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Bell Laboratories Record

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A New Era in Loading

By WILLIAM FONDILLER
Assistant Apparatus Development Engineer

IN 1900 were issued the basic Pupin patents on the loading of telephone lines. Up to the present time savings of approximately $200,000,000 in plant investment have resulted from the use of loading coils in the local-cable plant. An additional saving of fully half this amount has been realized in the toll-cable plant, due to the combined use of loading and vacuum-tube repeaters. Thus, the development of suitable designs of loading coil to meet the severe conditions of the modern telephone network is a problem of the first importance.

The idea of "loading" in telephony is analogous to the loading of a vibrating string with equal weights uniformly spaced along its length. If the distance between weights is sufficiently small, the vibration of the loaded string will be practically the same as that of a uniformly heavy string of the same mass. In the case of the telephone line, loading is accomplished by connecting inductance coils at regular intervals in the circuit as shown in Figure 1, thus increasing the electrical mass of the line. This increased mass reduces the friction (resistance) loss and, reacting with the elasticity (capacitance) of the circuit, also reduces distortion. Thus a speech wave entering a loaded line is transmitted with less attenuation and alteration of the wave form than in the case of a non-loaded line. In terms familiar to the power engineer, the loaded line transmits at a higher line-voltage, lower line-current and higher power-factor than the non-loaded circuit. The transmission loss may readily be reduced by loading to a third of its value for the non-loaded cable circuit, so that the same transmission efficiency would be obtained in a loaded cable three times as long as the corresponding non-loaded cable.

The usual form of loading coil consists of a toroidal or ring core with a copper winding applied over it. The spacing of loading coils in cable is generally about one mile. Thus in the case of a long circuit, such as the New York-Chicago cable, the talking current would traverse the windings of approximately 900 loading coils connected in the toll line.

In the early loading coil the core was formed of hard drawn fine iron wire—one of the rare instances of designedly using for a core an unannealed magnetic material. The explanation is that the advantage of loading inheres in the inductance which the coil adds to the talking circuit, but this inductance can be introduced only if the speech currents traverse the coil windings and hence sustain losses due to the resistance of the winding and to eddy currents and hysteresis in the core. All of these losses must be kept low by proper coil design and since those due to hysteresis and eddy currents increase rapidly with the permeability of the core, a low limit of permeability is imposed. Our loading coil designs at the outset employed cores developing only the initial permeability of the core material, approximately 35, whereas in the electrical industry generally the aim was to use the maximum permeability obtainable in iron, in the neighborhood of 5,000.

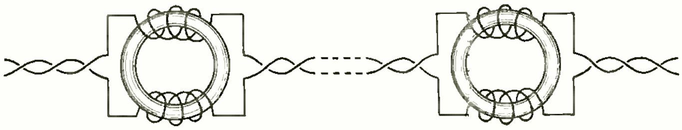


Fig. 1—Method of connecting loading coils into cable pair

Wire-core loading coils met the requirements of the plant up to about 1914. By that time a successful design of vacuum-tube telephone repeater had been developed, but it could not be used advantageously on lines loaded with the coils then standard. The reason for this incompatibility was the unstable inductance of the coils which would undergo large changes, due to excessive currents in the telephone lines produced under abnormal conditions of operation or by induction from outside sources. Such currents seriously magnetized the core and altered its permeability.

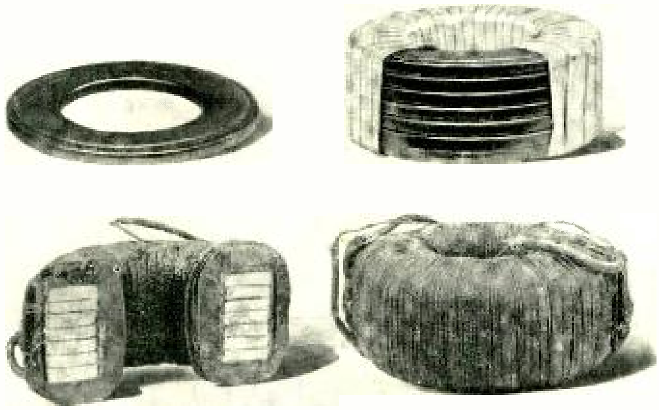


Fig. 2—Loading coil with compressed powdered core: top, left—core ring, right—partially taped core; bottom, left—coil sectioned, right—coil ready for potting

There followed from an intensive period of development work a type of loading coil in which a stabilizing self-demagnetizing effect was secured by the introduction of non-magnetic gaps in the toroidal core. This solution was later superseded by a much more satisfactory one, involving the introduction of innumerable minute gaps resulting from our development of a new magnetic material, compressed powdered iron.

The essential improvement in core material demanded for repeater operation was increased magnetic stability when subjected to large magnetizing currents. This was achieved to a high degree by the powdered electrolytic iron core. Where the older loading coils were liable to a permanent change in inductance of over 25%, the new coils maintained their inductance to about 2% under similar service conditions. Another important characteristic was the enormous resistivity of the finely-divided iron, resulting in lower eddy-current losses than for rolled or drawn metal. Cores were conveniently formed by stacking compressed rings of powdered iron as shown in Figure 2.

This material, first introduced on a commercial scale in 1916, was revolutionary in importance and for the past ten years has been standard for loading-coil cores. So economical were the powdered iron cores, as compared with the iron wire cores, that they rapidly superseded the latter, and the use of vacuum-tube repeaters, in association with loaded circuits, became general in the Bell plant.

Over this period extensive developments occurred in telephony and telegraphy, involving vacuum-tube repeaters, carrier-frequency transmis-

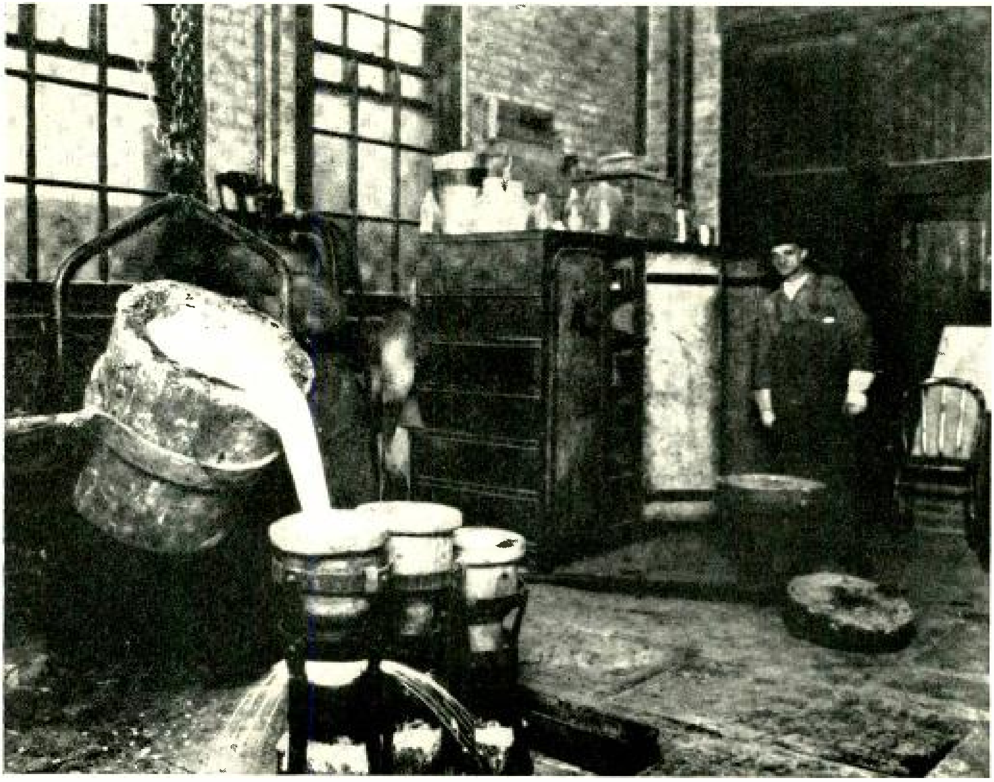


Fig. 3—Casting permalloy into ingots suitable for later crushing and grinding

sion and extensions of loaded cable. It was at this stage of the communication art that there evolved the remarkable nickel-iron alloy, permalloy, discovered by G. W. Elmen. Its striking combination of properties, the highest initial permeability and lowest hysteresis loss of any known material, arrested the attention of our design engineers who immediately began to consider its possible uses in electrical communication.

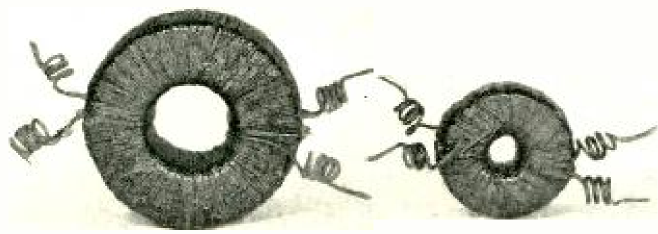


Fig. 4—Compressed powdered core loading coils: left, electrolytic iron core; right, permalloy core

Its first important application was to the continuous loading of transoceanic telegraph cable where high permeability was essential. Here the permalloy in ribbon form was spirally wound over the submarine cable conductor. Other applications were in the design of electromagnets and transformers which also employed strip or sheet permalloy cores. The problem of its use for loading coil cores did not, however, readily yield to solution.

At the outset it was evident that permalloy in the form used for submarine telegraph cables was wholly unsuited as a loading coil core material. Its susceptibility to permanent magnetization and the variation of its permeability with current rendered it markedly inferior even to iron wire as a loading coil material. However, its intrinsically low hysteresis remained a sufficient lure to those seeking a means to utilize it.

Our experience with powdered electrolytic-iron for cores pointed to a means for correcting the magnetic instability of permalloy by having recourse to a multi-airgap core. The problem then was to produce a core of powdered permalloy which should retain to as great a degree as possible the desirable properties of sheet permalloy. Through the metallurgical skill of the development engineers of the Western Electric Company, combined with the experience of our Laboratories, the problem was solved. Means were developed by which permalloy was embrittled so that it could readily be ground to the desired fineness and these operations, accompanied by suitable heat treatments, yielded the compressed powdered-permalloy core of today.

This development, described here in a few sentences, required, however, continuous experimental work over a period of several years before it was brought to a successful issue. It represents the result of highly cooperative efforts, embracing researches and developments in chemical, metallurgical and electrical fields.

Between the powdered and the sheet permalloy differences in properties exist amounting almost to an antithesis—each material being eminently suited to the use to which it is applied. Sheet permalloy has an initial permeability of approximately 7500, powdered about 75. In resistivity, on the other hand, powdered permalloy is approximately 50,000 times as great as sheet permalloy. The residual effect of d.c. magnetization on sheet permalloy results in a reduction of about 50% of the initial inductance; for powdered permalloy only one-half percent.

These striking differences in characteristics are, of course, due to the fine subdivision of the permalloy in the powdered core, in the production of which each grain is carefully insulated before pressing the core rings. Though permalloy in sheet form was not itself suitable, it nevertheless constituted a strong invitation to develop a core design adapted to the loading coil problem. Not by virtue of the extremely high initial permeability which made it valuable for submarine cable, but because of its low hysteresis has it become suitable.

As compared with the powdered iron core, the new permalloy core has greater magnetic stability and approximately twice the permeability. The effect on the physical dimensions is indicated in Figure 4 which shows the No. 612 powdered-permalloy-core alongside of the No. 602 powdered-iron-core coil. In both cases the cores are formed by steel dies under pressures of 200,000 pounds per square inch. The two coils have substantially the same efficiency over the range of speech frequencies, but their relative volumes are about as 1 to 3. Figure 5 shows cases equipped with 200 coils of the types just described and indicate the marked saving in space. This is of great importance, particularly in metropolitan areas, where space in loading vaults is extremely valuable.

At present loading coils are being placed in the telephone plant, on local and toll cables, at the rate of about 700,000 each year, and that rate is expected to continue for some time. On the basis of this demand, the de-

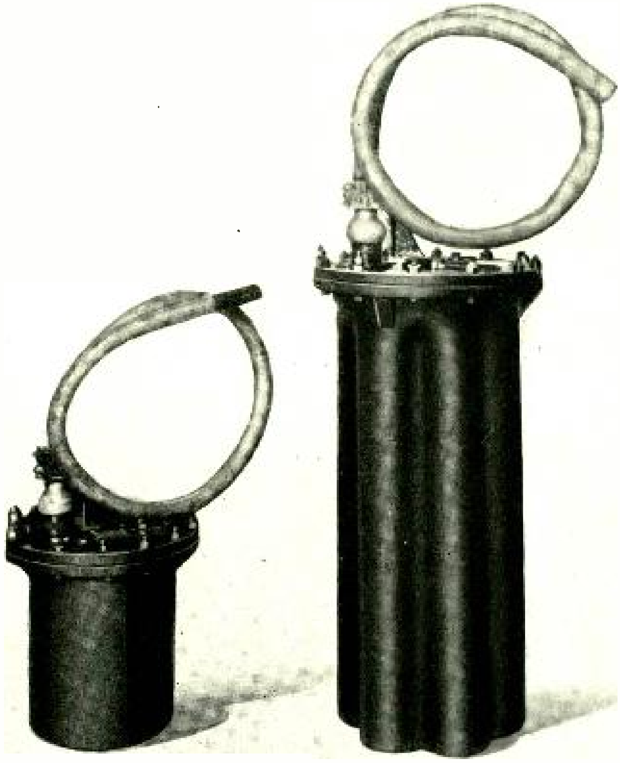


Fig. 5—Cast-iron cases each containing 200 loading coils: left, permalloy-core coils, weight 725 pounds; right, iron-core coils, weight 1750 pounds

velopment of a loading coil with powdered-permalloy core results in a very substantial saving in first cost. The new loading coils are the full equivalent of the old, and in certain respects, notably as to freedom from magnetization and modulation, are decidedly superior.

To those concerned with development and research, however, this coil is not the final word. Though inaugurating a new era in loading today, it represents but another step in advance of the many that have preceded it. In its turn it will no doubt, be superseded as our continued experimental work points the way to further improvements in the future.

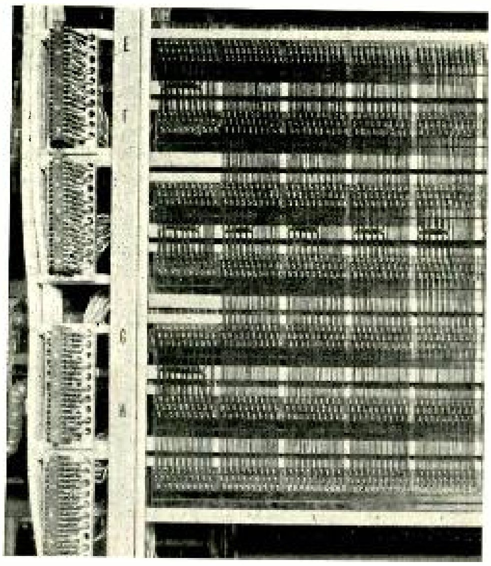
The head, and two of the pioneers, of the Bell System: left to right, Robert W. Devonshire, first employee of the System and since 1913 Vice-President of A. T. & T.; President Gifford; and Thomas A. Watson, who assisted Alexander Graham Bell in his telephone experiments. The picture was taken on the occasion of a testimonial dinner to Mr. Devonshire on August 17, 1927, celebrating his fiftieth Bell System anniversary

New Step-By-Step Equipment

By E. H. SMITH
Systems Development Department

As our cities grew in population it became necessary to group more people and larger numbers of activities in the same space. The one- and two-story buildings began to grow into five- and six-story buildings and the engineer and the architect were called in to investigate the problems that came with this grouping. Engineering skill and ingenuity responded to this demand by bringing into being the modern skyscraper. Much of the progress of the country can be traced to instances in which the engineer made two things grow where one had grown before.

The growth of business enterprise concentrated in small areas has resulted in increased expansion of the telephone plant and it has become necessary to adapt the central office equipment to the skyscraper idea. The equipment design of the step-by-step machine switching system has recently been developed to fit in with this tendency and large savings in building space are resulting. The selecting mechanism for routing a call through an exchange area is mounted on structural iron frames which were formerly nine feet high and were designed for buildings found in the various localities; in many instances they were placed in quarters rented in commercial buildings and even in dwelling houses. It is obvious that a frame designed to meet so many building conditions could not, in the nature of things, be economical for all of them, and it follows that the use of this kind of structure in the modern telephone building is generally wasteful.

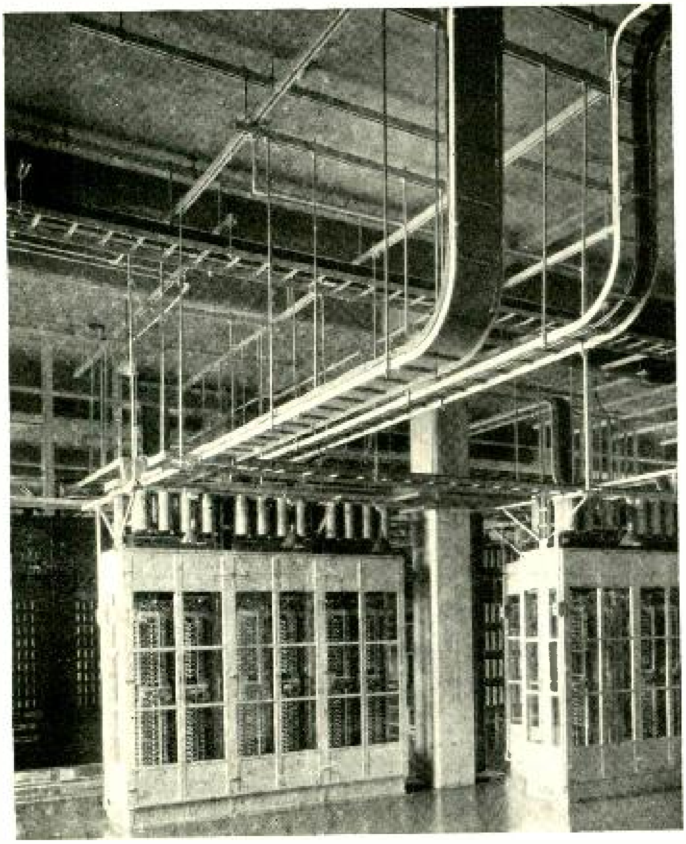


Part of a distributing terminal assembly, showing strap wires used instead of jumpers to group many switches on a small number of trunks

Extensive investigation in building design for telephone equipment has resulted in the establishment of fundamental dimensions for column spacing and ceiling height to which the equipment engineer has adapted the supporting structure for machine-switching apparatus. The clear ceiling height is twelve feet six inches and the step-by-step selector frames, relay racks and distributing frames have now been redesigned to a uniform height of eleven feet six inches. This allows one foot above the frames to care for the interconnecting cables. Clearly, the eleven-foot-six-inch frame uses the available content of the modern telephone building more efficiently than was possible with the nine-foot frame.

Although increasing the height was the primary consideration, other improvements were incorporated in the new frames: better methods of wiring, greater accessibility of the equipment for installation and maintenance, more uniformity with other systems. The changes also have promoted the practical and economical handling of the equipment from a job-engineering and a merchandising standpoint. To obtain these improvements not all of the capacity gained by increasing the height of the frames could be turned into net saving, but part had to be sacrificed to gain other advantages somewhat less tangible but of great importance to the system as a whole.

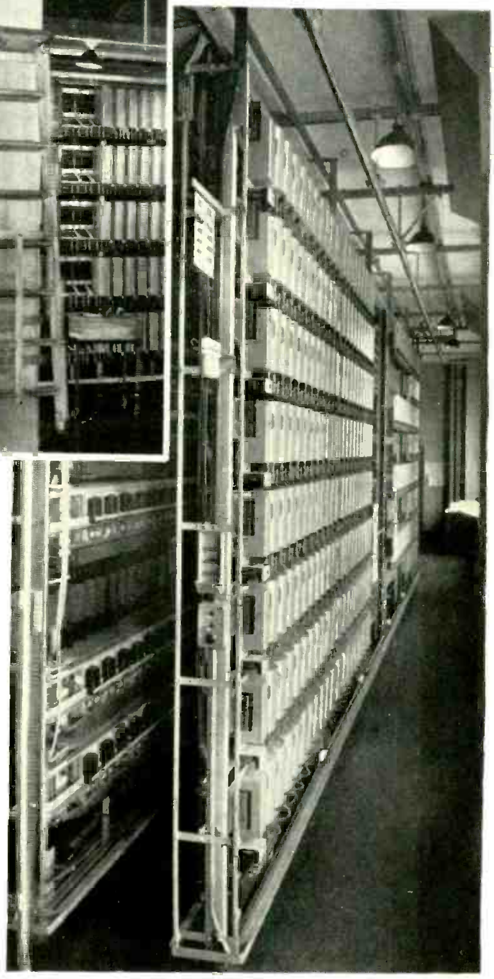
The low-type frames for selectors, repeaters and connectors consist of two bays or groups of shelves mounted on supporting frameworks and placed back to back. In the case of the selector frames, a means of terminating and distributing the trunks of the multiple banks known as the distributing terminal assembly closes one end of the space between frameworks. The selector frames mount six shelves, the repeater eight and the connector five shelves per bay. The new high selector frames mount eight shelves, the repeater frames twelve shelves, and the connector frames seven shelves per bay. Instead of being placed back to back, the two bays of the selector frame are in the same vertical plane with the distributing terminal assembly between them. The



Installation of 9-foot frames under a high ceiling at Reading, Pa. Length of the hanger-rods tells its own story repeater and connector frames are single-bay structures and are located in an office layout end to end in line, thus giving the step-by-step office parallel

Old-type connector frames at Reading, adjoining a distributing frame of standard height

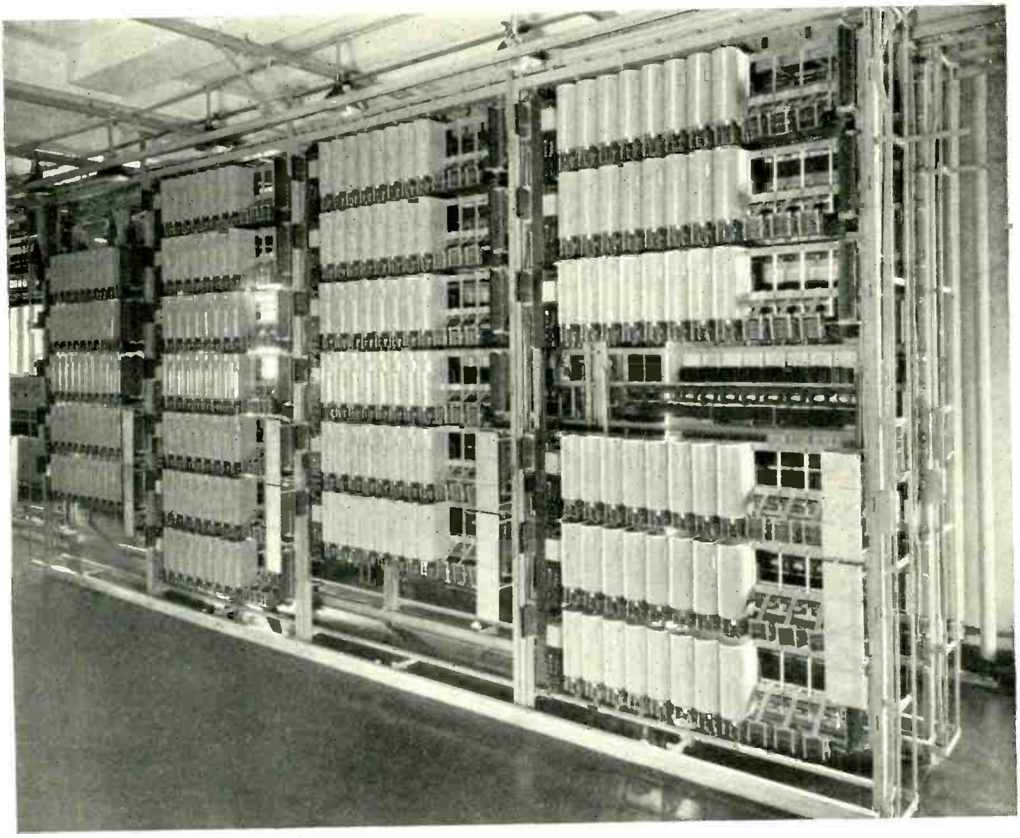
lines of single-sided frames. The wiring sides of these frames are placed facing each other with an aisle between them. Since there is little maintenance required on the wiring side, the aisle space allowed is sufficient to permit the maintenance man to work without cramping, but the aisle is not wide enough to be used as a thoroughfare. However, a wider aisle is used on the apparatus side where the bulk of the maintenance work is done. In the case of the double-sided nine-foot frames there was, under the worst conditions, less than twelve inches aisle space between the apparatus on the inner or wiring side. This made the wiring, particularly the distributing terminal assemblies, very inaccessible. With the frames in a straight line and the minimum of one foot eight inches between the guard rails the accessibility of the equipment has been very much improved.



Two of the first high-type selector frames, as installed at Springfield, Mass.

Notwithstanding the increased aisle space, floor plans of various offices, which were laid out with the new frames, showed an average saving of twenty per cent in the space required for the frame equipment. In some cases this saving ran as high as thirty per cent. An important result is that the use of high frames will often postpone large investments in additions to existing buildings. In one instance it was found possible to place three central-office units in a building where only two units of the old-type frames could have been installed. There are also many intangible savings in floor-plan space, as illustrated by the fact that at one of the earlier offices the Telephone Company's engineers desired to place two complete units on a single floor for economy in cabling and maintenance. They could not have done this using nine-foot frames but did accomplish it by installing the high frames.

The economy of this design is reflected in the Associated Companies' orders for high frames for additions to existing central offices. In the original plan it was not proposed to use the high frames extensively on additions except where the originating unit was small in comparison to the ultimate office and where the present floor plan lent itself readily to the use of the high frame. Changing the floor plan of an office generally involves some cabling difficulties and complicates the alarm equipment and maintenance and is, therefore, not resorted



High-type connector frames under a high ceiling at Springfield to unless other substantial economies may be realized. There have been a number of cases, however, where the use of the high frames on small additions made it possible to care for the equipment without additions to the building. A saving of twenty per cent in floor space also represents a saving in cabling, since the frames and equipment can be mounted nearer other apparatus to which they are cabled. The line finders and connector frames, for example, may be grouped nearer to the intermediate distributing frames; the associated cable runs are the most expensive in the office.

The high frames of course require rolling ladders for maintenance work since fifty per cent of the equipment is out of reach of a man standing on the floor. However, it has always been necessary to maintain one-third of the low-frame equipment from a stool or some form of portable ladder. It is rather difficult to express quantatively the relative convenience of the two schemes, but it is believed that experience in the field will show that the easy accessibility of the frames will offset the disadvantages inherent in the use of rolling ladders.

The more accessible arrangements of the distributing terminal assembly has greatly facilitated the interconnection of punchings by means of strap-wiring. These connections are often very complex, since they serve to distribute the traffic by giving any desired number of selectors access to a group of trunks.

Although the floor-space saving will be the major economy resulting from the use of the high frames, there are other not inconsiderable savings. Each of the shelves to be mounted on the frames consists of a fully wired unit with the local cables connected to the terminal strips in the factory. The installer's work is thus reduced to a minimum since he is only required to erect the framework and connect the switchboard cable to the terminal strips. Any shelf can be mounted in any position on the frame, and without re-forming cables after the remaining units have been installed. The flexibility inherent in shop-wired units makes quicker installation of the equipment possible and the rearrangements for additions comparatively simple.

The first step-by-step machine-switching office using these new frames was placed in service at Sioux City, Iowa, on May 1, 1927. A number of offices of this type are now being installed and all new offices will make use of these improvements.

The Life History of an Adsorbed Atom

By JOSEPH A. BECKER
Research Department

WHEN one substance is held on the surface of another it is said to be *ad*sorbed; if it penetrates into the interior it is *ab*sorbed. This article tells the story of what happens to an atom of, say, caesium or thorium when it strikes the surface of a tungsten filament.

In the telephone business we are interested in the story because adsorption phenomena play a vital part in the oxide-coated filament which we use in most of our vacuum tubes. This filament, while it is the most efficient and most generally suitable filament for commercial purposes, represents a complex case of adsorption and electron emission phenomena. Hence it is desirable to study simpler types of filaments in which adsorbed particles make it easier to boil out electrons. Our interest in vacuum tubes is so great that we cannot afford to neglect anything which promises to give us cheaper electrons. To free these electrons it is necessary to heat the filament. Practically all this heat is wasted energy. For the same amount of this wasted energy, a tungsten filament whose surface is covered with thorium will yield 100,000 times as many electrons as the clean tungsten filament; and if the surface is covered with caesium this yield is 100,000,000,000,000,000,000 (1 with 20 zeros after it) times as great. Little wonder then that the habits of such adsorbed atoms should be studied.

The chemist is interested in adsorbed atoms because they are the keystone to catalysis. The mysterious phenomena of catalysis are bound to play an increasingly important part in the history of civilization. By means of it new and useful compounds will be made; our food and fuel supply may be augmented. Even now we depend on catalysis for many essential products.

The research physicist is interested in adsorption because it opens up a new world of study. The physicist knows a good deal about the structure of the atom, how atoms behave in the gaseous state, what they do in the solid and liquid states. Until recently what happened on the surface was little understood. The study of the emission of electrons and positively charged ions from the surfaces of hot bodies has given the physicist a powerful tool with which to pry open the secrets of this new surface world. Due to this study, a good deal of which has gone on in our laboratories, a fairly complete picture of this new world can be given. When a caesium atom strikes a clean tungsten surface it is ionized, that is, it gives up its valence or outermost electron to the tungsten and becomes positively charged. This exchange takes place because the tungsten surface has a greater affinity for electrons than the caesium atom. The positively charged ion induces a negative charge on the surface and since the distance between them is about two one-hundred millionths centimeters the electrical field between them is simply huge—larger than any that man can produce—and the caesium is held by very strong forces. In fact it will stick to a tungsten surface at a temperature of 800 degrees C. for an appreciable time, even though solid caesium at this temperature would explode with terrific force and become a vapor.

The strong electrical fields produced by the adsorbed caesium are in such a direction as to help pull electrons out of the tungsten. That is why such an enormously greater number of electrons boil out of caesiated tungsten surface than out of the clean tungsten surface. Of course, after the tungsten surface is completely covered no more electrons can be pulled out of it and the electrons must come from the caesium itself. This explains the rather startling fact, shown by experiment, that electrons are more easily obtained from partially caesiated tungsten than from thickly covered caesiated tungsten or from pure liquid caesium itself.

C. J. Calbick and J. A. Becker with the apparatus which yields information on adsorption phenomena

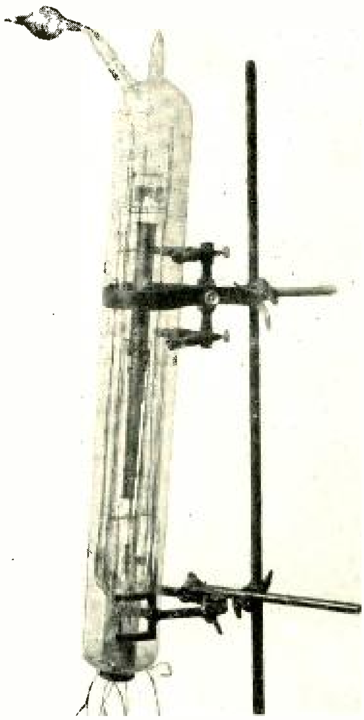
Since these strong fields are in a direction to help the negative electrons escape from the surface we should expect that they would hinder the escape of *positive* ions. Here again experiments beautifully confirm the hypothesis and show that if a few caesium atoms can be made to stick to a hot tungsten surface the rest stick more easily.

Of course, if the temperature is too high the caesium atoms that strike the surface will not stay very long, but they stay long enough to give up their valence electron and then they evaporate as ions. Under these conditions every atom that strikes the surface comes off as an ion.

If the temperature is lowered somewhat, a few caesium atoms stick, then the rest stick more readily; in fact for a while every atom that strikes sticks until about one-fourth of the surface is covered. By now the affinity of the surface for electrons has been partially satisfied and hence not every atom that strikes is ionized. Experiments show that in this condition both atoms and ions evaporate.

If the temperature is lowered still further, the surface is covered still more and now only atoms evaporate. If the temperature is low enough the surface is more than completely covered.

These evaporation characteristics were deduced from a long series of experiments which revealed the number of atoms that were adsorbed under various conditions and how this number was related to the number of atoms and ions that evaporated at various temperatures. When one reflects that atoms are so small that we can never hope to see an individual one and also that they are uncharged and hence cannot be measured as a current of electricity, it seems marvellous that experiments should exist which permit us to practically count the atoms that are adsorbed.



This complex vacuum-tube is used to study adsorption of caesium on tungsten

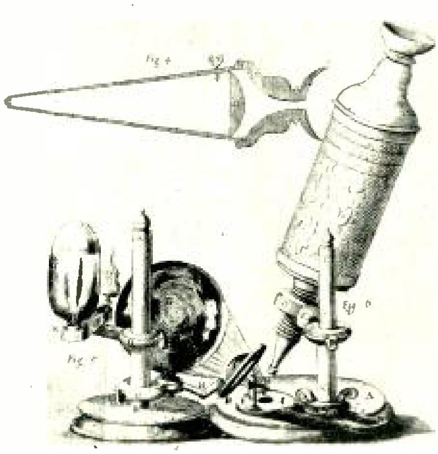
A life history would be incomplete if it did not tell how long an adsorbed atom stays on the surface. Of course, the length of life depends on the temperature; due to the strong electrical fields by which one atom or ion influences others, the life also depends on the number adsorbed. These two factors determine the life; and if the adsorption characteristics mentioned above are known, the number of seconds that an adsorbed atom spends on the surface can be deduced. Thus at a temperature of 500 degrees C., at which an object is just visible in a dark room, and when the surface is half covered, an atom will, on the average, stay for 40 seconds. This life is about a million times as long as that for a caesium atom on bulk caesium at the same temperature.

Finally, a life history should tell us whether or not an adsorbed atom moves over the surface and if so how far. Heretofore chemists, who have done most of the work on adsorption, have assumed that adsorbed atoms are held most firmly by the "active centers" in a catalyst and that these were the edges and corners of the surface crystals. The experiments with caesium and other adsorbed substances show unquestionably that the atoms are not bound to any one spot on the surface but that they move about like a two-dimensional gas or like drops of water on a red-hot stove. If an atom were the size of a tall man and were born in New York it might die in Paris after having made numerous side-trips around the world.

A Tour Through the Microscopic Laboratory

By ANNA K. MARSHALL
Apparatus Development Department

WHEN one reads of the struggles of the early microscopists to learn more of the world about them, great admiration for their courage is aroused. They had at their disposal no such array of apparatus as has the present-day worker; in fact, they had to begin by making their own microscopes. Nor had they the public's support and confidence; their work was not completed until by diligent showmanship they had proved to a hard-headed world the new facts they discovered.



Hooke's Microscope, a striking contrast with the precision instrument of today

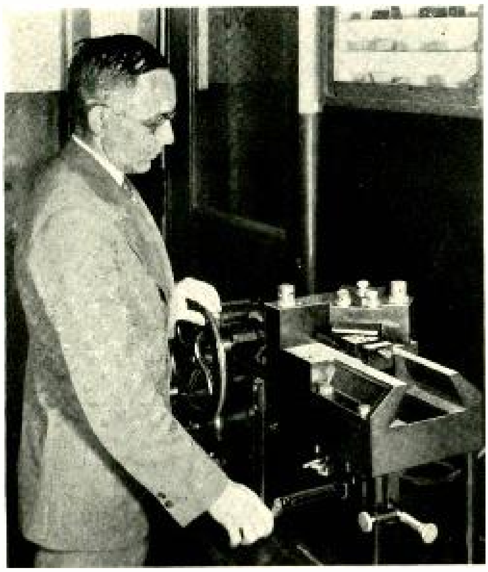
For some reason every early worker in this field labored long and diligently in a "dusty, stuffy room." That seemed to be considered a necessary part of such work. With what awe those men would look upon the spacious, shining quarters utilized for a microscopic analysis laboratory in our Bell Telephone Laboratories! Housed on the court side of the recently built steel frame and masonry structure, this laboratory has the unique privilege of having every inch of its rooms arranged in exactly the manner most desirable for easy and efficient use of the apparatus.

By the arrangement in the new laboratory there is an absolute separation of work, three phases being recognized as essential. There are three rooms,—the preparation room in which specimens are prepared for their subsequent study under the microscope; the operating room in which the various kinds of microscopes are placed for the study of specimens; and the darkroom for completing the pictorial proof of the observations made in the microscopic researches.

The preparation room is a complete laboratory in itself. Here the specimens are cut, ground, polished, etched and heat-treated as the case requires. This insures the microscopic apparatus in the operating room against all dust or acid fumes. The principal materials examined are metals, although as has been told* pre-

* Bell Laboratories Record, *Feb.*, 1926, *p.* 235.

viously, many telephone materials find their way into this laboratory for one reason or another. With the metals, as with any other work, it is a matter of experience to be able to prepare them easily. Here is at hand most modern apparatus for the purpose.



H. A. Anderson preparing to cut a specimen of lead cable sheath on the microtome

Those specimens which are too large for the purpose of examination are placed in a power hack-saw which cuts through a specimen, then automatically stops. The next step is to grind a flat surface. Very hard metals require the action of a coarse abrasive. And since this is a long process if done by hand, recourse is had to an electrically operated grinding wheel. The friction of two surfaces rubbed together causes heat, which is an unwanted factor during this operation since heat tempers metals, and their structure is thereby changed. To remove this heat, a stream of cold water is run over the specimen throughout the grinding process. This grinder has two wheels, a very coarse alundum wheel on one side and a finer wheel of emery on the other side. The latter is used for cutting specimens too hard to be cut with the power hack-saw. When the specimen has been sufficiently flattened, it is then carefully ground down by hand on abrasive papers of successively finer grades. Each paper is used for a period long enough to insure the removal of the coarser scratches made by the previous paper. During this work, the surface of the specimen must be kept perfectly flat. The abrasive papers are therefore

R. R. Ziegler puts the final polish on a steel specimen

laid face up on the plane surface of a heavy metal bench plate. After this process, the specimen is ready for polishing on electrically run discs, of which three are in use. In case the specimen must undergo a heat-treating process before it is polished for examination, both an oven and a furnace are available in the laboratory.

Another piece of apparatus in the preparation room appeals to general interest. It is a microtome of sturdy construction primarily intended for the sectioning of wood for microscopic study, but introduced by this laboratory into the role of a metal-sectioning apparatus. That is, soft metals such as lead, gold, aluminum, and copper are cut with a specially honed knife and in this way prepared for etching much more easily and with much clearer and more accurate results than by polishing.

After metal is either polished or cut, its structure can be brought out for study by the application of acids. The etching is carried on under a fume hood which is equipped with an electric blower to carry off all acid fumes as quickly as they rise, thus safeguarding the health of the workers as well as preserving the apparatus from the injurious effects of the acids.

A viewing microscope is kept in the preparation room and is used to watch the progress of the preparation of specimens. This microscope has an historical interest in being the first one used for successful high-power photomicrographs.

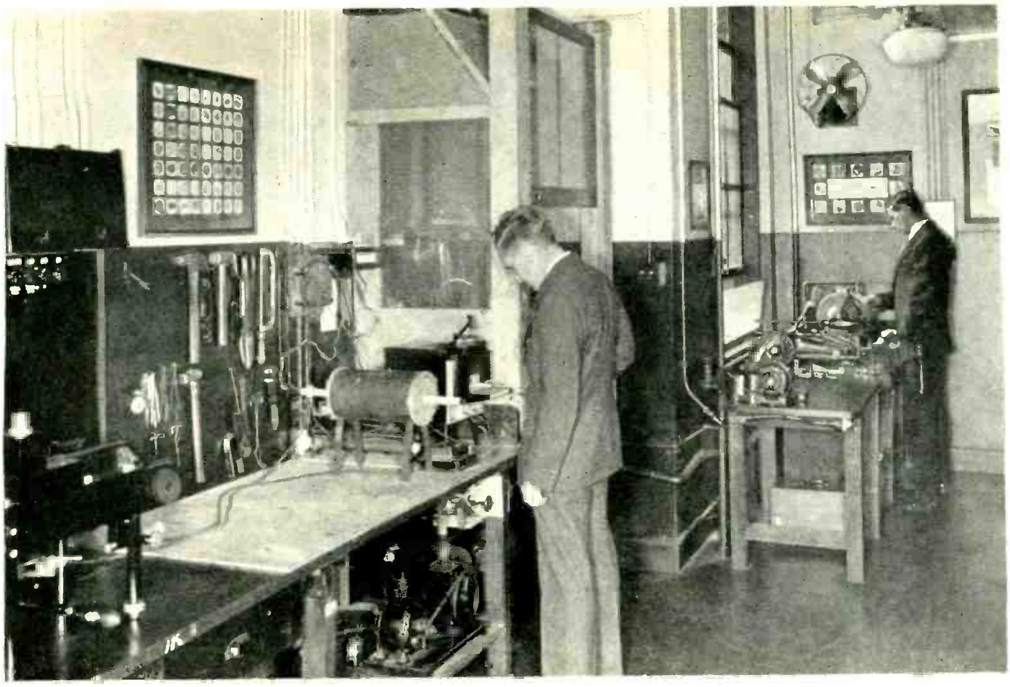
The other laboratory, which for convenience is called the operating room, is more than three times as large as the preparation room. Here are the microscopes of various kinds on which studies of the materials are made. If a large specimen is to be examined as a whole, it is placed on the outfit known as the gross metallurgical outfit which does not include a microscope at all but has a large stage for holding the specimen while it is viewed through low-power lenses up to a magnification of about thirty-five times.

For studying specimens that must be magnified higher—from fifty to six thousand times—a metallurgical microscope is used. The combination of lenses, eyepieces and bellows-extension gives the desired magnifica-

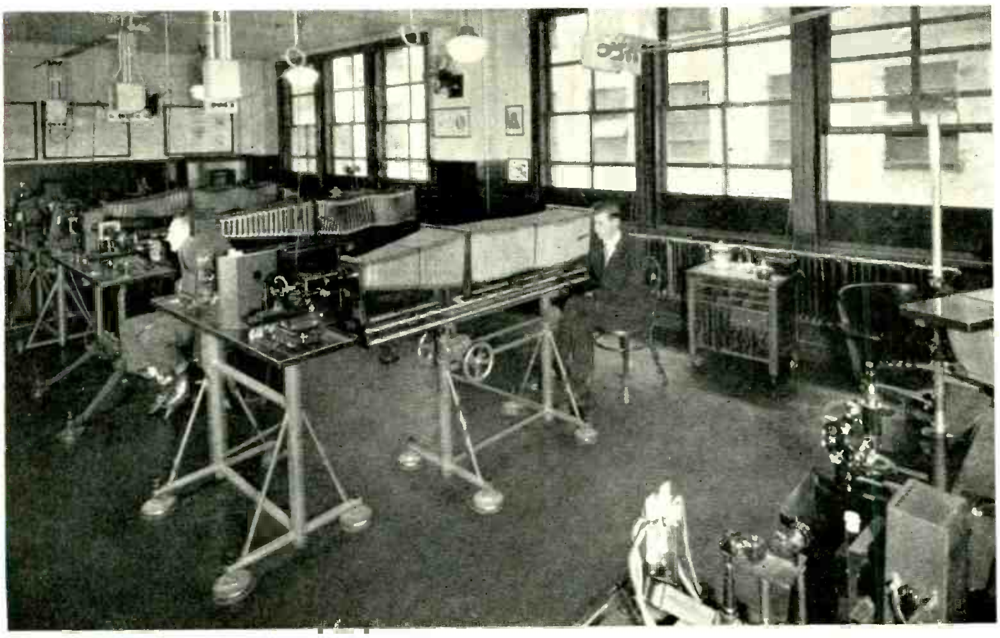
R. M. Sample uses the micro-manipulator

tion. The crystalline structure of metals and metallic alloys is studied in minute detail; conclusions are drawn as to the causes for defects in metals; changes are seen due to various treatments of the metals; and improvements are suggested.

The layman thinks of a microscope in terms of magnification or enlargement of the optical image over the dimensions of the object. He disregards the matter of resolution which denotes the ability of the microscope to "resolve" or produce sharp images of very small particles. It is known that by decreasing the wavelength of the light used, resolution

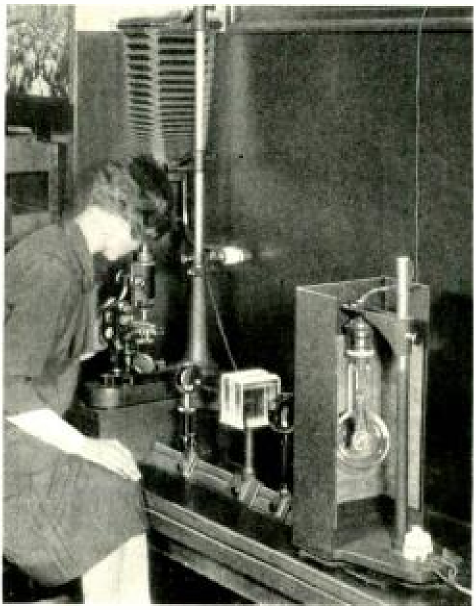


One corner of the preparation room. Mr. Sample about to place a specimen in the electric furnace; at the grinding wheel, Mr. Ziegler prepares a flat surface on a very hard specimen



The operating room with its array of microscopes. In the immediate foreground is the ultra-violet equipment may be improved. This fact led to the development of the ultra-violet microscope which utilizes very short wave-length light. Ultra-violet light is below the visible spectrum and consequently the eye cannot visualize with this light. In this microscope all optical parts are of quartz, as glass is opaque to ultra-violet light. The successful use of ultra-violet light on metallic specimens is a development of this laboratory.

The ultra-microscope is used for the study of colloidal solutions in solid or liquid form. A colloidal solution may be briefly described as one in which very small particles of matter are dispersed in a medium. The dimensions of the particles are usually considered to be sub-microscopic. The actual particles are not observed but their presence is made known as bright points by the light which they scatter. The colloidal solution is intensely illuminated and these particles shine brilliantly the same way that dust particles floating in the air of a darkened room are made visible by means of a beam of sunlight.



Miss Marshall adjusts the microscope before photographing a timber section

A microscope for viewing transparent objects is used for the study of such materials as wood, paper fibers, and porcelain. It was by this means that some interesting features of the microscopic structure of rubber were recently brought out.

Provision has been made for studying the effect of heat upon metals during the actual heating process. This is accomplished by means of the heat-microscope, a novel combination of furnace and microscope. The specimen to be investigated is placed in the small furnace, the heat turned on and a watch kept on the specimen by means of the microscope which is attached in such a position that the surface of the specimen is directly in the view of the observer.

Other apparatus in the laboratory includes the micro-manipulator, a delicately made affair for dissecting small specimens with the aid of the microscope. Its motion is made possible in any direction and for unbelievably short distances by means of small screws to direct the movements. In this way microscopic materials may be treated quite as though they had the size of visible materials. The micro-character tester makes a fine line along a metallic specimen; by the study of this line under the microscope one can see the relative differences in the hardness of the crystals which make up the materials under observation.

The dark-room is divided into two parts, and quite illogically, it would seem, there are no doors. Entrance is through a maze which effectively cuts off light from the first part, a room used only for the printing process. Another maze with black curtains leads from this room into the developing room where the plates are developed. Thus both printing and developing can be carried on at the same time without interruption or delay to either.

The photomicrographic laboratory is internationally known for its developments by F. F. Lucas, in the field of high-power metallography.

When this laboratory speaks in terms of high magnifications, it limits itself to the point at which it is able to obtain perfect detail and resolution. Its province is not merely to magnify to great power, but at the same time to obtain results which can be read by those who know the language of the photomicrograph. Highlights and shadows on the photographic print are full of meaning to the investigator as guide posts in his search for more serviceable and more economical materials for the Bell System.

An Official Appreciation

Assistance rendered by the Bell System to the Canadian Government in effecting a tie-in of Canadian broadcasting stations for the Diamond Jubilee Celebration has been acknowledged by Premier W. L. Mackenzie King in the following letter to President Gifford:

"The broadcast of the official ceremonies at Ottawa in celebration of the Diamond Jubilee of Confederation was a great success. Speech and music alike were heard throughout Canada and beyond, and grateful reports are being received daily. What began as a daring venture became an outstanding, unifying feature of the National celebration.

"The Government of Canada appreciates greatly the assistance, so readily and generously given by the American Telephone and Telegraph Company, by your direction, not only in counsel, but through the use of equipment and facilities which made possible the application to this National purpose the results of the scientific research by your System, to which the communications of the world owe so much.

"On behalf of the people of Canada who received the message, as well as on behalf of the Dominion Government, I tender appreciative thanks."

Winged Words

NEW York's cheers for Lindbergh were still resounding when the Lindberg Aeronautics Corporation soared into the spotlight. An individual with a name similar to that of the famous pilot was found, this name appropriated, the idea incorporated under the laws of Delaware, advertisements made for stock-selling recruits and preparations made to unload on cheering patriots from $10,000,000 to $100,000,000 of securities bearing Lindberg's name.

© Underwood and Underwood

Through Western Electric transmitters, Col. Lindbergh's words start their radio journey

The National Better Business Bureau and those of Philadelphia, New York, Cleveland and St. Louis, acting in concert, obtained and disseminated the facts. The bubble—"There's millions in the Air"—burst, and many good dollars consequently remained safe in the pockets of investors.

To the Better Business Bureau of Cleveland, in which city was discovered the innocent "Lindberg" whose name was taken by the promoter, Assistant Secretary of War Davison wrote:

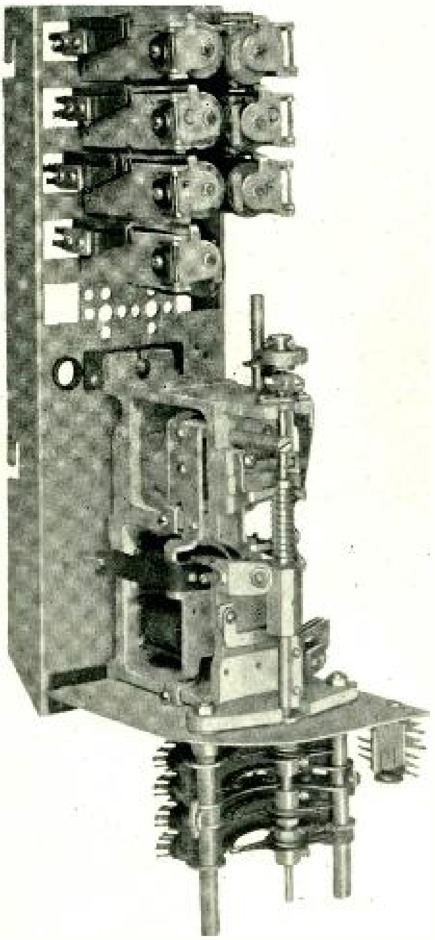
". . . The history of events shows that whenever some medium of general benefit to mankind is evolved the 'wild-catter' is usually on the job prepared to feast on the gullibility of those who look for quick and big profits."

The Bureau has investigated a large number of "investment" schemes, has published its findings in pamphlets available at its headquarters, 383 Madison Avenue, New York. Among these pamphlets are: Which Way Decimo?; Boston Curb Exchange; Universal Lock Tip; International Transportation Association; Read Before You Sign.

Cutting Expense Corners in Systems Drafting

By W. L. HEARD
Systems Development Department

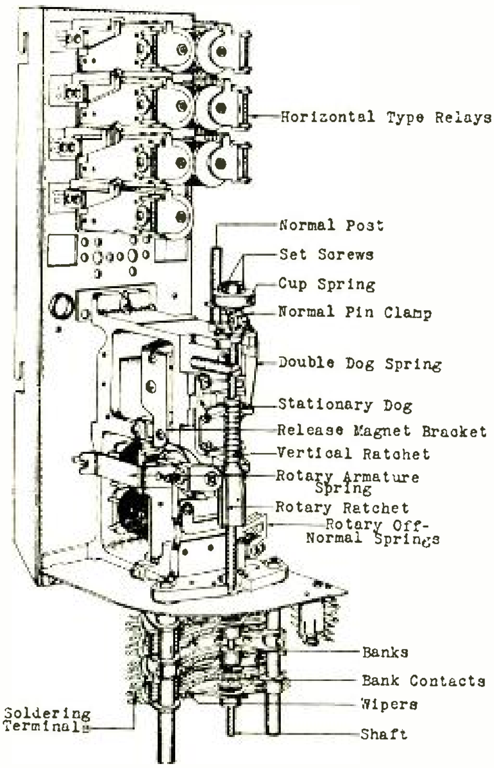
ONE often hears of the advancements which have been made in photography in the last few years, but few realize the extent to which it is used as an aid to the engineer. Some instances which are universally recognized, of course, are the blueprints and photostats made from the tracings and sketches used by the engineers. These are not, however, the only ways in which photographic processes may serve to simplify the making of intricate circuit and equipment drawings.



This half-tone was made from the photograph with which the process started

In connection with the preparation of certain of our engineering information, it is desirable to portray certain objects in three dimensions. In making perspective drawings of such things as sequence switches and connectors the amount of drafting time required is quite long and the work exacting. To reduce this time and its resultant costs, there has been developed in the Systems Drafting Department a scheme which has resulted in materially reducing the expense and time of making these drawings. The method used has all the flexibility, both as to change in size or modification of detail, that could be desired. It meets one of the complicating requirements that the drawings be made from one and one-half times to four times the size of the actual reproduction which is placed in our specifications.

The apparatus is first photographed. Over the resulting print a piece of transparent celluloid is placed to serve as tracing cloth. Upon this the photograph is then traced in free-hand. Celluloid is used because its greater transparency makes it easier to see the details of the photograph. The image on the celluloid is then en-

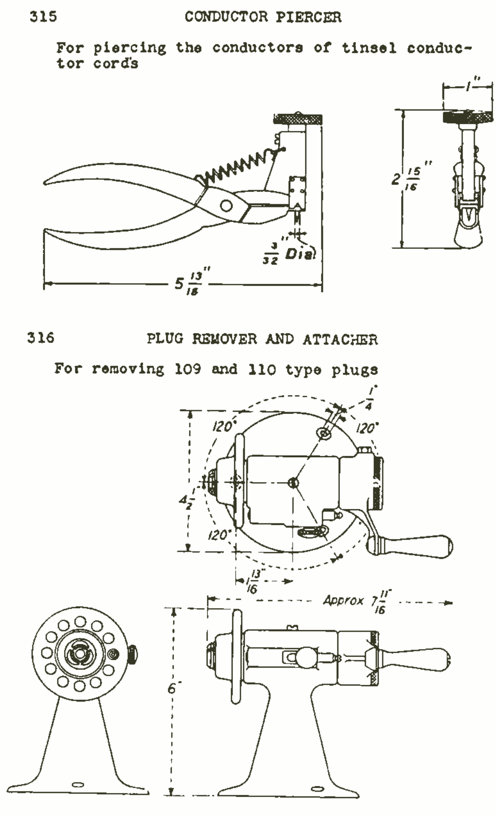


This line-cut was made from the zincographed print which is the final result of the process

larged by making a photostat the desired size. From this photostat the apparatus is traced directly on tracing cloth where the drawing is completed as to details, such as shading, lettering, and marking.

The final step, from the enlarged tracing with the added details and notes to the reduced reproduction that may appear on the specification sheet, is accomplished by a process known as zincographing. This is an interesting process which gives reproductions of sketches, typing, and similar information used in the preparation of engineering data, the only limiting factor being that a legible black and white original must be available.

The first step is to photograph the original or master copy, obtaining a negative on glass or paper, which may be either an enlargement or a reduction as desired. Portions of it may then be blocked out or other



Excerpt from a zincographed specification for cord-repair tools

parts inserted if necessary. The negative is next stripped from its plate or film, put on a large sheet of glass and backed up by a sensitized zincplate. This is then placed in a vacuum printing frame and given a brief exposure, after which the plate is removed, rolled up with ink, and developed. At this stage, the design stands out clearly in black ink on the surface of the plate. Corrections may be made on this plate or designs etched in as required. After these operations have been completed, the plate is ready for printing. The press used has two cylinders, around one of which the zinc plate is bent. This revolves and leaves an impression on a rubber blanket which covers a second revolving cylinder. This latter roller in turn transfers the impression to the paper.

Some of the advantages of the use of this method of printing are the prompt deliveries which can be obtained; from one to three days are required for the usual run of material. Considerable time and effort are also saved due to the fact that copies made in this way do not require elaborate checking, as is the case with material which must be copied or which must be set up on a regular printing press. This process can be used over and over with the same master; and the master copy can be changed again and again by blocking out and patching.

In the Systems Development Department, all specifications are now prepared by this method; and drawings and other data are furnished on this basis wherever the number of copies required will make the expense of this reproduction justifiable. Where a large number of copies are needed, which is often the case, this method is cheaper than blueprinting. Ordinary paper is used and the cost is not much more than that of the paper itself. With blueprints, on the contrary, there is little reduction in price due to quantity production since the sensitized paper is the main item of cost. In our Systems Department, over three million pages of such zincographed copy are produced a year, and these find distribution to all parts of the Bell System.

Some Bell System Statistics

Thirty-three machine switching offices are now in service in New York City, to which three hundred eighty thousand telephones are connected out of a total of two million two hundred thousand Bell-owned dial stations. These in turn are a sixth of the Bell stations, and almost an eighth of all telephones in the country.

The Bell System owns about three-fourths of the nation's telephones, nine-tenths of the wire used for exchange and toll service and about a third of the central offices. Parent and operating companies employ about five-sixths of the telephone workers.

Stockholders in the American Telephone and Telegraph Company on June thirtieth numbered four hundred twenty thousand, of whom seventy-three thousand were employees. In addition one hundred ninety thousand had purchases in progress under the terms of the Employees' Stock Plan.

Five New Telephone Pioneers

SO far in 1927 five of the Laboratories staff have become members of Edward J. Hall Chapter, Telephone Pioneers of America, an organization of those who early made telephony their life work. Its membership is open to employees of the Bell System or independent companies with twenty-one years or more of telephone experience. The new members are H. L. Bostater, G. W. Folkner, A. D. Hargan, E. E. Hinrichsen and A. W. Lawrence.

H. L. Bostater

Mr. Bostater joined the maintenance force of the Central Union Telephone Company at Columbus, Ohio, immediately after graduating from Ohio State University in 1904. The next year he was transferred to Western Electric at Clinton Street, Chicago, as an equipment engineer, and did almost every variety of work in that field, from writing specifications to supervising the standardization of circuits. In 1912 he came to the circuit laboratory here for development work on semi-mechanical call distribution. In 1915 and 1916 he worked on step-by-step equipment, and from 1917 to 1922 was in charge of its development. Since then he has been engaged in system development and cost estimate investigations.

G. W. Folkner

In February of 1906 Mr. Folkner started at West Street as a draftsman, and stayed until 1909, when he was moved to Hawthorne with the organization for manufacturing relays, drops and signals. In 1915 he was transferred to the technical end of panel machine switching development, at which he remained until the first three trial installations were in service, in Newark. Then, in 1915, he came back to West Street, to fit the designs of panel apparatus to the requirements of commercial manufacture.

Mr. Hargan entered the telephone business at West Street in 1906, in the switchboard section of the manufacturing organization. From 1913 to 1916 he was at Hawthorne in connection with switchboard manufacture; then he came to the engineering department at West Street for work on panel machine switching apparatus, in which he is now engaged.

Mr. Hinrichsen's experience start-

A. W. Lawrence

E. E. Hinrichsen

A. D. Hargan

ed earliest of this group, in September, 1901, for the Central Union Telephone Company. He worked all over Illinois at plant work of nearly every sort. In the spring of 1905 he went to the Interstate Telephone and Telegraph Company, an independent company at Aurora, Illinois, where he stayed a year. With this background of field experience he entered the equipment engineering section of Western Electric at Clinton Street, and later moved with it to Hawthorne. In the fall of 1908 he was moved to the circuit laboratory at West Street, and stayed there until his health made a rest necessary, in 1917. After returning he continued his former work, but in the present Systems Development Department, which had just been organized.

Mr. Lawrence's entire telephone career has been at West Street. He entered the engineering inspection section in the spring of 1906, and later was engaged for many years in design of special apparatus and modification of standard apparatus for specific field conditions. He is now in charge of special orders and of specifications for testing and laboratory apparatus, and for all telephone apparatus except that used in machine switching.

News of the Month

At the centenary exhibition of the Baltimore and Ohio Railroad, to be held near Baltimore from September 24 to October 8, the American Telephone and Telegraph Company will exhibit a telephone train dispatching system in operation, and representative telephone devices from the first switchboard to the latest developments of the Laboratories.

* * * *

Radio Engineer E. P. Hentschel and Junior Physicist J. D. Wallace, Jr., of the Naval Research Laboratory, were recent visitors to the Laboratories.

* * * *

S. P. Grace has been appointed a member of the Committee on Communication and of the Board of Examiners of the A. I. E. E.

Mr. Grace described some recent research work of the Laboratories on July 15 at the Tri-State Conference of the New York, Pennsylvania and Ohio Independent Telephone Associations held at Jamestown, New York.

* * * *

John Mills delivered a demonstration lecture at Chautauqua, New York, on July 19, accompanied by the film "The Magic of Communication" and illustrated by a public-address system and a set of head phones for those with impaired hearing. Mr. Mills was assisted by R. E. Kuebler, who had supervised installation of the demonstration equipment.

* * * *

R. V. L. Hartley and O. E. Buckley sailed aboard the Baltic on August 20 for Liverpool. From there they went to Leeds to attend the meeting of the British Association for the Advancement of Science, held from August 31 to September 7. September 10 to 15 they plan to attend the Technical and Scientific Congress of Telephony and Telegraphy to be held in connection with the Volta Centenary and Exposition at Como, Italy. Mr. Hartley is to read a paper on "Frequency Relations in Electrical Communication" and Mr. Buckley a paper on "High Speed Ocean Cable Telegraphy."

* * * *

F. F. Lucas is to present a paper, "A Resume of the Development and Application of High-Power Metallography and the Ultra-Violet Microscope," to the International Congress for Testing Materials at Amsterdam on September 12. While in Europe he is to visit the Carl Zeiss optical works at Jena for a conference of a week or more with their scientific staff on development of new high-power photomicrographic equipment. He has been invited to attend a conference with the staff of R. Jung Company, Heidelberg, on preparing metallic specimens with a microtome, and to visit the Leitz works at Wetzler, Germany. Before returning he will visit metallurgical works and laboratories in Germany, Holland, France, Belgium and England.

* * * *

W. L. Tierney recently visited broadcasting stations using Western Electric equipment at San Francisco, Tacoma and Seattle. He is now supervising installations of a one-kilowatt set for the Gurney Seed Company at Yankton, South Dakota.

Operation of the five-kilowatt transmitting station installed under supervision of H. S. Price for the Stromberg-Carlson Telephone Manufacturing Company at Rochester, New York, is scheduled for the early part of this month.

W. L. Black is in charge of installation of elaborate speech-input and control systems at the Sagamore Hotel and the Eastman School of Music for use with the broadcasting station.

On July 27, F. S. Bernhard completed installation of one-kilowatt broadcasting equipment for the Milwaukee *Journal.*

H. R. Kimball was at Hawthorne during August installing and testing a test set for measuring the reflection coefficient on single channel carrier telephone systems.

From July 17 to 26 F. B. Monell was at Hawthorne in connection with equalizers for the reproducers of Movietone equipment.

E. Montchyk and J. T. Butterfield were for a time in Boston for the study of 1-A bearings, used on the driving shafts of machine switching frames.

H. N. Van Deusen, J. R. Townsend and H. G. Arlt spent the week beginning August 1 at Hawthorne for conferences regarding specifications for sheet metals, standardization of screw threads and standardization of metal finishes.

H. S. Smith is now at Hawthorne in connection with the development of a special cord for use with dial telephones.

B. Friele was in Utica, New York, August 11 in connection with modification of frames and covers for step-by-step switches.

* * * *

W. A. Boyd, H. F. Kortheuer and R. M. Moody recently attended Inspection Survey Conferences at Hawthorne. Similar conferences at Kearny were attended by H. F. Kortheuer and T. Mellors.

E. F. Helbing went to Springfield, Ohio, in connection with new gasoline equipment for type "T" engines made by the Foos Gas Engine Company. During the latter part of July he visited the factory of the Midwest Air Filters, Incorporated, at Bradford, Pennsylvania, to inspect equipment used in testing air-filter units.

During the second week in July, P. B. Almquist, Local Field Engineer for the Inspection Department at San Francisco, was in Portland and Seattle in connection with field work in his territory.

* * * *

C. H. Amadon was in Brookline, Massachusetts, during August for some timber preservation experiments.

On July 29, E. St. John witnessed impact tests on steel manhole covers at the factory of the Central Iron and Steel Company in Harrisburg, Pennsylvania.

E. M. Honan and J. B. Dixon visited the American Brass Company's plant at Ansonia, Connecticut, on July 26 and 27.

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J. L. Dow, E. H. Smith and D. H. Wetherell attended the cutover of the new step-by-step machine-switching office at Springfield, Massachusetts. This is the first such office entirely of Western Electric manufacture.

Modifications in picture-transmission equipment are being tested by C. E. White and E. P. Bancroft at Chicago and San Francisco, respectively.

R. H. Miller visited Albany, Buffalo, Syracuse and a number of other cities in connection with methods of toll operation.

H. H. Spencer spent several days at Manchester, New Hampshire, testing telegraph ground-potential compensators.

A. R. Kemp and C. L. Hippensteel were at Providence, Rhode Island, August 9 to 12, to inspect the rubber compression testing machine which is being built for the Laboratories by the Henry L. Scott Testing Machine Company.

H. Boving returned to the Laboratories on August 15 after spending three weeks at Hawthorne on the development of enameled wire.

R. M. Burns left for the Pacific Coast on August 12, where he is to spend two months visiting Seattle, San Francisco and Los Angeles investigating cable sheath corrosion and examining samples that were set in the field last year.

R. E. Waterman went to Boston August 11 to visit Montan, Incorporated, in connection with some wood preservation tests.

H. A. Larlee and W. G. Breivogel recently returned from Hawthorne, where they had been working on problems of manufacture of telephone sets.

F. F. Farnsworth recently returned from a two weeks' stay at Hawthorne, spent principally in work on simplification of metal finish practice.

Club Notes

THE 1927-28 bowling season will open on Friday evening, September 30, at Dwyer's Manhattan Alleys, 1680 Broadway, the same place which was used for the 1926-27 tournament. The league will be divided into three separate groups; a fourth will be organized if demand is great enough; placement of the men in the individual groups will be based on their average for the previous season. For the past four or five years the league has been composed of twenty-four teams, but now the number of men desiring to bowl as regulars is increasing. It will be possible to engage twenty-eight alleys instead of the usual twenty-four if enough men are interested, and so it is hoped that those who have not yet filled out their application blanks will do so at once to enable the committee to complete their arrangements. Those who have not received blanks should call G. A. Brown on Extension 881.

A new feature in the contract for this season is free instruction to league members given by a prominent bowler of national reputation, between the hours of noon and 2 P. M. from Monday to Friday. A committee will be appointed to arrange in advance for this instruction, and to decide on the hour and day for our league members. A bowler receiving instructions will be charged the regular bowling fee of twenty-five cents a game.

This year a gold medal will be given to the bowler making the high score rolled in each group, instead of one medal for the high score in the three leagues.

Success of the league depends greatly on the number of substitutes available. Each week some of our regulars are missing and their places filled by men who like to bowl occasionally. It is therefore the desire of the committee to have these men submit their names as part-time bowlers. No previous experience is necessary; our system of handicapping covers everyone who is desirous of bowling whether his average is one hundred or two hundred.

Bowling officers for the 1927-28 season are as follows:

A. F. Gilson, General Chairman.
G. A. Brown, General Secretary-Treasurer.
F. H. Graham, Chairman Group "A."
G. B. Small, Secretary-Treasurer Group "A."
A. G. Eckerson, Chairman Group "B."
B. Leuvelink, Secretary-Treasurer Group "B."
E. R. Smith, Chairman Group "C."
W. H. Berthold, Secretary-Treasurer Group "C."

Golf

The Fall Golf Tournament, consisting of two rounds of medal play, will be held on two Saturdays in September at the Salisbury Country Club, Garden City, Long Island. On September 17 twenty-eight golfers will qualify for the finals, which will be played on September 24. Those qualifying will be divided into two classes, the twelve players with low gross scores in Class A and the remainder in Class B.

In the qualifying round prizes will be given for the two best gross scores and for the two best net scores. Prizes in the finals will be awarded to players having the best gross score and the three best net scores in each Class. Entry blanks must be filed with D. D. Haggerty, Room 164, not later than September 10, accompanied by an entry fee of two dollars.

The golf committee has just completed the revision of the Club handicaps which may be had by calling at Room 164.

Music

The Club orchestra will resume its activities on Tuesday evening, September 27. The orchestra has made steady progress since its organization three years ago, and plans are under way to make the fourth season the best ever. The committee in charge of music is now considering employment of a paid director for the activities of the music group. A hearty welcome will be extended this year to all new members. If you are planning to attend the rehearsals for the 1927-28 season, kindly communicate at once with the business manager, W. A. Krueger, Room 81, extension 798.

Dance

The first dance of the fall and winter season will be held Friday evening, October 7, on the roof of the Hotel McAlpin. The music will be furnished by Deacon Johnson and his entertainers, formerly of the Hotel Astor and the Bellevue Stratford.

Attendance has been limited to five hundred by the management of the Hotel McAlpin, so it is advisable to purchase tickets at once. Admission will be $1.10 each, including tax. No tickets will be sold at the door. D. R. McCormack will manage all of our dances and entertainments for the 1928 season.

Hiking

This month there will be two hikes and two campfire suppers. September 10, the trail leads through Westchester County from Heathcote to Nepperhan, about eight miles, with Phyllis Barton as leader and hostess. Those who are going should notify her. The group will leave the entrance to the new building at 12:30, and the expense will be about a dollar. The other hike will be from Arden to Tuxedo, a distance of about fifteen miles. It will take place on Sunday, September 18, and will be led by T. Temple. Miss Barton would like to hear not later than the previous Friday from those who intend to go. The train leaves the Erie station in Jersey City at 9:00; a ten-ride ticket will be bought for the group. Total expense, about $2.25.

Two campfire suppers will be held on the Jersey shore, at Englewood, on September 15 with Miss Barton as hostess and along the river on September 27, when Miss Brisbane will be hostess. To enjoy either evening meet at the entrance to the new building at 5:10 and bring along sixty cents.

Athletics for Women

Swimming. Although seashore and lake swimming are most to be desired we certainly have a good time in the pools during the fall and winter months. This year there are to be two classes for the women at the Carroll Club pool, one on Monday evenings from seven o'clock to seven-thirty, and the other a continuation of the spring class on Wednesday from five-thirty to six. Both of these classes will run through a ten-week period; at the end of that time a new class will be formed for those who wish to continue the instruction. The cost will be $2.50 for eight lessons.

Basket Ball. While we are planning a swimming class for Monday nights, this should not in any way interfere with the Basket Ball games which will also be held on Monday nights. This season we are planning to play at the Manhattan Trade School Gymnasium, which is larger than our court last year. We hope that all members of last year's team will come out and many more. Our plans for the season are not completed as yet, but we hope to have plenty of good snappy practice work up to the first of the year and after that to have games scheduled for almost every week to the end of the season. We want everyone interested to sign up because we will need the best players we can get to represent the Club in both the Modified Girls' Rules and the Boys' Rules teams and to do this we will want those who are just starting to play the game as well as those with experience. The best player makes the team. Come out and try for it.

We will also appreciate information regarding any outside girls' teams in order to make up our schedule. If you know of one let Marie Boman know, so that she can get in touch with the manager.

Riding. We still have some tickets available for riding at Unity Riding Academy. These are one dollar and a quarter for one hour's riding. If you would like to try the horses see Marion Gilmartin for tickets.