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Bell Laboratories and the War

THE importance of electrical communication in war and the importance of Bell Telephone Laboratories in those arts of communication were manifest in the First World War. The Laboratories, at the time operating as the Engineering Department of the Western Electric Company, made several important contributions to the war effort of the United States. First was its contribution to the facilities and services which Bell System Companies provided during the hectic years of 1916-1918, when munitions plants boomed in cities where normally telephone traffic was relatively light and when Army camps and Navy stations arose in widely separated and almost uninhabited sections.

Only a couple of years earlier the Laboratories' research program had resulted in extending the possible range of telephone service to transcontinental distances. Vacuum-tube repeaters and circuit arrangements which were developed for the first transcontinental line were rapidly applied to improving the quality of telephony and increasing the distance over which it was possible. The 1915 transoceanic experiments in radio telephony, from Arlington, Virginia, to Paris and from Arlington to Honolulu and Panama Canal points, developed principles which were applicable immediately to wartime problems of radio telephony.

The vacuum tube had also been put into service in 1917 in an experimental carrier current system for multichannel transmission over wire circuits. Carrier current telephony, because it permitted three or four additional messages to be transmitted over the same pair of conductors, proved of great value in meeting the sudden demand for additional facilities between cities of importance in the wartime program of munitions production.

Because of its background of experience and techniques and because of its highly trained force of scientists, engineers and technicians the Laboratories (*i.e.*, the Western Electric Engineering Department) was called upon to make many developments for the Signal Corps and for the Navy. A prominent outgrowth of this background of knowledge was a radio telephone system between ground and airplanes in flight—first demonstrated to the Army at Wright Field in August, 1917.

The arts of electrical communication are adaptable not only to communication between human beings but also to communication between man and machines, or between machines and man. The remote control of a switching mechanism at a telephone central office which is accomplished by dialing is an illustration of a system for communication between man and machine. Another is the operation of a distant typewriter by what is typed at the sending station of a teletype system. Of the converse case, the most popular illustration is television where a mechanism scans a distant scene and re-creates it for an observer. In wartime all these varieties of electrical communication are important in military operations. There must be communication not only between the human beings who are engaged but also between these humans and machines. Mines, for example, are fired by remote electrical control. Information transmitted from machine to man serves to detect the presence of an airplane or of a submerged submarine. An unconscious communication from man to man is illustrated in the detection of miners and sappers by properly placed listening devices. Electrical systems for many of these types of military communication were designed in the Laboratories during the First World War. Important also in military operations is privacy or essential secrecy in communications between operating units; equipment and methods for sending coded messages were other outgrowths of the Laboratories' ingenuity and experience.

The personnel of the Laboratories also contributed individually to the war effort by volunteering for service, usually in the Signal Corps, because of their specialized training. The nucleus of the Division of Research and Inspection which the Signal Corps established near Paris was drawn from the Laboratories. Its officer in charge was the late Lieutenant Colonel Herbert E. Shreeve; and Major O. E. Buckley, who is now President of the Laboratories, was in charge of its Research Section.

Now, in this World War, the Laboratories is again called into action for the assistance of the military forces. The problems presented to it are of the same general type as before. The Laboratories must develop improved communication facilities for Bell System Companies; and it must develop or improve a wide variety of specialized systems for military communication. The armed forces, whether on land, at sea or in the air, must communicate between their various units and with their bases and with their Government headquarters. This communication must be rapid, reliable and highly secret. There must also be communication between their mobile units, between tanks, airplanes, ships or submarines; and there must be machine-to-man systems for communication which can be used to detect and localize those of the enemy. The speeds, however, with which these vehicles can move are today many times what they were in the first war—a result, of course, of the general advances in scientific knowledge.

Correspondingly more difficult, therefore, have become the problems of detection and localization and of communication in general. On the other hand, the art of electrical communication has advanced during the past two and a half decades, fully as rapidly as the other arts which are of service in wartime. Its apparatus and techniques are today far superior to those in the earlier war. The Laboratories today is an organization with a long and successful background of experience and it now has more scientists and engineers with a broader overall range of scientific and engineering abilities. It has a larger force of draftsmen, mechanics, instrument makers and other technicians. The experience of its entire force, men and women, is greater and their individual abilities certainly no less than in the earlier conflict. And their loyalty and determination to do their utmost in this national emergency are deep seated and strong.

In the present World War the military problems on which the Laboratories works come to it from several sources. First is the National Defense Research Committee. This organization was created by President Roosevelt in 1940 with authority and funds to promote researches of importance in the program of national defense. Its membership includes representatives of the Army and of the Navy and leading research men from universities and industrial laboratories. One of its eight members is Dr. F. B. Jewett, Vice-President of the American Telephone and Telegraph Company. On some of its subcommittees are members of the Laboratories.

The N.D.R.C. farms out to academic or industrial laboratories various research problems which its experts feel might lead to military equipment of great value in the present struggle. Its program was well under way by the time of Pearl Harbor and it had started on a large variety of military problems. Over thirty of its communication projects had been assigned to the Laboratories under contracts made with the Western Electric Company and were progressing rapidly. By the middle of 1942 the number of projects assigned to the Laboratories had increased to over a hundred and twenty-five.

The peculiar advantage of the N.D.R.C., as an organization, lies in the fact that it allows our Government to do, in the broad field of military arts, the same sort of thing that the Bell Telephone System has done for years in the communication arts. In our System, the American Telephone and Telegraph Company supplies funds to the Laboratories for work basic to the electrical arts of communication. In carrying this out, fundamental research work is undertaken but nobody knows what, if anything, of value will come from any particular research; however, from past experience everyone knows that some new principles, devices, discoveries or inventions will arise and that in time most of them will lead to useful developments and equipment. After the equipment has been designed it can be specified to the Western Electric Company for manufacture. And after that company has decided on the most economical process of manufacture, the Operating Companies of the System can be advised of the availability of certain types of equipment adapted to certain functions of communication.

Through the N.D.R.C. that sort of flexibility becomes possible to a larger extent in Government operations. The Army and the Navy, for example, under the law must buy equipment on a specification basis, suitable for bids by one or more manufacturers. In other words, they must be able to describe concretely what they wish to buy. Because the results of research are unpredictable they cannot buy research services that may or may not develop something to fit their immediate problems. They cannot directly contract for the exploratory pioneering work of research upon which important but unforeseen developments can later be based. The organization of the N.D.R.C., however, permits exactly that desirable operation. It can start research projects, drop them if unfruitful and follow any leads they develop. And through the Army and Navy representatives on the committee the various research programs can be chosen with reference to military necessities. When a project has led to principles, devices or techniques that can be embodied in apparatus of probable military value, the Army or the Navy comes more formally into the picture. They can then introduce their additional technical requirements and contract in the usual way for the manufacture of the apparatus which the research has projected.

The Laboratories is working on a considerable number of apparatus development projects of this character, under contracts made by the Western Electric with the Army and the Navy. There are some contracts covering equipment and devices that have derived from the Laboratories' continuing development work and have been found to be of military value. That is particularly true of radio telephone systems where the Laboratories has long been in the lead. Also, there are many contracts covering developments which have arisen entirely from the requirements of the Army and the Navy and on their direct orders.

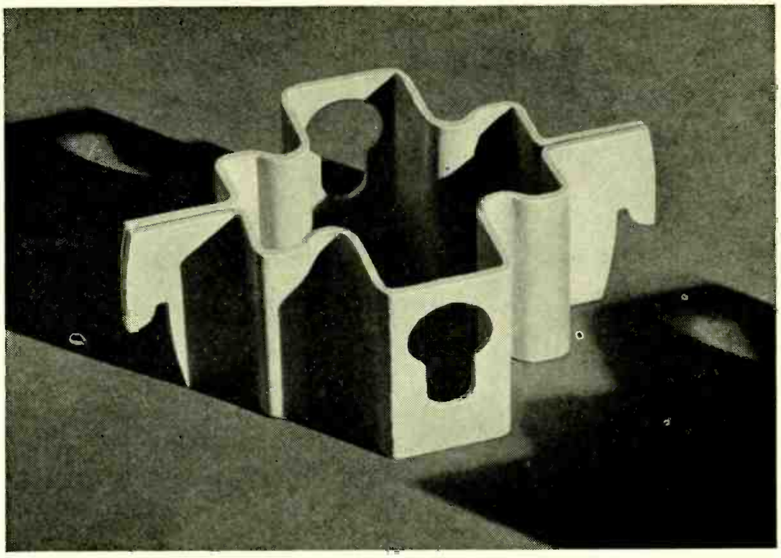
All of these military developments are necessarily secret and confidential. Information as to what they are or as to the techniques and devices they employ would be all too valuable to our enemies. Each technical group in the Laboratories, therefore, keeps to itself the information as to the projects on which it is working; or it releases to other groups which carry part of the work only information necessary to the successful accomplishment of their portions of the total task. This is the present necessity.

In that matter the Laboratories differs from manufacturing companies which are concerned with the production of military equipment. It is possible, for example, for workers in an airplane factory to tell their friends that they are working on airplanes—provided they give no indication of the output of their factory, or such details as the firing power or protective armor or flight-control instruments of the planes which they help to produce. A member of the Laboratories, on the other hand, must sometimes appear to his friends as not doing his part in this war for he can tell them no particulars of his work. About the most that he can tell them has been said in this article. He may not even know the function of the complete apparatus to which he contributes parts or its military significance. He is somewhat in the position of a secret agent who can admit nothing, may not even know the purpose of his mission nor how it fits in with those of other agents and with the plans at headquarters. That is the position of almost everyone in the Laboratories.

Those who are "in the know" on any military project and are devoting their full energies to it, can take it for granted that the other groups, as to whose work they are uninformed, are similarly employed on projects of importance. Those who assist the technical workers by service and supply, those that do the clerical work, the accounting, shop work and building of models—all the others in the Laboratories organization—can assume that what they are doing is of vital importance. Some day the whole story can be told, but at present all the men and women in the Laboratories can feel sure that they are contributing importantly to winning the war, provided they do their work in the most productive and efficient manner possible.

In this war, as in World War I, members of the Laboratories are joining the Armed Forces. Both Army and Navy and the Selective Service, however, recognize the importance of scientific workers behind the lines. In the war ahead it may very well be that victory will be due not only to organized manpower and industrial facilities but equally to the genius of the scientists and engineers who devise the new tools of conflict. And for that reason the authorities have been unwilling that the work of the Laboratories should suffer too great loss in its technical personnel.

On the other hand, there are duties in the military forces for which the background and training of Laboratories personnel is peculiarly suited. The Laboratories has, therefore, cooperated with the Signal Corps by nominating, in response to requests, members of its personnel who would be best fitted for specified responsibilities. Through such voluntary enlistment and through calls upon reserve officers and under the Selective Training and Service Act, 182 men have gone into active service. In addition, nineteen have been loaned to the N.D.R.C., twenty-one others are spending part time on the section committees of the N.D.R.C., three are engaged in work with the Navy Department, one with the War Department and one with the War Production Board. The fact that the armed forces are taking men from the Laboratories because of peculiar expertness and giving them corresponding responsibility is indicated by their present military rank. In the Army the Laboratories has 7 Lieutenant Colonels, 21 Majors, 17 Captains, 22 First Lieutenants, 17 Second Lieutenants, 8 Sergeants, 5 Corporals, 56 Privates and 4 Aviation Cadets. In the Navy the Laboratories has 2 Lieutenant Commanders, 1 Lieutenant, 4 Lieutenants (jg), 4 Ensigns, 3 Petty Officers, 5 Seamen, 2 Aviation Cadets; and in the Marines 1 Second Lieutenant and 3 Privates. Three are Cadets in the U. S. Merchant Marine.



Partition Flexibility at Murray Hill

By J. G. MOTLEY
Construction Engineer

IN A large progressive organization, rearrangement of factory and office space is of frequent occurrence, and if partitions have to be moved, it is generally expensive as well. With a research and development laboratory, such relocations are particularly frequent because, instead of consisting of one moderately stabilized manufacturing procedure, the work is continually changing; different types of work requiring different space and equipment are of regular rather than of rare occurrence. In designing the Murray Hill laboratory, therefore, one of the major considerations was complete flexibility in the partitioning and services. It was desired not only to be able to provide laboratory and office space in almost any size needed, but to be able to make later changes and rearrangements quickly and economically. The solution finally reached was to have the basic building include no partitions except the side walls and those around the stair wells, toilets, and elevator shafts, and to use standard steel panels for all interior partitions. This would eliminate the dirty time-consuming procedure of subdividing space with masonry and plaster walls, and would drastically reduce the time required to make such subdivisions.

After an extensive study of various types of partitions, it was decided to base the design on the use of double-wall steel panels for all interior partitions and to use for the side walls and columns a single-wall steel wainscotting manufactured by Snead and Company. It was planned to run partitions under the floor beams for the most part, and a constant height is maintained between all floor beams and the finished floor to simplify their relocation. The main buildings are 52 feet 8 inches wide inside with a central row of columns spaced twenty-four feet apart. Deep girders down the center of the building were avoided by running two shallower girders, one each side of the center row of columns. This had the additional advantage of providing a convenient space between the central girders in which duct work and large service risers could be run from cellar to attic. Windows are spaced on six-foot centers; and beams run from the piers between each pair of windows to the central girder on that side. The bottoms of these beams have been built at the same height as the central girders.

Except in those areas where the entire width of the building is to be used as a single room, a six-foot corridor runs down the length of each building on one side of the central row of columns. This provides rooms 27 feet deep on one side of the corridor and rooms 19 feet on the other side. The partition along one side of the corridor runs under one of the central girders; and to permit standard height partitions to be used for the other side, a false beam is run the full length of the building. Similar dummy beams are run at certain places in the office wing of the building and wherever an expected partition does not line up with the regular beams. Transverse partitions may be run under any of the floor beams; and individual rooms may be twelve feet wide or any multiple of six feet wider than this. This general arrangement is indicated in Figure 1.

The standard metal panels used are three inches thick and, except in a few locations, four feet wide. They are packed with rock wool to decrease the transmission of sound or heat. The sheet steel forming the two sides is coated on the inside with mastic material to deaden sound, and is stiffened by transverse members welded to the sheets on nine-inch centers. The support along the bottom is designed to form a double wire-way, which is reserved for telephone and signal wiring. Another wire-way is provided at the top, which is used for miscellaneous wiring, chiefly that for lighting switches. The panels are held in place by their two side members, and the adjacent panels effectively form posts which slide over punched steel pieces fastened to the floor between each pair of panels. At the top they carry a forked sliding plate that is

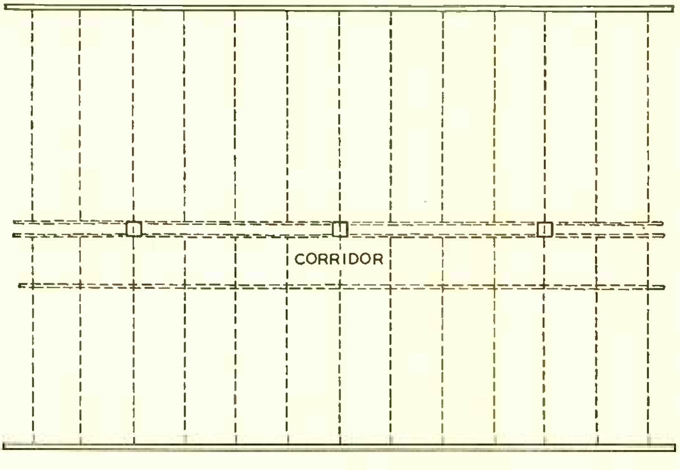


Fig. 1—Arrangement of beams and girders in a typical section of the main laboratory building. The central corridor down one side of columns is indicated. The central columns are spaced on 24-ft. centers and the rooms on one side of the corridor are 27 feet deep and those on the other, 19 feet. Transverse beams are on 6-ft. centers

pushed over a flange fastened to the ceiling. After the panel is in position this plate is locked in place by a wedge. This is shown in Figure 2. The panels have the sound-stopping value of a four-inch tile and plastered wall, and could obtain a fire underwriter's rating as a one-hour wall.

The floor plate over which the posts slide is designed to leave a three-inch space between panels; and a link plate—shown at the left in Figure 3—is slipped between the panels at about two-foot intervals and turned to lock them in place. These link plates have an open center to provide a vertical wire-way between panels. After these are in place, a cover plate, shown at the right in Figure 3, snaps over them and over the edges of the panels to complete the finished wall. Before the cover plate is put in place, however, the space between the panels is stuffed with rock wool. Flat metal finishing strips running the width of one panel are clipped in place without screws to cover the bottom and top wireways. Telephone terminal blocks are mounted concealed on the lower plates where the layout permits.

Fig. 2—Placing one of the steel panels in position in the Murray Hill Laboratories

Along the outside walls, single-wall steel wainscotting is held far enough away from the brick walls to allow service pipes and conduit to run along the side walls under the windows and up the piers between them. This wainscotting also is coated with mastic on the inside and stiffened as are the double-wall partitions, and is similarly finished on the room side. The panels beneath the windows and up the piers are removable without special tools to give access to the various services. At each pier between windows a door is provided to give access to the 50-amp. circuit breaker on the power wiring or to telephone wiring, which runs up alternate piers. Immediately below the windows, two horizontal troughs are run: one for electrical wiring and one for signal wiring. These general arrangements are evident in Figure 4, left. Similar wainscotting is applied around interior columns, each of which carries a lighting cabinet on the corridor side. This is indicated in Figure 4, right.

Where transverse partitions abut the outside column enclosure, facilities are provided to permit the partition to be securely fastened to the wainscote. This same provision is

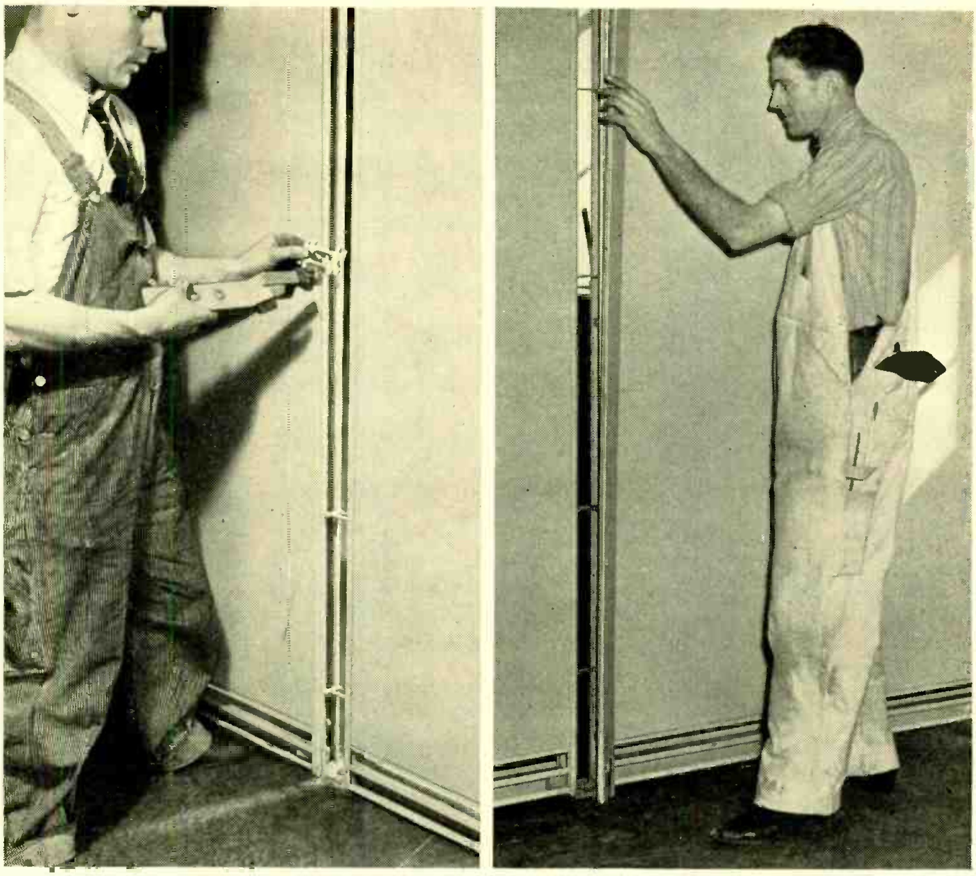


Fig. 3—At left, metal spiders hold the panels together and provide a three-inch vertical wire-way; at right, a cover strip encloses the space between panels

made at the columns at the center of the building for the corridor partition as well as for the transverse partition. Special panels with a removable top-filler section are provided to permit intercommunicating ducts to pass from one room to another, or for the installation of ventilating fans if a fully enclosed area such as a dark room or air-conditioned room is required. A special panel with an escape door located above normal position of services is provided in small chemical laboratories where a secondary means of escape is desirable, thus avoiding the sacrifice of space for a standard door. The great majority of panels are four feet wide from center to center of posts. They are interchangeable with the standard door units which are wide enough to permit a standard 3-ft. x 5-ft. desk to be carried through without turning the desk onto its side.

By use of these standard panels and fittings and of a few panels of special width, the partition problem is very satisfactorily solved. A research laboratory, however, is much more than a room with four walls. It requires a wide variety of facilities such as compressed air, vacuum, oxygen, nitrogen, hydrogen, steam at several pressures, water, drain lines, as well as

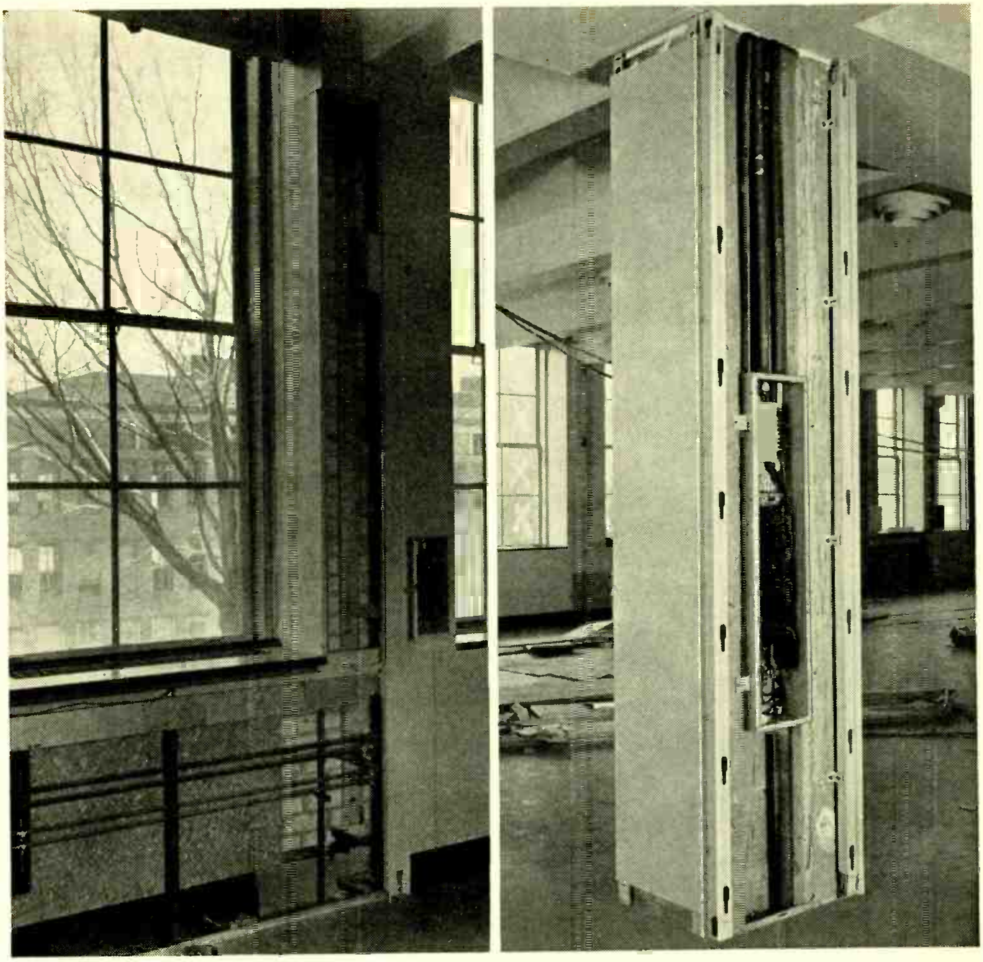


Fig. 4—Left, steel wainscotting on outer walls showing horizontal runs of piping beneath windows, the wire-way, and the door to give access to circuit breaker or telephone wiring. At right, single wall wainscotting around central column

power at different voltages and phases. In all, fifteen services are available at the Murray Hill laboratory with space provided for others if necessary. To get these from the side walls, where they run up from the cellar, means had to be provided for carrying them along the partitions. Supports cannot be screwed or nailed to a partition consisting of two thin steel sheets with nothing but rock wool between them, and, even if they could, it would be undesirable to do so because the simplicity of rearrangement, one of the major objectives sought, would be thwarted.

To overcome this difficulty, laboratory engineers, working with representatives of Snead and Company, developed a number of devices that permit piping, wiring, shelves, and almost anything that would conceivably be used, to be fastened to the partitions quickly and securely, and to be removed just as easily without marring the panels.

The basic unit of this system of supports is the steel fitting shown in the photograph at the head of this article. In cross-section it is something like a maltese cross, and has two wings projecting from opposite sides. The end post strips of the panels are of heavier steel than the panels themselves, and are punched with narrow slots every six inches for the entire panel height. These slots are shown in Figure 2. After the panels are in place and locked together, these fittings are slipped in the vertical space between them with the two wings vertical. They are then turned to bring the wings into the slots in the ends of the panels and the fittings driven down. The design is such that the slots in the wings provide a wedging action and hold the fitting tightly to the panels. The keyhole slots in the two faces of the fitting provide the points of support for whatever is to be fastened to either side of the panels. The fittings may be readily removed by the reverse of the process for installing. Cover plates, used where these keyhole fittings are employed, have matching holes punched in them. Standard punched cover plates are provided for certain arrangements of services, but individual holes may be

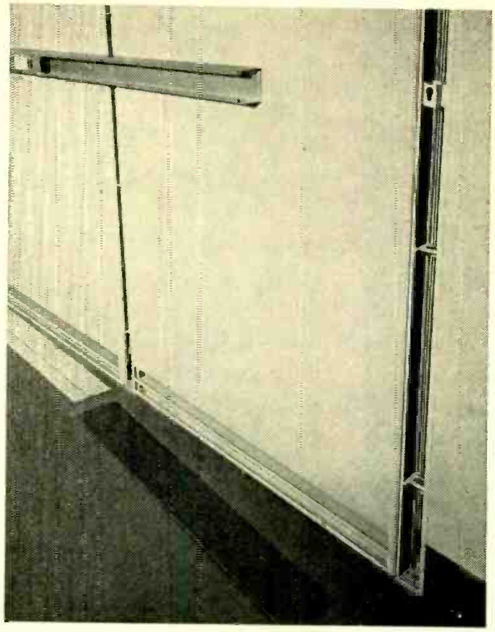


Fig. 5—Use of keyhole fitting to support horizontal wire-way

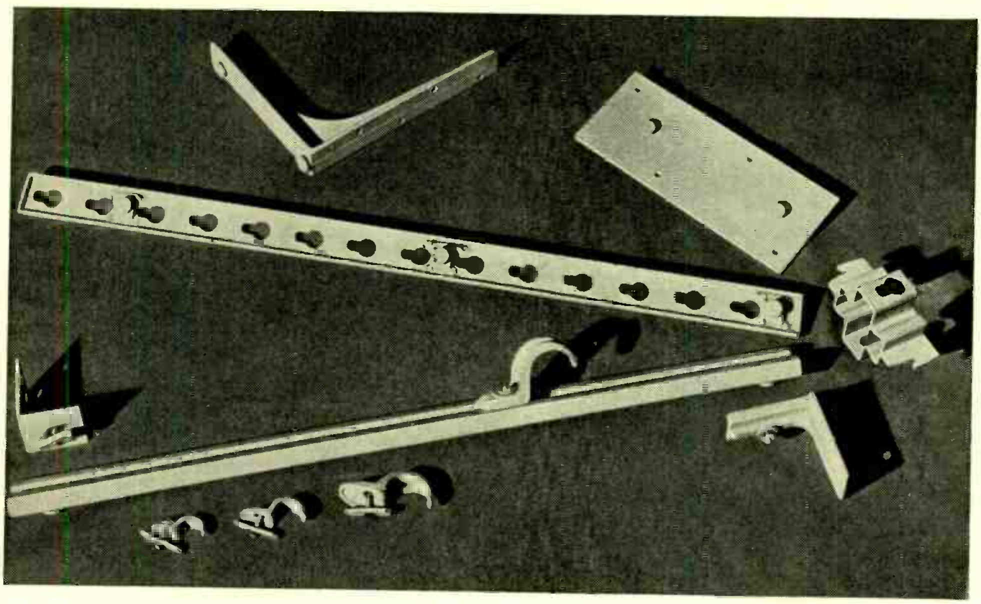


Fig. 6—Some of the special fittings designed as mountings on the steel partitions

punched with a hand tool if needed. Punched covers may be readily replaced by plain covers should the services supported by the keyhole fittings be removed.

The use of these fasteners to support a horizontal wire-way to a partition is shown in Figure 5. A single bolt and nut fastens it at each post. A nut has been designed with an arm on one side that enters the keyhole when it projects downward. When a bolt is screwed into the nut, the arm turns and holds against the side of the fitting while the bolt is tightened. Such bolts and nuts may be used, of course, to fasten anything desired to the posts. The most common needs, however, are for piping and shelving, and for these there were designed the long bars shown in Figure 6.

The pipe support, of two standardized lengths, is a narrow rectangular box with a slot down the front and two buttons on the back that slip into two keyhole fastenings as indicated in Figure 7A, and wedge tight as they are pushed down. Standard single-bolt

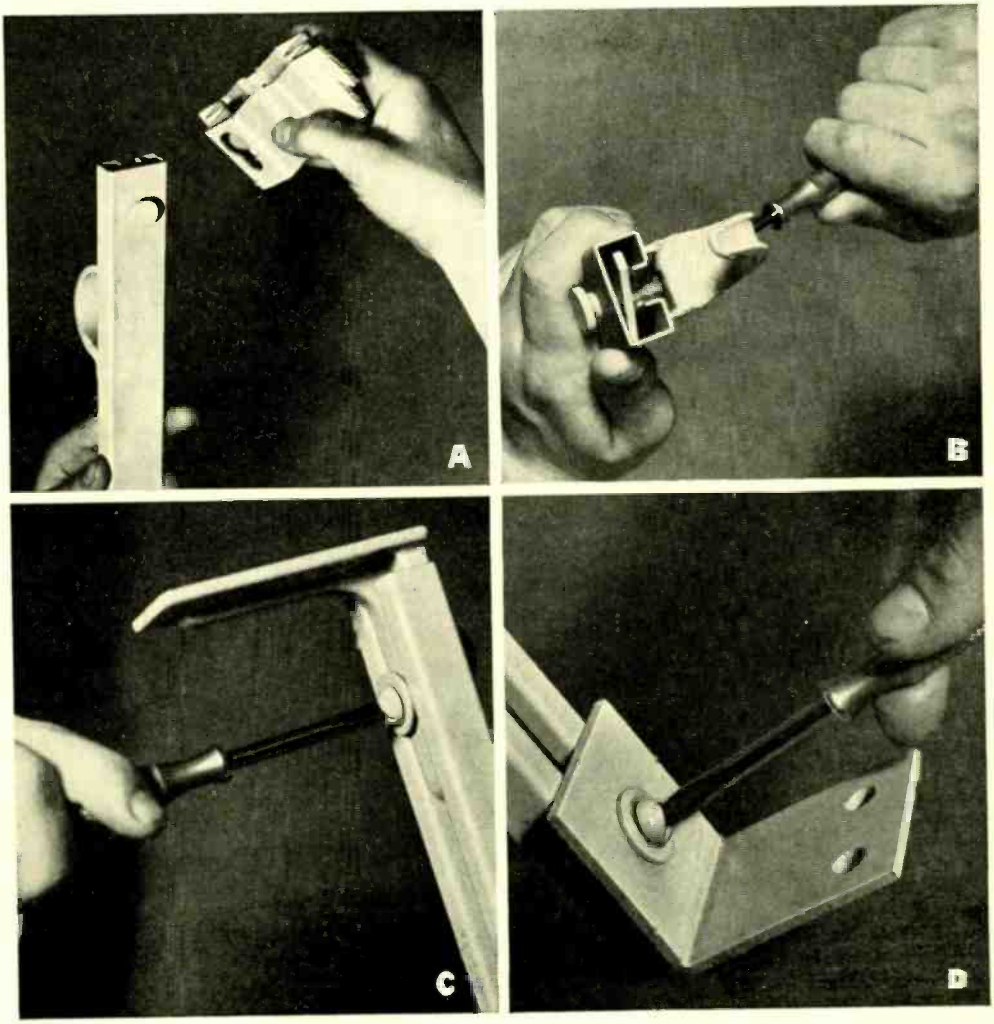
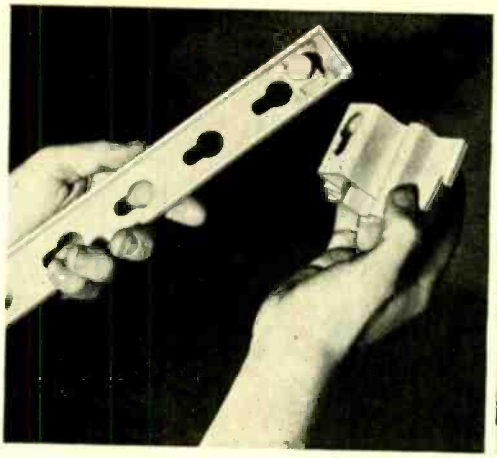


Fig. 7—Pipe supporting bracket



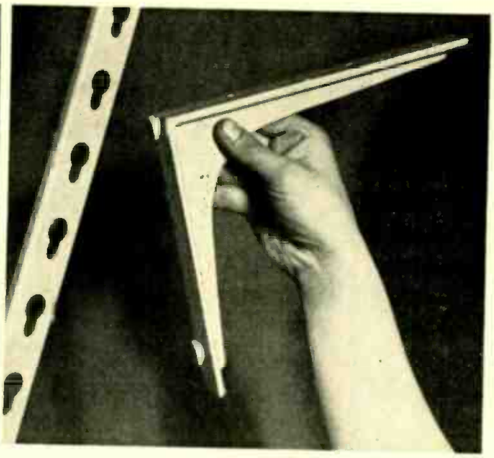


Fig. 8—Shelf supporting bracket

pipe clamps, Figure 7B, to hold piping to the racks, are fastened by a bolt and clamping nut similar to that described above. The continuous vertical slot permits adjustment for the pitch of pipes if they are to drain. Angle brackets, Figure 7D, have been designed for fastening to the pipe supports to hold a drain line which runs along the bottom of the support, and a wood shelf, Figure 7C, to support the cocks or valves for the various services. This bracket is designed to slide in the support from the top.

The other fitting, Figure 8, designed for shelf brackets, provides a series of keyhole slots two inches apart. Each bracket has two buttons that fit into the keyholes of the supporting piece and wedge in place. Typical uses of these devices in the laboratory may be seen in the accompanying photographs.

As already pointed out, the piping for the various services runs up from the cellar at the piers between the windows, and is then carried horizontally along the wall beneath the windows. Two methods are provided for getting the pipe out into the rooms. That most commonly used is to run along the interior partitions on the supports described above. A "shadow box," shown in Figure 9, has been designed through which the piping is brought out. This is merely a narrow slot with deep sides that hide the space behind the wainscotting except

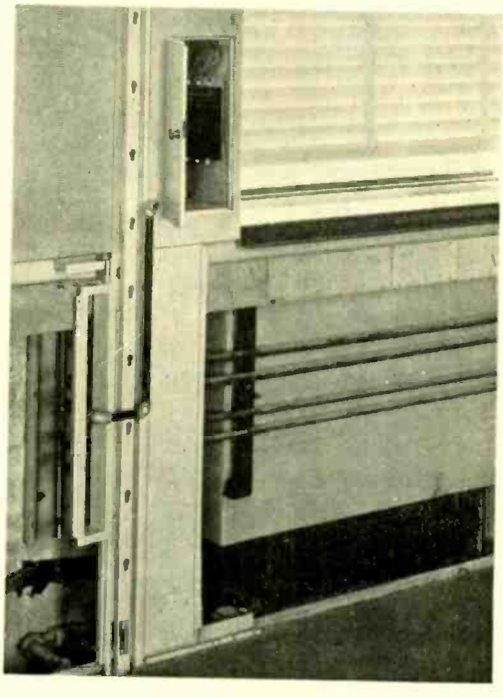


Fig. 9—Side wall showing "shadow box" through which pipe or conduit may be brought out

immediately behind the shadow box. Without these, the piping along the side walls behind the wainscotting would be visible from a wide angle in the room. The shadow box plate may easily be replaced with a plain plate should the service lines be removed.

The other method of bringing out service pipes is by trenches in the floor which extend eight feet from the outer wall as shown in Figure 10. These trenches which have been installed only where required are used principally in the chemical laboratories. They have waterproof covers, and special cover sections where the services turn up to service strips. Floor fittings have been provided for use where the piping turns up to an "island" bench.

With this partition panel and wainscotting, and the various fittings designed for fastening things to it, rearrangement of space and apparatus attains nearly ideal flexibility. Practically no loss of material is incurred in making changes because there is no marring or cutting necessary. All panels and supporting structures may be reused indefinitely. Occasional painting is all that is normally to be expected.

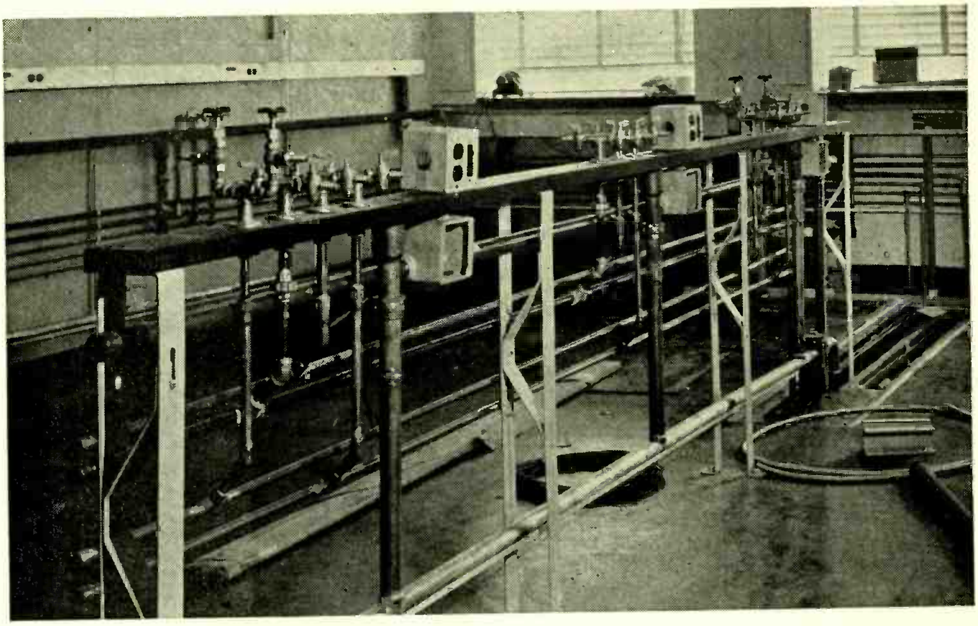


Fig. 10—One of the chemical laboratories showing floor duct for island services

Abrasion Test for Textiles

By A. C. WALKER
Chemical Laboratories

TELEPHONE cords are subject to a great deal of abrasion, kinking and bending in service, and this treatment often frays their braided covering. To minimize this wear, studies are made in the Laboratories on the resistance to abrasion of threads of different materials, and of treatments to improve the life of cord braids. One test is carried out by an abrasion apparatus which wears threads or braids until they break; and the time required is taken as a measure of wearing qualities.

Threads tied in endless loops are suspended from hooks fastened to a stationary crossbar. Weights are hung from the loops and the threads are then arranged about staggered pins mounted on a movable plate. As this plate oscillates up and down under the action of a motor-driven cam it rubs the threads against each other. The cabinet, Figure 1, which encloses the apparatus is air-conditioned for humidity and temperature. Seventeen samples can be tested at a time.

Experiments were carried out on different rubbing surfaces and on the position of the threads around the pins before this design was adopted. Wear may be caused by rubbing the threads on roughened surfaces. Pins of sand-blasted glass, quartz and sapphire were tried, but even these extremely hard materials gradually become polished with use. The roughened surfaces fill with the products of abrasion and the results were rather inconsistent.

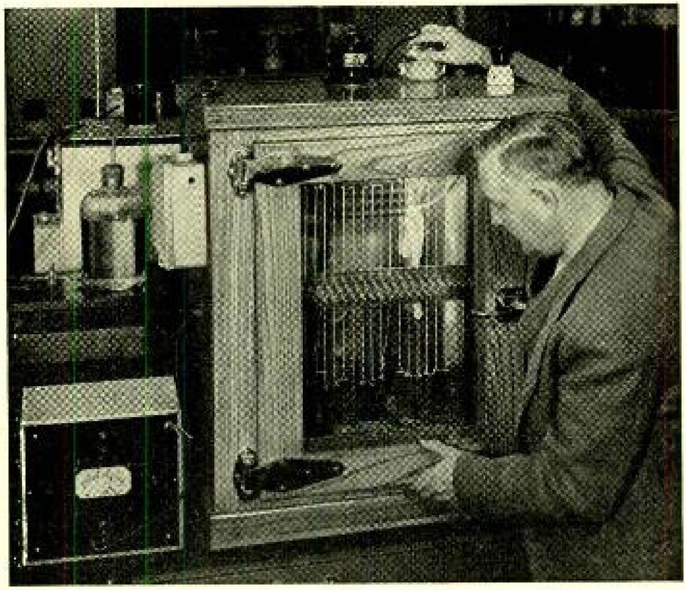


Fig. 1—Resistance to abrasion of the textile used in the braided covering of telephone cords is tested by arranging sample threads in pairs over pins and rubbing each pair against itself until it breaks

The threads are looped around the middle pin so that they twist together in a sharply bent loop as illustrated in Figure 2. Oscillating the bar draws the threads over one another and wears them at the sharp bend. It is important to have two threads in parallel because it minimizes the tendency of the single strands to twist and untwist during the rubbing action. The threads are prevented from twisting about one another by resting the

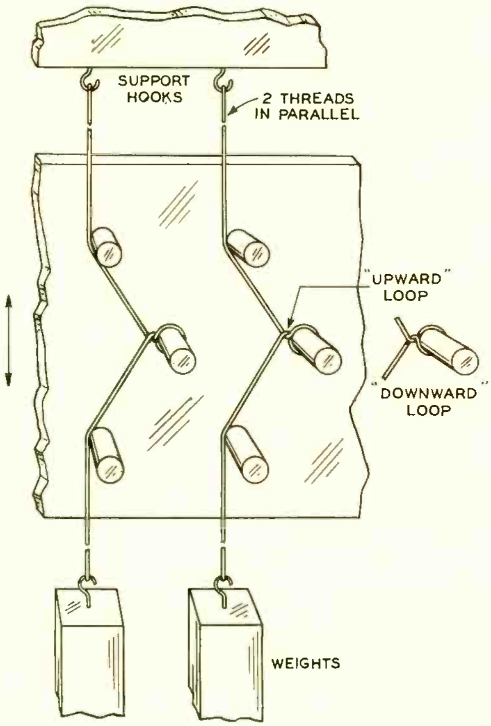


Fig. 2—Threads are looped around the middle one of three pins to form a sharply bent loop. As the pins move up and down the threads are abraided at the bend

square weight lightly against a backing plate. When the direction of twist of the loop around the middle pin is in the direction indicated by the arrow in Figure 2, the thread wears at a different rate than when the loop is formed in the other direction.

When a thread breaks, the weight hung from it falls on a balanced rod and actuates a mercury switch to stop the motor which drives the oscillating plate. At the same time a lamp lights on top of the cabinet. A counter records the number of strokes. The apparatus can be restored to its running position by a manually controlled arm which acts on the balanced rod.

Air circulation is maintained within the cabinet by an impeller fan which is driven by a motor mounted on top of the cabinet. A fin-type copper coil through which water flows provides cooling. The interior of the cabinet is lined with tinned copper and sealed to prevent loss of water vapor from the humidified atmosphere. Air temperatures are maintained to plus or minus 0.1 degree C.

Humidity within the apparatus is controlled by the simple method shown in the functional sketch of Figure 3. In a tightly sealed metal box is mounted a 25-watt electric lamp. Hanging from a hook beside the lamp there is a long cloth wick, the lower end of which dips into water in the bottom of the box. The level of this water is maintained by a syphon arrangement connected with an external water supply located on top of the outer container. A trace of wetting agent in the water assists in maintaining effective wick action over long periods. The apparatus is enclosed in a wooden container to insulate it from atmospheric temperature changes.

Dry air is supplied to the inlet tube at one side of the apparatus. By adjusting the distance of this tube from the flared outlet mounted through the opposite wall of the box, the operator controls the amount of moist air picked up from the highly humid atmosphere within the box. The inlet tube has a micrometer adjustment attached to the outside of the wooden container. With 3/8-inch diameter flow tubes and a 1/8-inch orifice on the inner end of the inlet tube, between two and three cubic feet of air can be brought to 65 per cent relative humidity per minute by the use of a 25-watt lamp.

The humidity within the test cabinet is electrically measured by a hygrometer of a type recently developed by the National Bureau of Standards for use with radio sounding balloons in measuring the humidity of the upper atmosphere. This hygrometer is mounted on the inside wall of the cabinet just in back of the upper hinge that is shown in Figure 1. A bifilar coil of fine palladium wire wound on a small insulated aluminum tube. This coil is coated with a varnish containing lithium chloride to make it slightly conducting. The electrical surface leakage between the two parallel windings of palladium wire varies with the humidity and is measured after amplification by a vacuum tube. Different concentrations of lithium chloride in the surface varnish provide units having different humidity ranges. For example, a varnish containing 0.35 per cent lithium chloride is useful in the range from 40 to 70 per cent relative humidity.

Where the surrounding humidity does not fluctuate much and the temperature is maintained relatively constant, this method is reliable and responds very rapidly to small changes. The relative humidity can be maintained within 0.5 per cent for several hours.

One of the principal limitations to the reproducibility of results attainable in testing textiles is the lack of uniformity in the materials. In measuring the abrasion resistances of spun mercerized cotton used for telephone cord braids the method just described gave results which checked within plus or minus 15 per cent of the average for groups of seventeen samples. This is considerably better than might be expected on the basis of the variability in the spun yarn, as shown by analyses of the results of several hundred tests. Because the time required to test threads is short compared to testing finished cords, this method lends itself to rapid preliminary studies for improving wearing qualities.

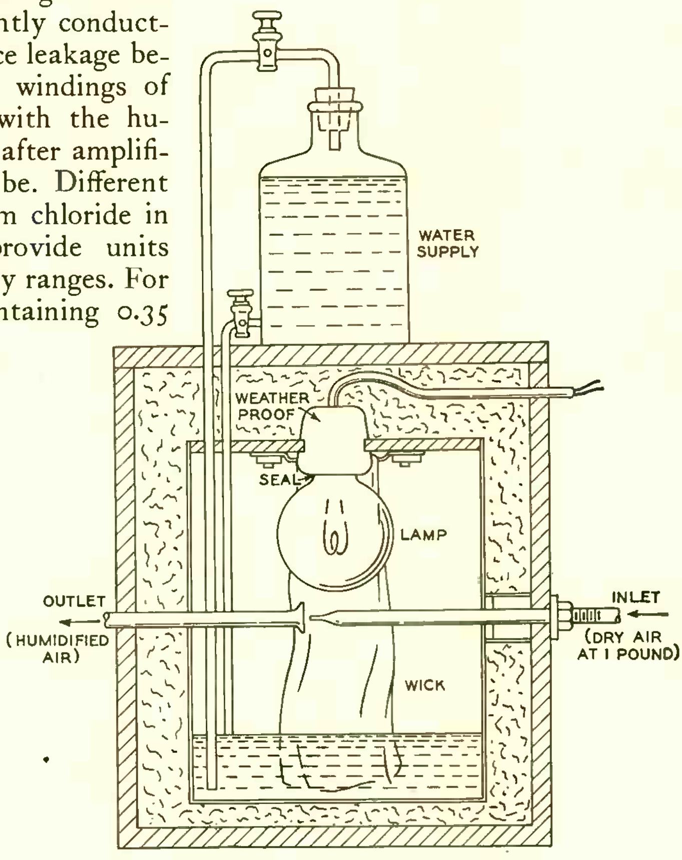


Fig. 3—Humidity in the test chamber is controlled by forcing dry air through a metal box containing moist air. Water in the bottom of the box is drawn up by a wick and evaporated by the heat of an electric lamp

Recording Plastometer for Organic Plastics

By F. J. BIONDI
Chemical Laboratories

UNDER the influence of heat and pressure organic plastics flow, and on this property the ability to mold them depends. To attain a reproducible product, time, temperature and pressure have to be controlled in the molding process. It is also necessary to know and control the effects of chemical composition and of physical factors such as moisture content.

Many devices have been used to measure the flow properties of plastics. One of these, the parallel plate plastometer, has recently been improved by the Laboratories to plot automatically the relation between the variables measured. A specimen of the material is deformed by a known force at a specified temperature and the decrease in its height with time is magnified and recorded. The plastometer developed has two horizontal plates P, Figure 1, which press between them a small cylindrical pellet of the plastic. An electrically heated and thermostatically controlled steel block C surrounds the specimen. The frame which supports this block also mounts bearings for a shaft connected to the upper plate. Weight W deforms

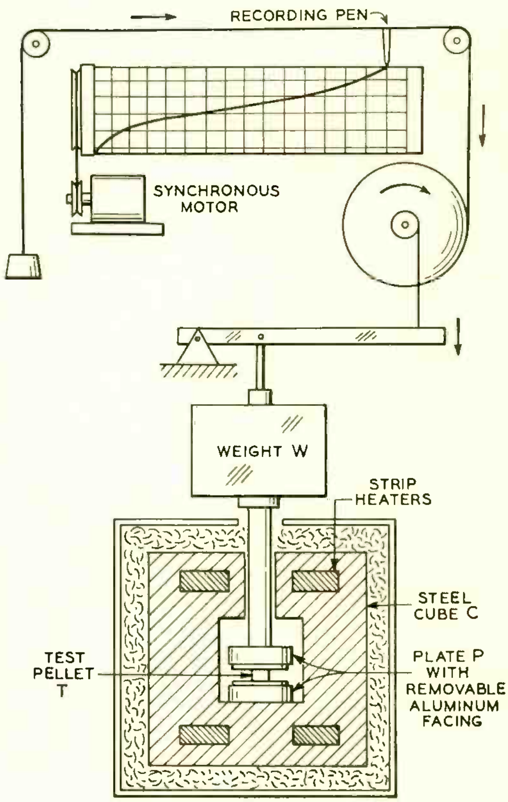


Fig. 1—Schematic of the recording plastometer showing the test pellet between two parallel plates p

the specimen. It is supported by the upper end of the shaft which is also connected by a universal link to the multiplying and recording apparatus.

A series of levers and pulleys multiplies the movement between the plates approximately thirty times. This multiplying mechanism and that which drives the paper on which the record is made are housed in the cabinet at the top of the machine. Below the plastometer are the temperature regulating equipment, voltage control and auxiliary switches. The electronic regulator controls the temperature of the steel block within narrow limits from room temperature up to 300 degrees C.

Flow curves obtained by deforming

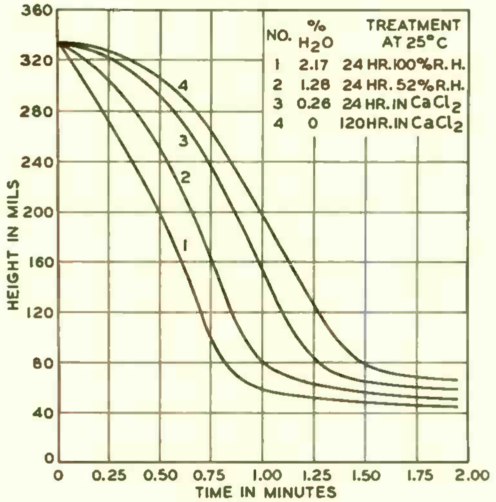


Fig. 2—A typical thermoplastic: Increased moisture makes pellets flow more rapidly

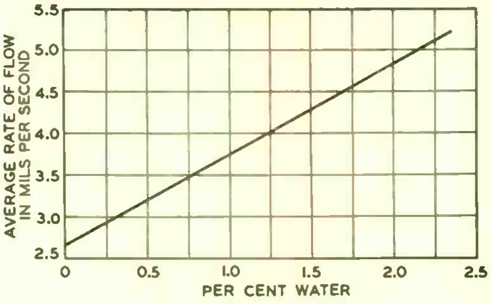


Fig. 3—Curve showing the average rate of flow of pellets of different moisture content, computed from the data of Figure 2

pellets molded from one of the thermoplastic materials currently used in telephone equipment are illustrated in Figure 2. They show that flow occurs more rapidly as the moisture content of the pellets increases. Figure 3 gives the relation between the average rate of flow and the moisture present. These curves show that the average rate of flow can be nearly doubled by changing the moisture content of the pellet two per cent. Moisture affects the flow of other plastics but not always to this extent. It is one of the variables, however, which must be measured and controlled if powder of constant flow characteristics is to be supplied to molding machines.

The recording plastometer also has been used by the Laboratories to measure the individual and combined effects of the other variables which affect the flow of plastics.

Quality Control in Ordnance Inspection

By G. D. EDWARDS
Director of Quality Assurance

[*For some months Mr. Edwards, as a consultant to the War Department, has been working on the application of quality-control procedures to the inspection of Ordnance material. At a meeting of A.S.M.E. at Cleveland in June he outlined his viewpoint on quality control. Excerpts from his address follow; the complete text appears in the September issue of* Mechanical Engineering. *The illustrations are by courtesy of* Firepower, *official magazine of the Ordnance Department, U. S. Army.*—EDITOR.]

WE HAVE a few items in the telephone industry, such as linemen's climbers, body belts, and safety straps, which are purchased by the thousands, where failure may be a real hazard to life or limb. For the Army, however, there are any number of types of matériel produced by the hundreds of thousands or even by the millions in which certain kinds of defects mean almost sure death not merely to one but to a whole group of brave men who are perfectly willing to risk their lives in fair combat. The blood of these men will be on our hands if we leave any stone unturned to prevent their being done in as a result of defective Ordnance.

I'm sure I don't need to tell you that if you are manning the lone after-gun in a bomber, with an enemy fighter on your tail, that fighter is likely to get the bomber and its whole crew including you, if a defective shell jams your gun before you succeed in putting him out of business. If you are inside a tank which is struck by a heavy shot, it won't do you much good to try to dodge the pieces of steel which spall off the inside surface of an excessively brittle armor plate and carom around inside the tank until they have killed or wounded every man they strike. If you are an officer or one of the crew manning a heavy gun and a shell explodes just before or immediately after leaving your gun because of a base cavity in the steel shell or in the explosive with which it is loaded, it is quite probable that you won't live to tell the tale. The gun itself may also be rendered useless at the same time to other men in the vicinity who are fighting for their lives.

These are representative of situations which we meet constantly in Ordnance inspection work and they call for a degree of perfection in mass production which has been uncommon in much industrial work in the past.

Determination of the presence of many of the defects which will cause such dire results often requires test and inspection procedures which are themselves destructive. In these circumstances we are forced to take some chances if we are to give the field forces any ammunition, armor plate, or other matériel to fight with at all.

But even where the necessary inspections are not destructive, you all know our common enemy called "inspection fatigue."

If you have before you a hand truck containing say 15,000 cartridges, and you are given the job of inspecting and gaging them visually 100 per cent, I don't have to tell you that by the time you have looked at 9000 of them, they will all look alike to you, and you won't know whether the discoloration which evidences necessary shoulder anneal, for example, is there on the 9001st cartridge or not. This is no insult to your intelligence; it is just a plain illustration of experience.

So 100 per cent manual inspections are not the answer where large quantities of material are involved, even if we could put up with the resulting production delays. Mechanical gaging and photoelectric cell gaging are being introduced wherever possible to eliminate inspection fatigue; but even the best of these substitutes have their margins of error.

In other words, we have to recognize that the element of risk just can't be eliminated from quality considerations in mass production, and the real problem is how to reduce the chances we must take to a minimum without unduly impeding output. Quality-control techniques are *built* around limiting such risks to a predetermined degree, and they are thus admirably adapted to the problem in hand.

Of course the great value of quality control lies in its ability to focus a spotlight on the existence of unfavorable conditions before evidence that difficulties are developing would otherwise become available. It will do this, however, only if it is properly used, that is, if the right factors are selected for control watching, and if the mechanics of the control plan are so arranged and simplified that the necessary computations and plotting of inspection results will be carried out, and conclusions drawn from them, accurately and promptly.

If quality control is properly used in this way, an early start can be made on tracing the causes of difficulties, production of quantities of defective material can be avoided, testing and testing-equipment time and material can be conserved, actual stoppages of production can be prevented in some cases, and inspection can be converted from a hindrance to a boost for output.

So the first essential in Ordnance inspection work is that our own quality-control procedures be simple; and the second is that when such a procedure is introduced, it be oper-

Educated fingers and trained eyes pass the perfect cartridges into trays and reject those with scratches and other surface imperfections. Every cartridge is given this hand-visual inspection

"God Help Me if This Is a Dud" is no empty fear when an American fighting man throws lead at the enemy. His ammunition must be high quality. Guardian of that quality in Ordnance plants is visual inspection illustrated here

ated expeditiously though with meticulous conformity to the detailed provisions of its plan.

While all of the results I have cited from the proper operation of a well-designed quality-control plan will obviously redound to the immediate benefit of the manufacturer, these results also make it evident that it is distinctly to the advantage of the Ordnance Department for its manufacturers to have the quality of their products in control, particularly in these days when output of satisfactory matériel is all-important.

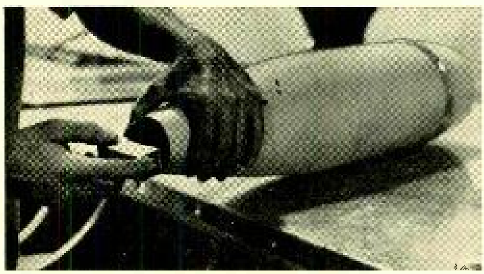
Ordnance inspections for acceptance may hence be so well planned that they will encourage manufacturers to get their quality into a condition of statistical control. The evidence, which control at a satisfactory level provides that quality is acceptable, is a perfectly sound basis for reductions in the volume of acceptance inspection. Such reductions cut down the amount of finished product awaiting acceptance, which the manufacturer must keep around in his own way; they eliminate the provision he must make for housing such material; they correspondingly reduce his inventory; and they enable him to get his money back more quickly. This sort of encouragement to control can thus be made quite persuasive to the manufacturer. At the same time the Department must be wholly impartial in its inspection and acceptance of good Ordnance matériel, regardless of whether or not the producer of such matériel uses any statistical approach whatever to his quality problem.

However, we like to look forward hopefully to a time when, for some types of matériel at least, manufacturers who have demonstrated their own dependability and sufficient quality control might possibly, with adequate Ordnance oversight of their inspections, provide *themselves* at least some of the quality evidence necessary to Ordnance acceptance of their product.

Some types of matériel, such as armor plate, for example, can only be inspected and tested on a sampling basis, and the sample is destroyed in test. Any sample at all thus consumes precious plate which we would much prefer to have on tanks or planes. Quality-control procedures make use of the continuing results from a succession of samples which individually can be extremely small in percentage as long as control is maintained. The risk of accepting poor plate under these conditions can be held to substantially lower levels than would be possible with much larger samples and no quality-control procedure.

In approaching such a quality-control problem, we are requiring samples from every production lot of output for a time. As soon as the inspection and test results from a series of consecutive lots are uniformly within control limits, the manufacturer becomes eligible for a reduction in inspection. Continuance of such evidence of control would reduce the proportion of lots from which samples of the same size would be required, in successive steps, to a half, a quarter, and perhaps even lower. If the manufacturer loses control, he loses eligibility for reduced inspection, and it can only be regained by his regaining control of quality.

Now for the perennial question about the bad lots of product that might be accepted under this plan, before lack of control becomes evident. The answer, of course, is that without a control procedure, and even with perhaps larger samples from every lot, we would be just as likely, and perhaps more likely, to accept bad lots of product. So even in those



A T-shaped gage is used to measure the amount of amatol poured into a shell. Too much or too little won't do. Gages insure that good shells pass for shipment and poor ones are rejected for reloading

Weighing in for the big battle, loaded shells step on the scales just like the fighters they are. The operator classifies this 155-mm shell to determine range table

rare instances where there is no urge to reduce inspection, the application of control criteria to the existing inspection procedure will reduce the risk of accepting bad product. At the same time we acquire a means for determining what that risk is, so that we can decide whether or not we are inspecting as thoroughly as we should.

This whole question of defective material is something like a boil on the back of a man's neck. The amount of attention the man devotes to it is out of all proportion to the comparative weights of the boil and of the rest of his body. The worse the boil gets, the greater this disproportion. But once the poison gets out of the boil and it is reduced to the small-pimple class, it demands less and less of the man's attention.

If the defective material produced by a process approaches boil proportions, it won't do any good merely to pick at it with your inspection fingernails. You can't "inspect" into a product quality that was not put there by the manufacturing process. The manufacturer has just got to find the source of the poison and correct the process. Once he gets the boil reduced to pimple proportions, he can keep his eye out by inspection means to make sure it doesn't get bigger again.

We have no intention of allowing the Ordnance inspector to become a sieve for weeding out defectives from the product of a low-quality manufacturer. That is the manufacturer's job. But we will help him to get the quality of his product under control at a satisfactory level by advising with him and by making constantly available to him all information as to levels and trends in his quality which may be evidenced by Ordnance inspection results on his product.

The principles necessary for immediate use of quality control can be presented to the average layman of reasonable education in such language that he can understand and use them without his necessarily taking the time to delve into all of their theoretical bases and refinements. The average inspection supervisor can certainly acquire in short order the habit of plotting his experience with a particular product against time or against output; of putting simply computed limit lines on his chart; and of noting significant quality trends or departures from the proper levels. He can certainly be taught that some all too commonly used sampling inspection procedures accept product which does not differ significantly in quality from that which they reject; that there are procedures, often requiring less inspection, the use of which will largely reduce the amount of good material rejected and at the same time will improve the over-all quality of the material which he accepts; and what is the general nature of these latter procedures.

Some commonly used sampling inspection procedures appear to have been invented by men who have never played poker. If you draw a five-card hand from an honestly shuffled, honest deck, none, some, or all of the cards in your hand may be face cards, of course. If your hand contains no face cards, you certainly cannot conclude that the deck contains none. Yet I have seen cases, and Ordnance inspectors are far from the worst offenders, where ten per cent samples were being drawn from containers of fifty piece parts (that's about the same as a five-card hand from a fifty-two card deck), and a container was being rejected as soon as a defect was found in its sample. The accepted containers were probably just about like the rejected ones of course. That sort of thing just isn't necessary.

Handling Night Calls at a Dial PBX

By W. M. BEAUMONT
Switching Development Department

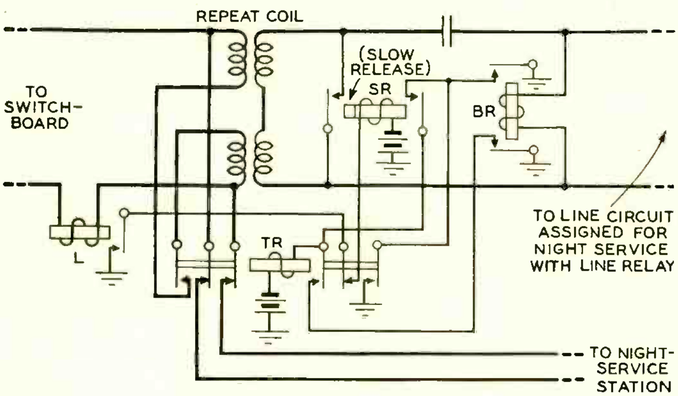
In LARGE dial PBX's, incoming calls from a central office are usually completed by an attendant at a manual switchboard or cabinet. These manual positions are not ordinarily attended at night, since after business hours there are few if any incoming calls. It is common practice, however, for the switchboard attendant, before leaving for the day, to connect some or all of the central-office trunks to certain designated lines, where any incoming calls may be received. These night connections are made by plugs and jacks at the 701 PBX[1] and by keys at the 740 PBX[2], which are two widely used PBX's standard in the Bell System. For some time a need has been felt for more extensive use of outside trunks when the manual board is not attended. To make this possible with these two PBX's, a new night-service circuit has been developed that permits any of the PBX lines to be reached at night instead of just those plugged up at the switchboard.

This night-service circuit has three branches: one appears at a jack at the switchboard, and into this jack one of the incoming trunks will be plugged at night; another branch runs to the PBX switching apparatus, and is assigned a station number; the third branch runs to some station assigned to answer incoming calls at night. Very commonly this station will be a watchman's telephone, equipped with two or more lines as in the 1A key telephone set[3] or equivalent equipment, where any of the lines can be "picked up" and "held." The watchman answers all incoming calls, which reach him by way of this circuit. He determines the number wanted, places a "hold" on the calling line, and then dials the line wanted over another line associated with his set. The watchman then tells the called party that there is an incoming call for him, and to dial the night service number. The watchman then hangs up, thus releasing the step-by-step switches through which his connection was established. Dial tone is then received by the called station, and the number of the night-service circuit may be dialed. When this circuit is reached, the watchman's station is automatically disconnected, and conversation may proceed between the outside line and the called station.

The means by which this is accomplished is shown in the accompanying illustration. At the left, the circuit runs to the PBX switchboard, where at night it is connected to a central-office trunk. At the upper right, it runs to the PBX connector bank, where it may be reached by any PBX station dialing the proper number. At the lower right, it runs to the station that is to handle incoming calls at night, and here incoming calls may be answered and "held." An incoming call will ring the bell at this station, and when the handset is lifted to answer the call, relay L

[1] RECORD, *Sept.*, 1929, *p.* 36. [2] *Aug.*, 1928, *p.* 399. [3] *June*, 1940, *p.* 315.

operates on the resulting flow of current, and operates relay SR through a back contact on TR. The operation of SR closes two contacts: one placing a "short" across the side of the circuit the called subscriber will ultimately



Circuit for handling night calls at a dial private-branch exchange

reach so as to prevent clicks from being heard by the calling subscriber as the connection is being established; and the other establishing a path through which relay TR will later be operated.

The watchman determines the number wanted, holds the incoming trunk, dials the wanted number, asks the person answering to dial the number assigned to the night-service circuit so as to pick up the outside call, and then hangs up. The hold condition still persists, however, and so relays L and SR remain operated. When the called station reaches the night-service circuit as a result of dialing, relay BR is operated, and remains operated until the called station hangs up. The operation of BR closes two contacts: one to operate TR through a front contact of SR and one to hold TR operated after SR releases. When TR operates, it opens the circuit to the night station, opens the circuit to SR so that it will release to remove the short-circuit across the line, and closes the circuit at the central-office side of the repeating coil so that conversation may proceed. When the called station hangs up, relays BR, TR and L will release, thus restoring the auxiliary line circuit to normal.

The basic purpose of this switching procedure is to permit incoming calls to be completed to any station of the PBX. Outgoing calls from restricted stations must also pass through the night station attendant for completion. If, for example, a restricted PBX station should dial the number of the night service circuit in an effort to make an outside call directly, relay BR would operate, but relay TR would not because its operating circuit is open at the contacts of SR. As a result the outgoing trunk circuit is open at the mid-point of the repeating coil by the open contact on relay TR, and the attempt to call the central office is blocked. The night-service circuit, however, enables the watchman to place outgoing calls when requested to do so by the station users. After receiving the details of the call from the calling party, the watchman originates the call, and when the called party answers, requests him to hold the line. He then operates a "hold" key to hold the outside call, and calls the PBX station to tell the calling party that the station called is connected to the night-service circuit. The calling party then dials the night service number to complete the connection.

A PBX may be equipped with as

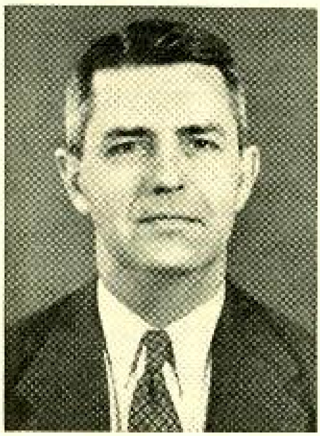
many of these night-service circuits as are needed to handle its incoming night traffic. Each circuit will require a line to the night attendant's station, a PBX line number assigned to it that may be dialed, and an appearance at the switchboard. Other methods of providing equivalent service are being studied, but this is being standardized at once to meet immediate demands.

Contributors to this Issue

G. D. EDWARDS entered the Bell System in 1913 on graduation from Harvard. After a year at Hawthorne he took up transmission work at the Laboratories, and in 1920 he went to Sweden as transmission engineer and later as chief engineer of the Stockholm-Gothenburg cable project. Returning in 1924, he entered what is now the Quality Assurance Department; later he became its head. His work there is described in the following excerpt from his Cleveland talk:

"Until now my business life has been with the Bell Telephone System where we have a continuing acceptance inspection problem rather similar in character to that of the Ordnance Department. I have been fortunate enough to have been closely associated with this problem in the Bell System for fifteen-odd years, and to have been responsible for its general guidance at headquarters for the past ten to twelve years.

"The increasing difficulty of inspecting 100 per cent or even large percentages of the quantities of certain types of apparatus which the Bell System was using practically forced us into the beginnings of quality-control acceptance procedures as early as 1923. Not only were the economies of these procedures soon evident, but we found that under some circumstances we could secure noticeably better quality by their use than by 100 per cent inspection. The application of quality-control techniques in the telephone industry has thus grown to a point where we now tend to insist upon reasons for not using them, rather than on reasons for using them."



J. G. Motley

FOLLOWING GRADUATION from Webb Institute, where he specialized in marine engineering and naval architecture, J. G. MOTLEY entered the student course of the Western Electric Company at Hawthorne. After the usual shop training and installation experience, he was assigned to the Physical Laboratory of the Engineering Department at New York but left a year later to serve with the U. S. Army at the Mexican border. During most of World War I he was in France with the Field Signal Battalion of the 27th Division.

Upon his return from France in April, 1919, he was first with the machine switching design group and then with the Radio Development Department on the installation of broadcasting equipment. Late in 1922 he transferred to the Plant Department where he engaged in plant operation and construction work. Since the fall of 1939 he has been Construction Engineer of the Murray Hill Project.

W. M. BEAUMONT entered the Bell System as substation installer with The Bell Telephone Company of Pennsylvania