frontage of an entire block and will consist of a sub-basement, basement and fourteen stories in addition to an imposing central tower. The height above the street will be 88 meters and the area covered, 2,280.6 square meters. It will be absolutely fireproof and have a steel frame faced with native stone. Floors and partitions will be of concrete. Access to the various stories, including the tower, will be provided by six elevators having a capacity of sixteen persons each. This building will be the first in Spain to be so amply equipped with elevator service.

The first two floors, the cornices, part of the tower and balcony will be faced with granite from the nearby Guadarrama range. Sand stone will be used for the remainder with the exception of some of the decorative features which will be in Colemar calcium in classical Spanish style. The coat of arms of Spain, eight meters high, will be carved in stone on the face of the tower and shields of the various provinces will figure in bas-relief in the adornment of the pinnacles.

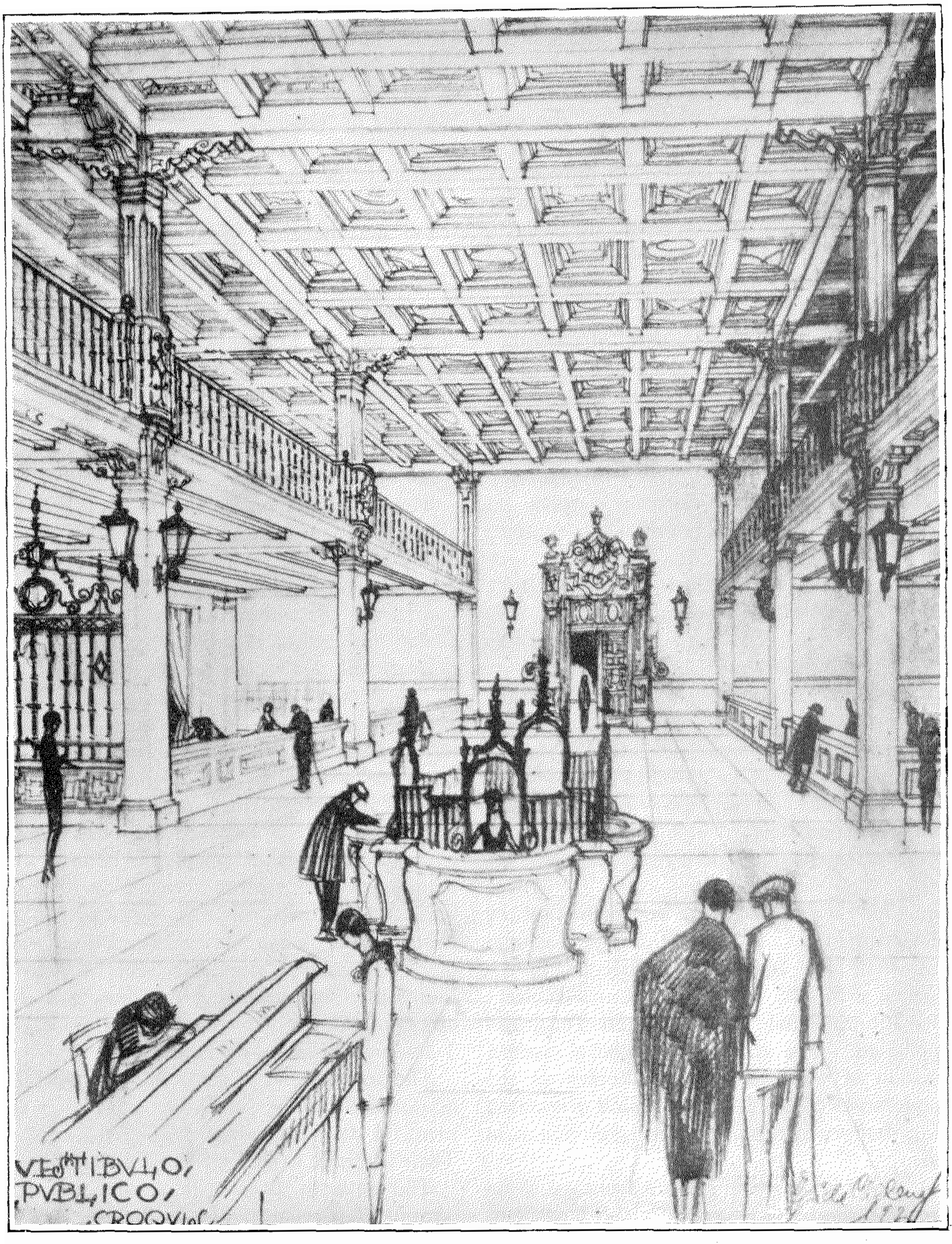
The sub-basement eight meters below the street level will contain the heating, ventilating, power and other service plants for the building. The telephone cables will be led into the basement from the water canal of Isabel II. Storerooms and locker rooms for many of the employees will also be located on this floor.

The ground floor will consist of an arched vestibule, an exceptionally fine lobby and a patio in the rear covered with art glass. It will be used entirely by the Commercial Department. In the center of the lobby, an information desk will be located and near the front entrance a series of telephone booths will be installed with operators in attendance for handling long distance calls. It is planned to maintain this telephone service twenty-four hours a day. On one of the walls will be placed an illuminated map showing the lines and central offices of the telephone system of the Compañía Telefónica Nacional de España.

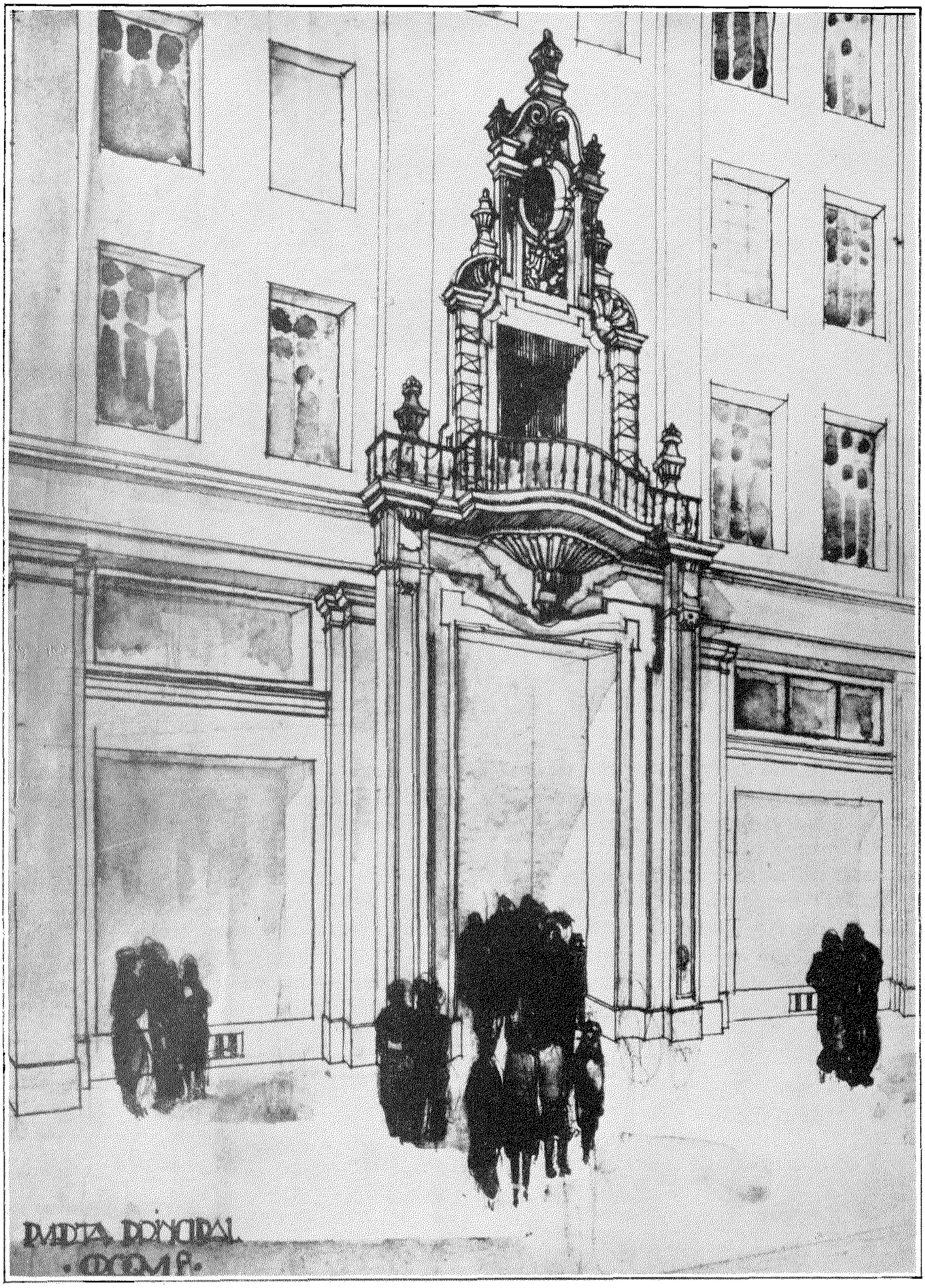
The second to the sixth floors inclusive will accommodate the machine switching equipment for the principal local exchanges in Madrid. Their ultimate capacity will be 40,000 lines.

The seventh floor will be devoted to the Traffic Department. Here, beside the offices of the staff, will be located the long distance board, the infirmary and the operators' rest room.

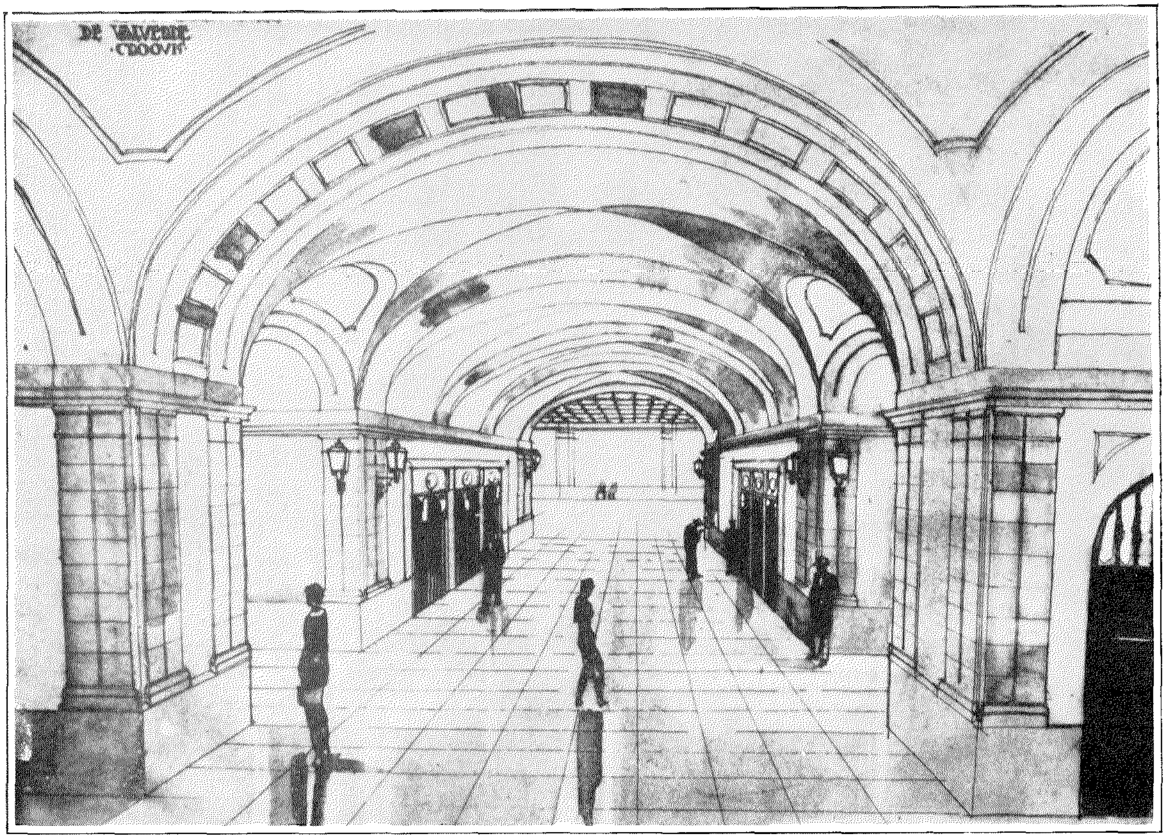
Offices for the executive and administrative forces of the Company will occupy the remain-



Main Lobby of the New Headquarters Building of the Compañia Telefónica Nacional de España, Madrid



Main Entrance to New Headquarters Building of the Compañia Telefónica Nacional de España, Madrid



Vestibule, Opening on Calle de Valverde

ing floors with the exception of the top story which will provide an assembly room for employees, a library and other accommodations for the Company's personnel.

The tower will contain an observatory open to the public for the enjoyment of the exceptionally fine view of the city and surrounding country.

The building will be located in the heart of Madrid's business section in close proximity to subway, street car and motor bus lines, leading banks and the post office, smart shops, office buildings, hotels, theaters, clubs, cafes and restaurants. The new home of the Press Association is rising two blocks away on the Grand Vía and directly opposite a new hotel is being built. Plans for the project were formulated with the idea of convenience to the public, as well as of making the building an adornment to the modern business section and a monument to the enterprise of the Spanish metropolis.

Coin Operated Telephone Pay Stations[1]

By E. S. McLARN

Engineering Department, International Standard Electric Corporation

Introduction

MESSAGE rate telephone service is given by keeping a record of the number of incoming calls through the use of a message register associated with each line requiring the service, by an attendant collecting a fee at the time and at the place the call is made or by the use of a coin collecting device. The message register plan is used when dealing with subscribers under contract where an accounting can be had at prescribed intervals. Telephones of a public and semi-public nature cannot be handled by the message register scheme and such telephones require either an attendant or the use of a coin collecting device at the telephone. It is, of course, impractical to have an attendant at many places where telephones must be installed for the convenience of the public and under these conditions the coin operated pay station is the logical solution.

Choice of a particular type of coin collector is dependent largely on local conditions. In this paper, construction of coin collectors, operating features, requirements and the limits of different types in general use in the United States of America will be discussed.

Classification of Coin Collectors

Coin collecting devices, generally called coin collectors, are classified as "local" or "combined local and toll", according to the facilities provided by them. A local collector will receive a coin of one denomination only, whereas a combined local and toll collector will receive coins of several denominations. Each of these two classes are further sub-divided into "post-payment" or "pre-payment" collectors, according to their plan of operation. In the post-payment plan the operator is signalled in the regular way and no money is deposited until after the desired connection is established. In the pre-payment plan a coin must be deposited before the attention of the operator can be secured.

[1] The courtesy of The Gray Telephone Pay Station Company in loaning photographs from which illustrations were reproduced is gratefully acknowledged.

General Requirements

Successful coin collector service necessitates the formulation of requirements from two distinct points of view, that of the public and that of the operating company. To the telephone using public the coin collector should be a matter of convenience. It should enable the patron to obtain telephone service with the least amount of effort. It should accept coins in general circulation and should exact no penalty for acts of ignorance or stupidity on the part of the user.

The operating company, on the other hand, must balance receipts against equipment and maintenance costs. It cannot go to extremes in catering to the public, and must place its collectors only where the revenue will warrant it. Disputes should be avoided in order that good-will may be maintained; and to this end the company must buy equipment that will be at least reasonably fool-proof.

Hazards Encountered

There are many objections to coin collect operation, some of which are inherent in both the post-payment and pre-payment plans; some apply only to the post-payment and others to the pre-payment plan. Those peculiar to post- and pre-payment operation are discussed later under these subjects. Those common to both plans are as follows:

1. Inability or failure through negligence of the calling party to secure coins of the proper denominations.
2. Stoppage of the coin chutes through the use of bent or sticky coins, of paper wads, bent wires, etc.
3. Fraudulent operation.
4. Robbery.

The latter two objections are of much importance to the telephone company, having to do with those of the public who are dishonestly inclined. Coin collectors accumulate an appreciable amount of money between collection periods. If not wisely and strongly constructed and properly mounted they afford a lucrative revenue to thieves. Furthermore, methods of "beating" (obtaining calls by fraudulent means) that would deprive the company of rightful revenue must be guarded against. Experience with coin collector operation in the United States during many years has shown that the dishonest element does not lack cleverness and diligence; and in consequence an endless battle of wits is waged between it and coin collector designers. The many schemes invented for beating the mechanism and the means devised for defeating them are interesting and show astonishing ingenuity. It would not be the part of wisdom to discuss them publicly for it would tend to spread the practices among those so inclined.

A method of beating so obvious that it ought not to be passed by is that of depositing spurious coins, discs, washers, etc., of a size to reproduce the effect of the proper coins. By observing certain precautions such losses can be minimized but not entirely avoided. The use of complicated electrical and mechanical devices for detecting and rejecting washers, iron discs and lead slugs will further reduce this loss but is not justified as the cost and maintenance of such appliances are quite out of proportion to the services rendered.

A method practiced to some extent (notably in Chicago) to prevent the use of substitutes consists in arranging the coin collectors to accept slugs of a particular design only, these being purchased by the patrons from clerks on the premises. The principle involved is exactly that of the lock and key, the coin openings in the collector being fitted with projections that will admit discs bearing a certain type of slotting only. Many combinations are, of course, possible and the proprietor of an establishment in which the scheme is practiced has his own particular combination. He sells the slugs to patrons and redeems them when returned by the operating company. The objections to the scheme are, first, facilities for dispensing slugs must be provided, thus making the stations of use only at attended premises; second, probable increase in the tendency toward fraudulent operation by disclosing to the public the fact that legal coins are not required for coin collector calls; and third, the problem of stock keeping is complicated since each coin collector is different.

The coin collectors described hereafter do not differentiate between legal coins and substitutes. If the substitutes are of proper size and have sufficient weight they will operate the collectors. The experience of one of the large operating companies in the United States shows that the losses from the use of substitutes can be kept to about one-fourth of one per cent of the total collections. When losses due to this source begin to mount up, methods for controlling them would be along the following lines:

(A) A Governmental act to make the practice a misdemeanor and a suitable penalty provided.

(B) Remove the offending pieces from circulation so far as possible. This requires the cooperation of manufacturers in the vicinity of the collectors giving the trouble. Many commercial articles, such as price tags, slugs and washers, and the by-products of metal stamping factories in the shape of metal discs, may be a proper size to operate the collectors and a slight change in diameter will make them unsuitable.

(C) By warning the proprietors in whose establishments the practice is more prevalent.

(D) By offering a suitable reward for information leading to the arrest and conviction of persons using substitutes.

(E) By removing the coin collectors where the trouble is very pronounced.

Post-Payment Plan of Operation

The post-payment plan requires that coins be deposited only upon instructions from the operator and not before. No changes or additions in the central office equipment are necessary for this plan. With the substation telephone there must be associated a simple and inexpensive mechanism that does not affect the circuit or standard equipment in the least. This mechanism provides a receptacle for the coins deposited and notifies the operator when coins of the proper number and denomination have been deposited. The plan is suitable for both common and local battery systems, individual, code ringing, or selectlve party lines (automatic systems excepted).

It is apparent that operating methods on post-payment lines need not differ from those on flat rate lines except that the operator must see that the correct deposit is made by the calling party

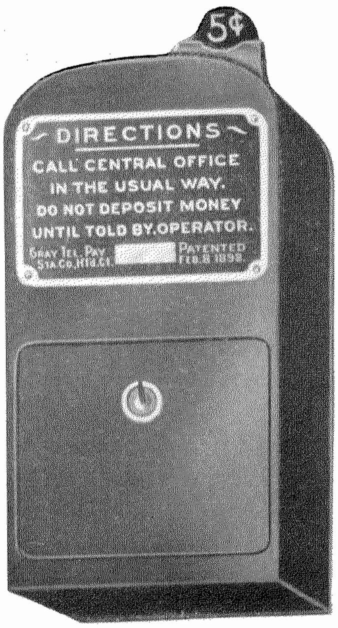


Figure 1—Single Slot Post-Payment Coin Collector

at the proper time. To this end she must be schooled to ask for the deposit when it is due and to recognize the signals made by the coins deposited. The best operating results are secured by grouping all post-payment lines under operators handling only this class of calls.

Many situations arise in post-payment operation demanding careful handling in order that

Figure 2—Single Slot Post-Payment Coin Collector Attached to Desk Stand

the public may be satisfied. Usually any controversy between the patron and operator is referred to the operator's supervisor for adjustment. The causes are varied but the most pronounced are due to alleged premature depositing or over depositing, double connections, cut-offs, and wrong numbers. Since the money cannot be returned the patron's word must be taken and credits or refunds arranged for unless it is evident that he is cheating. This causes much extra clerical work and undoubtedly

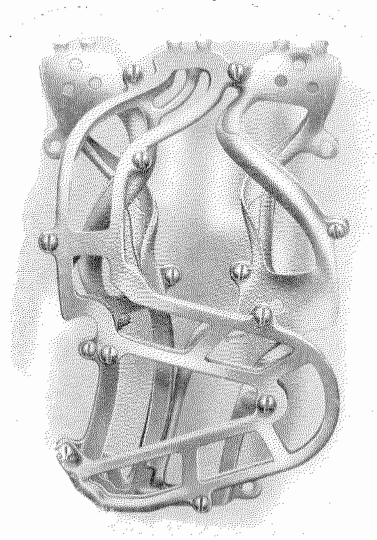


Figure 3—Spiral Coin Chutes of Post-Payment Multi-Coin Collector

the loss of considerable revenue rightfully belonging to the company.

Other objections to post-payment operation as compared to pre-payment are: a marked increase in the operator's time per call since the connection must be set up before the operator demands the fee and conversation must be prevented until the coins are deposited, also the fact that the plan is not adaptable to automatic areas.

Construction of Post-Payment Collector

Post-payment collectors are made both in the single and multi-coin varieties.

A typical single slot machine is shown in Figure 1. The signalling mechanism consists of a spiral chute arranged with respect to a gong so that the coin in passing will strike the gong once. The vibration thus set up is picked up by the telephone transmitter and becomes audible to the operator. For successful operation the collector must be mounted rigidly to the telephone set, else the vibrations will be muffled or entirely lost to the operator. Figure 2 shows the collector attached to a desk stand.

The post-payment multi-coin collector as used in the United States usually is arranged to accept a nickel (five cents), a dime (ten cents), and a quarter (twenty-five cents), local calls requiring a nickel and toll calls any of the three denominations needed to make up the cost of the call. The signalling mechanism is an extension of the principle used in the single slot machine. A nickel strikes a gong once; a dime strikes the same gong twice, and a quarter strikes a gong with an entirely different tone once. Figure 3 shows the chutes of the multi-coin type. They are constructed of lead composition to reduce the rumble from rolling coins and are spiralled to permit undersized coins to drop out of the openings provided for the purpose before striking the gongs. Figure 4 illustrates the post-payment multi-coin collector attached to a magneto wall set. It will be noted that the transmitter is attached to the front of the collector which gives the best possible sort of resonant connection. A post-payment multi-coin collector associated with a desk stand and fastened rigidly to a shelf is shown in Figure 5. All of these collectors are provided with doors, fitted with locks, for access to the cash compartment.

Pre-Payment Plan of Operation

According to the pre-payment plan the patron is required to pay for his call before connection is established. Money so deposited must in many cases be refunded and equipment must be provided at the central office for the purpose. At manual offices such equipment will consist of a "return" and a "collect" key associated with each cord circuit. There also will be a suitable source of current supply and auxiliary apparatus such as the coin signal lamp, relays, resistance lamps and fuses (Figure 6). At automatic central offices the functions of the "return" and "collect" keys are performed automatically by an arrangement of the central office mechanisms and circuits to cause the coin to be returned on "busy", "free" and "no answer" calls and to be collected on completed calls.

At the substation in addition to the usual common battery equipment there is required a mechanism that will serve as a reservoir for deposited coins, that will notify the operator of the number and denomination of coins deposited, that will establish calling conditions only upon insertion of a coin and that will, upon energization from the central office, return or collect the coins as the situation demands.

Use of Colored Sleeves

Operating methods on a pre-payment basis will differ somewhat from those on flat rate lines since the operator has the additional function of returning or collecting the money deposited by the calling party. Her memory is aided and she is directed to the proper operation by the use of white and red sleeves that are placed on the "collect" key. These sleeves prevent the operation of the keys so long as they are in place.

Figure 4—Post-Payment Multi-Coin Collector Attached to Magneto Wall Set—Front Transmitter Mounting

Figure 5—Post-Payment Multi-Coin Collector and Desk Stand Rigidly Mounted

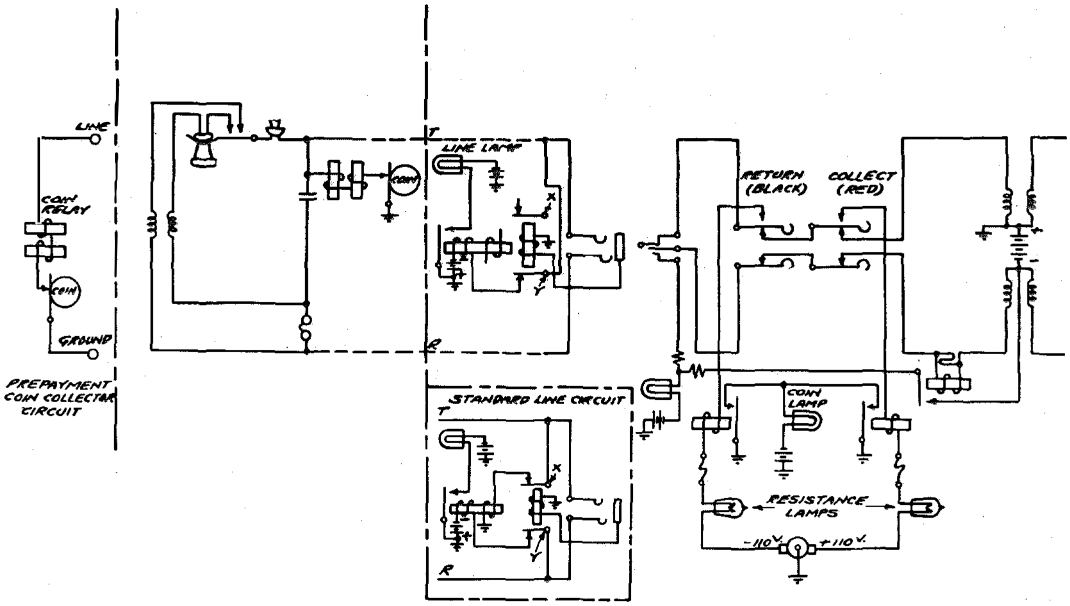


Figure 6—Pre-payment Coin Collector Circuit—Manual System. Standard Line Circuit changed to adapt it to Pre-payment Service

The exact routine for the use of the sleeves may vary according to the ideas of the operating company but in general the practice is to use white sleeves on "pay" calls and red sleeves on "free" calls. When an operator answers a call that in the event of successful termination requires the collection of the money deposited she places a white sleeve in the "collect" key. (It is usual to keep white sleeves on a number of collect keys associated with the cord pairs next to be used in rotation.) She now rings the called station and removes the white sleeve only when the call is answered. When ready to take down the connection the absence of the white sleeve indicates that the "collect" key is to be operated. If it remains on the "collect" key the operator knows that she was unable to complete the call and the "return" key is to be operated.

If the operator answers a call that requires no payment she removes the white sleeve, returns the money and slips a red sleeve in the "collect" key. This is allowed to remain until the connection is taken down and shows the operator that she need not operate either the "collect" or "return" key.

This, in brief, is the principle of the two-sleeve method of operation and it is extended to cover many common but out of normal conditions such as develop, for example, on a cut-off, a wrong number call, successive calls from the same party without his hanging up, reverting calls, and cancelled or abandoned calls. The routines by which the two-sleeve method is made to cover these conditions and many others will not be described in detail on account of space limitations. It is easy to understand, from what has been said, that the use of a white or red sleeve on the "collect" key at different stages in the progress of a call (keeping in mind that white means to pay and red the opposite) will keep the operator informed as to the final operation required of her.

Operation on Toll Calls

If the toll board happens to be of the type adjacent to the "A" board with the subscriber's multiple available to the toll operator, the problem of returning and collecting the deposit in pre-payment boxes is simple. Some or all of the toll operator's cord circuits are equipped with "return" and "collect" keys and the toll operator is responsible for this function.

Where the toll board is separate from the "A" board, the subscriber's multiple is not available to the toll operator and connection is made to it by means of a toll switching trunk. While it is just as desirable in this case to have the "return" and "collect" functions in the hands of the toll operator, it has not been found practicable from an equipment point of view. The regular practice, therefore, consists in equipping a part of the toll switching trunks with the "collect" and "return" keys, the toll switching operator depressing one or the other as ordered by the toll operator over a call circuit. A high tone or low tone audible signal informs the toll operator whether her instructions have been followed, the usual practice being to use the high tone in refunding and the low tone in collecting.

Operation on Party Lines

The pre-payment plan is best adapted to individual lines but it is used to some extent on party lines despite certain operating difficulties. While the coin relays in the coin collectors will not respond to A.C. or pulsating ringing current, there is danger of their being operated on the D.C. component of superimposed ringing current. Hence if pre-payment collectors are used on selective party lines only A.C. or pulsating ringing current should be used, for in ringing over the tip side of the line on a reverting call the coin relay of the calling party would be apt to respond to superimposed current.

Other objections to pre-payment party line operation are as follows:

1. The possibility of depositing a coin on a busy line. The chance of this happening on a four-party line is, of course, double that on a two-party line.
2. Ringing back on the tip side of the line on a reverting call may cause premature operation of the tripping relay in machine ringing since the tip side of the line would be grounded through the coin relay at the calling station.
3. In the standard substation circuit the removal of the receiver shunts the condenser causing the line to be grounded through the transmitter, switchhook, induction coil and ringer (Figure 7). At a tip station on a

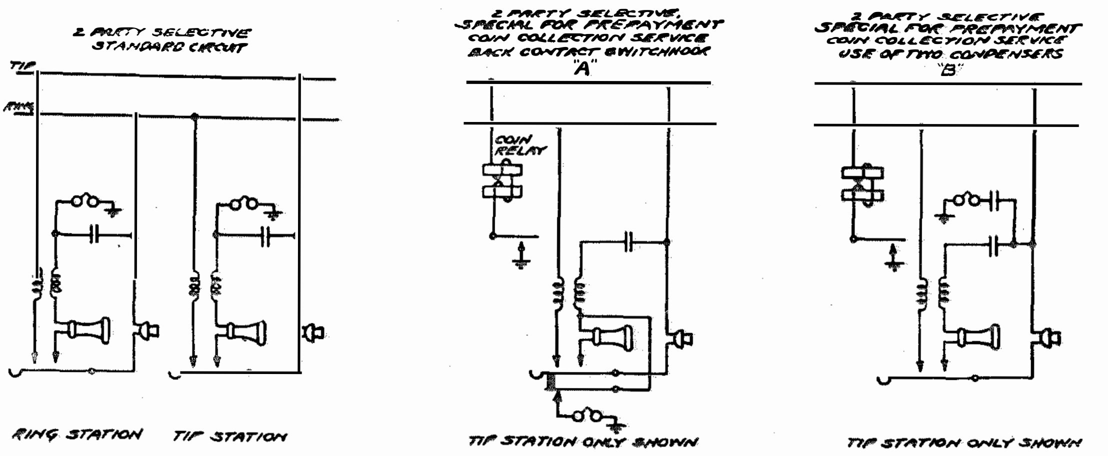


Figure 7—Standard Two Party Selective Circuit and Modifications for Pre-payment Coin Collect Service

selective party line this would give the same results as depositing a coin and may be avoided by special substation circuits as shown. The circuit "A" can be beaten on desk stand installations by the insertion of a pin through the desk stand cord so as to connect the ringer to ground when the receiver is removed. Therefore it is used only on wall sets and the split condenser circuit "B" is used on desk sets.

4. Operation is not practical on jack per station party lines. Here the tip and ring springs of one of the multiple jacks is reversed with respect to the other to allow selective ringing on either side of the line. As explained previously, the toll switching operator handles the collecting and returning of coins on toll calls, the trunk being plugged into the multiple. If the call happens to be one on which the trunk is plugged into a "reversed" jack, the coin relay of the calling station would ground the ring side of the line. This may prevent the disconnect signal being given on the trunk since the supervisory relay may not release when the calling party hangs up. In addition the coin relay could not be operated under this condition.

The advantages and disadvantages of the prepayment plan may be summed up as follows:

ADVANTAGES

1. A saving of operating time amounting to $10.00 or more per year per station over the post-payment plan.
2. It can be used in automatic districts, where it functions entirely automatically on local calls.
3. It minimizes disputes between patrons and the operating company.
4. Refunds and credits are minimized.

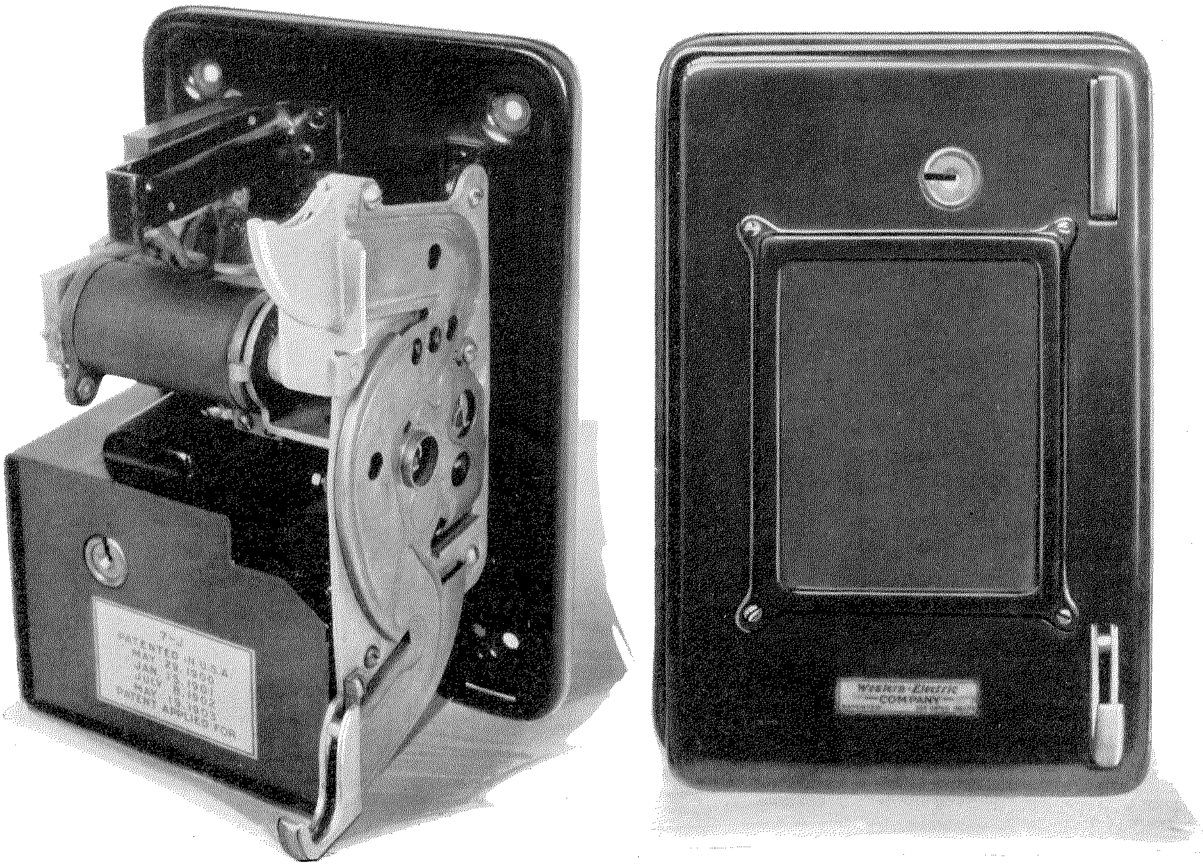
DISADVANTAGES

1. The first cost in central office and substation equipment, as well as the maintenance cost, is considerable.
2. It is not particularly well adapted to party line operation.
3. It is not adapted to local battery systems.

Construction of Pre-Payment Coin Collectors

Pre-payment collectors are made in both the single and multi-coin varieties. Pre-payment operation requires that the coin be deposited before the line signal is displayed in manual systems and before dialing is possible in automatic systems. Hence, a circuit condition making these sequences possible must be set up as soon as the coin is deposited and not before. Further, since for one reason or another a call may not be completed, the coin must first be held in suspension until a series of events determines whether it should go into the cash box of the collector or be returned to the calling party. It will be apparent in later description how these results are secured.

The single coin type, Western Electric Company No. 7, is used largely in residences and at-



Interior of 7-J. Exterior of 7-J.

Figure 8—Pre-payment Single Slot Coin Collector

tended places, such as drug stores, where it may be associated safely with wall and desk sets of standard design without danger of being stolen. A resonant connection with the transmitter is not required so that a more flexible arrangement may be secured by making the coin collector a separate unit.

It is not the practice to install the multi-coin type (Western Electric Company No. 50) in residences but rather in public places where almost any liberty may be taken with it without fear of detection. It must therefore be exceptionally strong in construction and securely mounted by methods that will resist removal by unauthorized persons. Since a resonant connection with the transmitter is required the best possible results are obtained by combining the coin collector functions in the same structure with the transmitter, receiver, switchhook and, in automatic systems, with the calling dial. To complete the multi-coin collector substation, only a desk set box exactly like that used with a desk stand is required.

Single Coin Type (7-J and 7-K)

The Western Electric 7-J (Figure 8) and 7-K coin collectors differ only in coin capacity. The size of the cash box in the former is approximately 42 cubic inches and in the latter, 72 cubic inches.

A deposited nickel comes to a rest on a cradle made up of two prongs, one of which is hinged, causing a pair of contacts to close. The coin itself could be used as a part of the circuit but this practice is objectionable due to the varying resistances caused by dirt on the coins. If the coin is undersized it will pass through the cradle into the "return" chute. If it is oversized it will not enter the coin chute. The cradle may be oscillated by a polarized electromagnet called the coin relay. Current of one polarity tips it in one direction causing the coin to be deflected into the cash box. Reverse current causes the coin to be deflected into the return chute. At the left of Figure 6, the circuit of the pre-payment collector is shown and at the right a complete subscriber's line circuit including the manual central office equipment essential for coin collect purposes. It will be noted that the wiring of the line relay is changed slightly from the standard arrangement of non-coin collect lines to prevent the line lamp from lighting when the receiver is removed from the hook but at the same time causing it to light when the tip side of the line is grounded through the windings of the coin relay when a coin rests on the cradle. The change is easily made by disconnecting the ring wire at the cut-off relay spring Y and reversing the tip wire from springs X to Y. The operator plugs into the answering jack and the disposition of the coin held in suspension is then in her hands. She may return it or cause it to pass into the cash box by operating either the black or red key associated with the cord circuit.

The housing and cash box door are provided with locks from which the keys can be removed only when the lock bolt is extended. The housing lock, a flat key type, is furnished in twelve combinations and the cash box lock which is a corrugated key type in 2,000 combinations. Burglar alarm springs are furnished when desired. These function only when the bolt of the cash box lock is withdrawn, closing the circuit of a bell or buzzer and battery installed locally.

Both the housing and cash box door of the No. 7 type coin collector are of heavy gauge sheet steel. The chute and coin mouth are so constructed that expensive tools would be required to adapt the collector to coins of any other dimensions than the five cent piece.

Multi-Coin Type

The multi-coin pre-payment collector is the same in principle as the single coin type but with some mechanical variations to care for the variety of coins to be handled and the addition of signalling mechanism enabling the operator to differentiate between the coins deposited.

Figure 9 shows the Western Electric Company's and the Gray Telephone Pay Station Company's 50-G coin collector equipped for manual service and Figures 10 and 11 the same coin collector for machine switching service. The machine switching collector is the same as the manual in all respects except that the card holder has been omitted from above the transmitter and a calling dial mounted in its place. It will be noted that the instruction card is mounted above the collector in a card holder attached to the back of the coin entrance gauge.

The No. 50 type of collector is used also to some extent for post-payment operation. For this service, it is identical with the pre-payment box except for the omission of the coin relay and the substitution of a coin runway from the chutes to the cash box, as illustrated by Figure 12. This arrangement obviously is advantageous, inasmuch as the boxes may at any future time be converted to pre-payment operation for either manual or automatic districts.

Figure 9—No. 50-G. Multi-Coin Pre-payment Collector Arranged for Manual Service

In place of the cradle used in the single coin machine, a platform called the "trap" is provided on which the coins are held in suspension. This platform is normally horizontally supported by a pivoted vane under control of the coin relay. When the coin relay is energized it causes the vane to swing to the right or left, depending upon the polarity of current applied. The trap on which the money rests drops and the vane deflects the money to the right or the left into the cash box or into the "return" chute. In the No. 7 type of collector the weight of the coin on the cradle causes the grounding contacts to close. The No. 50 type is arranged so that the first coin deposited, no matter what denomination, causes the contacts to close by operating a trigger. Succeeding coins do not affect them and they remain closed until the coin relay is operated.

The signalling mechanicm of the pre-payment multi-coin collector is the same in principle as the post-payment type. The chutes, however, are not spiralled since the pre-payment collector is always rigidly mounted upright and the process of weeding out undersized coins is secured by mounting the chutes at an incline to the vertical. These chutes which are removable as a unit are mounted in the upper housing together with the two gongs. This housing with the transmitter, and in automatic systems a dial as well, mounted on its face is equipped with a number of springs insulated from each other and the housing. These springs engage other springs on the back-board of the collector, thus connecting the transmitter and dial in the circuit when the upper housing is placed in position.

Both the upper and lower housings and the cash compartment door are made of heavy sheet steel with all joints electro-welded. It will be noted from Figure 11 that the holes in the back-board for mounting the collector are covered by the housings and thus accessible only if one has keys for the upper housing and the cash door. Burglar alarm springs are a part of the multi-coin collector, these closing whenever the cash door lock bolt is withdrawn. A feature of the design of the multi-coin collector (and also the single coin type) is the arrangement of all the mechanism so as to be accessible without disturbing the cash compartment door. Thus repairmen need only be supplied with a key to the upper housing which allows repairs to be made to both the chute and electrical mechanism without jeopardizing the money in the cash box in any way.

The lock on the upper housing is the flat key type and forms a part of the coin collector. The lock on the cash compartment door is of the corrugated type, extremely strong and difficult to pick. It is supplied in many thousands of combinations and must be ordered separately as it does not form a part of the collector.

Two sorts of coin receptacles are available for use with the No. 50 type collector. The 2-A

Figure 10—No. 50-G. Pre-payment Coin Collector Arranged for Machine Switching Service

is a sheet metal box of approximately 60 cubic inches capacity without a cover allowing access to the cash when the cash compartment door is removed. The 6001-A coin receptacle is made up of three parts as shown in Figure 13 and used as indicated in Figure 14. The box has approximately 52 cubic inches capacity. The object of this device is to provide a box that

It can be unlocked only by means of a special key inserted from the under side of the cover after the seal is broken and the cover removed.

Coin Relay of Pre-Payment Coin Collector

The coin relay is polarized and wound to operate on positive and negative direct current of 110 volts. The resistance is approximately

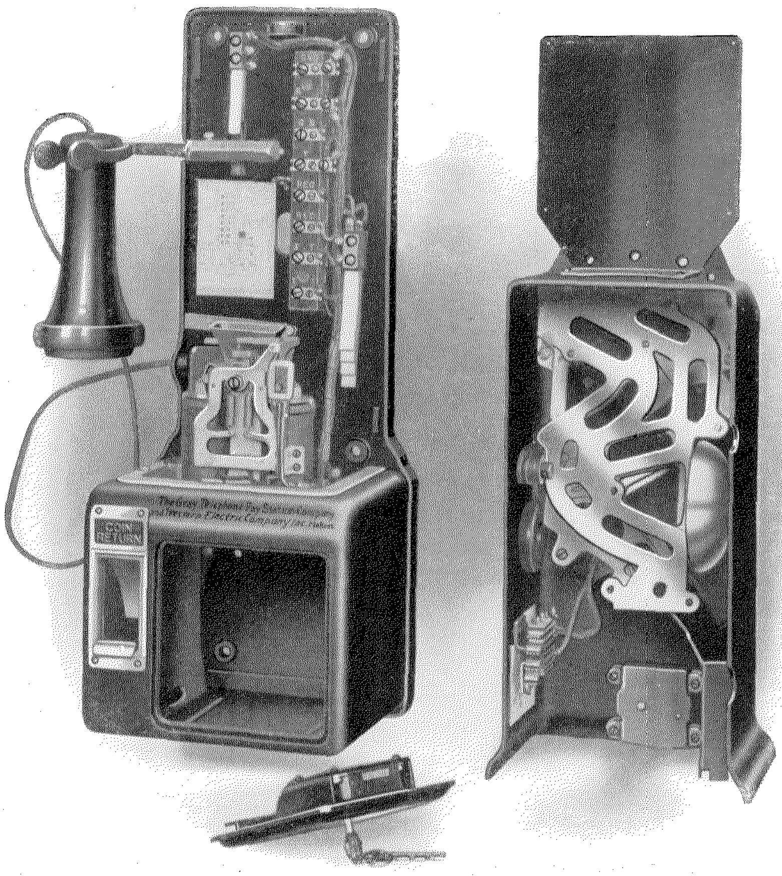


Figure 11—Interior View of No. 50-G. Pre-payment Coin Collector Arranged for Machine Switching Service

will act as a depository for the coins but will close up tightly upon removal from the coin collector. The employee authorized to make field collections does not have access to the cash. He must return the box to the company office where the seal is broken, the money removed, the box reset and a new seal applied. The act of inserting the box into a collector operates a lever which opens the shutter covering the hole through which the coins pass. Withdrawal of the box allows the shutter to close and lock.

1,000 ohms (500 ohms per spool). It would be desirable to make use of the usual central office storage battery of 24 volts for this service in order to save the extra power plant required but it is not practicable for several reasons. Perhaps the most important is ground potentials which in some instances have been known to reach more than 30 volts. In addition the relay must be made unresponsive to alternating and pulsating ringing current and to accidental surges of current that may come on the line from the central office battery. In other words it must necessarily be designed to be insensitive; and when it is remembered that, on toll calls, the relay may be called upon to discharge a hopper full of coins, it will be appreciated that considerable energy is required.

The pre-payment coin collector to justify its existence must deliver satisfactory service under any and all conditions encountered in normal operation and must be able to cope with abnormal conditions in the best possible manner. In consequence its operating characteristics must be so circumscribed with limiting requirements that nothing but an apparatus of the utmost precision will meet the situation. Perhaps the idea can be best illustrated by giving the electrical tests which the coin relays of all multi-coin collectors must pass before they can be put into service.

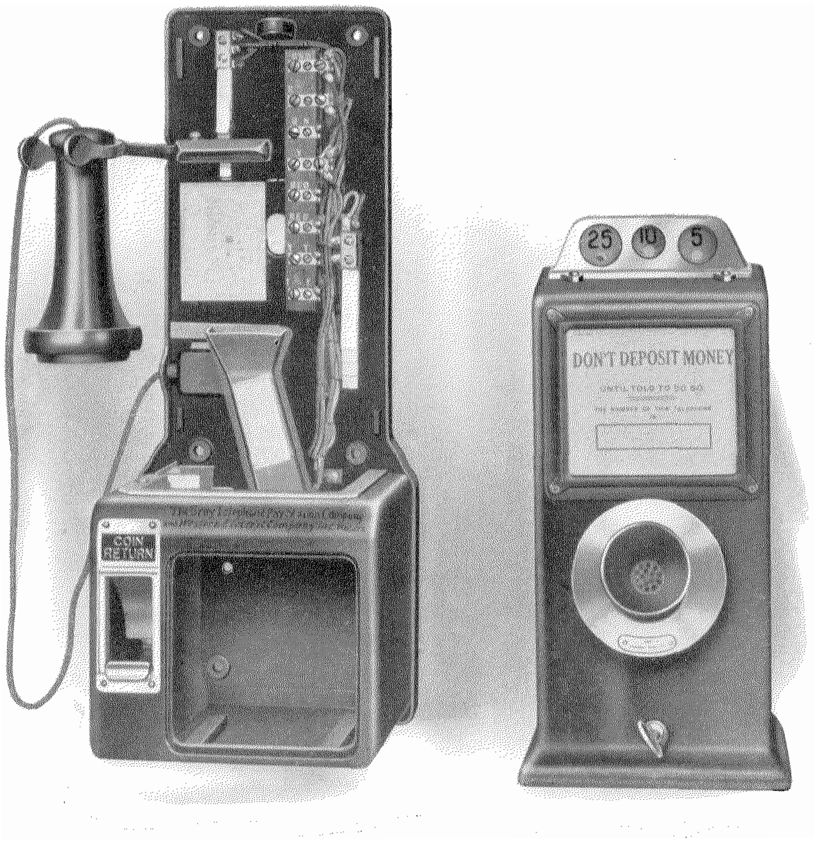


Figure 12—Post-Payment No. 50 Type Coin Collector

The electro-magnet shall safely deposit or refund a charge of one dime up to eleven nickels when a direct current of 60 volts is impressed upon the coils immediately after the magnet has been operated in reverse direction by a direct current of 120 volts.

The magnet shall not operate when a direct current at 40 volts is impressed in either direction upon the coils and eleven nickels are dropped, one after the other into the coin hopper through the coin chute, while the current is passing through the coils.

The magnet shall return to normal position after it has been operated in either direction with a direct current at 120 volts and the 120 volts have been reduced to 30 volts without a break in the current.

The magnet shall operate in the correct direction with either polarity when a current of 120 volts is impressed upon the coils and the armature is tilted the full amount of the play in the opposite direction to that selected for operation.

All tests involving the electro-magnet shall be made with an upper housing in place.

In addition to these electrical tests there are a large number of mechanical requirements insuring permanence of adjustment that each coin collector must meet before it is considered satisfactory for service.

ELECTROLYTIC CORROSION OF WINDINGS

Despite the use of the very best methods and materials in constructing the coils of the coin relay, electrolytic corrosion during a protracted period of dampness is apt to occur, causing the windings to open unless certain precautionary measures are taken. The electrolytic action is caused by the central office battery potential between the winding and the core and can be prevented by connecting the coin relay into circuit so that the windings will be negative with respect to the core. Any current leakage between core and winding will then be from the core to the winding and thus eliminate the transference of copper from the winding to the core. At the left of Figure 15 is shown the right and wrong methods of connecting the collector when the usual practice of grounding the positive side of the central office battery is followed. At the right of Figure 15 the connections are shown when the negative side of the central office battery is grounded.

Sources of Current Supply

Pre-payment coin collector operation requires direct current of 110 volts. Ordinarily a variation of from 100 to 120 volts is allowable but in areas where appreciable ground potentials are encountered, it may be necessary to restrict the regulation to 110 plus and minus 5 volts.

There are four possible sources of current supply and whatever the source it must be supplemented by reserve equipment to insure a satisfactory current supply at all times.

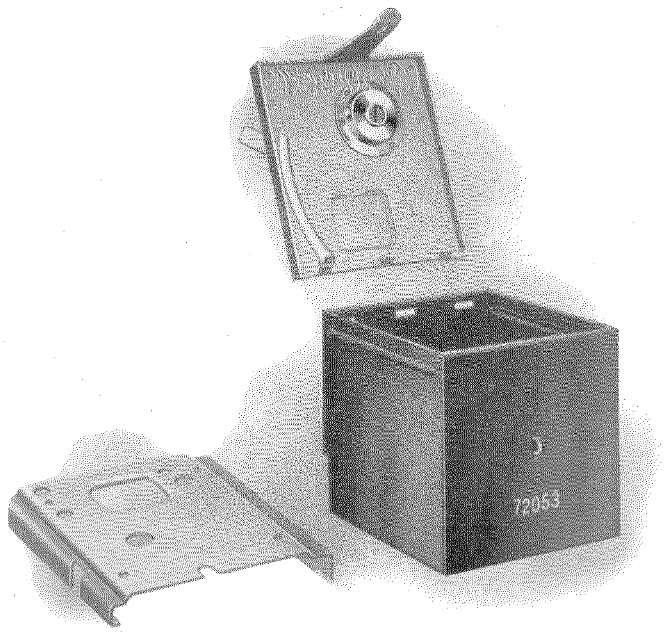


Figure 13—No. 6001-A Coin Receptacle

(1) *Commercial Power Supply*—If the commercial power happens to be 110 volt direct current properly regulated it would be suitable. The objection to this source is the complication that would probably arise with the regulatory board of the fire insurance companies. Introducing such an enormous source of energy into the signalling circuits of the telephone plant would require the use of protective devices approved by the said regulatory board and undoubtedly it would want to carry its jurisdiction to the entire telephone plant. This can be avoided by the use of one of the three sources of current supply following.

(2) *Dry Cells*—Such source is suitable for small offices where the energy drain would call for a replacement of not more than 400 to 500 dry cells per year.

(3) *Motor-Generator Set*—This may be a simple direct or belt connected set with the motor adapted to the available commercial power supply, and the generator delivering plus and minus 110 volts direct current or the generator may combine the function of supplying coin collect current with that of supplying ringing current. The combined generators are available direct or belt connected to single motors operating from the commercial supply or they may be secured direct connected to two motors, one of which operates from the commercial circuits while the other operates from the central office 24 or 48 volt storage battery. In case of failure of the commercial power supply the storage battery motor is arranged to automatically take up the load without stopping the machine.

Combined ringing and coin control generators are available in three sizes as follows:

Size	Direct Current for Coin Control		Alternating Current for Ringing (Requires use of transformer with taps to give different ringing voltages)	
	Amp. per Side	Volts per Side	Amp.	Volts
P-½	.25	100–120	1.00 1.00 1.25 1.25	100–108 95–103 80–88 72–80
P-1	.38	100–120	3.00 3.00 4.00 4.00	100–108 95–103 80–88 72–80
P-2	.50	100–120	6.00 6.00 8.00 8.00	100–108 95–103 80–88 72–80

(4) *Storage Batteries*—Where the coin control current drain exceeds the capacity of the combined ringing and coin control generators, storage batteries must be used.

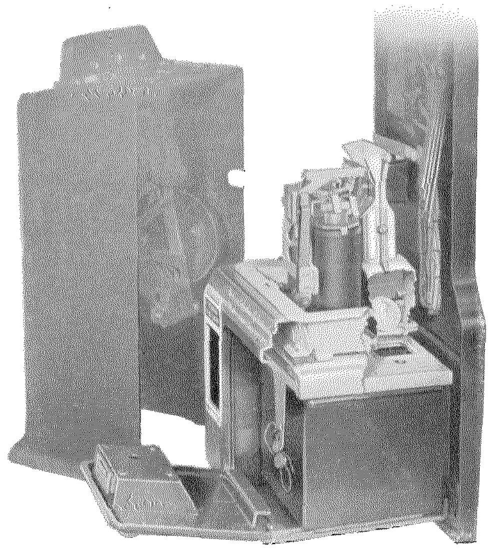


Figure 14—Sectional View of No. 50 Coin Collector with No. 6001-A Coin Receptacle

This would happen only in rare instances such as in some of the offices in the city of Chicago, where the coin collector development is exceedingly heavy due to the use of the local pre-payment collector in residences.

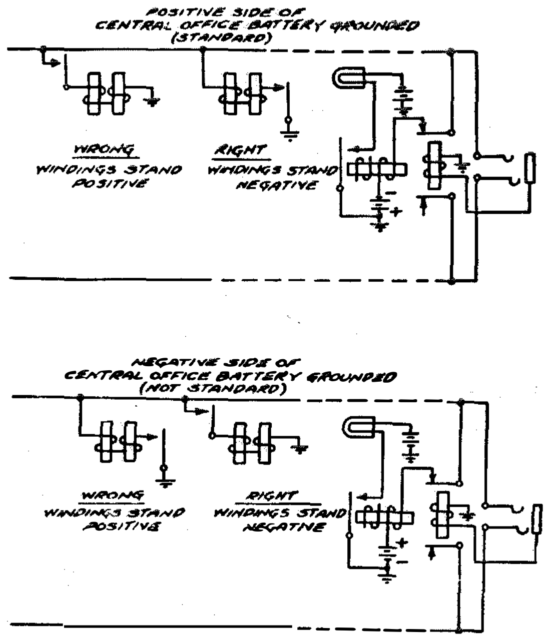


Figure 15—Pre-Payment Coin Collector Circuits—Methods of Connection to Prevent Electrolytic Corrosion

Conclusion

There is a distinct field for coin operated telephone pay stations that cannot be economically handled by any other type of station. There are, however, many disadvantages to such stations, the most serious of which come about from the idiosyncrasies of the telephone using public. Operators may be trained to handle the service as well as human frailties will permit. The equipment may be designed to function year in and year out according to plan. Yet there will still be much to be desired to make the service perfect.

The best that can be done to combat these evils is to provide equipment as nearly fool- and burglar-proof as the bounds of reason will permit and to be careful not to install collectors of both the post-payment and pre-payment type in the same general district. These precautions, together with the use of prominently located instruction cards and the tendency of the public to do the right thing after it becomes familiar with the service, make coin collector operation entirely practicable and a source of considerable revenue that would not otherwise accrue to the operating companies.

The Prague Radio Broadcasting Station

By E. M. DELORAINE

European Engineering Department, International Standard Electric Corporation

THE Prague 5-kilowatt radio transmitting station, which was put into operation for the first time on Christmas Eve, 1925, replaces a previous equipment of 300 watts output.

The station is operated by the Czecho-Slovakian Administration of Posts and Telegraphs in co-operation with the "*Radio-Journal*" of Prague. The equipment is of Western Electric design and manufacture and was installed by the International Standard Electric Corporation. Like other broadcasting systems, it comprises essentially the microphone, the speech-input equipment, the radio transmitter, the machinery for power supply, and the radiating system. The microphone and speech input equipments are located near the centre of the town, and the radio transmitter is installed in the suburban district of Stratnice, approximately three miles distant.

The studio, which is of the usual design, is shown in Figure 1. The microphone used generally in the studio is of the condenser type. A two-valve amplifier is associated with the microphone and is located in the studio in order to meet the conditions of minimum capacity in the leads between the two electrodes of the microphone and the grid of the first amplifier valve. For broadcasting from locations outside of the studio, the standard high-quality carbon microphone is employed in connection with a special amplifier, Figure 2. The audio-frequency currents are conducted to the amplifier room and amplified to the desired level. The amplifier and associated apparatus, which form the speech input equipment, are shown in Figure 3. The various component circuits are made up on panels which are, starting on the left from the top:—the battery supply panel, the monitoring amplifier panel, the signal and control panel; and on the right, the meter panel, the volume indicator panel, and the main amplifier panel. This equipment is described in a previous article on The Milan Broadcasting Station.[1]

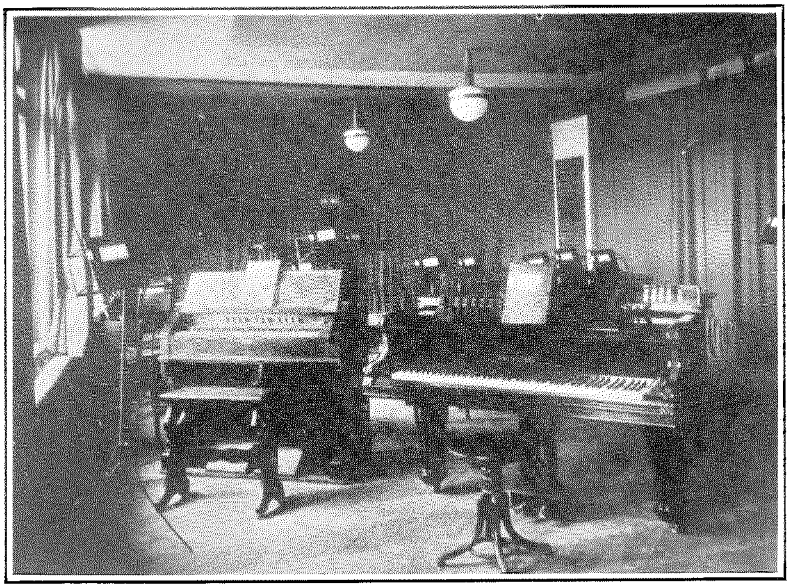


Figure 1—Prague Broadcasting Station Studio

The front of the radio transmitter is illustrated in Figure 4, a rear view of the panel in Figure 5, and a diagram of the circuit in Figure 6. The

[1] "The Milan Broadcasting Station," by E. M. Deloraine. ELECTRICAL COMMUNICATION, Vol. 5, No. 2, October, 1926.

apparatus has been arranged in the form of units, each of the essential component circuits of the transmitter occupying one panel. Of the six panels which constitute the transmitter, three are assigned to the generation and control of the power supplies necessary for the radio-transmitting circuits proper which occupy the other three panels. The radio-transmitter circuits are designed for generating a modulated carrier-wave at a power level of approximately 500 watts, for amplifying this to a power of 5 kilowatts by means of a high-frequency power amplifier, and for delivering this energy to the antenna. The generation of the modulated carrier-wave is performed by means of five radiation-cooled tubes, while the high-frequency power amplifier requires two tubes of the water-cooled type, Figure 7. For the first group of tubes, rotary machinery supplies the filament and the D.C. (direct current) plate supply, dry cells being used for grid polarisation. For the water-cooled tubes, however, rotary D.C. machines supply the D.C. filament and grid current, but the anode supply is obtained from a three-phase rectifier.

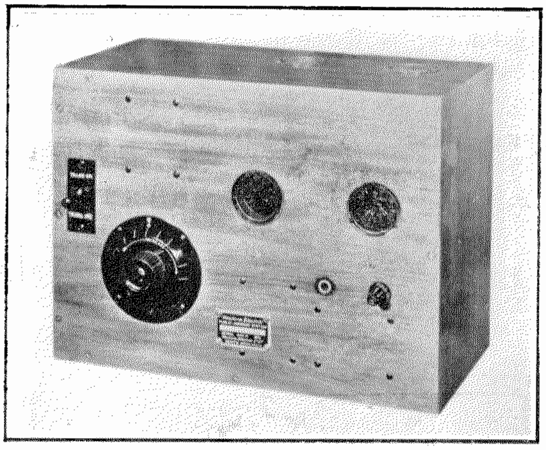


Figure 2—Special Amplifier

The first panel on the left of Figure 4 is the A.C. (alternating current) power supply panel. The transmitter operates entirely from a three-phase, 50-cycle, 220-volt supply and requires approximately a power of 25 kilowatts at a power factor of 0.8. The supply is connected directly to the main power disconnecting switch, seen in the middle of the lower panel, after which it passes through fuses and is distributed to the various circuits. The four motors driving the generators and the water circulating pump are started by a magnetic switch which operates automatically, as will be explained later.

The transformers for supplying plate and filament power to the rectifier unit are operated with primaries in parallel from the 220-volt, three-phase supply through a magnetic switch, each transformer being protected by fuses. The rectifier high voltage transformer, which is shown on the general lay-out of apparatus, Figure 8, is mounted directly behind the A.C. power panel. It is protected against overload by means of two relays, seen on the front of the panel, and it can be insulated by means of a safety switch which is opened whenever anyone is working inside the transformer enclosure.

The radio transmitting equipment is designed for automatic starting, through the operation of a number of relays. The sequence, when starting up, is as follows:—The main power disconnecting switch must be closed; the master control push-button switch is then operated. This closes a contactor, which starts all the motors together.

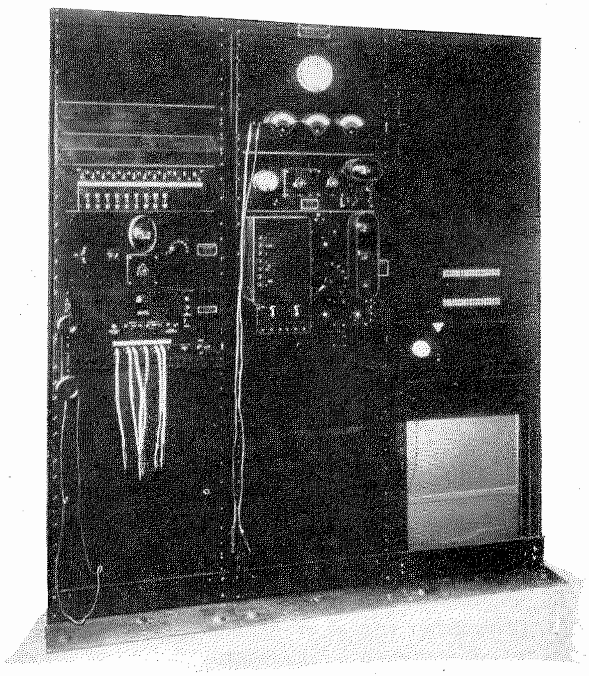


Figure 3—Speech Input Equipment

The filament current and the negative grid supply are applied immediately on the high power amplifier tubes—the anode voltage being applied to the

10,000-volt rectifier system after a delay of approximately 15 seconds to ensure that the amplifier filaments are well heated before the plate voltage is applied. There are, also, several relays interlocked with the relay operating the rectifier to ensure that the amplifier circuits and the cooling system are in the proper operating condition. It is necessary, for instance, to provide for the required negative grid-voltage, the normal circulation of water, and appropriate water-temperature. The relay circuits are arranged also to shut off the rectifier if the door of the enclosure is open, or if there is an overload on the high-voltage rectifier transformer or a failure of water supply, of negative grid supply, or of amplifier filament supply.

An A.C. voltmeter is provided in front of the panel for measuring the line voltage on each phase and the voltage across the primaries of the filament lighting transformers. The latter voltage is kept constant and is adjusted by means of series compensating rheostats.

The second panel comprises the D.C. power circuits and D.C. apparatus. It includes means for controlling the filament, plate and grid supplies for the oscillator modulator tubes and for the power amplifier tubes. Four D.C. circuits are included, these being the 14-volt circuit for heating the filaments of the oscillator modulator-tubes and a monitoring rectifier tube in the high-frequency output circuit, the 1500-volt circuit for supplying the plate voltage to the oscillator modulator tubes, the 22-volt circuit used for filament supply to the high power amplifier tubes, and the 250-volt circuit to supply the negative grid voltage for the power amplifier tubes. These various circuits are suitably protected against overload by means of fuses or relays. During the process of starting, the oscillator modulator filament current is applied approximately 20 seconds before

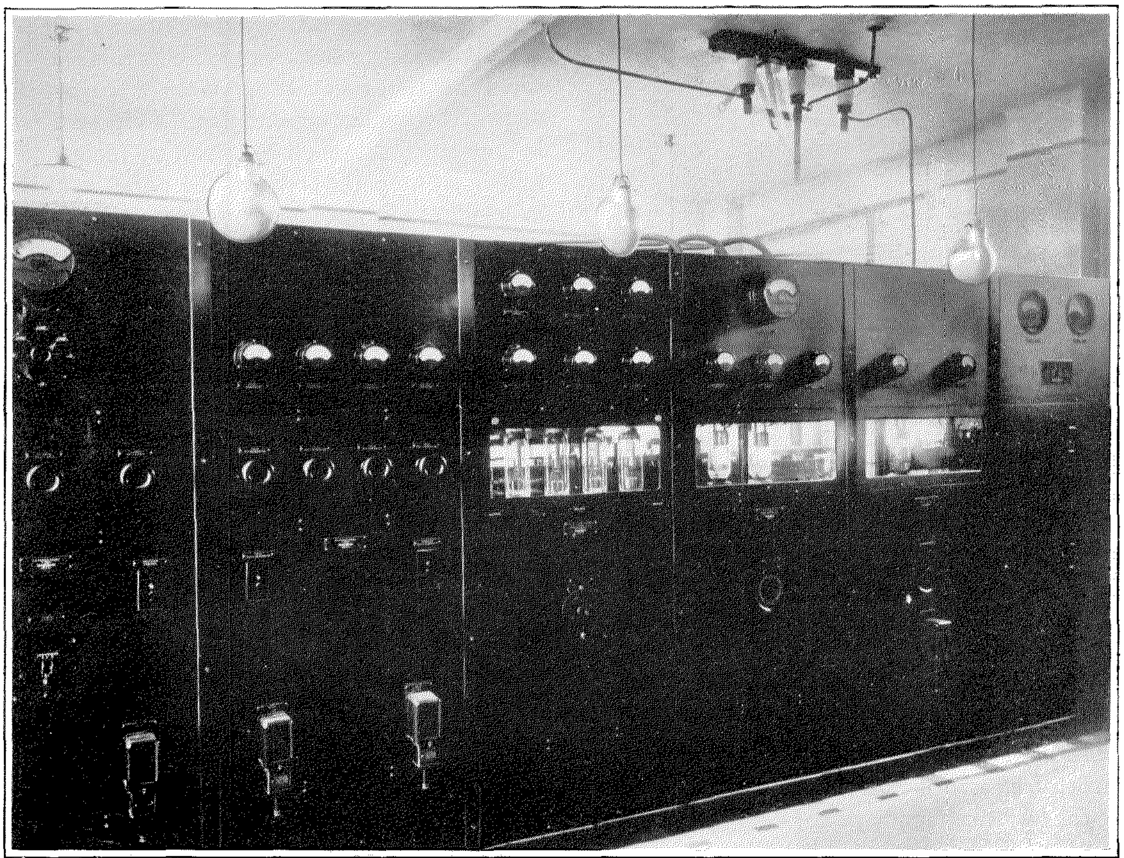


Figure 4—Radio Transmitter—Front View

the 1,500-volt plate supply. In consequence the high-frequency oscillations are impressed on the grids of the water-cooled amplifier tubes a few seconds after the 10,000-volt plate voltage has been applied. The circuit of the 1,500-volt generator is grounded on the negative side, the positive lead being connected to the oscillator modulator through an overload relay. The 22-volt generator has its field circuit connected through the flow and water-temperature protection contact. A reversing switch is inserted in the main circuit. The direction of the filament heating current is reversed periodically, in order to prolong the life of the tubes, as the plate current returns mostly through one half of the filament when the switch is in one position and through the other half when the switch is in the other position. The 250-volt circuit includes a potentiometer with the positive side grounded, and taps at points corresponding to 250 volts, 150 volts and 100 volts to ground. These various negative voltages are used in connection with the values of 10,000, 7,000 and 4,500 volts for the water-cooled tube anode supply.

The voltages supplied by the 14-volt, 1,500-volt, 22-volt and 250-volt generators are adjusted from the front of the panel by means of individual field rheostats. Voltmeters are placed above the corresponding field rheostats.

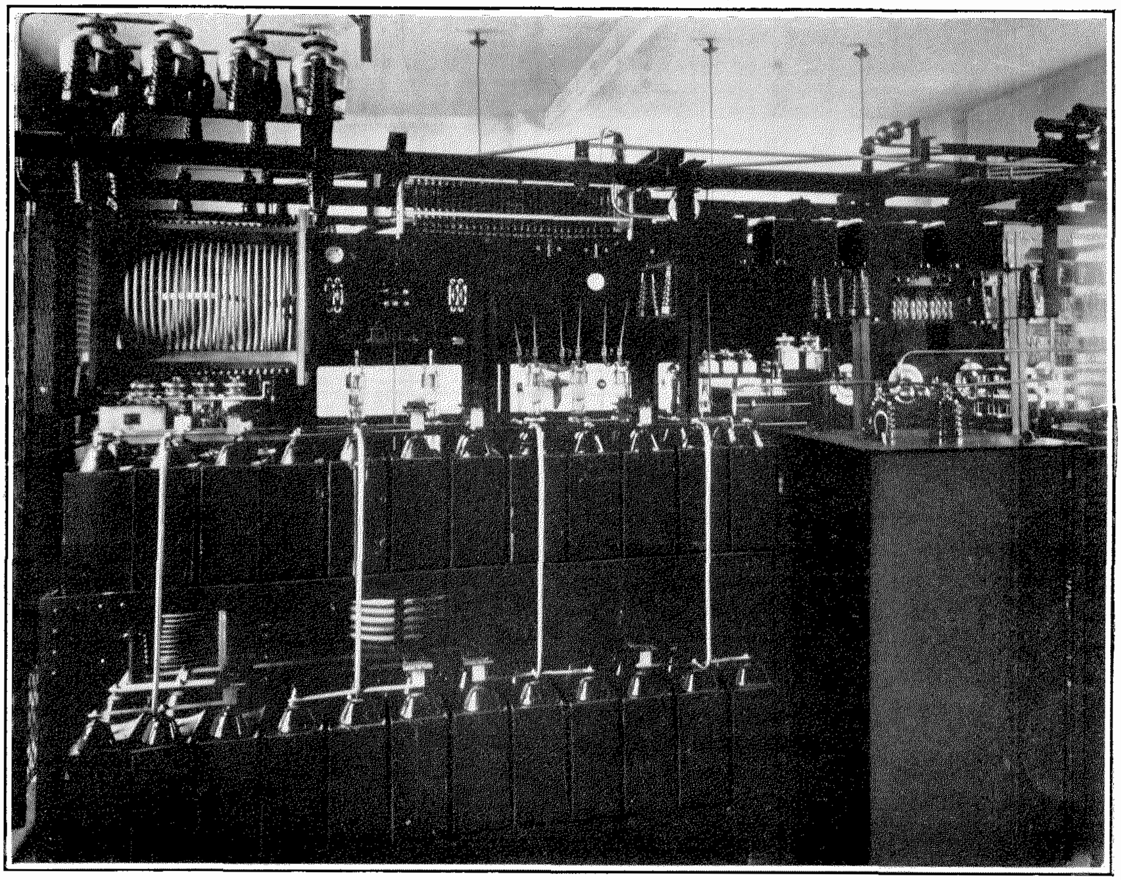


Figure 5—Radio Transmitter—Rear View

The fourth panel constitutes part of the rectifier for the 10,000-volt anodes supply. This rectifier employs three water-cooled tubes as well as a high-voltage transformer and a filter coil and condenser (Figure 8), these being installed at the back of the transmitter enclosure. The rectifier is of the three-phase, single-wave type. The secondary of the high voltage transformer is star connected, the neutral point being joined to the filter coil. The rectifier tubes are operated with their plates grounded and their filaments con-

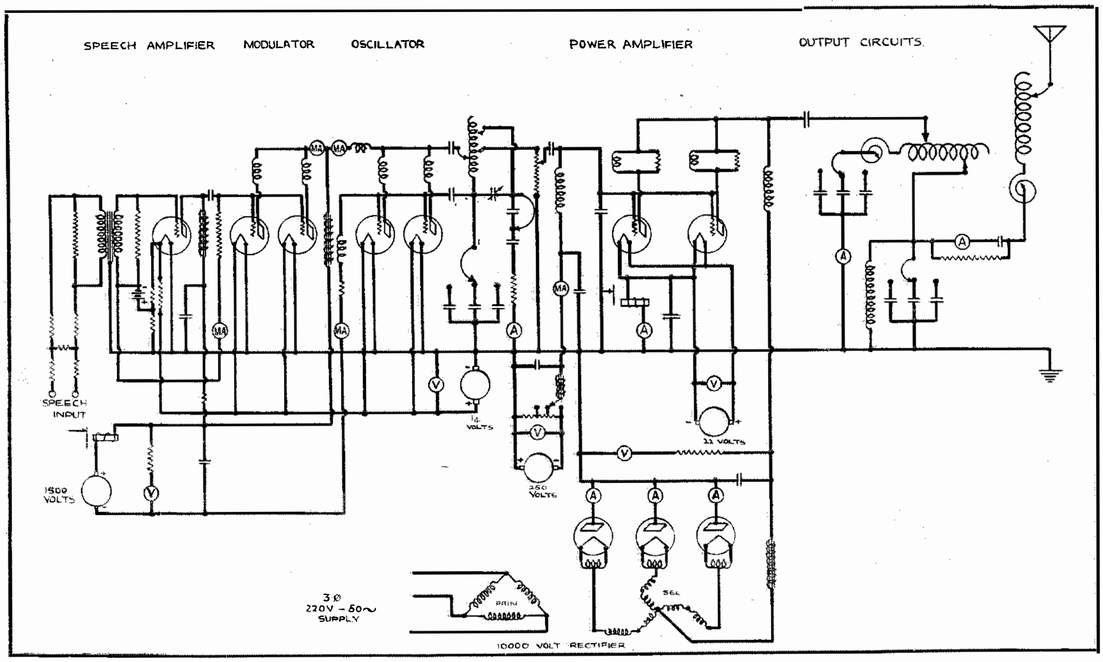


Figure 6—5 K. W. Radio Broadcasting Transmitter—Schematic of Circuit

nected to the legs of the high-voltage transformer at mid-points of the secondary windings of the filament-heating transformers. Each secondary winding of the transformers is grounded through the associated rectifier tube during a fraction of each cycle in such a way as to cause the neutral point of the star to assume a direct current voltage with respect to ground. This voltage presents a ripple, which would result in a modulation of the carrier wave at ripple frequency. In order to smooth out the amplifier anode supply, the rectified current is passed through a series choke coil, which, in connection with a parallel condenser, reduces the ripple to the necessary extent. The rectified voltage is measured by means of a D.C. voltmeter with a high external resister. The transformers, choke coil and condenser of the rectifier are protected against excessive voltage by means of air-gap protectors.

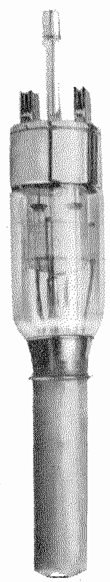


Figure 7—Water-Cooled Tube

The remaining three panels, namely, the third, the fifth and sixth, are part of the radio transmitter itself. The third panel is the oscillator modulator unit. It comprises essentially one stage of low-frequency amplification, an oscillator of the Colpitts type, working in connection with a Heising modulator. It will be seen from Figure 6 that the line connecting the transmitter to the studio terminates in a suitable manner on the primary of a step-up transformer, the secondary of which is connected to the grid of the speech amplifier tube. This tube is capable of a plate dissipation of 50 watts and is operated with an anode voltage of 1,000 volts. This supply is obtained from the 1,500-volt generator, and is stepped down by means of series resistance. The output currents are impressed on the grids of the modulator tubes by means of a coupling circuit of the choke coil and condenser type.

The modulator consists of two tubes operated in parallel, each tube being capable of a plate dissipation of 200 watts and of being operated with an anode supply of 1,500 volts. A battery of dry cells is used for polarising the grids of the amplifier and modulator tubes. The D.C. grid circuit of the modulator includes a milliammeter, an indication of current on which means that the modulators are seriously overloaded. The modulated energy from the output of the modulator tubes is applied to the oscillators by means of the modulator choke coil. Two tubes, of the same type as in the case of the modulator, are used in parallel. The oscillator circuit consists of grid and plate tuning condensers and a tuning inductance connected between grids and plates of the oscillator tubes. A load resistance is connected in series in the circuit as a permanent load on the oscillator; a necessary addition inasmuch as the grid circuit of the amplifier tube has a variable impedance for the various portions of a cycle. The permanent load resistance reduces the reaction of these impedance variations on the performance of the oscillator. The oscillator plates receive their supply from the 1,500-volt source, to which is added the audio frequency voltage from the modulator. The various adjustments on the oscillator are obtained by means of taps on the oscillator coil and, also, by changing by steps the value of the condensers in the circuit.

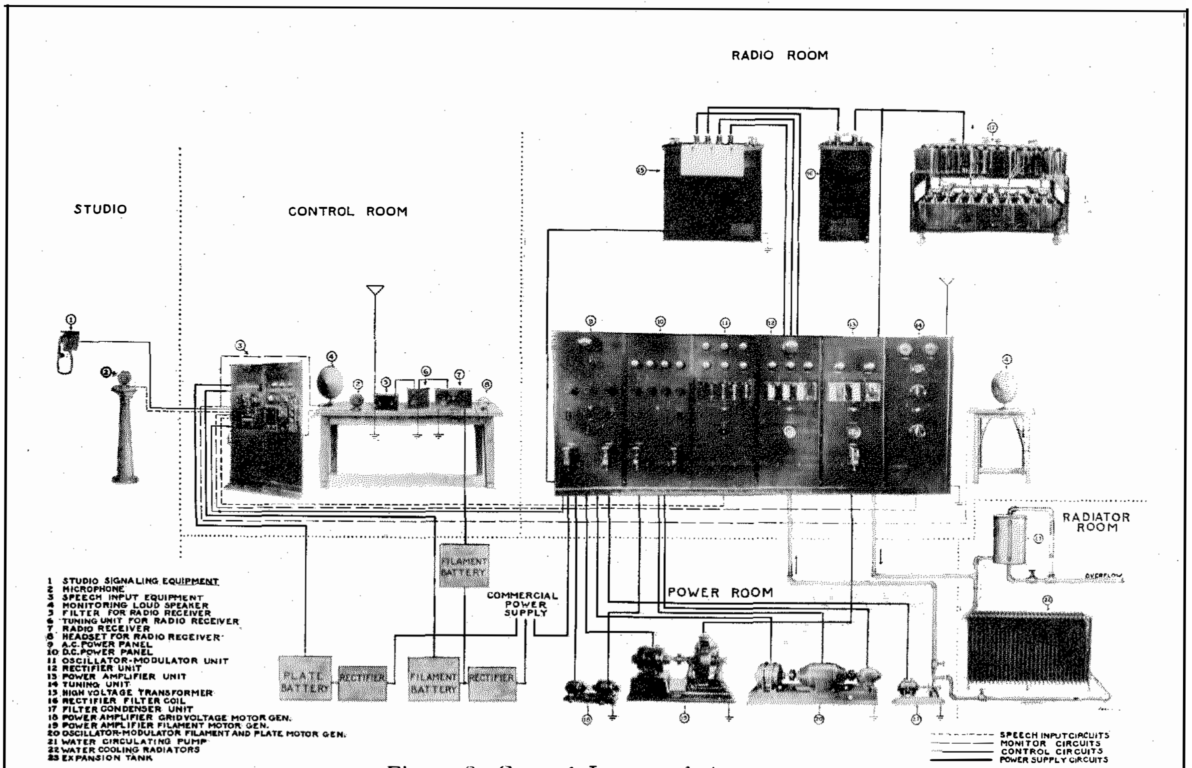


Figure 8—General Layout of Apparatus

Meters are provided on the front of the oscillator modulator unit for measuring the plate and grid current in the modulator and oscillator tubes. One meter reads also the high-frequency current circulating in the oscillator output circuit, and another reads the plate current of the speech frequency amplifier tube.

The high-frequency power amplifier occupies the fifth panel on the transmitter. It uses two water-cooled tubes operated in parallel with 10,000 volts D.C. on the plate and 250 volts D.C. on the grids. The radio frequency input voltage is obtained from a coupling tap to the oscillator coil through a coupling resistance.

The negative grid voltage is supplied to the grids in parallel through a choke coil and ammeter indicating the value of grid current. As this is a high-frequency amplifier, and as no distortion in the low frequency wave is introduced as long as the envelope of the high-frequency wave is not distorted, it is advantageous to operate the water-cooled tubes with large alternating grid voltages, resulting in an appreciable flow of grid current. This method of operation results in the production of harmonics at radio frequency, but the output and antenna coupling circuit are such as to prevent their radiation from the antenna.

The 10,000-volt plate supply is brought to the tubes through a radio frequency choke coil and a suitable anti-singing circuit, preventing the generation of oscillations due to inter-electrode capacities. The plate current returns to ground from the filament through a plate current ammeter and overload relay.

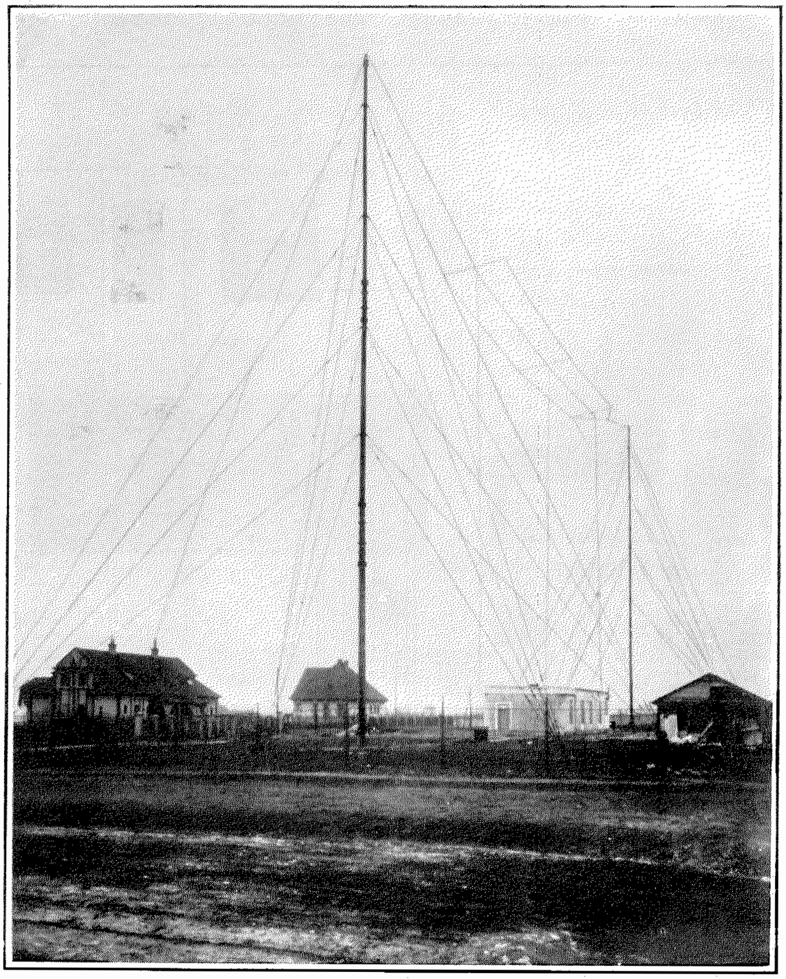


Figure 9—Antenna System

The water cooling system is connected to the water jacket of the tubes through insulating hose coils. The resistance of the column of water contained in the connecting rubber tube is high enough to reduce the losses through this path to ground to a very small value.

The amplifier output circuit and antenna coupling and tuning circuit occupy the last panel of the transmitter. The output circuit, besides filtering the harmonics from the amplifier output, has the function of offering the correct impedance to both the amplifier and to the antenna in order to ensure an efficient transfer of energy from one circuit to the other.

The amplifier output circuit consists of a closed resonant circuit comprising an inductance coil, a tuning and a coupling condenser. The circuit is tuned approximately under conditions of no voltage by means of taps on the coil and by using the proper number of fixed condensers in parallel or in series. Final tuning is accomplished from the front of the panel by means of a wheel operating a sliding contact at the top of the coil. The condition of maximum current is indicated by a radio frequency ammeter inserted in the closed circuit.

A coupling condenser is connected in series in the primary closed circuit, and also in series in the antenna circuit. The advantage of this method of coupling is due to the decreased efficiency of the coupling condenser for harmonic frequencies. A choke coil is connected across this coupling condenser to prevent the accumulation of static charges on the antenna.

The antenna is tuned by means of the antenna loading coil. As will be explained later, the antenna at Prague is of the multiple-tuned type, the centre down-lead being also the antenna feeder. (Figure 9.) As a consequence, the tuning of the antenna is secured by proper setting of the loading inductance in the various down-leads. The antenna tuning at the station can be used only as a vernier adjustment. The antenna ammeter indicates the antenna feed current. An artificial antenna, which is adjusted to simulate the outside antenna, is provided for the purpose of testing the transmitter without radiation. A monitoring rectifier is provided in the tuning unit to rectify a portion of the antenna current for monitoring purposes. The radio frequency voltage for the operation of this rectifier is obtained from a condenser potentiometer connected across the coupling condenser, the rectified currents being fed through a transformer to a monitoring loud speaker of the "Kone" type. This enables the attendant to follow and check the transmission.

Next to the transmitter room is the power room, where the various machines are installed. (Figure 10.) The 14-volt generator is a shunt machine self-excited, and the 1,500-volt generator is a double commutator machine, each commutator supplying a voltage of 750 volts. The field excitation is obtained from the 14-volt generator. These two generators are bolted on a common base plate and are driven from one common three-phase, asynchronous motor.

The 22-volt generator, coupled directly to a three-phase asynchronous motor, is a compound-wound, self-exciting machine, the commutator and pole pieces being of special design in order to reduce to a minimum the commutator ripple. The brushes are made of metallic copper gauze. The 250-volt generator is shunt-excited and is driven from a small single-phase, squirrel-cage motor. The pump, which is used to circulate water through the jackets of the tubes in the rec-

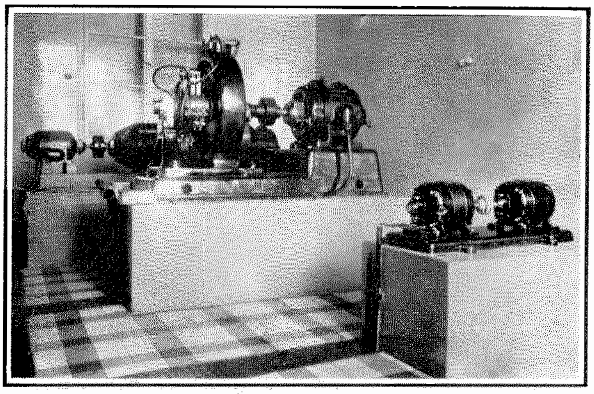


Figure 10—Motor Generator Sets

tifier and amplifier unit, is driven from a similar machine. The water is cooled by passage through a radiator of adequate dimensions.

The antenna system has been designed to obtain high radiating efficiency. The ground system is of the fish bone type, a central bus-bar following the whole length of the antenna, and small wires being connected across this central feeder. The length of the ground system is approximately 100 metres and its width is approximately 50 metres. The wires are laid parallel to the ground with a spacing of 50 centimeters. The two antenna masts are 40 meters high and 80 meters apart. The antenna consists of three down leads in the form of 6-wire cages 2 inches in diameter, and a flat top 40 meters long. The down-leads are consequently 20 meters apart. The two outer down-leads connect to ground through loading coils located in small housings, and the central one terminates on top of the building and connects to the radio transmitter through the antenna tuning inductance and coupling condenser.

In order to determine the power radiated from the antenna, a number of measurements of signal strength were conducted at distances of 1.1 kilometers and 6 kilometers from the antenna. The town of Prague lies between these two circles. A portable signal strength measuring set, Figure 11, was used for the tests. It consists essentially of three units: a loop, a double detection receiver and a local signal oscillator. The field of the radio wave is determined by direct comparison in the loop between the e.m.f. induced by the distant transmitter and an e.m.f. introduced by the local oscillator. The incoming radio wave is amplified in the receiving unit and produces after detection a certain deflection on a sensitive galvanometer. The loop is then rotated until the signal is reduced to an extremely small value, and the local signal oscillator is adjusted to give, at the same frequency as the station, a deflection equal to that obtained previously from the distant signal. It is possible from knowledge of the current supplied by the local oscillator and the geometry of the loop, to determine the strength of the incoming signal.

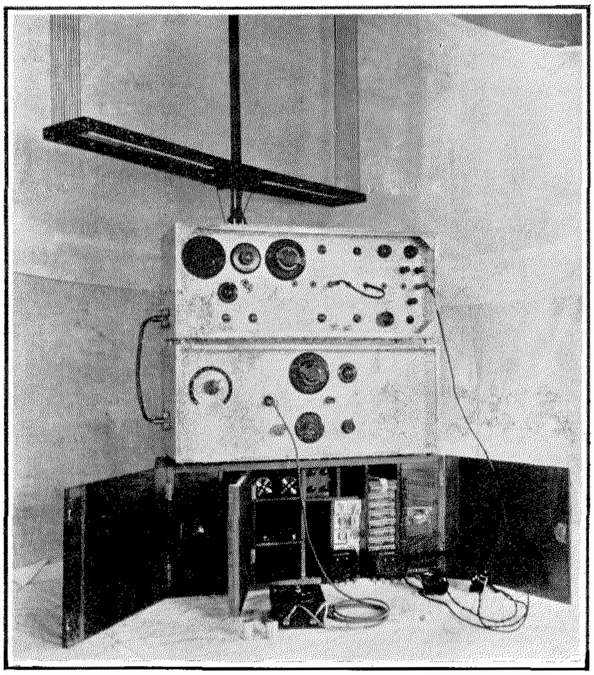


Figure 11—Signal Strength Measuring Set

The electric field strength was measured at six points, all approximately on a circle of 1.1 kilometers radius with the station as center. These points were very nearly equally spaced around the circle. The mean effective height of the antenna corresponding to the measurements on this circle was found to be 20.7 meters.

Similar measurements taken at twelve points on a circle of 6 kilometers radius give a mean effective height of 19 meters. Assuming that this decrease of effective height in the case of the second circle corresponds to losses in radiated energy between the two circles, the radiation resistance corresponding to the first figure is 5.07 ohms. The total antenna current in the antenna is 31 amperes. The radiated power is consequently 4.9 kilowatts.

The antenna input power was measured under the same conditions and was found to be 7.6 kilowatts. The antenna efficiency is consequently 64.5 per cent.

The input to the high-frequency amplifier during these experiments was 1.3 amperes at 9,400 volts, the negative grid voltage being 250 volts, and the amplifier grid current 63 milliamperes. The corresponding input power to the high-frequency amplifier is consequently 12.2 kilowatts and the efficiency of the amplifier under these conditions is 62 per cent.

The various values of field-strength were found to indicate that the radiation from the multiple-tuned antenna is practically equal in all directions. This is to be expected considering the small dimensions of the antenna compared with the wave-length. The high radiating efficiency of this type of multiple-tuned antenna justifies entirely the slightly increased complications in the process of tuning the antenna. In practice, provided that the antenna structure is sufficiently rigid, it is found that after being tuned the first time, the antenna needs very little readjusting.

Broadcasting In Japan

By R. E. A. PUTNAM

Engineering Department, Nippon Electric Company, Ltd.

JAPAN, like other countries, has undertaken the task of working out in its own way the solution to the problem which was suddenly thrust upon it by the recent popular demand for radio entertainment. The idea of permitting private interests to control broadcasting services for advertising purposes or for political reasons has never been given serious consideration, in spite of the pressure brought to bear upon the Government by numerous applications for broadcasting licenses from large business concerns and influential newspapers in Japan. It is worthy of note that the potential value of this new medium as an educational factor in the life of the nation gained early recognition, and it is this conception which was consistently advanced and eventually adopted as the basic principle underlying present day service.

Organization

Many difficulties of a perplexing nature were naturally encountered in attempting to guide the radio broadcasting industry into a well defined channel, rather than permit it to develop and expand along the lines of least resistance. Foremost among these was the question as to whether the new industry should be maintained as a Government monopoly, or whether its operation and management should be entrusted to private interests. After some delay the Government announced that the latter solution would be adopted. This policy was undoubtedly influenced partly by the necessity of concentrating all the Government departments on the work of reconstruction of communication facilities which had just previously been impaired seriously by the 1923 earthquake and fire,[1] and partly by the realization that a service devoted to the interests of the people should not be dependent, especially during the early period of growth and expansion, upon the political fortunes of its management.

Following closely the announcement of the Government's policy, representatives of the larger business concerns in Tokyo interested in advancement of the radio industry arranged a series of meetings which culminated in the formation of a non-profit-earning corporation known as the Tokyo Broadcasting Association. Sufficient capital was subscribed by the members to finance the corporation's preliminary program; and negotiations conducted with the Government were successful to the extent that the Association was granted the exclusive right to operate a local broadcasting station and to maintain this service by monthly fees collected from licensed radio receiving sets in Tokyo and vicinity included within a radius of approximately 160 kilometers. The Government in turn insisted on the Association's agreement to certain provisions and stipulations which insured to itself some measure of control of the broadcasting problem and the Association's activities.

The Tokyo Broadcasting Association's agreement with the Government furnished a definite basis for further negotiations by local organizations in other parts of the country. However, it was only in the Osaka and Nagoya districts that negotiations were successful; the organizations in the remaining four districts of the Empire failed either in their efforts to obtain the necessary financial support, or to satisfy the Government as to their respective abilities to fulfill their obligations to the public.

At a time when negotiations between the Government and the local broadcasting organizations were still pending, elaborate plans were being prepared and carried out by co-operation of members of the electrical industry for the express purpose of stimulating public interest in broadcasting. In Tokyo these plans led to the opening of a radio exposition in the fall of 1924 at which time samples of the radio products of Japan, together with those of other countries, were suitably displayed.

The Nippon Electric Company took a leading part in this program and was fortunate in having been able to display at the exposition a Western

[1] "Description of Damages Done by the Earthquake to Wired and Wireless Telegraph and Telephone Installations of Japan," S. Inada, ELECTRICAL COMMUNICATION, Vol. 3, No. 2, October, 1924; "Telephone Reconstruction in Tokyo and Yokohama," S. Inada, ELECTRICAL COMMUNICATION, Vol. 5, No. 2, October, 1926.

Native musicians photographed after a program broadcast by a W.E. 10 watt set during a demonstration in the Spring of 1925. The man standing at the rear is a Nippon Electric Co. engineer in charge of the broadcasting equipment

Electric No. 101-B, 500-watt radio telephone broadcasting equipment which had just been received from America. This equipment was loaned to the exposition management under whose auspices it was operated for a period of three weeks at reduced output by special arrangement with the Government. Regular programs were provided from a temporary studio on the exposition grounds.

In the early part of 1925 this broadcasting set was used under somewhat similar arrangements at Osaka, where it was permitted to operate for a period of three weeks at one-half its rated output capacity.

These demonstrations gave the public its first taste of modern broadcasting, and the response indicated a degree of enthusiasm exceeding all expectations. With this experience as a background, the newly organized broadcasting associations were enabled to complete their negotiations with the Government, and to make plans for the immediate establishment of permanent broadcasting stations with the assurance that their venture would not prove to be a failure.

Present Status

Radio broadcasting was begun regularly in Japan about the middle of 1925. The degree of success attained is best indicated by the fact that this service gained immediate popularity, rivalling that previously experienced in other countries. The growth in the number of radio receiving sets greatly exceeded the original estimates of the promoters, and at the end of the first year of operation the total number of subscribers to the three broadcasting stations was approximately 280,000. New subscribers are now being added at a rate which indicates that the 400,000 mark will be exceeded early in 1927.

At the present time any person desiring to operate a radio receiving set must first become a subscriber to the broadcasting service in the district in which he resides. An application to this effect must include a general description specifying the type of circuit and wave-length range of the radio receiving set which it is proposed to use. Although this application is filed with the local broadcasting company, the actual licensing of the applicant is a Government function, and the application is not accepted until the Government examiners are satisfied that the receiving set will comply with their official regulations. In general, licenses are granted on all types of receiving sets which appear to be incapable of radiating energy or of being tuned above 600 meters wave-length.

The entire cost of the broadcasting service is borne by the subscribers who pay a monthly fee of 1.00 yen (par 49.8 cents) each to the local broadcasting association, and an additional yearly fee of 1.00 yen to the Government. The latter item is intended to cover the Government's expenses incurred in examining applications for receiving set licenses, and in making periodical inspections to insure that all receiving set installations comply with existing regulations.

Broadcasting Equipment

The Tokyo Broadcasting Association officially started its service in the spring of 1925 at a temporary station using a 500 watt Point-to-Point radio transmitter borrowed from the Electrotechnical Laboratory of the Tokyo Municipality. This service was maintained for about three months pending the arrival of a 1,000 watt Western Electric broadcasting set and the construction of a permanent station.

The site selected for the new station was on the top of Atago Hill, a low-lying but prominent elevation overlooking the principal business district of Tokyo including Tokyo Bay. When first acquired by the Association this location was a bare and desolate site as a result of the fire following the earthquake of 1923. The original means of ascent was by long flights of stone steps, and all construction material and equipment for the station had to be transported to the top using a derrick specially erected for the purpose. Later, at considerable expense, a motor road was completed to the summit for the convenience of the operating staff and visitors.

The new station began operation in July, 1925, on a 375 meter wave-length with the call letters JOAK. Designed with the idea of eliminating all possible risks of interruptions to service, the building housing the radio equipment, studios and general offices is of reinforced concrete and virtually fire and earthquake proof. With power service supplied from two independent sources, two complete broadcasting equipments, and an emergency storage battery capacity capable of operating the entire station for 10 hours, it is felt that the installation would prove most useful in the event of a repetition of the 1923 earthquake with consequent destruction of all wire communication facilities.

One of the two broadcasting sets is the Western Electric No. 106-A set rated at 1,000 watts antenna input power, and the other is a product of local manufacturers, having a somewhat lower power output. The former is depended upon for the transmission of all important programs, and the latter is reserved principally for use in emergencies. Installed side by side, the difference in space requirements of the two radio transmitter designs is one of the first points noted by visitors in their comparison of equipment. Whereas the Western Electric transmitter is contained within or controlled from one panel only, the other radio transmitter has its control and equipment distributed over five panels of equivalent size.

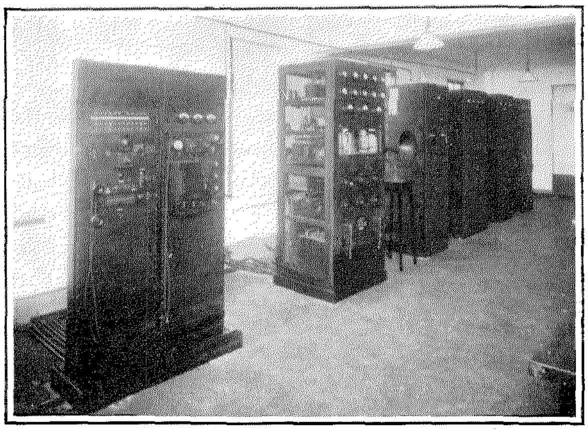
The No. 106-A radio broadcasting set is similar in many respects to the 500 watt set used in the Birmingham Broadcasting Station.[2] Speech amplifiers, microphones and studio signalling apparatus are fundamentally the same. The power panel, however, is eliminated, and the motor-generator controls are on the transmitter panel instead. In the radio transmitter another difference exists in that only one oscillator and one modulator tube are used instead of two tubes; and that a stage of radio frequency amplification employing a water-cooled tube is added between the oscillator-modulator combination and the antenna. The principal advantage of this new arrangement is that the oscillator frequency is practically independent of the antenna capacity so that the wave-length of the radiated carrier will not vary as does that of the ordinary transmitter when the antenna sways in the wind.

From the standpoint of operation the 106-A broadcasting set is especially easy to control and adjust. The power equipment is remotely controlled from the radio transmitter panel by means of a master start-stop switch, and any necessary voltage adjustments can be made from the same panel. Adequate protection to the apparatus is provided by fuse and relay equipment designed to interrupt automatically the power supply in case of failure of the cooling water supply, or the existence of other abnormal conditions. Other relay combinations are provided to insure that the various power supplies to the vacuum tubes are applied or removed only in the proper sequence. In general, one operator is able normally to start up the set, make any necessary adjustments at the radio transmitter or speech input equipment, and have the entire equipment ready for broadcasting within one-half minute.

Protection to the operator is assured by complete shielding of high voltage circuits, and by the provision of door switches which automatically shut down all power equipment in

Tokyo Broadcasting Station on Atago Hill

[2] "The Birmingham Broadcasting Station," A. E. Thompson, ELECTRICAL COMMUNICATION, Vol. 2, No. 3, January, 1924.



Tokyo Broadcasting Station—Showing W.E. Type Speech Input and Radio Transmitter at Left of Loud Speaker and Portion of Spare Radio Transmitter at the Right

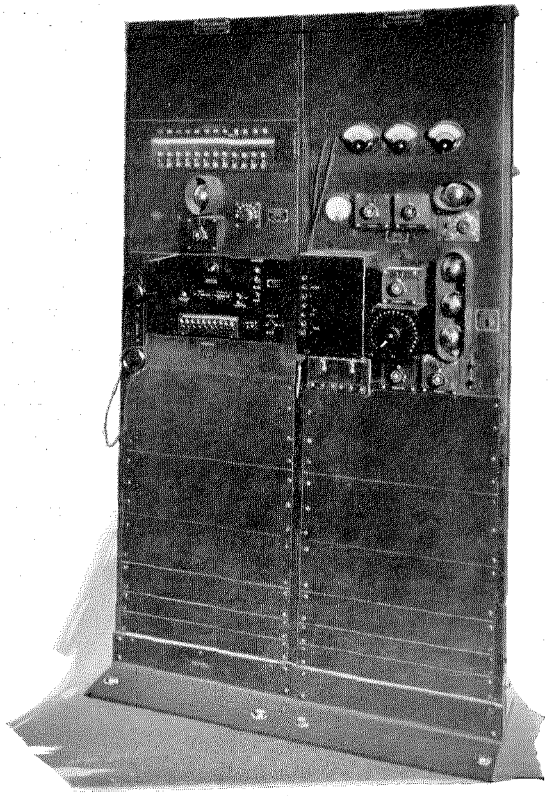
case the operator fails to take this precaution before exposing the high voltage apparatus and power terminals inside the transmitter panel.

The power equipment consists of two 3-unit motor-generator sets. One set furnishes direct current at 22 volts for the vacuum tube filaments, and a 250 volt supply for various control circuits and grid biasing purposes. The second set includes two 2,000 volt generators with armatures in series to provide the 4,000 volt supply to the plate of the water-cooled tube.

The antenna used with this station is of the flat-top type, with an effective length of about 20 meters, suspended between two self-supporting steel towers approximately 50 meters in height. With this is used an insulated counterpoise supported on the roof of the building housing the studios and transmitter equipment. Frequent reports of the reception of this station at points in Australasia and on the North American Continent indicate that the antenna system is quite efficient.

The studio arrangement in the Tokyo station is typical of that being adopted in Japan. It differs somewhat from European and American practice in that provision must be made for certain types of musical programs in which the artistis are accustomed to sing and to play their musical instruments while in a sitting position on the floor. Accordingly, a special studio is provided for this purpose, duplicating as far as possible the usual features of construction to be found in a typical Japanese home. A second studio furnished in foreign style is used for the presentation of band selections, orchestral numbers and radio dramas. A third studio of small proportions is reserved for speeches and special announcements as occasion requires. A small control room is so located that the control operators have a direct view of the activities in all three studios.

The Osaka Broadcasting Association acquired the Western Electric No. 101-B broadcasting set following its successful demonstration in Osaka, and arranged for its immediate installation in temporary quarters on the roof of an eight-story steel and concrete structure in the heart of the city. Although the Government's final regulations specified 1,000 watts as the required antenna input power, it granted the Osaka Association a license to use its temporary installation pending the construction of a permanent station, and assigned it the call letters JOBK and an operating wave-length of 385 meters. This temporary station was officially opened on June 1, 1925, and at the moment of writing is still in operation, owing to legal and

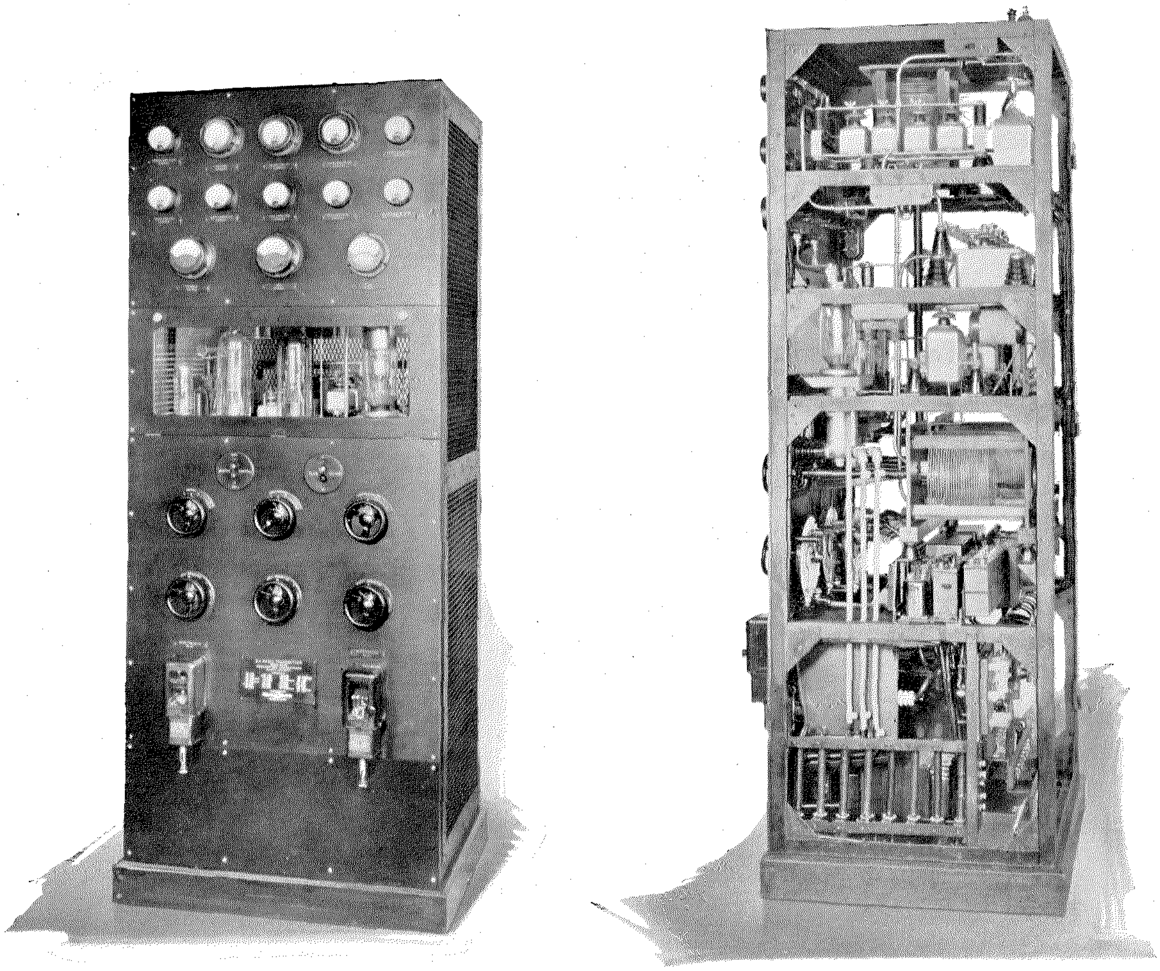


W.E. Type Speech Input Equipment

technical difficulties encountered in securing a suitable site for a permanent station. According to present plans, however, a new station employing a Western Electric No. 106-A broadcasting equipment will be in operation early in 1927.

It is worthy of note that the existing 500 watt equipment has been in operation for more than 15 months without experiencing a major breakdown, and that no serious interruptions occurred which might be attributed to design or equipment defects. This equipment, except for slight modifications and improvements, is identical with that previously [3] described. It may be mentioned in this connection that reliability of operation is considered of primary importance, and that an operating license is granted only after the Government's engineers have made exhaustive tests covering the installation, and have satisfied themselves that it complies in all respects with approved standards.

The Nagoya Broadcasting Company opened its permanent station in July, 1925, with the call letters JOCK and an operating wave-length of 360 meters. A broadcasting equipment imported from England is installed here and is operating with 1,000 watts input to the antenna.



Front View — Side View

W. E. Type Radio Transmitter

Early Receiving Set Regulations

In connection with the early history of radio broadcasting development there are certain aspects of the Government's policy in handling the radio receiving set problem that are worthy

[3] Thompson, Loc. Cit.

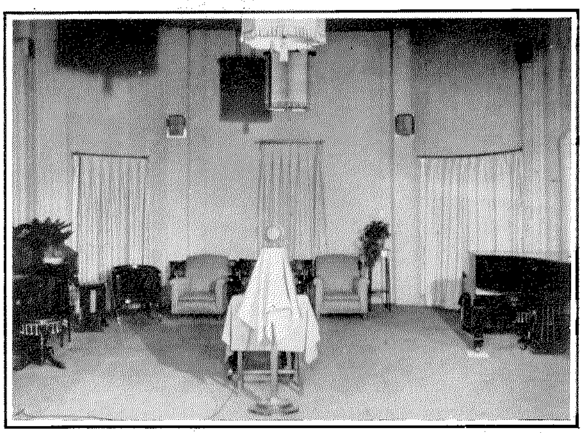
of mention. As in many European countries, the prospect of a widespread use of receiving sets by private citizens was viewed with alarm by military authorities and other Government departments operating radio telegraph communication facilities; and it was freely predicted that constant trouble would be experienced from unauthorized interception of important commercial and Governmental messages.

As early as 1923 imported receiving sets began to appear in the local market, and these secured a limited distribution among amateur experimenters. Some of these incorporating the long-wave tuning circuits were particularly objectionable from the above mentioned viewpoint; and in addition the majority of vacuum tube sets employed the simple regenerative circuits which were known to be causing serious interference in America. In an attempt to cope with this situation by discouraging the sale of such apparatus, the Government promulgated a set of regulations specifying the technical characteristics that would be required of radio transmitters and receiving sets before an operating license could be granted. These regulations were at the same time, a virtual announcement of the Government's intention eventually to permit radio broadcasting; and they constituted the first comprehensive effort to establish a basis for the growth of the industry without permitting it to get beyond control.

Under this plan the public was to be protected from unscrupulous manufacturers by the requirement that the individual items entering into a radio receiving set installation should include only products specifically approved by the Government laboratories. This applied to the receiving set proper, and all accessory items such as vacuum tubes, headphones, auxiliary amplifiers and loudspeakers. The receiving set itself was to be capable of being tuned to signals in either of the two broadcasting wave-length bands, namely, 200–250 meters and 350–400 meters, but incapable of being tuned outside these ranges. Furthermore, sets were not to be approved if they were arranged so that external circuit modifications could be devised to change the tuning range, or cause regeneration. With an additional provision for limiting the dimensions of the receiving antenna, and a further requirement that the set be sealed by a Government inspector to prevent circuit modifications, it was felt that no further objections would be raised to the general use of radio sets by private citizens.

Although ideal in many respects, these regulations were found to possess certain disadvantages in practice. In 1924 when plans for broadcasting began to take definite form, manufacturers undertook to supply approved receiving equipment to meet the growing popular demand. However, only a few manufacturers were able to build receiving sets covering satisfactorily the specified wave-length ranges, and those who succeeded found their product comparatively inefficient and quite expensive. Again, dealers handling approved receiving equipment sometimes found their stocks of receiving sets temporarily unsalable owing to real or apparent scarcity of approved accessories such as headphones or vacuum tubes. The general public gradually became aware of the fact that simple and inexpensive crystal detector circuits using unapproved apparatus could be easily assembled to give about the same efficiency as equivalent approved factory-made sets, and small dealers handling unapproved apparatus accordingly grew rapidly in number.

When applications for receiving set licenses in Tokyo alone began to flow in at the rate of about 300 per day following the opening of regular broadcasting service, it became evident that the majority of receiving set owners were assembling their own sets. Appreciating the difficulties involved in attempting to maintain the existing regulations and at the same time develop a self-supporting broadcasting service,



Tokyo Broadcasting Station, Main Studio

Osaka Broadcasting Station—Temporary installation of W.E. Type No. 101-B equipment on the roof of the Mitsukoshi Department Store
Reception of this station has been reported from Pennsylvania—(October 25, 1926)

the Government decided in favor of the latter policy and forthwith undertook to encourage the use of home constructed sets by making it especially easy for their owners to obtain operating licenses. This action indirectly legalized the use of the majority of expensive imported sets that had previously secured wide distribution, and incidentally relieved many local dealers of serious financial embarrassment that would otherwise have existed by reason of their inability to dispose of their extensive stocks of imported sets.

Programs

Broadcasting service in Japan is probably taken more seriously than in the majority of countries. This is readily apparent from the fact that amusement features constitute only about one-third of the daily program which averages perhaps eight hours total. The remainder of the program is made up of items which might be broadly classified either as educational or as news. A typical daily program, for example, may begin at nine o'clock in the morning with a lecture on domestic science followed by talks on other subjects of general interest, and a noon hour program either musical or educational in nature. During the late afternoon and early evening a brief period usually is devoted to features of interest to children. During these hours lectures following some prearranged schedule are usually also given on foreign languages for the benefit of students. The study of English probably receives the greatest amount of attention, with French and German next in importance. The evening program from 8:00 to 10:00 P.M. is almost exclusively reserved for musical programs and radio dramas. In addition, weather forecasts are given at least twice daily and important news items are contributed at intervals by local newspapers.

One of the most useful services performed is the broadcasting of market reports on securities and commodities. These reports are sent out about once every hour throughout the working part of the day, and are said to form the basis for a considerable share of business transacted at points remote from the large cities, especially in those communities where telephone and telegraph facilities are scarce and long distance communications are subject to considerable delay in transmission during the busy hours of the day.

Among the musical programs provided are usually to be found three or four periods a week devoted to foreign music rendered by Japanese artists. Foreign artists of note residing or traveling in the country are also engaged for one or more studio performances when practicable. This represents an effort on the part of the program managers to interest foreign residents in Japan, and at the same time to meet a growing demand on the part of Japanese listeners who appear to enjoy and appreciate this type of music.

Results

As a result of observations made during the first year of operation, some unexpected tendencies in the growth of the broadcasting industry are now in evidence. First in importance is the fact that the public response to the broadcasting appeal is considerably different in various localities. For example, the program service furnished by the Tokyo, Osaka and Nagoya stations has been of about the same standard, yet at the end of the first year of operation the subscribers to these stations numbered approximately 160,000, 80,000 and 40,000, respectively. These figures are not representative of the comparative populations involved.

A second consideration of interest, based on an analysis of the existing types of receiving sets in use, is the fact that more than 80% of the licensed sets are of the crystal detector type. There is also evidence to indicate that the great majority of crystal sets have been constructed by their owners.

A third observation is to the effect that radio transmission over distances in excess of about 50 kilometers is notably unreliable for the assigned broadcasting wave-lengths. The high atmospheric absorption and resultant fading effect experienced probably is a characteristic of the country, the interior portions of which are generally mountainous. Consequently, a number of important communities, which were thought to lie easily within the range of one of the three existing broadcasting stations, have found reception entirely unsatisfactory.

As these facts have gradually become evident, the officials in charge of broadcasting have been led to the conclusions that the majority of small communities will be unable to support a local station under existing arrangements if the expense of providing programs is included. It has become obvious also that successful plans for a nation-wide service must be based on the general use of crystal detector receiving sets.

Plans for Expansion

Recently, negotiations have been conducted between the three broadcasting companies and the Government with the intention of reorganizing the industry so as more effectively to conduct an enlarged program for expansion. These negotiations have resulted in the formation of the Japan Broadcasting Corporation, which is essentially a holding company authorized to acquire the stock of the three existing local organizations and to pool the earnings for establishing supplementary services throughout the Empire.

Although the future plans of the new Corporation have not as yet been made public, it is probable that they will provide for the eventual replacement of the existing stations by higher power equipments, and for the establishment of several additional equipments of uniform size in other large communities. Smaller isolated communities possibly will be covered by the use of low power relay stations inter-connected by wire lines with centralized studios in the larger cities.

At the present time the broadcasting art has progressed to a point where no technical difficulties are likely to be encountered in operating or interconnecting any desired number of broadcasting stations distributed over wide areas. The principal problem involved is, therefore, one of financing, and on the solution of this problem depends the time required by the new corporation to achieve its purpose and extend its service to all crystal receiving sets within the Empire. Certainly, the importance to the nation of the ultimate realization of present plans for a unified and comprehensive broadcasting service is scarcely to be over-estimated; and it seems safe to say that from an educational standpoint alone the potential possibilities inherent in such a service are not to be equalled by any other medium.

Osaka Broadcasting Station—Japanese musicians in studio of temporary station

Pioneers of Electrical Communication

ANDRÉ MARIE AMPÈRE—II

By ROLLO APPLEYARD

European Engineering Department, International Standard Electric Corporation

FRANCE, amidst her greatest woes, has always produced men who could establish her glory. It was thus in keeping with immemorial precedent that in the troubled period of transition from the eighteenth to the nineteenth century there should be born, at Lyons, André Marie Ampère, a genius destined to found a new era. At the date of his birth—January 20, 1775—Lyons was the chief centre of French commerce, and France was entering upon a revolution. Louis XVI, with the best intentions but with deplorable ineptitude, had succeeded to the throne scarcely a year previously. The people of France had developed beyond its institutions, and neither the monarch nor his ministers possessed the qualities needed to sweep away abuses. Accordingly it happened that the boyhood and youth of Ampère were passed at the seething focus of the reaction that culminated in outbreaks against the combined forces of the Dantonists, the Robespierrists and the fatal Commune. Upon the industries of Lyons the consequences descended heavily, for 30,000 of its silk workers were thrown out of employment; and in the midst of the turmoil Ampère's father, on November 23, 1793, fell on the scaffold—a victim of the terreur.

André was then eighteen. The shock broke the delicate threads that sustained the balance of his mind. He passed his days in silence, listlessly contemplating the sky, or aimlessly making with his fingers pyramids of sand. In vain his friends tried to arouse him. All faculty, all sentiment, was for the time obliterated. The blow was intensified because of the loss of the companionship that had existed between him and his father. His father had been his only instructor. Finding that the natural bent of his son was mathematics he had permitted him to discover his own path, with the result that by the age of 11, André had acquired sufficient facility to apply algebra and geometry to his problems. When he was 12 his father had introduced him to the Librarian of the College of Lyons, who showed him copies of the works of Euler and Bernoulli. This had given an impulse to his studies, and he had devoted himself more closely to Latin in order to be able to learn about the calculus. It is recorded that just before his father's death André read the "Mécanique Analytique," of Lagrange,

Portrait of Ampère. From a Lithograph of a Drawing from Life. By Boilly

and worked through almost all the calculations it contains. His memory even then was prodigious, and his perceptive faculties were astonishing.

For a year after the tragedy, the cloud overshadowed him. Then it began to lift. His interest was aroused first by glancing at a book by Rousseau on botany; thus he was led again to

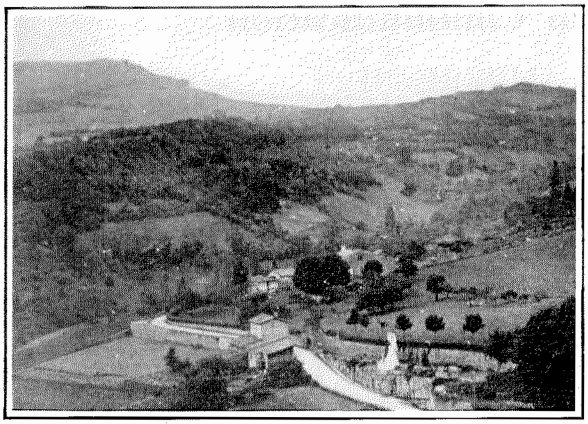


Figure 1—Polémieux, Showing the Monument to Ampère
The house in which the Ampères lived is just beyond the last bend of the road on the left of the statue.

prose, and from prose to verse. Measured language numbed the mental pain and quickened his intellect. His own attempts at poetry soon became interspersed with x's and y's and there was produced a formula for determining all the powers of a polynomial. It was poetry lacking the art of versification, but it was blazoned with algebra in amazing variety. His brain was again trying to work, and the effort only needed direction.

Direction came in the usual way. His mother had a little property at Polémieux-les-Mont-D'Or—about nine miles north of Lyons. It was there that André's boyhood had been spent with his parents. The house—la petite maison blanche—and garden exist there to this day (Figures 1 and 2), resting peacefully upon the hill-side, unchanged—as if still celebrating his obsequies. You may approach Polémieux by road from Lyons by way of Mouton and Limonest, and then by a pleasant descent through about 8 kilometres of country lanes to the village in the hollow. You may best return to Lyons by the road that wanders near the stream, to Neuville, and thence by the track that borders the Saône. It was in this picturesque district of Mont-D'Or that Ampère found direction. Amongst his notes of that melancholy period there is at last an entry:

"Un jour que je me promenais après le coucher du soleil le long d'un ruisseau solitaire. . . ."
The memorandum there ends, but it suffices to record his first meeting with Julie Carron, and the first phase of a romance that is inseparable from his story.

They were married on August 6, 1799, and the register supplies particulars of their parentage: "André Marie Ampère, youngest son of J. J. Ampère, deceased, and of Antoinette de Suttières Sarcey, of the parish of Polémieux, to Catherine Julie Carron, eldest daughter of the late Claude Carron and of Antoinette Boyron of the parish of Saint Germain, Mont-D'Or."

Their combined income was meagre. They went to live at Lyons, but as he could not then (1800) obtain there sufficient recompense, he accepted a professorship at the Ecole Centrale du Département de l'Ain which had been established at Bourg-en-Bresse. As this institution is so closely associated with his epoch-making researches, its history deserves more than passing notice.

There was a communal school at Bourg as long ago as 1391, presided over by a lay-rector. For centuries it was situated in La Verchère. In 1404 the school in common with everything else suffered as the result of plagues and wars. There was a development in 1561, when poor children were admitted free; and in 1572 it was enlarged, and the lay personnel was increased. Ecclesiastical troubles followed, which brought the Jesuits to Bourg in 1614. A chair of philosophy was founded there in 1661, and it became in 1744 a centre of intellectual life, inspired by the astronomer Lalande. In 1751 the college was rebuilt, and in 1761 a physical laboratory was set up, and a second course of philosophy was introduced. Two years later the Jesuits were suppressed, and those at Bourg quitted the college. They were

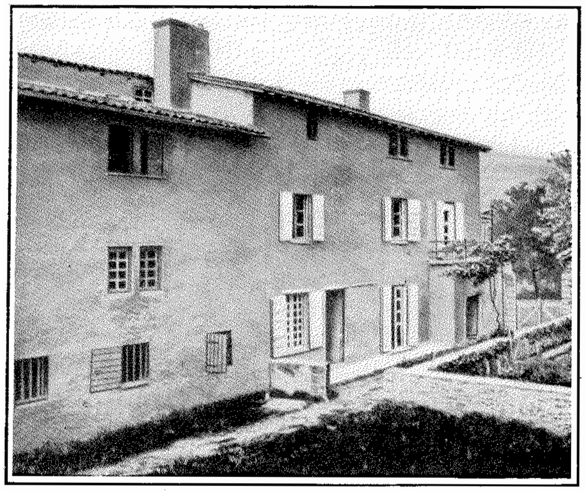


Figure 2—Ampère's House at Polémieux

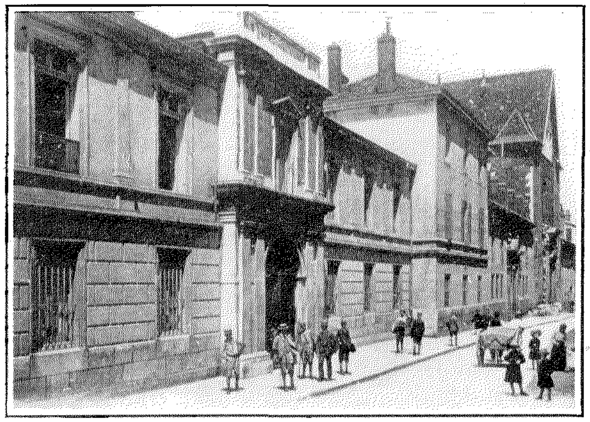


Figure 3—The Lycée Lalande at Bourg-en-Bresse

replaced by seven priests all born in the town. In 1793 the college was closed, but it was reopened under the name of the Ecole Centrale. It was there that Ampère was a professor from 1801 to 1803. In 1805 the Ecole Centrale was replaced by a municipal secondary school (Figure 3).

The distance from Lyons to Bourg at the beginning of the nineteenth century was too great to permit Ampère to return each day to his home. Circumstances obliged him to live in lodgings in Bourg, while his wife remained in Lyons; for on August 12, 1800, their son Jean-Jacques was born. Ampère's lofty ideals at this period are in such strange contrast to his surroundings, that when the high quality of his scientific achievements at Bourg is kept in mind, a profound lesson is taught of devotion in uncongenial environment. His aspirations may be gathered from a single paragraph of a letter he wrote at this time to his wife:

> "Quelle gloire attend celui qui mettra la dernière pierre à l'édifice de la physique moderne; quelle utilité ne doivent pas en espérer les arts les plus nécessaires à l'humanité."

Those luminous thoughts, however, must be sought amidst the record of grim facts:

> "Je suis en pension, à quarante francs par mois, chez Beauregard; on me demandait soixante francs à l'auberge de Renaud, où il fallait manger avec les plus grands sottisiers que j'aie vus de ma vie. Cela passait toute expression. . . . J'ai vu le cabinet de physique, le laboratoire de chimie et l'unique petite chambre avec alcôve, petit débarras à mettre le bois. J'ai été fort content des machines; le laboratoire a un grand manteau de cheminée par où doivent s'exhaler les vapeurs nuisibles; il y a assez de ressources pour les différentes expériences . . . adresse tes lettres au citoyen Beauregard. . ."

and we find her addressing them accordingly:

> "De Mme. Julie Ampère au citoyen Ampère. Chez le citoyen Beauregard, professeur d'histoire à l'Ecole Centrale du département de l'Ain, à Bourg près l'église Notre-Dame."

Further details of his daily routine followed with the confession that he had his supper at six, very tired after having

> "pilé, broyé, porté du charbon et soufflé le feu pendant douze ou treize heures, mais content d'avoir réussi quelquefois. . . ."

Consolation, tinged with the mildest of admonishment, came with little delay from Lyons:

> ". . . . prenons patience et réjouissons-nous de pouvoir parler à Pâques de tout ce que nous avons dans l'âme . . . mon pauvre Ampère, tu es trop content de m'envoyer tout ce que tu gagnes . . . Tu fais donc toujours ces vilaines drogues."

This correspondence, which has been described as a veritable conjugation of the verb aimer, ends abruptly, for calamity once more overtook the great philosopher, and plunged him into despair. His Julie died on July 13, 1803.

The drama is intensified by the struggle that Ampère had made to obtain an appointment in Lyons whereby he hoped to secure means to alleviate the sufferings of his wife, and by the coincidence that Bonaparte, as first Consul of the Republic, had just nominated him, on the advice of Lalande and Delambre, as a professor at the Lycée of that city. The world was left to him desolate, and he naturally sought to withdraw from the scenes that once delighted and now tortured him.

In November, 1804, Ampère was nominated for an appointment at the Ecole Polytechnique at Paris. Four years later he became Inspecteur Général of the University of Paris. In 1809 he was professor of Analytical Mathematics and Mechanics at the Ecole Polytechnique, and he became a Chevalier de la Légion d'Honneur.

From 1806 to 1810 he was a member of the Bureau Consultatif des Arts et Métiers, and in 1814 a member of the Institute. He entered the Académie des Sciences in the section of Geometry. During this period his activities were as intense, thorough and illuminating as they were multifarious. For with mere erudition he was never content; he sought the truth, elevated ideas, general principles, and he preferred them if they could be directly applied. A survey of his memoirs shows that his investigations relate to transcendental mathematics, applications to mechanics, electricity and magnetism, optics, the theory of gases, molecular physics, animal physiology, the theory of the earth, metaphysics and psychology for which he confessed he had a "passion." He was always a man of science, and in everything a man of fervour. Intermittently he was a man of faith.—"Le doute," he wrote, "est le plus grand des tourments que l'homme endure sur la terre."

The first memoir contributed by Ampère was published in Lyons in 1802. Following upon the work of Pascal, Fermat and Buffon, it dealt with the mathematical theory of play, and with the evaluation, in accordance with the laws of probability, of the danger that awaits a player who takes a prescribed chance. This was presented to the Institute by Delambre, and it resulted in Ampère being appointed as professor at the Lycée de Lyon. Three years later he extended this investigation and published an account of his researches on the application of the Calculus of Variations to problems in mechanics. In 1806 he was at work at the theory of derived functions leading to a demonstration of Taylor's Theorem, and he was also giving a demonstration of the principle of virtual velocities. From that time until 1815 he contributed other papers on purely mathematical subjects; he proceeded into molecular physics and chemistry, and added a memoir upon the determination of the proportions in which bodies combine, taking account of the number and disposition, respectively, of the molecules of which the integral parts are composed.

His attraction to physics and chemistry at this period steadily increased, and he was writing on such subjects as Mariotte's Law, the classification of simple bodies, and the magnetic state of conductors. Then followed his brilliant series of memoirs on electro-dynamics, for which most of his previous studies was unconsciously a preparation. His immortal work on the mutual action of two currents was published in Annales de Chimie et de Physique, Vol. XV, pages 59–170, 1820. His last efforts were concentrated upon the classification of the sciences, and upon determining the shape of the surface of luminous waves in a medium in which the elastic constants are different in the three dimensions of space.

It is rarely that a phenomenon in physics appears suddenly in the firmament of knowledge. Between the years 1802–1820 there were portents concerning the action of an electric current upon a magnetic needle, for Romognosi published on August 3, 1802, in the Gazetta di Trento, his paper entitled "Articulo sul Galvanismo." The great advance, however, began on July 21, 1820, when Hans Christian Oersted issued his four-page pamphlet "Experimenta circa effectum conflictus electrici in acum magneticam." Information concerning the discovery reached Paris, by way of Switzerland, on September 11, 1820. An academician who had just returned from Geneva repeated before the Académie des Sciences the experiment of the Danish philosopher, and on September 18, Ampère presented his memoir and demonstration that two electric currents exert mechanical forces upon one another. His contributions to the subject were read at its séances on September 18th and 25th, and October 9th and 30th of that year.

In the First Mémoire of this series of discourses after reviewing all the facts observed by Oersted, Ampère distinguished between the directive action, and the attractive or repulsive action. He introduced the astatic needle, and he showed that the directive force of a current is always exactly perpendicular to the direction of the current. He also carried out a demonstration with his "galvanoscope," and he announced that a conducting helix traversed by a current exerts an action resembling that of a bar magnet in all respects, and hence that the earth's magnetism could be explained by terrestrial electric currents circulating in the direction from east to west. Such currents, he suggested, might be caused by chemical action between the heterogeneous materials in contact within the globe, in accordance with the principle established by Volta for metals. He declared that whatever hypothesis might ultimately be adopted there would remain these three new facts: first, two electric currents (Figure 4) attract one another when they are in

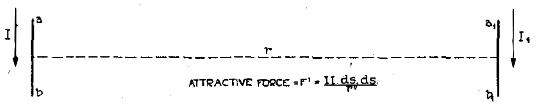


Figure 4—Parallel Elements of Circuits

the same sense, and they repel one another in the contrary case; second, these attractions and repulsions are absolutely different from the (static) electric attractions and repulsions previously known; and third, a magnet acts in all circumstances, whether upon an electric current, or upon another magnet, as if it consisted of an assemblage of closed electric circuits each traversed by a current. He emphasized the fact that in this electro-dynamic action consideration has to be given rather to plane areas than to straight lines. He also drew attention to the effect of increasing the number of turns, and to the comparatively small importance of shape of area. Moreover he introduced the idea that elementary portions of circuits could be dealt with, as regards their electric currents, in accordance with the principle of the parallelogram of velocities, i.e., that the action between two infinitely small portions is a function not merely of the distance, but also of the angles that determine their relative positions in space. (Figure 8.)

His Second Mémoire, read at the Académie Royale des Sciences on June 10, 1822, relates to his determination of the formula that represents the mutual action of two portions, infinitely small, of "conducteurs voltaïques." The impossibility of subjecting infinitely small portions to experiment had been overcome by him by precise observations upon portions of finite length placed successively with respect to one another at different distances and in different positions—i.e., at different angular settings. He also adopted, with great advantage, null methods of measurement, and the method of counting oscillations.

For a concise account of his original researches in electro-dynamics attention may be directed to his treatise entitled, "Exposé des nouvelles découvertes sur L'Electricité et le Magnétisme de M. M. Oersted, Arago, Ampère, H. Davy, Biot, Erman, Schweiger, De la Rive, etc.," which was published in 1822. The principles enunciated by him have for a century been subjected to analysis and they have been recognized as the solid rock upon which the structure of electrical theory must be built. He discovered the mechanical action between electric currents, and he established mathematically and by physical demonstration the law of that action. This Maxwell declared to be one of the most brilliant achievements in science; for the whole, theory and experiment, had "leaped full grown and fully armed from the brain of the Newton of electricity," perfect in shape, unassailable in accuracy, and summed up in a formula from which all the phenomena could be deduced—the cardinal formula in electro-dynamics.

Ampère's theory begins with the reasonable assumption that the action between two very small elements of a circuit, or circuits, conveying an electric current, is in the straight line joining those elements (Figure 4–8), and that the effect is directly as the product of the steady currents in the two elements, respectively, and directly as the lengths of the elements. Then follow his experimental laws of steady currents so far as the mechanical force upon other conductors is concerned. He found that: two equal currents close together (Figure 5a) in opposite directions neutralize each other; if two wires close together—one straight and the other containing small sinuosities (Figure 5b) but approximately straight—have the same current through them, their effects

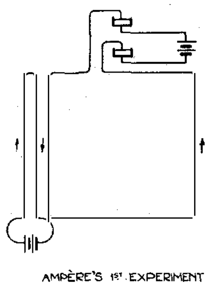


Figure 5*a*—Straight Circuit Doubled on Itself

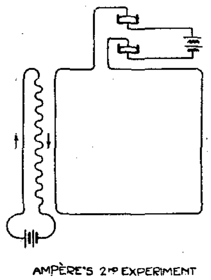


Figure 5*b*—One Straight and One Sinuous Circuit Doubled

neutralize each other; if a conductor (Figure 6) whether carrying a current or not, is free to move only in the direction of its length, a current in a closed circuit of any kind placed near it is unable to move it; the action of a closed circuit on any portion of another circuit is perpendicular to the latter circuit. He showed that every linear con-

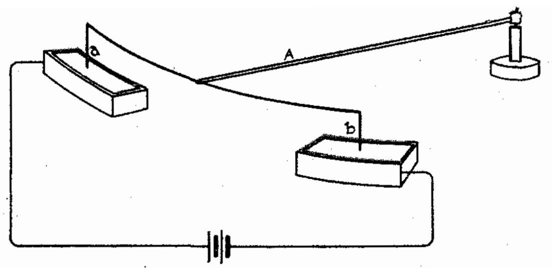


Figure 6—Conductor Constrained Except Along the Direction of Its Length

ductor carrying a current is equivalent to a magnetic shell, the bounding edge of which coincides with the conductor, and that the moment per unit area of the shell—i.e., the strength of the shell—is proportional to the current. He also proved by experiment that if there are three conductors A, B, C (Figure 7), bent into similar plane closed figures, but of different dimensions—such that C is N times greater than B, while A is one-Nth of B—and placed at different distances from one another, with the same current through each conductor, there is mechanical equilibrium, provided that the distance BC is N times greater than the distance AB.

De la Rive, who was in close touch with Ampère's time and a personal friend, recalls the diversity of views held concerning the discovery of the mutual action between currents. It was the first example of a set of forces in which the actions are exerted in lines at right angles to the respective directions of the forces, and not in the direction of the forces themselves. Moreover, the intensity depends not simply upon the distance r between acting particles of conductors,

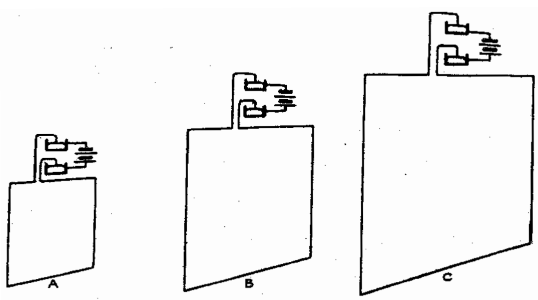


Figure 7—Apparatus to Demonstrate Law of Force Between Similar Circuits—Loops of Different Sizes and Spacings

but upon a variable element—the sense of the current. Ampère began by seeking for an expression for the force of attraction or repulsion between two infinitesimal portions, ds, ds_1, of the conducting system under investigation, taking into account the three dimensions of space and the distance between the elements (Figure 8). From experiments upon conductors of finite length, carrying currents II_1, he showed that

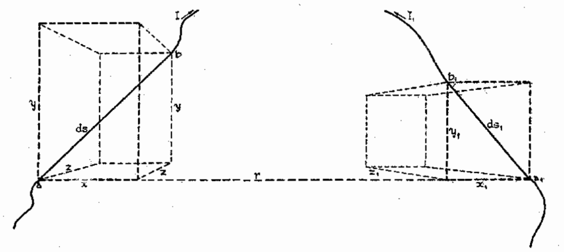


Figure 8—Elements of Two Circuits, General Case with Reference to the X, Y, and Z Axes

there are four cases or conditions of equilibrium, and from these he was able to express the attractions and repulsions in mathematical form, involving coefficients.

Denoting by α and β the angles which ds, ds_1, respectively, make with the line joining them, and by γ the mutual inclination of the planes containing, respectively, the angles α and β, he was able to express the mutual action of the two elements by:

$$\frac{II_1 (\text{Sin}\,\alpha\,.\,\text{Sin}\,\beta\,.\,\text{Cos}\,\gamma + K\,\text{Cos}\,\alpha\,.\,\text{Cos}\,\beta)}{r^n}$$

where n and K were constants to be determined by experiment. He was unable to determine K in time for his "Communiqué à l'Académie" of December 11, 1820, and he did not then realize that K is negative. Ultimately he identified the co-efficients, and he then expressed the required force as

$$\frac{II_1 (\text{Sin}\,\alpha\,.\,\text{Sin}\,\beta\,.\,\text{Cos}\,\gamma - \frac{1}{2}\,\text{Cos}\,\alpha\,.\,\text{Cos}\,\beta)}{r^2}$$

From this brief survey of his crowning achievement, it is seen that he concerned himself primarily with the geometry of the problem. For his purpose it sufficed that directed forces acted between particles across an abyss. With what substance, imaginary or real, that intervening space was filled was, to him, of minor importance. Nevertheless, his conception that molecules subjected to the action of continuously circulating electric currents might be regarded as equivalent to magnets, was a significant step in that advance of knowledge relating to the constitution of matter which has led the modern school to the equations of free space, and to the present electron theory.

If from this point, the highest in his scientific career, the rugged ground over which Ampère trod is contemplated, the impression upon the mind is that during those dreary years he moved consciously towards a definite object. He never drifted. Inspired by a passion for research, and guided by his genius, he concentrated upon a single purpose. Once before he had been near to success and had just missed his mark; here at last was a reward in full measure. On the occasion of his previous disappointment he wrote (September 3, 1814) to his old friend Ballanche, from Paris:

> "Mon ami, je n'aurais jamais dû venir à Paris. Pourquoi ne suis-je pas resté toute ma vie professeur de chimie à Bourg ou à Lyon! . . . Heureux ceux qui cultivent une science à l'époque où elle n'est point achevée, mais quand sa dernière révolution est mûre. La voilà faite entièrement par Gay-Lussac, qui termine l'ébauche créée par le génie de Davy, mais que j'eusse infailliblement faite. . . . Nous riions de si bon coeur à Lyon! Mais ici on ne rit pas."

Gay-Lussac had just published in the Annales de Chimie the results of his experiments upon Iodine. Ampère had examined the nature of Iodine, but he was distracted by other work and other circumstances, and his discoveries concerning the element were not published in time to secure to him priority. It was at that stage that he decided to return to mathematics, which he had somewhat neglected in favour of chemistry. No school-boy ever went back to his play-ground with more enthusiasm:

> "Je vais me remettre aux mathématiques. J'éprouve une certaine difficulté d'abord, mais la première répugnance vaincue, le charme revient quand je puis écarter toute autre pensée et m'y consacrer uniquement, absolument uniquement; je voudrais ne plus quitter les calculs."

To such a research worker, the field was always ripe, and the glory lost in one direction by mischance was gained a thousand fold in another by dint of the pluck and genius that never forsook him; for as his correspondence proves, he laboured always with the same activity, the same fire, the same exaltation, the same carefulness—nothing so mobile as his ideas, nothing more persistent than his character.

It happens that by examining the biography of his English contemporary, Sir Humphry Davy, a significant side-light can be thrown upon his association with the early history of Iodine.

The fame of Ampère extended throughout Europe, and men of science were anxious to make his acquaintance. The circumstances under which Sir Humphry Davy visited him are recorded by John Ayrton Paris, F.R.S., who was a Fellow of the Royal College of Physicians and fully conversant with the facts. Incidentally the account reveals the magnanimity of the Emperor Napoleon towards men of scholarly attainments. Napoleon had sternly refused his passport to several of the most illustrious noblemen of England, but he gave it to Davy, unconditionally.

Accordingly, Sir Humphry "accompanied by Mr. Faraday as secretary and chemical assistant," and Lady Davy not to be outdone, "accompanied by her own waiting-maid," left London on October 13, 1813, and embarked for Morlaix in Brittany. At the time of their arrival in Paris, Ampère was staying a few miles from the city, and consequently it was not until November 5, 1813, that the philosophers met. They became so engrossed in scientific discussion that Lady Davy—attended by her maid, and wearing "a very small hat, of a simple cockle-shell form" representing the mode in London but not in Paris—slipped out into the Tuilleries Garden where she became the centre of such a crowd of Parisiens that she was requested to retire. An Officer of the Imperial Guard offered his arm; the throng became so dense, however, that it became necessary to send for a corporal's guard, and the party quitted the Tuilleries surrounded by fixed bayonets.

A few days later, the junior chemists, led by Thénard, gave Davy "a sumptuous dinner" in Paris; and it is significant of the relationship between the savants of the time, that "as it was by the chemists only that this dinner was given," neither Arago nor Ampère was included. What happened upon this occasion to "the secretary and chemical assistant, Mr. Faraday," is not recorded. It is of more importance to observe that on the morning of November 23, 1813, Ampère called upon Davy and placed in his hands a small portion of a substance which he had received from M. Clement. It had been in the possession of the French chemists for more than twelve months, but they had not determined its nature and composition. It was spoken of by them as "X, the unknown body," and it was produced in 1812 by B. Courtois a manufacturer of saltpetre in Paris.

Courtois had shown it to Clement who made some experiments without favourable result. Ampère received a specimen which he "carefully" folded in a piece of paper and deposited in his pocket. When he reached home it had vanished. Clement gave him another specimen and it was this that Ampère gave to Davy—for which generosity Thénard and Gay-Lussac were extremely angry with Ampère. Infinite credit is due both to the heart and mind of Ampère for this act of grace done in the grand manner of a great Frenchman, and it supports the statement of Davy's biographer that nothing ever exceeded the liberality and unaffected kindness and attention with which the savants of France received the English philosopher.

The literature appertaining to Ampère reveals him in many aspects. In the Nouvelle Biographie Générale, Vol. II, pages 403–415, there is a concise account of his life, and a list of his Memoirs from 1802 to 1827. In the Revue des deux Mondes for February, 1837, there are two appreciative articles concerning him by Sainte-Beuvre and by the younger Littré. Arago's account of him in the Galerie des Contemporains Illustres, Vol. X, is classic. A special number of the Revue Générale de L'Electricité for November, 1922, contains a series of articles by M. M. Marcel Brillouin, P. Appell, A. Pérot, J. Pomey, H. Coquet, and M. P. Janet, on various aspects of his achievements and history. A book by Louis de Launay, published in 1925, under the title "Le Grand Ampère," is a sympathetic review of Ampère's life and work, and touches gently on the mistake of August, 1806, when he married Mademoiselle Potot, from whom he was separated in 1809. Beyond these sources of information there is his Correspondence, and there is also a book which as a human document surpasses them all, entitled "La Vie et les Travaux d'André Marie Ampère," by C. A. Valson (1886). Add to these the works of De la Rive, and it will be realized that in literature the name and fame of Ampère are well guarded. His electro-dynamic theory receives extensive treatment in the works of Maxwell, and it provides Tait with a theme in quaternions. (See Tait: Quarterly Journal of Mathematics, 1866; and Quaternions, paragraph 399. See also Forbes: Philosophical Magazine, February, 1861.)

Observing his work as a whole, it is seen that at different periods of his career he gained world-wide distinction in different fields, the first of which was mathematics. His early efforts in physics, as De Launay has pointed out, were comparatively non-productive. He perhaps realised this, for as the result of his conversations with Davy he proceeded to make a name as a chemist. Nevertheless in 1805 he confessed:

> "Je m'occupe plus que jamais de métaphysique . . . combien est admirable la science de la psychologie . . . la seule chose qui m'intéresse encore."

His versatility, and the temperament that caused him to allow his mind rapidly to wander from one subject to another, however, could be brought under control. The surface ripples were unable to divert the steady under-current of concentrated thought that led to such results as his electro-dynamic theory. Mathematics kept him to the track.

It is usual to associate Ampère with the invention of the electric telegraph, but it is more appropriate to think of him in this respect as one of a large group who contributed at the initiation of the idea. Ampère directed attention to a notion put forward by Laplace that it might be possible to cause a magnetic needle to deflect at a very great distance by using long conductors with a battery in circuit. The chief proposal of Ampère was to provide a number of such circuits and magnetic needles, each identified with a letter of the alphabet, and by this means to spell out messages. A suggestion of greater practical importance to telegraphy, however, was Ampère's astatic galvanometer.

Although plain living and high thinking had been his rule, Ampère in 1824 was on the border of bankruptcy. His sister Joséphine who had tried to maintain his domestic budget in equilibrium and to protect him from household cares, was at last obliged to confess to a negative balance:

> "Ma pauvre soeur . . . m'a caché pendant près de cinq ans des déficits . . . au total 4000 francs de dettes."

He had expended most of this sum upon instruments for his experiments. For about ten

Figure 9—Portrait of Ampère. From an Engraving of a Drawing from Life. By Ambroise Tardieu

years he had been troubled also with rheumatism. To complete his discomfort, critics were busy. Physicists in France were suggesting that his theories were opposed to Newton's laws. In fact, Ampère, at the dawn of the era he created, had to confess that of all the members of the Académie, the only one that received his theories favourably was Fourier.

Beyond the borders of France, criticism at one time was even more severe. Unable at first to follow the analytical deductions, Davy, Faraday, Seebeck, De la Rive, Prévost, Nobile, and a host of others raised objections. The truth is that until Babbage returned from a visit to Paris where he had an oral explanation, Ampère was not understood in England. This explanation to Babbage destroyed all misconceptions, and led to the complete triumph of Ampère, but the triumph was somewhat late. He had lost all illusions about life. He knew at last the meaning of detachment. He had also learned that:

> "Le vrai but de la politique ne doit pas être de rendre les hommes heureux, mais de les rendre meilleurs. . . ."

He had even learned to cast aside the credulity that says:

> "J'aime mieux le croire que d'y aller voir."

To posterity, therefore, he left the task of combining happiness with betterment, and analysis with faith.

Thanks to the courtesy of the Librarian of the "Bibliothèque de la Ville de Lyon" it has been possible to obtain copies from the original prints of portraits of Ampère. The reproduction at the beginning of this paper is from a lithograph of a drawing from life by Boilly. Figure 9 is from an engraving of a drawing from life by Ambroise Tardieu.

When searching at the Bibliothèque for these portraits for the present article, there were found by good fortune some manuscripts (Lyons Library, References 15653, 15670, 1102) of exceptional value, one page of which is reproduced in Figure 10. It is part of the draft of his famous Mémoires of 1823 and 1824 on the mutual action of two conductors.

That Ampère disliked writing may be inferred:

> "Etre assis, écrit-il, devant une table une plume à la main, c'est le plus pénible, le plus rude des métiers."

He could obtain no inspiration when seated; he preferred to stand up or to walk about when thinking. He suffered from short sight, and accordingly he wrote in somewhat large characters. His duties as Inspector General of the University obliged him to move about France a good deal, and it was his custom to associate his ideas with the places where they originated in his mind: The Theory of Avignon, The Demonstration of Grenoble, The Proposition of Marseille, The Theorems of Montpellier.

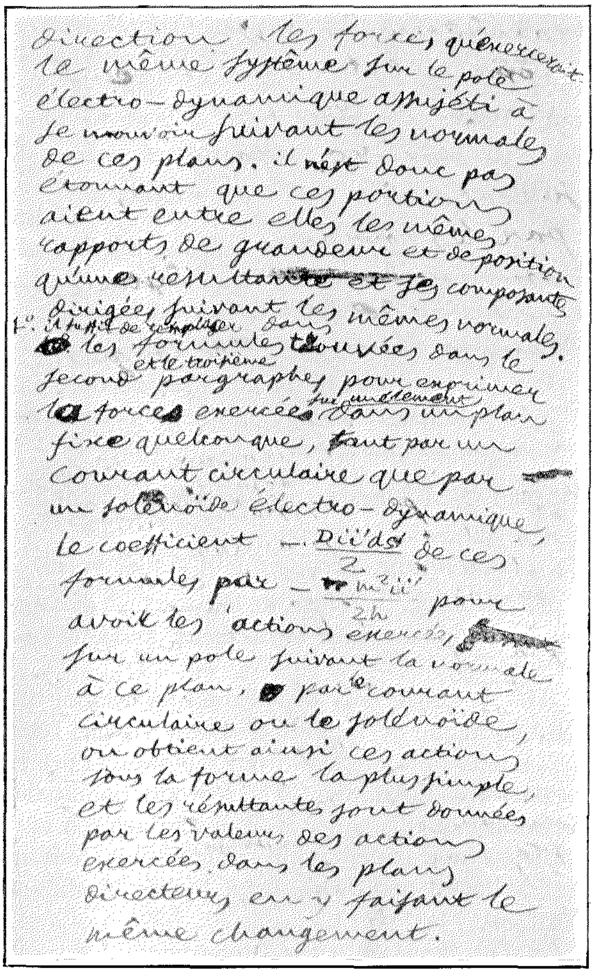

direction : les forces qu'exercerait
le même système sur le pôle
électro-dynamique assujéti à
se mouvoir suivant les normales
de ces plans. il n'est donc pas
étonnant que ces portions
aient entre elles les mêmes
rapports de grandeur et de position
qu'une résultante et ses composantes
dirigées suivant les mêmes normales.
1°. il suffit de remplacer dans les formules trouvées dans le
et le troisième
second paragraphes pour exprimer
les forces exercées suivant la normale dans un plan
fixe quelconque, tant par un
courant circulaire que par
un solénoïde électro-dynamique,
le coefficient [illegible] de ces
formules par [illegible] pour
avoir les actions exercées
sur un pole suivant la normale
à ce plan, par le courant
circulaire ou le solénoïde,
on obtient ainsi ces actions
sous la forme la plus simple,
et les résultantes sont données
par les valeurs des actions
exercées dans les plans
directeurs en y faisant le
même changement.

Figure 10—Ampère's Manuscript at the Bibliothèque de la Ville de Lyon

His intention was to establish psychology as a science for all time. The attractiveness that it had for him was occasionally overpowering. This explains why a letter to him from Davy upon physics and chemistry received no reply:

> ". . . n'ayant plus le courage à fixer ses idées sur ces ennuyeuses choses là."

This passion for psychology was balanced somewhat by the fascinations of chess. His working room was open to all, but it was difficult to get out of it without playing. His friends, when in a hurry, would adopt the low tactics of challenging his ideas upon electric currents and upon light-waves: and it is recorded that Ampère was then always "échec et mat."

André Marie Ampère died of pneumonia at Marseille on June 10, 1836, and was there buried. In 1869 his remains were transferred to Montmartre Cemetery. Thanks chiefly to the efforts of Mascart, the name of Ampère has been adopted universally as the designation of the unit of electric current, and thanks largely to Joubert his memoires have been reproduced for posterity. Thus his works follow him. They constitute the proper memorial of a philosopher. Yet, if there is ever to be a temple of scientific research in Paris, devoted in the noblest sense, to the welfare of mankind, France may appropriately write across its portal the name of Ampère, for his gifts to humanity can be repaid only in contributions that further the purpose for which he lived.

Recollections of Charles E. Scribner

By J. E. KINGSBURY

Standard Telephones and Cables, Limited, London

MY association with Mr. Scribner was more often when he was abroad than at home, but I cherish also some—all too few—memories of his activities in the United States and of his home life, first in Chicago, later at his Riverside Drive flat in New York and also at his Vermont farm. When I first met Scribner his reputation as a telephone expert was already well established.

It was in 1886 or 1887, perhaps the latter part of the former or the early part of the latter, that Scribner paid his first visit to London after the establishment of the Western Electric Company's business there. Mrs. Scribner and their first-born were with him. Scribner and his wife were obviously all in all to each other then and so remained until Mrs. Scribner's untimely death severed a relationship which throughout their lives was of the happiest nature.

He had been in London in 1879, and it was to him that was issued the patent for the Multiple Switchboard in November of that year. Another patent relating to the multiple was issued in 1881. Later there was occasion to call the attention of the National Telephone Company to the fact that they were infringing the multiple patent. Between 1879 and 1881 they had themselves experimented with a circuit which included multiple jacks and an engaged test and believing the 1881 patent to be the first, they maintained that they had anticipated it. When their attention was drawn to the patent of 1879 any idea of anticipation had to be abandoned, for it was only late in that year that exchange service was commercially embarked upon in England. Thus was Scribner's name early known to telephone men and his standing as a switchboard expert established. But it would be a great mistake to regard Scribner only as a switchboard expert. What impressed everybody was his wide knowledge of the telephone system as a whole and the manner in which he applied this knowledge to the particular problems of the mechanisms of intercommunication. His visits to Europe generally had to do with some developments of special importance in some large city. On the visit to London, to which I refer, I do not think it was on account of any special English condition; I rather think it was concerned with the Berlin telephone system, which was then in a tangle, and which could only be unravelled by the adoption of the multiple switchboard. This followed in due course and Mr. F. R. Welles established the German branch house with factory for the production of switchboards of the latest type. As the telephone systems developed there were always problems arising in some part or other of the Continent in which Scribner was consulted, and London was a stepping-stone in his path and we took advantage of it too, whenever we could, quite apart from any immediate problem of our own. Whatever it was, it was generally no new problem to Scribner. It had been solved already in the speedier progress in the United States.

It must not be supposed that Scribner had just to lay down the law and could rely upon it being followed. Technical officials had opinions of their own and sometimes held tenaciously to them, not seldom falling back on the argument that their own particular locality was a very special place and needed special treatment, regardless of the fact that telephonic communication has the same purpose the world over. It was with such that Scribner's characteristics shone. He knew, he could give chapter and verse for what he knew, quote without reference statistics, costs, and indicate probable results, but withal he was patient, perfectly ready to see the other's point of view; and though I have seen his patience sorely tried, I do not recall any occasion on which he failed to maintain an even keel.

There was one occasion when Scribner came over especially on London business. It had reference to the introduction of the Common Battery System. Again I will not tie myself down to a date, but I remember his coming into my office one morning with a copy of the "Daily Mail", containing Kipling's "Absent Minded Beggar", it was probably on this visit, and if so, it would be 1900. The common battery was recognized by most of the prominent telephone men as the system to be installed in all new exchanges, but there were some few exceptions and amongst those exceptions were some of the London engineers. Scribner came over to demonstrate the advantages and he was on this occasion accompanied by Mr. J. L. McQuarrie. We had a conference over which the General Manager of the Telephone Company presided. Scribner's attitude with all sincerity was that of one who was desirous of explaining a system which it would be to the advantage of the Telephone Company to adopt. Prominent officials of the Company were against its adoption and the conference assumed a distinctly party character. But Scribner produced his facts, marshalled his arguments and maintained his patience whilst refuting the objections submitted by the party opposite. There was, however, one point that was a serious obstacle. The Private Branch Exchange is to-day such a universal institution of the telephone organization in the United States that it may surprise some to know that it was in general use in Great Britain before it was introduced in America. It was not, of course, the exact counterpart of the Private Branch Exchange as we know it to-day, but it served the same purpose. There were quite a number of subscribers having small switchboards which enabled the sub-stations (generally 5) to communicate over the exchange line or permitted local intercommunication. The Company really provided the means for this local intercommunication and the facility of exchange communications, without obtaining adequate return for it. As such a system was not in use in the States, the Common Battery System as Scribner submitted it to the conference lacked this facility. Obviously the Company could not introduce a system which gave a service less convenient to their subscribers than the existing one. The "opposition" as I will term it, considered the point as fatal and there seemed to be a general impression that the facility required was impossible to obtain with Common Battery. I recall the incident as illustrating two of Scribner's characteristics—his patience and his inventive ingenuity. He put his questions and obtained with precision the service it was required to give. The session was adjourned; I am not sure whether it was morning to afternoon or afternoon till next morning, certainly not longer than the latter. Scribner and McQuarrie duly turned up at the adjourned session with diagrams of more than one method of accomplishing the required object, in a manner to which nobody could find any objection.

Common Battery would have had to come sooner or later, but its advent in Great Britain was greatly accelerated by this visit of Scribner and McQuarrie. Whilst new systems needed these special demonstrations, there were numerous other occasions when Scribner's advice and explanations were of value. Switchboard circuits might remain the same, but the parts were remodelled and their positions changed as successive developments necessitated. These today are trifles, but they were important enough then to be explained by the highest expert of the time.

When one went to the States, Scribner was always helpful and untiring in his efforts to smooth the way of visitors. He seemed to like to take on his own shoulders the arrangements for railway travel and apparently enjoyed carrying through those intricate (as they seemed to me) arrangements for coupons and "stop overs" and all those other features which must be done exactly right if the traveller is to avoid trouble. In 1905 there was a party of us on a tour of inspection consisting of Mr. Gaine, Sir John Gavey, Sir Andrew (then Mr.) Ogilvie, Mr. Frank Gill, and myself. The taking over of the Telephone System by the British Government was contemplated in a few years' time and the joint visit of the commercial and engineering representatives of the Government and the Company was concerned with a study of developments in the States and the determination of a policy which should provide for continuity in the conduct of the business. All the prominent men in the various branches of the American Telephone and Telegraph Company were interviewed from Mr. Frederick P. Fish, the then President, downwards and all with one accord received the visitors with traditional hospitality and gave freely all the information asked for and much advice from their store of experience. But Scribner somehow seemed to become the "intimate" adviser, and though there was necessarily some diversity of interest, he had the confidence of all and could, with his knowledge of differing conditions, emphasize or minimize the importance of points covered by others. As a switchboard expert he was consulted, of course, but I recall more particularly the much wider problems of telephony which were thoroughly familiar to him and which he explained with uncanny facility.

To see Scribner at his farm in Vermont was to see him really at home. That was my privilege on one occasion. My wife and I came down from Montreal and were instructed to alight at a wayside station. I looked for Scribner, but failed at first to find him. There was, however, on the platform one who had every appearance of a working farmer. Wearing a woolen jersey, an open collar, a broad brimmed hat and well-worn clothes with gaiters, I believe it would have been difficult to recognize him but for the broad welcoming smile. Scribner's smile was one of his characteristic features. Full of humour, he would often illustrate even technical subjects by an apt story and he had a ready wit. In the afternoon of our visit he took us with his sister and brother-in-law for a drive. I noted as one of the land marks a cemetery which seemed to be the end of the urban road. There was little traffic after we had passed it. On the return journey someone suggested that I might like to drive and I remarked upon the rule of the road being the opposite of the English and indicated that I might perhaps drive as far as the cemetery. "Oh yes," said Scribner, "Kingsbury can drive us to the cemetery right enough". Needless to say, I declined the privilege.

I happened to be in New York at the time of Scribner's retirement from active service. Mr. Theodore N. Vail was the chairman over a dinner of telephone men and I think Mr. Gerard Swope was master of the ceremonies and general arranger of everything which just suited his metier. Scribner himself was unfortunately absent, but his retirement was announced and his successor called upon to speak. Dr. F. B. Jewett's speech was brief and modest. What I remember of it was the expression of the hope that when the time came for him to retire from active work he could feel that he had advanced the telephone art to anything like the extent that his predecessor had. Coming into the business at the very beginning of the art, Scribner advanced with it, sought to overcome difficulties in the best way possible, free from any prejudices or predilecttions, but with a very straight aim for something practical. As every telephone man knows, his patents ran into hundreds and some of them were epoch-making. But my recollection of Scribner is not of a patentee. He had none of the inventor's partiality for his own creations to the exclusion of other's ideas. The prosperity of his Company and the "advancement of the telephone art" were Scribner's guiding motives.

Conditions to-day are so different that to those unfamiliar with earlier times it is difficult to realize the wide ground covered by an individual expert and the value to the industry of such ability and uprightness as that of Charles E. Scribner.

Dry Cells and Their Testing

By H. G. COOPER
Export Department, International Standard Electric Corporation

THOSE of us who live in large cities are apt to consider that dry cells, aside from their ever increasing use in the operation of radio apparatus, are approaching obsolescence. Individuals otherwise well informed in electrical matters often learn with surprise that in practically every civilized country in the world many millions are employed for the operation of buzzers and rural telephones, the ringing of doorbells and the ignition of small gas engines in isolated communities. Actually dry cells are rendering service under a great variety of conditions where the use of the storage battery, because of maintenance difficulties or for other reasons, is impracticable.

An understanding of the characteristics of dry cells is important because of the large number used under conditions which frequently make replacement both inconvenient and expensive. A brief description of their characteristics, therefore, will be given as well as the tests which have been devised for evaluating them.

Dry Cell Characteristics

Dry cells have two characteristics in which their users are interested; namely, the service life and the shelf life. The service life as the name implies gives an indication of the amount of energy which can be obtained from the cells when fresh. It is measured by discharging them through definite resistances either continuously or with periods of rest. Results are expressed either in watt hours or in ampere hours or simply in total hours of service until the cutoff voltage is reached.

Shelf life is a characteristic which is often lost sight of in testing dry cells. It relates to decrease in capacity due to deterioration while the cells are standing unused. No dry cell will give as good service after it has stood unused for one year as when it is fresh and the difference in various kinds of dry cells in this respect is very great. Some of the cheaper and less reliable brands will be nearly useless after standing for six months while others will give a large part of their original life after standing on the shelf for a year. Shelf life has been studied carefully in the United States in connection with service life by such organizations as the United States Bureau of Standards, the American Electro Chemical Society, the American Telephone and Telegraph Company and the National Carbon Company, Inc., which is universally known as a leading manufacturer of dry cells.

Service Life and Shelf Life Tests

The service life factor in dry cells is easy to measure and can be evaluated in a comparatively short time. Twenty-five years ago, the standard test for dry cells in the United States was to discharge them through a two ohm resistance and to calculate the ampere hours of service to 0.25 volts. Although this test gave different results with different brands of cells, it was found to be utterly impractical since the high current drain and the low cutoff voltage did not determine service conditions. A great advance was made in the introduction of the 10-ohm test in which dry cells are discharged through 10 ohms continuously to 0.75 volts. The results of this test are expressed as the hours of service or the ampere or watt hours to the cutoff voltage indicated.

The 10-ohm test has a limited value because it neglects shelf life. It is useful in the case of cells which are to be used on heavy duty service provided the certainty exists that they will be used shortly after manufacture. If, however, as is usually the case, the cells are to be used on light drain or on an intermittent type of service or are not to be placed in service for a considerable period after their manufacture, the 10-ohm continuous test is poorly adapted to determining relative performance. In such cases, the shelf life is far more important than the service life; it may easily develop that a cell which gives excellent results on a 10-ohm test would be nearly useless after shipment to India or Australia or, on the other hand, a cell of moderate capacity when fresh may by reason of its freedom from shelf deterioration over long periods be exactly the proper cell for selection in order that guarantee may be given of arrival at distant ports in good salable condition.

The problem of a test which could be completed in a short time and which would serve to indicate both the service and shelf life has been given considerable study by the organizations previously referred to. Up to the present time at least, the conclusion is that a short test will not indicate shelf life and, in general, is not suitable for commercial application.

As a result of the facts enumerated, the United States Bureau of Standards has adopted two service tests for dry cells. These are a heavy drain test which corresponds to service which exhausts the cell in about a month and a light drain test which corresponds to service on which a standard 2½ by 6 inch dry cell will last for six months or more. By holding dry cells for three or six months before they are put into service and comparing their life under these conditions with their life when fresh, a further estimate of their real value to users may be obtained.

The two tests are as follows:

(a) *Heavy Intermittent Service Test*—Four cells connected in series are discharged through 10⅔ ohms for two periods of one hour each per day, the period being eleven hours apart. The test is considered complete when the closed-circuit voltage has fallen below 0.85 volt per cell. The results of the test are expressed as the number of hours actual discharge to the cutoff voltage.

(b) *Light Intermittent Service Test*—Three cells connected in series are discharged through 20 ohms for ten periods of four minutes each during ten consecutive hours, six days a week. On the seventh day every other period is omitted. The end of the test is taken at 2.8 volts for the battery on closed circuit. The results are expressed in terms of the number of days the test is continued.

Dry Cell Testing Laboratory of the National Carbon Company—Each year about 100,000 dry cells are tested, requiring an average of 7,000 readings a day. The laboratory is kept at a constant temperature of 70° F. at 55% humidity. A large proportion of the readings are made with the aid of telephone switchboards

It is becoming generally recognized that it is advantageous to keep in touch with the characteristics of the products of the large manufacturers by means of tests closely approximating actual service conditions rather than to make quick tests which give little aid regarding the performance in service. Tests of the leading brands of dry cells are being conducted continuously by the Bureau of Standards, the American Telephone and Telegraph Company, and other large users. The railroads also often have tests made of the brands in which they are most interested.

The most complete dry cell testing laboratory in the world undoubtedly is maintained by the National Carbon Company, Inc., at Cleveland, Ohio. The accompanying illustrations, reproduced by permission of that Company, give some idea of the equipment. The whole test room is maintained at a constant temperature of 70° Fahrenheit and 55% humidity.

Battery testing was first seriously studied in connection with the enormous amount of research work which was done in the development of the storage battery. The results of the tests usually were expressed either in watt hours or ampere hours available from the battery under the test conditions. As long as most of the uses for storage batteries involved relatively low current drains it was reasonably accurate to define their capacity in terms of ampere or watt hours and to compute the current drain on the assumption that the product remained constant. Thus a 60 ampere hour battery could be considered as having a capacity of 2 amperes for thirty hours or ½ ampere for 120 hours and the actual results would bear out these assumptions quite satisfactorily. When, however, storage batteries were used on heavy drains, it was found that this simple relation did not hold. A battery rated at 60 ampere hours would not deliver 60 amperes for an hour and in general increased current drain resulted in decreased total output. This characteristic applies to an even greater extent to dry cells than to storage batteries. A dry cell, in fact, cannot be said to have any specific ampere hour or watt hour capacity. Its capacity varies with the kind of service on which it is discharged so that in the case of the ordinary 2½ by 6 inch cell one user may get 30 or 40 ampere hours per cell while another who uses it on a heavier drain may have to be satisfied with 10 or less.

These considerations have led American dry cell tests to be expressed universally simply as the period of service (usually hours or days) to be expected when the cell is discharged under specified conditions. This manner of stating the result of the test is both simple and practicable and is beginning to be adopted in countries other than the United States. It gives the user the information he requires; namely, the length of service that may be expected under given conditions.

The United States Bureau of Standards[1] gives the following minimum service to be expected from 2½ by 6 inch dry cells on the various standard tests:

Heavy Intermittent Service (Fresh Cells)	40 Hours
Light Intermittent Service (Fresh Cells)	160 Days
10-ohm Continuous Service (Fresh Cells)	185 Hours
10-ohm Continuous Service (Three Months Old)	180 Hours
10-ohm Continuous Service (Six Months Old)	175 Hours
10-ohm Continuous Service (Nine Months Old)	165 Hours
10-ohm Continuous Service (Twelve Months Old)	155 Hours

Internal Resistance Test

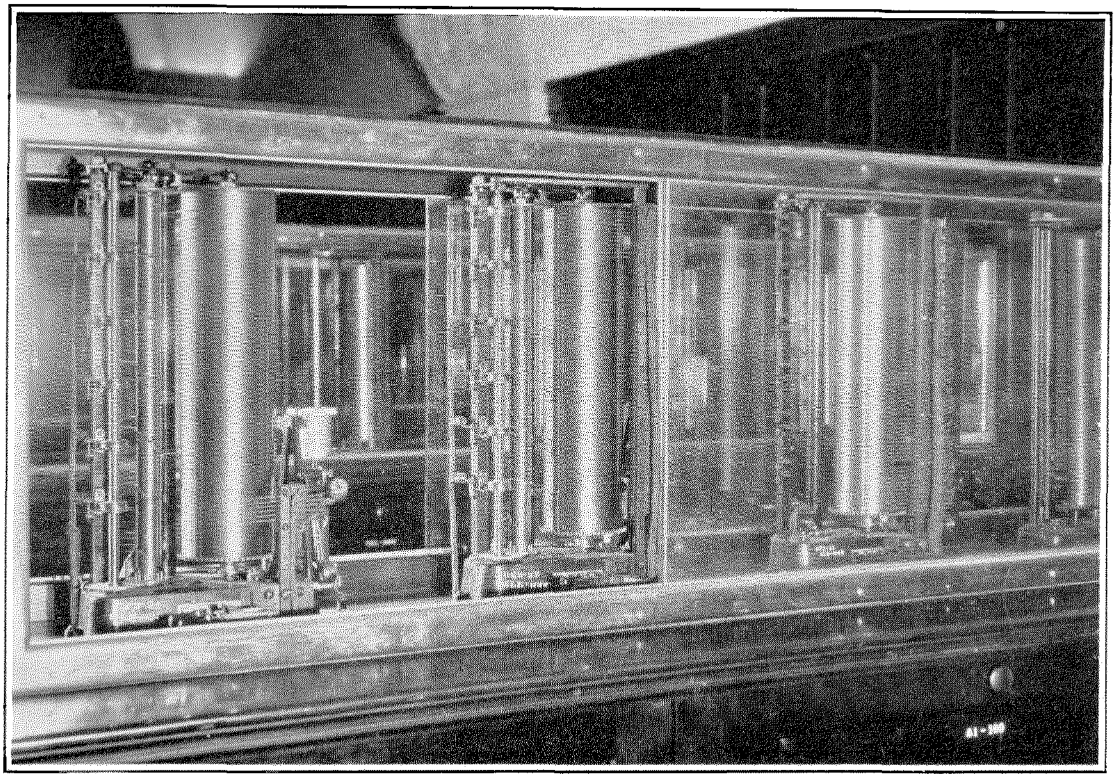
In the days of the gravity battery, the Daniell cell and the old wet LeClanche cell with its carbon manganese prisms or porous cup, the magnitude of the internal resistance was of the order of several ohms and often a considerable fraction of the total resistance of the circuit. It was not unusual to specify a maximum figure for internal resistance as determined by the formula $\frac{R'=E-E'}{C}$, where R' = internal resistance, E = open circuit electromotive force, E' = closed circuit voltage and C = current flowing. Later, their formula was applied to the dry cell; but as a result of improvements in the manufacturing process, it was found that internal resistance was not consistent in value as had been assumed but that it varied with changes in the current flow. Thus, at one milliampere (0.001 of an ampere), the internal resistance of the present day dry cell may be as high as 6 ohms; at 0.1 amperes, it may drop to 0.6 ohms; and, at 10 amperes, to 0.05 ohms. An internal resistance requirement is, therefore, meaningless unless the testing conditions are specified; in any case,

[1] Department of Commerce, Circular of the Bureau of Standards No. 139, "United States Government Specification for Dry Cells."

it is of little value in connection with modern dry cells inasmuch as their internal resistance is so small that it is a negligible factor in their service performance.

Flash Test

A very simple dry cell test, the so-called amperage or "flash" test, used in the United States may to some extent be considered as a measure of internal resistance. As standardized by the United States Bureau of Standards this test consists in short circuiting the cell momentarily through a critically damped or "dead beat" ammeter which with its leads has a resistance of 0.01 of an ohm. The highest reading of the ammeter is taken as the "amperage" of the cell. In the United States twenty years ago this simple test was very widely considered as measuring accurately the electrical capacity of a dry cell regardless of the service in which it might be used. For example, a cell giving 15 amperes was considered as capable of giving only half the service of a 30 ampere cell. This, of course, is not correct and users are gradually becoming familiar with the fact that there is no direct connection between the amperage of a dry cell and the service obtainable from it. This does not mean, however, that the amperage test is entirely valueless.



Automatic Dry Cell Test Controls—For controlling intermittent dry cell tests nine machines similar to those shown in the photograph are used. These machines revolve at various rates from once a minute to once a week. By interconnecting the machines practically any time schedule can be arranged

The following is quoted from a comprehensive circular issued by the United States Bureau of Standards on the "Electrical Characteristics and Testing of Dry Cells":[2]

"This easily-made test is of value in judging the uniformity of a group of cells purchased at the same time or in comparing the condition of one or more cells with the normal value for the short-circuit current of the same brand, provided the normal value is known. Thus, if the brand of cell is known to average 30 amperes when new and unused and the cell under test

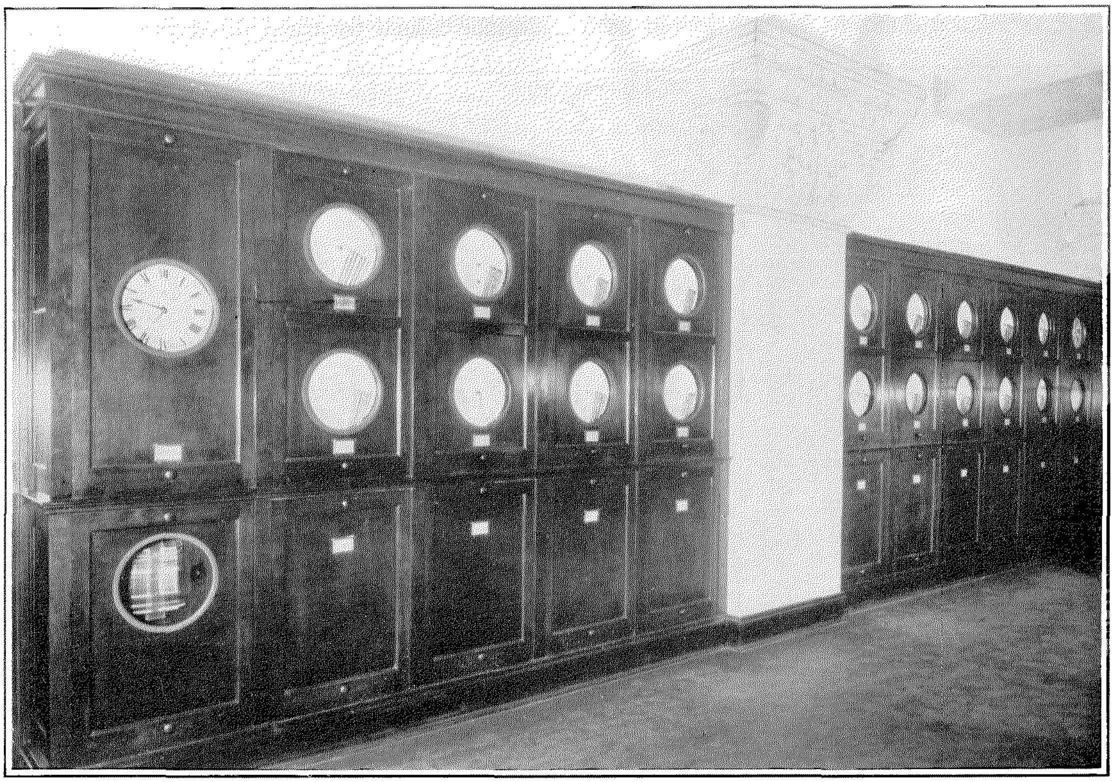
[2] Department of Commerce, Circular of the Bureau of Standards No. 79, "Electrical Characteristics and Testing of Dry Cells."

shows about this value, it is reasonably certain that the cell is in good condition. Records show, however, that cells of low short-circuit current may give a satisfactory performance on the light intermittent service test and, therefore, the short-circuit current readings ought not to be relied upon on choosing cells for telephone or similar light duty. This test gives no indication of the service capacity of different brands of cell."

"Some cells manufactured expressly for long-continued service give only 18 to 20 amperes when new, so that it is obviously unfair to compare them with 30 ampere ignition cells. But a cell which should give 30 amperes initially, which gives only 18 amperes on short-circuit, has lost a large part of its service capacity for heavy drains."

Differences in Dry Cell Manufacturing Practice

One of the more important differences in manufacturing practice among dry cell makers is that between the so-called "bag" type and the "paper lined" dry cell. Bag type dry cells are made by molding a mixture of powdered manganese dioxide, carbon and other chemicals around a carbon electrode, wrapping the molded mix in a cloth bag and setting it into a zinc can with a thin layer of starch and flour paste between the can and the molded mix. Paper lined dry cells are made by lining a zinc can with specially prepared paper and then tamping the chemical mixture into the cell around a centrally located carbon electrode.



Master Clock and Test Record Charts—At the left is the master clock that operates all the testing apparatus. Every test contact made in the laboratory is recorded on one of the charts shown in the picture

Twenty-five years ago the paper lined cell was somewhat inferior to the bag type on account of poor shelf life, so that by the time it reached the consumer it was sometimes unsatisfactory due to the deterioration which had occurred. At about this time, however, a leading manufacturer of dry cells established a very large and complete research laboratory for the careful study of all the factors in the manufacture of his product. Changes in formula and manufacturing method were soon worked out by this laboratory which greatly improved the shelf life of the paper lined product until it finally became fully as good as that of bag type. At present the paper lined dry cell is being used with satisfaction in every civilized country in the world.

American dry cells are practically always cylindrical in shape while European cells are usually square or rectangular. The American manufacturers make practically nothing but the cylindrical type because they are both the cheapest to make and the most efficient in their use of zinc which is the most expensive raw material used in dry cell manufacture.

The efficiency of a dry cell depends to an important extent on an even layer of moist mix opposite every part of the active zinc surface. This occurs to the greatest extent in a cylindrical cell, where every part of the zinc surface has the same thickness of mix back of it as every other part. With a square or rectangular cell, on the other hand, there are four zinc corners into each of which a mass of mix projects. As the corners are approached, there is less and less mix available for each square millimeter of zinc surface as may be seen by opening an exhausted square cell, in which it will be found that most of the chemical action has taken place in the middle of the sides, the zinc at the corners being almost uncorroded during the discharge.

In Europe, dry cell connections are practically always made through brass binding posts while in America brass springs, into which the connecting wires can be slipped quickly and firmly, are used on a large proportion of the product. When they were first introduced, there was some fear that they would jar loose and also that they would become corroded and so introduce a high resistance into the circuit. In actual practice, neither of these supposed difficulties occurs.

Some European dry cells are still made with a binding post for the positive hole and a three or four inch wire for the negative. This makes the connection of cells in series easy, but the completed battery has usually to be connected to two wires leading to the apparatus which it is to operate. This means that the wire from the negative pole of the battery must be twisted to one of the wires from the apparatus or else that a separate double binding post must be provided. On the whole we believe that the trade finds the cells with two binding posts much more satisfactory than the older practice of providing them with a post and a short wire connection.

Summary

Methods of dry cell testing and the reason for their adoption have been briefly described. The value of the short circuited turn test for quick comparative tests on brands of cells the characteristics of which are known has been indicated. Differences in dry cell construction also have been noted.

Large users of dry cells, such as railways and telephone concerns often make heavy intermittent service and light intermittent service tests on successive lots of the leading dry cells and thus gradually build up information as to the most reliable brands on the market. Unfortunately there is no quick and simple test available for determination of the service characteristics of dry cells. The small user especially must rely on the integrity of his dealer and the reputation of the manufacturer for producing a quality product.

Morkrum-Kleinschmidt Printing Telegraph Systems

By H. P. CLAUSEN

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THE printing telegraph may be described as a system of communication whereby messages are transmitted to distant points by means of electrical signals and reproduced in printed form. Specifically, an operator at the sending station presses a letter key similar to that of a typewriter and a corresponding letter is reproduced at the receiving station or stations. The entire art of printing telegraphy is bound up in the means through which this letter is reproduced at the distant point.

The printing telegraph in various forms has been used for many years, principally by commercial telegraph companies and railroads. Recently, however, the apparatus has been simplified to such an extent that its possibilities of speedy and accurate communication are rapidly finding application in commercial and other fields. In view of the increasing interest in printing telegraphy, this paper indicates various types of printers which have been developed to meet diverse service requirements and describes in some detail various types of present day telegraph printers and associated apparatus. In addition, early developments in the printer art are outlined.

Telegraph printers and systems applied to internal and to short lines represent a most interesting development, but those employed for such purposes are equal in capacity and in many cases substantially identical in design with those used on long circuits. The higher carrying capacity systems are used in cases where the cost of installation and maintenance of long lines is a determining factor.

Early Development

The early telegraph inventors realized the advantage of printed telegrams and many systems were tried out. Progress was slow, principally due to the tendency to simplify the apparatus at the cost of complication of the line signal. The systems devised worked excellently under laboratory conditions but failed when put into practical operation on lines of any length.

An important contribution to the art was made by Hughes, who invented a typewheel printer operating in a manner quite similar to the so-called stock tickers now in general use. The Hughes system has survived for many years and is still in wide use in European countries.

In the late seventies, a French telegraph engineer, Baudot, contributed a Multiplex system. The printer is in some respects similar to that developed by Hughes. Baudot's great success, however, was due to his invention of the so-called five unit code now used in most successful printing telegraph systems. Baudot, therefore, was the first to simplify the line signal and thus open the way to the important developments which have come later. Baudot apparatus is used very widely in Europe, particularly in France where hundreds of curcuits are in daily operation. The apparatus has been refined and great reliability has been secured at low speeds.

Another inventor, Wheatstone, utilized a perforated tape for transmission of Morse code signals. This took the rate of signalling out of the limitations imposed by a single operator and permitted a high line speed. At the receiving end the signals were reproduced as dots and dashes on a tape, which obviously required decoding before the message could be delivered. Various types of keyboard perforators by means of which the depression of a lettered key automatically perforated a tape in the proper code combination were developed. Surviving types of these perforators are the Kleinschmidt and the Creed.

Creed, an English inventor, later devised a means by which the laborious decoding of Wheatstone tape is avoided. His invention consists essentially of a receiving perforator by which the perforations in the sending tape are reproduced on a tape at the receiving station. This tape is then fed through an automatic printing machine in which typebars are actuated in accordance with the perforations in the received tape and produce the message on a narrow strip of paper.

About twenty-five years ago Donald Murray, a New Zealand newspaper man, developed a

Multiplex system using a modified form of Wheatstone transmitter but operating on the five unit code. He secured uniform speed of transmission and synchronous operation of the transmitting and receiving distributors through the use of tuning forks and phonic wheels, and devised a correcting system to take care of any slight irregularities in speed.

While Murray was carrying on his development work, Rowland, an American inventor, devised a system in which alternating current was used for the line signals. Very high speeds were possible with this system but the mechanical complications and the limitations of the fourteen unit signal were such that it has not survived.

Another invention proposed by the American, Wright, employed a line signal utilizing the zero interval, in addition to the positive and negative impulses. This system was not entirely successful, due principally to the complicated line signal.

In 1910 the Morkrum Company placed in commercial operation with the Postal Telegraph-Cable Company a direct keyboard page printing telegraph system employing the five unit code. The printers were the result of several years of development work by Charles L. Krum and Howard Krum, his son. They were designed to operate at a speed of sixty words a minute and could be duplexed, permitting an exchange of one hundred and twenty words a minute. After successful operation for many years, they were superseded by later developments of the same inventors, and represent the first commercial application of the five unit code combined with start-stop synchronism.

The original Morkrum system employed a free keyboard, that is to say, when a key was struck the operation of the transmitter sent a starting impulse over the line, followed immediately by the five unit code combination. A stopping impulse followed the five units so that seven signal impulses were sent for each character transmitted. This early work forms the basis for practically all successful single-line printing telegraph systems.

Edward Kleinschmidt, a New York inventor, had done a great deal of work for the Western Union Telegraph Company in developing apparatus for the early Barclay printing telegraph systems. Later on he developed apparatus for use with the Western Union Multiplex and also a single line system using the start-stop principle. Subsequent developments were expedited by the formation of the Kleinschmidt Electric Company, and on January 1, 1925, by the combination between it and Morkrum, resulting in the present Morkrum-Kleinschmidt Corporation. Original developments and contributions were made also by Cardwells, the Western Electric Company and the American Telephone and Telegraph Company.

General Types of the Printing Telegraph

Printing telegraph divides itself easily into several general classifications according to

(A) The degree of utilization of the line;

(B) The distinction between page printing, in which the message is printed in horizontal lines across a page, similar to a typewriter, or tape printing, in which the message is printed on a continuous ribbon of tape, and

(C) The method of operation, whether by means of a perforated tape or direct keyboard.

In general, heavy traffic lines are exploited either by high speed single channel systems or Multiplex systems. A high speed, single channel system consists of a high speed transmitter, which is operated by perforated tape supplied from several perforators. At the receiving end the messages are printed by a high speed printer on a tape and are then pasted on forms or blanks for delivery. The high speed system is economical of apparatus; but is usually expensive in labor, in addition, a severe handicap is imposed by the lapse of time between preparation of the message at the transmitting end and the delivery of the message at the receiving end. For these reasons the Multiplex system has grown in popularity. It is safe to say that most important circuits are exploited by Multiplex.

A Multiplex system is one in which the line is assigned successively, by means of a rotary switch, to one after another of several transmitting machines and at the same time a corresponding rotary switch assigns the far end of the line to one after another of the same number of receiving machines. If there are two machines at each end, it is called a double channel system; if there are four, a four-channel. In some cases as high as six channels have been worked, but it has been found in the United States that two and three channels give the most economical operation.

While the transmitter of a channel is connected with its distant receiving apparatus, the signals are transmitted at fairly high speed and picked up by the distant receiver. The rotary switches then disconnect this transmitter and receiver from the line but the printer completes the function of printing and spacing and restores itself awaiting the next signal. In the meantime, the rotary switch has assigned the line to transmitter and printer No. 2, etc. Full utilization of the possible line frequency is thus gained with a comparatively low speed for the apparatus of each channel. Since operators are assigned for each channel, the transmitting and receiving operators of Channel No. 1 are, for example, as directly connected as though they had exclusive rather than part time use of the line.

The rotary switches of the Multiplex, necessitating very close synchronism between the sending and reciving stations, makes the system somewhat more complicated than the single channel start-stop system. It, however, provides great carrying capacity and for that reason is used largely for heavy trunk line circuits.

The single channel, start-stop system is that in most general use and forms the principal subject of this article. It is based on the original Krum system and maintains synchronism between sending and receiving stations for the time required to transmit one character only.

Page and Tape Printers

In general it may be said that because of the absence of line spacing and carriage return mechanisms the tape printer is considerably simpler than the page instrument.

Tape and Keyboard Operation

The simplest machines are of the direct keyboard type, in which the depression of a key at the sending station sends the signal to the line directly. It is evident that with direct keyboard operation the maximum sending capacity of the machine is not utilized. Perforated tape operation gives much more continuous transmission. The perforator may be operated at any speed the operator can reach and perforates the five unit code crosswise of a narrow paper ribbon. This perforated tape is fed automatically to a transmitter connected with the sending apparatus. The tape is stepped along from one set of holes to another and sends signals to the line according to the perforations. The operator, therefore, may perforate at higher or lower than line speed; but as long as there is a loop of tape between the perforator and the transmitter, signals are sent to the line regularly at the predetermined speed.

In earlier keyboard systems "cadenced" operation was necessary. This meant that the operator had to depress his key or keys (as in the case of the Baudot) at a predetermined time indicated by a click or other signal. This naturally required much more highly trained operators than the present systems.

A Multiplex system must employ tape transmission. It, however, may print its message either in page or tape form. A start-stop system may employ either keyboard or perforated tape transmission and receive its message in either page or tape form.

Single and Multiple Magnet Printers

The Multiplex systems called for printers in which the selecting magnets for each of the five pulses could be connected directly with the rotary switch or distributor. The timing of the system was embodied in the distributor itself. It naturally followed that early single channel systems used the same printers, with single channel distributors. Local direct current to transfer the signals from the distributor was necessary. This became a distinct disadvantage, especially in commercial work, and led to the development of the first Teletype, in which the functions of printing are entirely mechanical and are performed with the aid of a governed motor, while the distributor itself is a mechanical device in which the setting of the five selecting units is controlled by a single magnet responsive to the line signals. This development greatly widened the field of the printing telegraph, as here at last was a simple compact printer, requiring no auxiliary apparatus and capable of being installed by merely connecting line and power leads.

Following the Teletype of the Morkrum Company much work on single magnet printers was done by Kleinschmidt and others and, later, by Murray and Creed.

Distribution and Intercommunicating Systems

Printing telegraphs are used largely by press associations for distribution purposes; that is, a single transmitting operator sends to a number of receiving stations. These may be concentrated in a single city or spread over long distances. For instance, there is in daily operation a system with transmission normally at New York but with receiving machines forming a network including Washington, Pittsburgh, Detroit, Chicago, St. Louis and as far as Kansas City. In some cases outlying stations are equipped with transmitting apparatus, but in general it has been found best to eliminate this intercommunicating feature.

Intercommunicating systems are required also for hotels, banks and large business houses, railroad yards, etc. In some cases a number of machines either for receiving only or transmitting-receiving are connected with a central switchboard, usually of the automatic or dial type. Any transmitting machine, therefore, by dialing the proper number may be connected with any of the other machines.

An interesting development of the press circuit is used by the Police Departments of several of the larger cities of the United States. A central operator transmits to all sub-stations or to groups of sub-stations police news such as descriptions of criminals and serial numbers of stolen automobiles.

Type Arrangements

The permutations of the five unit code provide thirty-two different arrangements of the units. By assigning code combinations to operate a shifting device from "Letters" to "Figures" and vice versa, it is possible to get two characters for each of the code combinations. It is, however, customary to assign a combination to "Space" between words and another, the "All Spacing", to "Blank." This reduces the available combinations, in a tape printer, to twenty-eight, giving fifty-six characters. On page printers, it is further necessary to assign one combination for returning the carriage and another for feeding up the paper for the new line. The number of characters is thus reduced to fifty-two, which has been found sufficient for most countries using the Latin alphabet.

It will be inferred from the preceding that printers are furnished only with capital letters. This has been standard practice for many years in all telegraph services.

Recently, there has been a demand for machines to print Japanese, Russian and other languages employing non-Latin alphabets. This has led to the development of a special printer (Type 18) using a "six unit" (or, with "start" and "stop" pulses, eight unit) code. These printers have forty-two type-bars with keyboards corresponding to standard typewriters.

Carbon Copies and Form Work

Tape printers are not designed for satisfactory reproduction of carbon copies. They, however, are well adapted for handling information destined to be used on large forms, as a gummed tape may be used and the information rapidly pasted in the proper spaces.

Page printers will make carbon copies as well as an ordinary typewriter. Forms, up to the width permitted by the printer carriage, may also be handled, although it is not advisable to attempt to secure registration on several forms separated by carbon paper. Form work, in general, is wasteful of line time and operator effort. It is often possible to transmit the information in straight message shape, thus doing away entirely with the printed forms.

Simplex and Duplex Operation

All printing telegraph systems may be used in simplex or duplex. A simplex installation is one in which the wire is used only one way at a time; that is, station A may send to station B or station B to station A, but B cannot send to A while A is sending. By the use of the duplex balance, well known in Morse telegraphy, both stations may send at the same time, thus doubling the output from the line. In the United States, practically all commercial lines are operated in duplex.

Morkrum-Kleinschmidt Printers

The apparatus produced by the Morkrum-Kleinschmidt Corporation includes everything necessary for equipping lines for the services mentioned, with the exception of high speed single channel systems. Apparatus is available

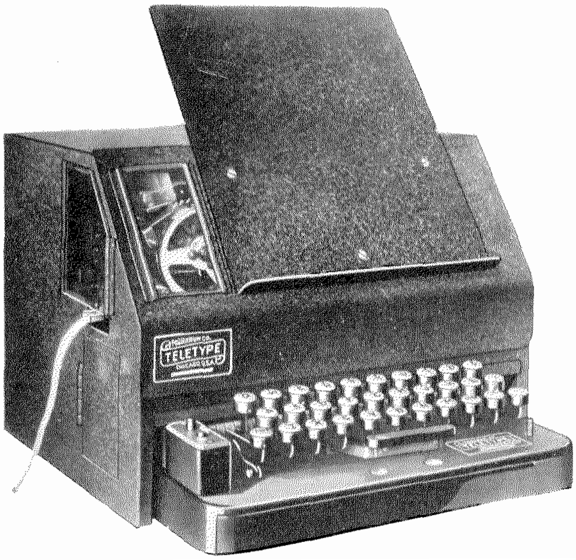


Figure 1—Type 11 Teletype—Receiving and Transmitting

to serve equally well small business establishments operating over interior or short lines and commercial organizations having long-distance lines and requiring means for utilizing to the fullest possible extent the message-carrying capacity of those lines.

Type 11 Printer (The Original Typewheel Teletype)

This instrument is shown in complete form, in Figure 1. Figure 2 is a view with the cover removed, showing the general details of construction. Figure 3 is the form installed in places where messages are to be received only.

The instrument is composed of three units, the keyboard transmitter, the printer and the motor, with governor. Where no transmitting equipment is required, the two latter units are mounted together on a base. The keyboard unit is the same as that used in the Type 14 machine described hereinafter.

The printing unit is a development of the Baudot printer, with the addition of start-stop synchronism and single magnet control of the

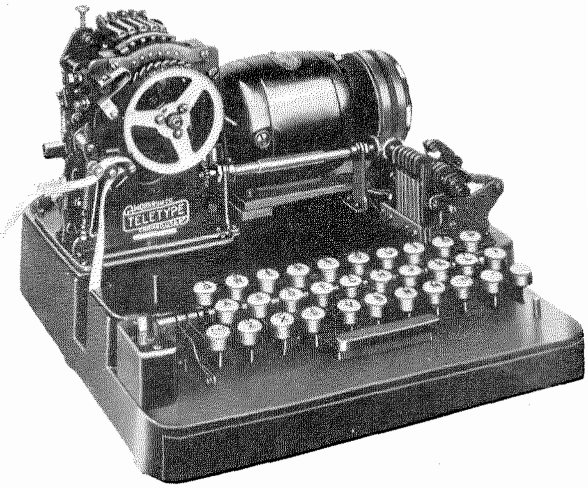


Figure 2—Type 11 Teletype—Cover Removed

selection. The signals sent over the line govern the setting of five "seekers", provided with extension toes resting on a "combiner" made up of two discs peripherally notched according to the combinations of the code. A spring tends to move all five seekers in a clockwise direction. As long, however, as the toe of any seeker rests on a raised portion of one of the combiner wheels, the train may not move. Seekers are set, according to the code, in position to bear on either the front or rear combiner wheel. For each setting, there is a point where there will be a notch under each one of the toes. At this instant, the seekers all move and thus release a latch which holds the printing arm. This arm flies up and engages a notch in a ratchet wheel, mounted on the same shaft as the combiners, and carrying a typewheel which has the letters

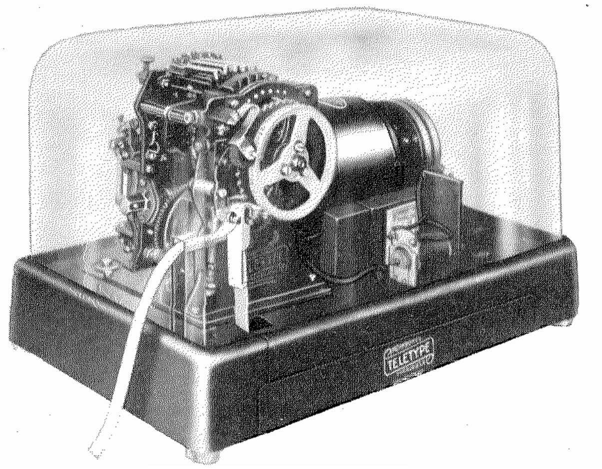


Figure 3—Type 11 Teletype—Receiving Only

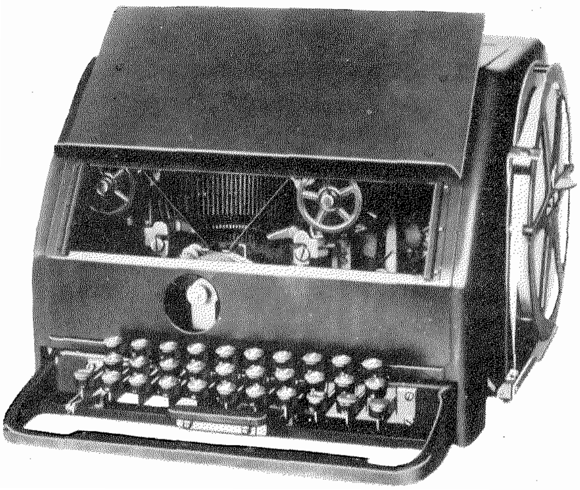


Figure 4—Type 14 Printer—Arranged for Sending and Receiving

corresponding to the different combinations engraved on its periphery. The tape is thus brought in contact with the proper letter, which is printed by pressure. The printing arm is then restored to its first position and latched there, awaiting the next letter.

The Type 11 Teletype may be operated very reliably and accurately at a speed of forty words (240 characters) a minute. It has the advantage of using the Baudot principle of selecting and printing the letters and is thus easily understood by those familiar with Baudot apparatus Its use is, however, uneconomical inasmuch as the carrying capacity of most lines as well as the readily attainable speed of operators is greater than forty words a minute.

While the Type 11 is in no sense obsolete, experience shows that in most cases the use of the Type 14 is preferred. For that reason a full description of the Type 14 rather than of the Type 11, will be given.

Type 14 Printer—Improved High-Speed Teletype

General Description. The Type 14 is a tape printer controlled by a direct keyboard. Figures 4 and 5 show the machine, arranged both for sending and receiving, with cover and with cover removed. Figure 6 shows the machine used as a receiver only. Depression of a key at the home station sends out an electrical impulse which operates the printing apparatus both at the home and at distant stations. Each instrument is driven by a motor and printing is

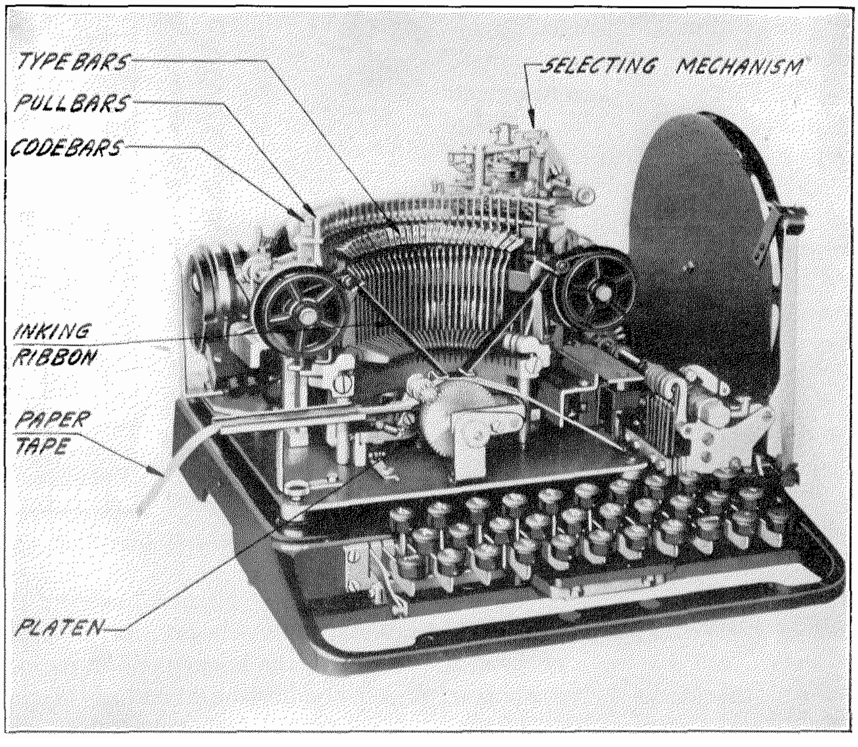


Figure 5—Type 14 Printer for Sending and Receiving—Cover Removed

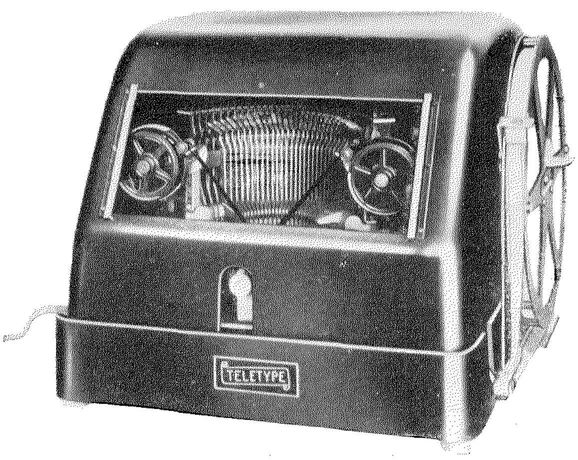


Figure 6—Type 14 Printer—Arranged for Sending Only

effected by entirely mechanical means; a single magnet which oscillates according to the code transmitted merely controls the mechanically operated selections.

Five Unit Code. If a given unit of time be divided into five intervals during each of which current may or may not be transmitted, it is possible to produce thirty-two different combinations of "current" and "no-current" intervals. Figure 7 shows graphically the combinations of the code. Each horizontal row represents the complete letter unit of time. The black spots represent current, the white ones no current. Thus, in case of the letter "E", current is sent during the first interval and no current during the remaining four intervals. Each combination of signals is preceded by a start and followed by a stop signal, used to maintain unison.

Keyboard Transmitter. Beneath the key levers of the keyboard are five selector bars. These are movable endwise and the top edge of each bar has a number of triangular notches arranged according to the requirements of the code. When a key is depressed the key lever strikes the slanting sides of these notches, moving the bars either to the right or left, depending on the letter.

Each selector bar (Figure 8) controls a vertical locking latch, so pivoted that the movement of its upper end is the reverse of that of the selector bar. To the left of the locking latches are six pivoted contact levers, each having a horizontal and a vertical arm, the latter being hooked. The horizontal end of each of these levers is opposite one of the locking latches while the hooked end controls a transmitting contact. The horizontal arm is further provided with a hump which bears on a contact cam. There are six each of the notched cams and contact levers. The cams are set on the shaft so that as the shaft revolves the notch in No. 1 cam passes over the hump of No. 1 lever, then the notch in No. 2 cam passes over the hump in No. 2 lever and so on. The pressure of the contact springs would cause each hump to rise into the notch of its cams and thus the contacts would close one after the other as the shaft revolves.

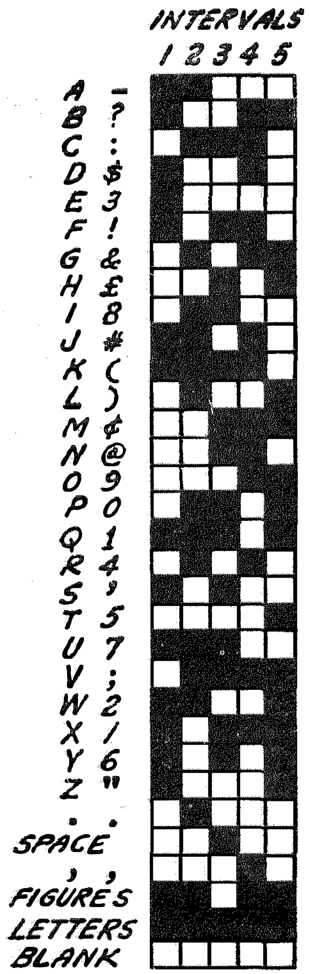


Figure 7—Five Unit Code

The locking latches, however, can prevent the contacts from closing; for, if a selector bar is at the right, the hooked end of its locking latch will catch the horizontal end of the contact lever. A "no-current" interval is thus secured. Therefore, if No. 1 bar is moved to the left and the

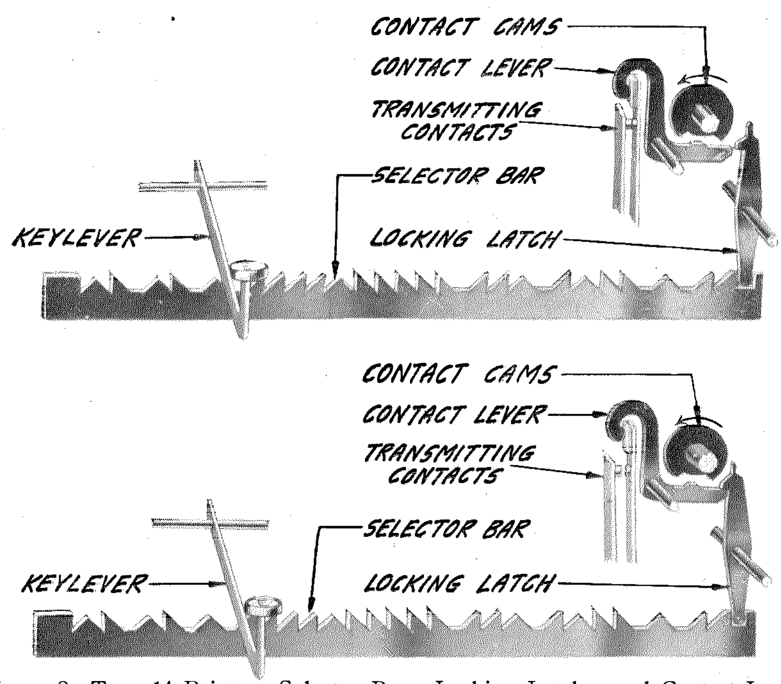


Figure 8—Type 14 Printer—Selector Bars, Locking Latches and Contact Levers

other four bars to the right, the code combination for the letter "E" will be sent to the line.

The function of the sixth contact lever is to send out the start pulse before each letter and the stop pulse after each letter. The cam on which this contact lever rests is so arranged that at the beginning of a letter the contact is opened and at the end of a letter it is closed. Normally, when the machine is at rest current is on the line. The method of synchronism is more fully described under "Unison."

At the beginning of each letter a locking loop (Figure 9) drops over the knife edges at the top of the locking latches. This locks the setting of the locking latches and through them of the selector bars. It is thus impossible to change the code arrangement of a letter after transmission of the letter has started. As it is impossible to depress a key while this lock is in, it also prevents too rapid sending.

Keyboard Transmitter Clutch. The keyboard shaft mounting the contact lever cams is revolved by a ratchet clutch mounted on a shaft driven by the motor. The operation of the clutch will be apparent from Figure 10. The tripping of the clutch is controlled by a universal bar which extends under all the key levers. Depression of a key moves the trip-off pawl to the left and thus throws out the clutch stop arm. The intermediate pawl prevents continuous operation in case a key is held down. It, however, may be made inoperable by adjustment of the eccentric screw.

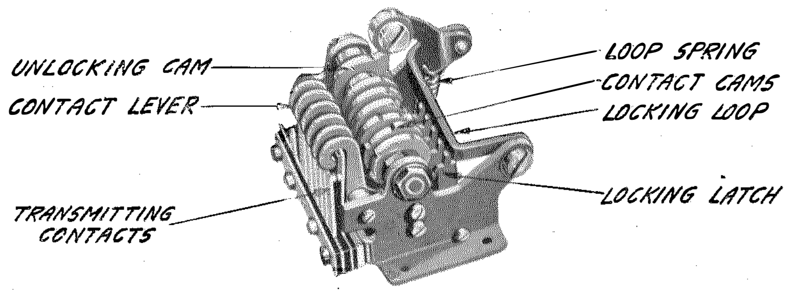


Figure 9—Type 14 Printer—Locking Loop

Printer Unit. The general appearance of the unit is shown in Figure 5. Where the printer is required for receiving only, the key levers and transmitting mechanism are omitted.

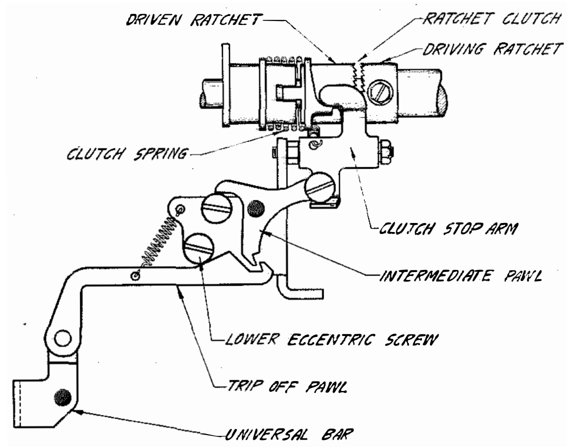


Figure 10—Keyboard Transmitter Clutch

The function of this unit is to translate into printed characters the signals sent out by the transmitter. The various characters are on typebars which are caused to strike a paper tape as it is pulled over a narrow platen. The platen may be shifted to print upper case characters. A typewriter ribbon is used for inking.

The printer, which is shown diagrammatically in Figure 11, has but one shaft. This is driven from the motor by a worm gear and has on it the clutch for the main operating cam, also the friction clutch for the selecting device.

Figure 12 shows the start-stop device. Movement of the magnet armature trips out the stop pawl latch, the stop pawl releases the stop arm

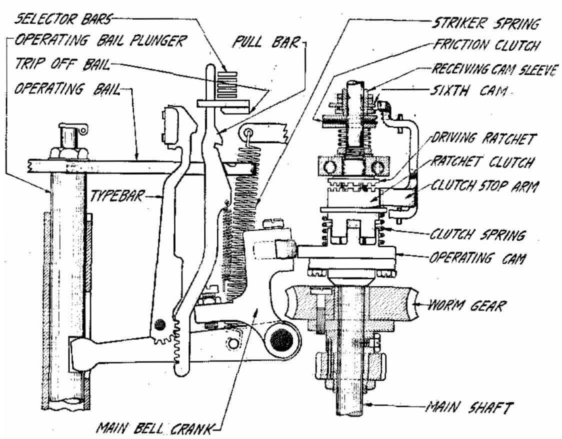


Figure 11—Type 14 Printer—Diagramatic View

and the receiving cam sleeve is frictionally driven for a single revolution and again caught by the stop pawl. The selecting is done by a series of "swords" and may be understood readily by reference to Figure 13.

There is a sword for each of the five selecting pulses and these swords are drawn away successively from the selecting bars by selector cams arranged on the receiving cam sleeve. As the sword is drawn away from the selector bars either one side or the other of its hilt strikes against the armature extension, depending upon

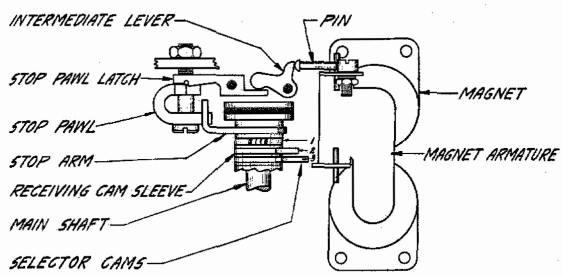


Figure 12—Type 14 Printer—Start-stop Device

whether the armature is against or away from its pole piece. As the cam continues to revolve it releases the selector bar operating lever and the spring moves the sword back, bringing it against either the right or left angle of the T lever, and thus moving the selector bar either to the right or left. This is done successively by all five swords and the five selector bars are thus set according to the permutations of the code. The sixth cam releases the power clutch

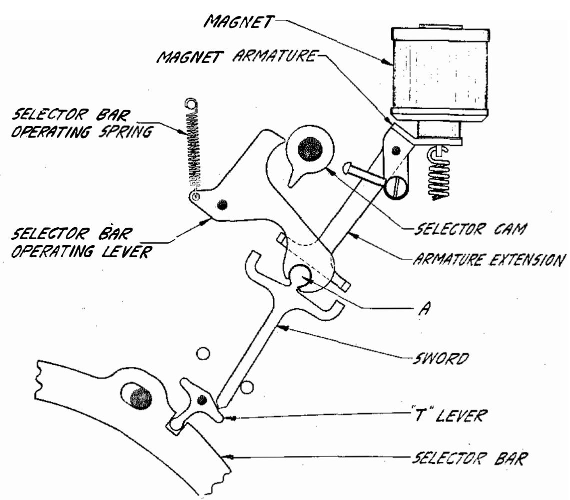


Figure 13—Type 14 Printer—Selecting Device

shown in Figure 14 through the clutch stop arm. This connects the sleeve carrying the operating cam to the motor driven shaft and the cam makes one revolution after which it is stopped by the clutch stop arm.

In Figure 11, the selector bars are shown at the upper part of the drawing. These are notched in such away that for each combination of the code a set of notches is lined up under one

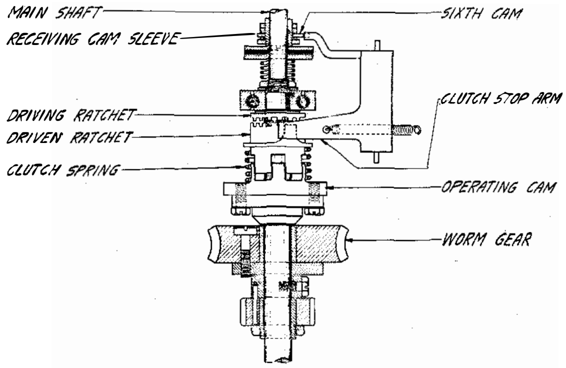


Figure 14—Type 14 Printer—Power Clutch

of the pull bars. Each pull bar is connected to a typebar. The pull bars are peculiarly shaped, each having a cam face on which the operating bail bears and a notch in which this bail may engage. The lower end of the pull bar has a rack which engages with a pinion on the lower end of the typebar.

As the operating cam revolves it moves the operating bail up and down through the main bell crank, which in turn is notched into the operating bail plunger. As the operating bail moves up it permits all the pull bars to drop against the selector bars. The bar under which the notches are lined up enters these notches and this brings its notch in position to be picked up by the operating bail. Further travel of the operating bail moves the pull bar upward and causes the typebar to hit the platen. The notches of the other pull bars are held away from the operating bail by one or more of the flat portions of the selector bars. Another cam surface at the upper part of the pull bar comes in contact with the trip-off bail and as the letter is printed throws the pull bar out of the notches of the selector bars. On its return stroke the operating bail, working on the lower cam surface of the pull bars, forces all the pull bars away from the selector bars and thus restores the printing mechanism for the next letter.

Feeding the Tape. Figure 15 shows the platen over which the tape passes. The tape is held against the platen by the feed roll. The platen shaft is revolved by a suitable mechanism a space of one letter for each revolution of the main operating cam.

Shift and Unshift. In order to print both upper and lower case characters a shifting and unshifting arrangement is provided for the platen. This is operated by a shift pull bar and an unshift pull bar. These pull bars have no typebars connected with them but are connected with suitable levers for moving the platen forward and back.

Ribbon Feed Mechanism. A standard typewriter inking ribbon is used and provision is made for feeding this slightly for each letter. A reverse mechanism is also incorporated so that when the ribbon is completely wound from one spool the feeding mechanism automatically reverses to rewind the ribbon. Similar mechanisms are found in standard typewriters.

Unison. The start and stop signals mentioned above as preceding and succeeding the selecting signals cause the printing units to revolve in unison with the transmitter. The motors of all machines on a circuit are held at approximately the same speed by the governors. The receiving sleeves of the machines are held by their respective stop arms. Transmission of the start impulse allows the selector magnet armature to trip off and the selector sleeves, being friction driven, start to revolve immediately. When the cam shaft of the transmitter has revolved far enough to send out the first impulse, the selector sleeve on the printer has revolved also to the point where the first sword operating cam sets the sword according to the

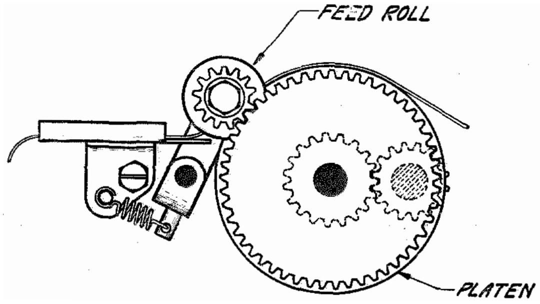
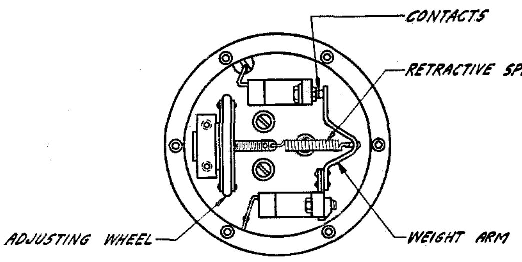


Figure 15—Type 14 Printer—Platen and Tape Feed Roll



Figue 16—Type 14 Printer—Governor

position of the armature. The following impulses of the combination are handled in like manner. The stop signal is always a "current" signal which attracts the selector magnet armature and thus puts the stop pawl in position to stop the receiving cam sleeve stop arm.

The receiving cam sleeve is geared to rotate slightly faster than the transmitting shaft. The cams, however, are spaced so that the distance from the first to the second cam is correspondingly greater than the distance between the first and second transmitter cams. The reason the receiving shaft revolves faster than the transmitting shaft is this: it is not possible to maintain several Teletypes at absolutely the same speed. No matter how delicate the governors, there will always be a slight difference in the speed of two or more units. If these errors were not taken care of these differences would cause the transmitting and receiving mechanisms to get out of unison so that, for instance, at the time the transmitter sent out the first impulse of a character signal, the receiving mechanism might be in position to receive the second. As the receiving mechanism completes its revolution sooner than the transmitter completes the corresponding one, it is possible for it to stop and wait for the transmitter to catch up. It starts again only upon receipt of the start signal from the transmitter. The difference in speed, therefore, is not cumulative. Each letter starts at the proper time and even with comparatively large differences in the speed of the motors the time of each revolution does not vary greatly. Start-stop synchronism, therefore, is approximate synchronism for the time of one letter only.

Governor. The speed of the several instruments on a circuit is held approximately the same by means of the governor (Figure 16). The current comes into it through slip rings on the periphery. Centrifugal force tends to open the contact against the pull of the retractive spring. The revolving speed at which the contact will open can be set by an adjusting wheel which increases or decreases the spring tension. Opening of the contacts introduces resistance into the circuit which reduces the motor speed.

The normal operating speed of the Type 14 instrument is sixty-five words, (390 characters) per minute. It is capable of a wide range of speed and special gearing may be furnished for speeds much at variance with the normal. It is interesting to note, however, that cadenced operation is not required on any of the Morkrum systems. The speeds indicated are those at which the printing mechanism functions for each letter. The operator may touch the keys at any rate, regularly or irregularly, up to the set speed of the machine. Should he exceed this set speed, the keyboard lock comes into operation and automatically locks any key-lever until the preceding letter has been transmitted. The difference in "touch" is at once apparent to the operator and signals him to slow down to proper speed.

While the Type 14 printer is usually used with direct keyboard transmission, the line signal is the same as that of other Morkrum systems (excepting the Multiplex) and the printer will operate just as well from perforated tape transmission. For duplex operation, tape sending, each station requires a receiving-only printer, a perforator (Figure 17), a transmitter

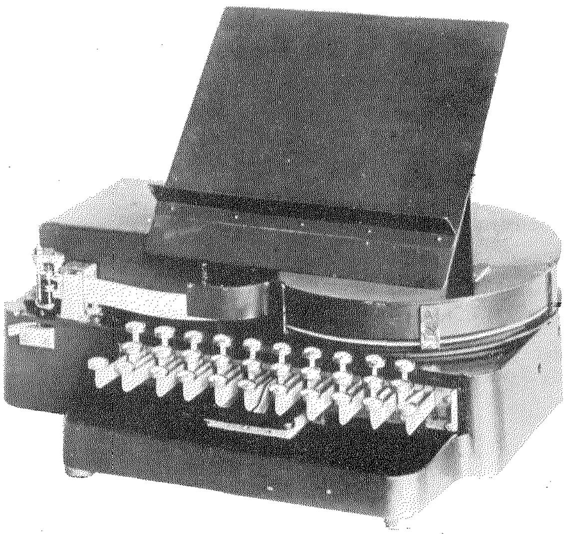


Figure 17—Perforator

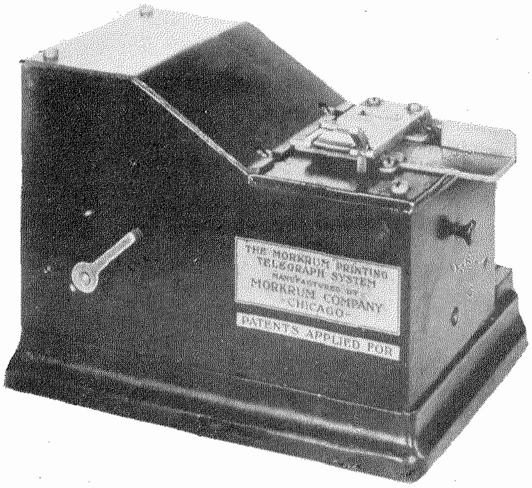


Figure 18—Transmitter

(Figure 18), and a distributor (Figure 19), together with line relays and the necessary duplex balancing equipment. For a keyboard duplex, each station requires a sending-receiving instrument and a receiving-only printer.

Type 12 Page Printers

The Type 12 system consists essentially of a five-magnet printer, originally designed for Multiplex operation, and either a keyboard distributor or a distributor for receiving only. Because of the five-magnet selector, local direct current must be provided either from the local power mains or a motor generator.

The keyboard distributor is a motor driven unit based on the standard keyboard described under the Type 14. The principles and many of the parts are identical. It has been necessary, however, to add a receiving distributor to sort out the received pulses. The keyboard distributor is driven by the same motor that drives the keyboard transmitter but is geared to run at a slightly greater speed, as described under "Unison." It consists of a cam cylinder, the starting and stopping of which is controlled by the start and stop pulses from the transmitting distributor (either home or distant), and a set of cam levers and contacts like those of the keyboard transmitter, except that no locking latches are provided. The contacts controlled by these levers are individually connected to the selecting magnets of the printer. As the cylinder revolves, each magnet is in turn connected to the line and receives or does not receive a pulse.

A receiving distributor is merely the keyboard distributor with the keys and the transmitting device left out.

The motors of both distributors are kept at constant speed by the standard governor, described under Type 14. As both distributors are of the same width, it is possible to substitute one for the other in the connection frames of the Type 12 sets.

The Type 12 printer base consists of a shallow wooden tray, lined with felt. On this tray rests a plate mounting a sub-frame with rails and connection clips for mounting the printer and either type of distributor. Provision is made on this base for mounting the various switches, relays, fuses, etc., required for line operation. A set of angle-iron legs may also be furnished, to form a table at the proper height for easy operation. A suitable cover is provided, with an opening through which the key-levers protrude.

The standard speed of the Type 12 apparatus is sixty words per minute but it may be furnished with lower gearing. It may be used in duplex with any standard type of line balancing equipment.

In the case of more heavily loaded lines, duplex operation with perforated tape transmission is preferable. In addition to the Type 12 printer and mounting frame, a perforator, transmitter and distributor, as well as a table for mounting these units to the line balancing equipment, are required. The distributor is the equivalent of the keyboard distributor previously described, with the key levers omitted.

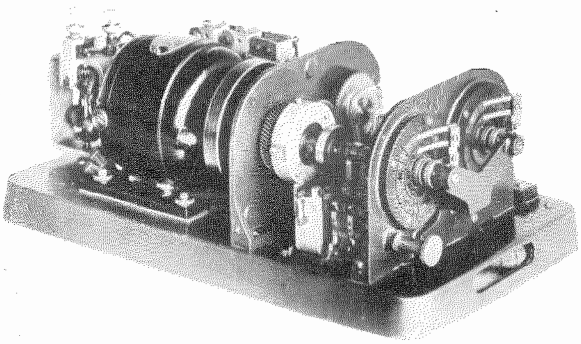


Figure 19—Distributor

Many other combinations of Type 12 instruments are used, such as a "press type" transmitting set, consisting of Type 12 printer, perforator, transmitter and distributor, together

Figure 20—Type 18 Teletype—Receiving and Transmitting

with necessary relays, all mounted on a steel frame table equipped with clip connections for the various units; also a press type double receiving station, mounting two printers, two receiving distributors and relays, fuses, etc. This is used at isolated stations which receive only and where no attendant is stationed. In case of trouble on one printer, the simple pushing of a switch throws the second printer into the circuit.

Control Relays

The three systems described, i.e., the Types 11, 12 and 14, may all be equipped with control relays, operating over a second line. These relays start and stop the motors of all machines on a circuit. Usually, the installation is so made that when there is current on the control wire, the motors of all machines are at rest. Opening the circuit at any of the stations releases all the control relays and the motors of all machines start. It should be borne in mind that this control circuit is entirely distinct from that used for transmitting the letter signals. It is entirely practicable to operate any of these systems over a single wire, but when this is done the motors at the stations would operate continuously, being started, say, at the beginning of the day and stopped at the close of business. The use of the control system permits of turning the machines on and off as desired.

Type 18 Page Teletype

To meet the requirements for single magnet printers in which the copy is produced in page form, the Type 18 printer has been developed. This is available with the usual arrangement of a five-unit signalling code and twenty-six typebars or with a six-unit code and forty-two typebars (like a standard typewriter). The normal speed is sixty-five words per minute.

The general appearance of this printer is shown in Figure 20 while Figure 21 shows the equipment designed for receiving only.

The keyboard used is similar to that described for the other instruments and the theory of operation is the same.

While control relays may be used, a novel starting and stopping device for the motor is

Figure 21—Type 18 Teletype—Receiving Only

included in the printer. Referring to Figure 22 contact No. 1 is closed when the paper carriage is in the "Figures" position. But the motor current continues to flow through contact No. 2,

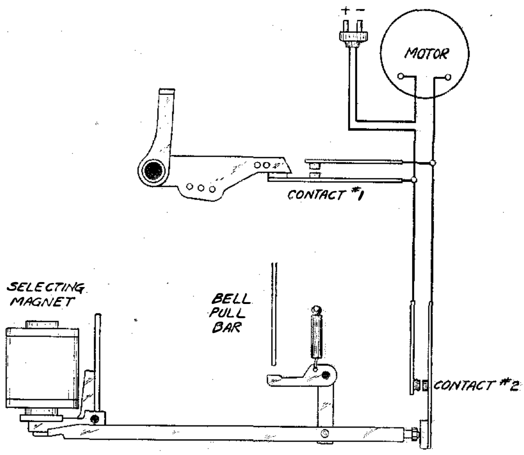


Figure 22—Schematic of Start and Stop Control Circuit—Type 18 Teletype

in parallel with it. Should, however, the "blank" selection now set up, a pull bar will drop in the proper set of notches, be picked up by the operating bail and its end will open contact No. 2, at the same time locking itself in the forward position by the latch controlled by the armature of the selecting magnet. The same operations take place at the distant station or stations and all the driving motors stop. All the printers are at rest, with the paper carriage in the "figures" position and contact No. 2 locked open by the latch as the selector magnet armature is held against its pole piece by the current on the line.

To start the circuit from any of the printers, the manual unshift button is pressed. This allows the carriage to drop and closes contact No. 1, starting the motor at that station. A key is then pressed, which opens the line through the "start" signal of the code. All the armatures knock off the latches holding the "blank" pull bars of all machines forward, contacts No. 2 close and all motors start. As the distant machines are still in the "figures" position, it is now necessary to touch the "letters" key of the home machine to get all machines in the same "case."

The operation of this printer closely resembles in principle that of the Types 12 and 14, as regards printing, ribbon feed, etc. The selecting mechanism is entirely novel and it will be of interest to indicate briefly the operation of the selecting magnet.

The magnet is arranged to control an armature which, in turn, controls a mechanical arrangement driven by the electric motor forming part of the machine, which permits setting the selector levers in accordance with the code requirements.

When the magnet armature is attracted, a pin barrel is pushed to the right, and one of the pins strikes the selector lever immediately below it. If the next signal is of the opposite sign, the pin barrel is forced into a position where the next pin will not strike its associated selector lever.

The selecting or code bars in this printer are latched normally to the left but tend to move to the right under the pull of their springs. When a selector lever is hit by a pin of the pin barrel, it withdraws this latch and locks it out. The selector bar then moves to the right. The permutations of the code thus are transferred to the selector bars. After a letter has been printed, all selector bars are restored to the left by a restoring bail. In case the selector latch for any bar has been locked out by the code combination of the succeeding letter, that bar immediately moves to the right again.

Type 22 Tape Printer

To meet the requirements for a tape printer for Multiplex work, the Type 22 tape printer has been developed. In general appearance, it is like the Type 14, the printing, spacing and ribbon feed mechanisms being identical. As the selection is obtained by five magnets, which get their pulses from a distributor, the setting of the code bars is under the control of these magnets, rather than of the single line magnet of the Type 14. Lack of space forbids a full description of this interesting instrument, however, it may be said that the selection is accomplished in the same manner as in the Type 12 machine. It is a motor driven unit, capable of operation at any speed up to eighty words per minute and may be used in place of the Type 12 on single channel or Multiplex systems with five magnet selection, including existing Baudot Multiplex circuits. The slight changes in the arrangement of the code in different countries may be taken care of easily in the placing of the type pallets. The machine is simple in construction and reliable in operation.

Multiplex Equipment

The Multiplex equipment of the Morkrum-Kleinschmidt Corporation includes a Multiplex system providing two to four channels. Briefly stated, a Multiplex terminal consists of a distributing table on which are mounted the distributors, speed control apparatus, and line balancing equipment. An operating table for each channel (Figure 23) also is required; each mounts a printer, perforator, transmitter, and tape stop unit. All are connected to the distributor table by cables.

Each operating table is arranged for a transmitting operator who prepares the perforated tape, and feeds it into the transmitter and a receiving operator, who handles and checks messages received from the distant end.

In the description that follows, reference will be made to the two-channel equipment.

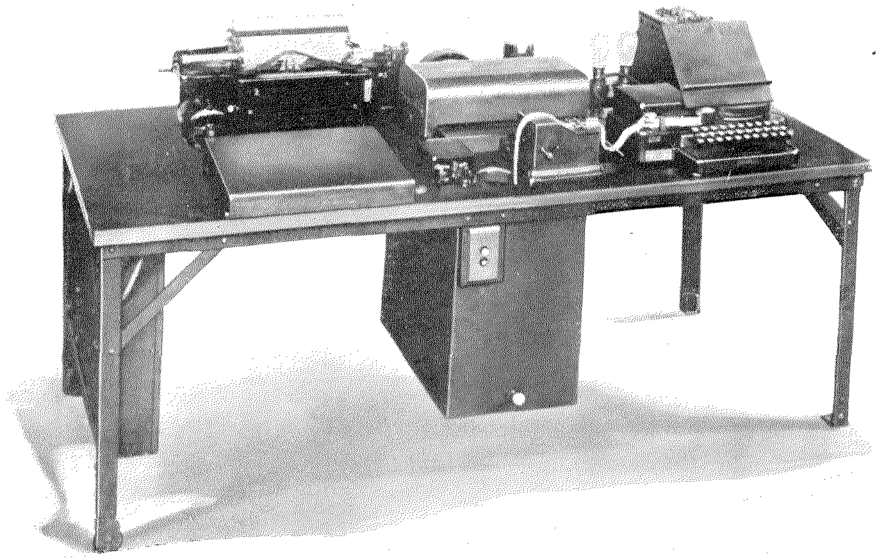


Figure 23—Duplex Operating Table

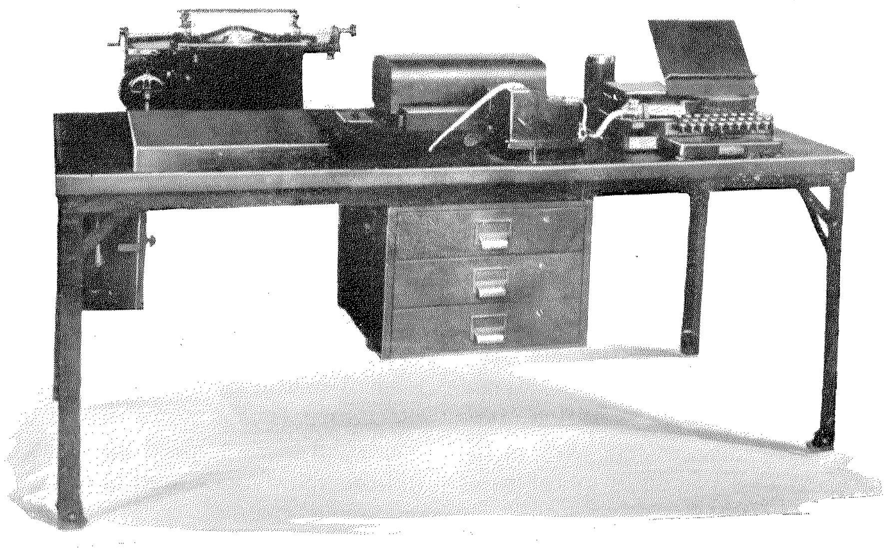


Figure 24—Duplex Test Table

It is the practice to assign a fully equipped test table (Figure 24) to each office. This table has a local distributor; the perforator, transmitter and printer units are the same as those used on the operating table and, therefore, these parts are interchangeable.

Associated with the equipment referred to, there is a double-decked distributing table (Figure 25), upon which are mounted the distributors, relays, line control switches, indicating lamps, as well as the usual line balancing equipment. On the lower deck of the table are the driving forks, automatic speed control unit, condensers, rheostats, and also a panel box in which all wires terminate.

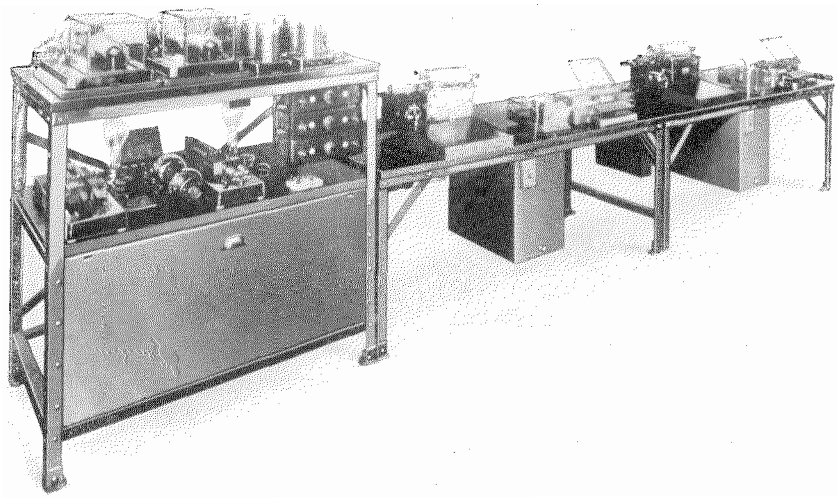


Figure 25—Double-decked Distributing Table

In the equipment manufactured by the Morkrum Company, the bases of the transmitting and receiving distributors are interchangeable. This is true also of the rotors for driving and controlling the distributors. The distributor cylinders are different, the receiving distributor having on it the speed correcting device. Both distributors are of the brushless type, the electrical connection being obtained by contacting plungers bearing on cam surfaces.

To avoid the collection of dust upon the distributor cylinders, a glass cover is used. The distributor is driven by a form of rotary converter which is supplied with current at both the DC and AC sides. Sufficient direct current is fed to give a speed of rotation slightly less than that required by the circuit; AC is then fed to the AC side by the driving fork, thus giving sufficient additional power to bring the motor up to the desired speed. As the AC is generated by the tuning fork, a very close speed control is obtained. For the receiving distributor, the tuning fork is further controlled by automatic correction from the signals themselves; and in this way, the speed of the receiving distributor is synchronized with that of its transmitting distributor.

The automatic speed control unit is a small rheostat, controlled by a reversible motor which rotates to the right or left, according to the position of the control relay: thus, if the receiving distributor is tending to run faster than its distant transmitting distributor, the circuit to the fork from the control rheostat operates so as to reduce slightly the speed of the fork and, therefore, of the rotor. The automatic control unit is most useful in taking care of fluctuations in speed due to temperature, friction, and other variable conditions which it would be hard to compensate for otherwise.

Figure 26 shows, in a diagrammatic way, the transmitter distributor speed control; and Figure 27 shows the means employed for controlling the speed of the receiving distributor.

The tuning forks used in the Morkrum system are of the standard type, quite similar to those used in the Western Electric Multiplex sets; the receiving fork, however, as arranged by the Morkrum Company has some additional magnets for the finer control gained through the automatic speed control feature just referred to, and shown in the lower portion of Figure 27.

Summary

Tape Printer. Type 11. This is the original Teletype, and prints its message by bringing

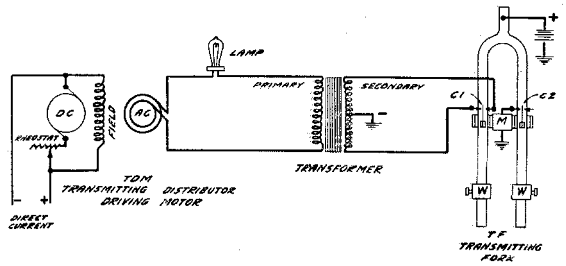


Figure 26—Transmitting Distributor—Speed Control

the paper tape in contact with the typewheel. It has a speed of forty words per minute and is available either in a combined sending and receiving station or separate receiving only station. A single magnet operates the selecting mechanism. The printer may be operated on a single wire, but it is desirable to provide a second circuit for starting and stopping the driving motors.

Tape Printer. Type 14. This is the high speed Teletype, printing on tape by means of typebars. The standard speed is sixty-five words per minute. Operating and control circuits have the same characteristics as the Type 11.

Tape Printer. Type 22. This is a Multiplex printer producing its record on tape. It operates at speeds up to eighty words per minute. The parts are largely interchangeable with the Type 14. It is of the five magnet type and must be used in connection with a distributor.

Page Printer. Type 12. This is a motor driven printer, taking paper up to 8½ inches wide. The printing is done by ball-bearing typebars. It is of the five magnet type and must be operated in connection with a distributor. It is used on both single line and Multiplex circuits and has a speed of sixty-five words per minute.

Page Printer. Type 18. This printer is of the single magnet selector type and may be used

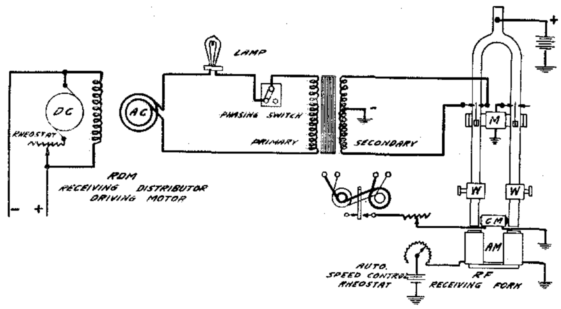


Figure 27—Receiving Distributor—Speed Control

without a distributor. A direct keyboard may be incorporated in it or it may be furnished in the receiving-only type. Like all the printers mentioned, the five unit machine prints its message in capital letters only, the upper case being used for figures and characters. It may, however, be furnished with forty-two typebars for printing non-Latin alphabets or to give both capital and small letters.

Morkrum-Kleinschmidt Corporation developments include the necessary keyboard perforators, transmitters, distributors, forks and all other associated apparatus for the system as well as the tables for mounting the apparatus.

The heavy demand for Morkrum-Kleinschmidt equipment from telegraph companies in the United States has made practicable the standardization of printer apparatus. Parts are produced by the most modern tool equipment and have been designed so as to be interchangeable in machines of the same type. Maintenance costs, therefore, are reduced to a minimum.

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