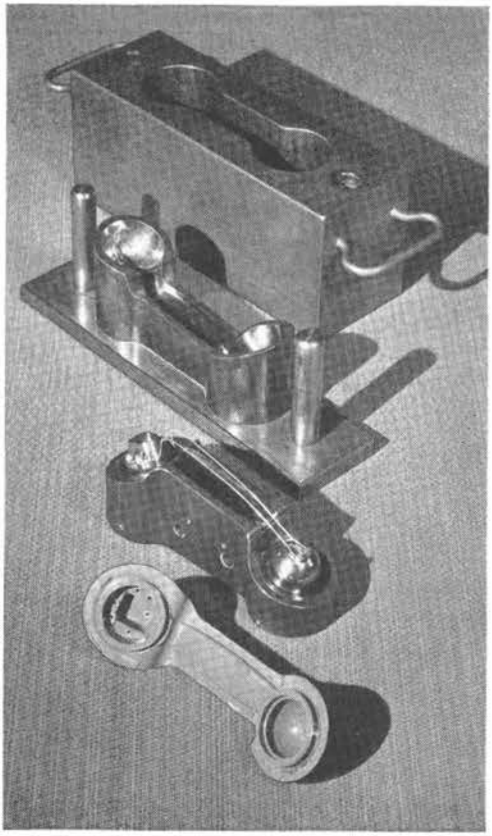

Molded Telephone Apparatus Design

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Insulating Materials Development

MOLDED plastics have so many properties valuable in telephone apparatus that their use has been increasing rapidly. They conform readily to intricate shapes; they take a smooth surface, often without polishing, and retain it well; and they can be made in a variety of colors where esthetic appeal is a factor.

Among the plastics available are hard rubber, cellulose acetate, shellac-mica, and phenol derivatives. Some are thermo-plastic and will soften with heat; others are thermo-setting and after molding will remain hard even up to the temperature of decomposition. Each material is available in several different grades, all of them with widely different characteristics.

First-hand information has been obtained within the last few years by the Materials group on the important characteristics of molded materials, on apparatus design principles consistent with these characteristics, and on production methods. These fields are so closely related that they must be studied together. Laboratory tests have been correlated with field experience and developments in fundamental design have been incorporated in specific applications.

The factors which affect a molded design may be conveniently classified as engineering and manufacturing requirements. One of the most important and severe of engineering demands is that equipment shall operate satisfactorily during a life of from fifteen to twenty years with little or no maintenance. The equipment on subscribers' premises or in public pay stations must withstand not only a variety of widely different climatic conditions, but also hard use at the hands of a public unfamiliar with and in some cases unmindful of its sensitivity. The dimensional requirements of new designs are often fixed by the necessity of assembly with existing equipment. Central-office apparatus is subject to space limitation to facilitate the interconnection of a large number of subscribers' lines. Often added to these are a combination of operating requirements which further complicate the selection of a design for molded telephone equipment.

Manufacturing requirements involve a number of factors, including the reliability of sources, the uniformity of quality, the cost of molds and accessory equipment, the feasibility of attaining specified tolerances, and the complexity of molding and finishing operations.

In considering the mechanical properties of molded materials the designer must not overlook fragility. The strongest of the commercially available plastics are about as strong in impact resistance as maple wood. Consequently, in relatively large moldings which carry several pounds of assembled apparatus, resistance to impact becomes a serious problem. By designing for proper distribution of impact stresses, however, breakage may be minimized. An illustration of this is in a molded design for the housing of the "combined" handset mounting. Most of the apparatus is mounted on a punched steel plate which in an early design was intended to seat on a continuous ledge inside the open end of the housing with a molded rim entirely surrounding it. When a set of this design was tested by dropping 30 inches to a wooden floor, the strongest available phenol plastic molding was broken. By a redesign, impact stresses were concentrated at less vulnerable locations; then a molding material of about one-eighth the impact strength formerly used withstood an indefinite number of drops without failure. This change made the use of a plastic material practicable.

Molded materials are generally poor in frictional wear resistance and products of wear sometimes injure electrical contacts by causing high contact resistance. The use of metal or hard rubber inserts or assembled parts which provide dissimilar materials for wearing surfaces are often helpful in such cases. Electrical contacts should be as far removed as possible from surfaces that are to suffer mechanical wear.

In subscribers' apparatus, such as the handset, appearance is important and involves several elements including shape, color, and finish as well as problems of sound transmission, weight, strength and manufacture. The addition of pigments to obtain light colors usually affects the strength and density of the materials and exposure to sunlight rapidly darkens many light-colored plastics. Some molded parts have the mold parting

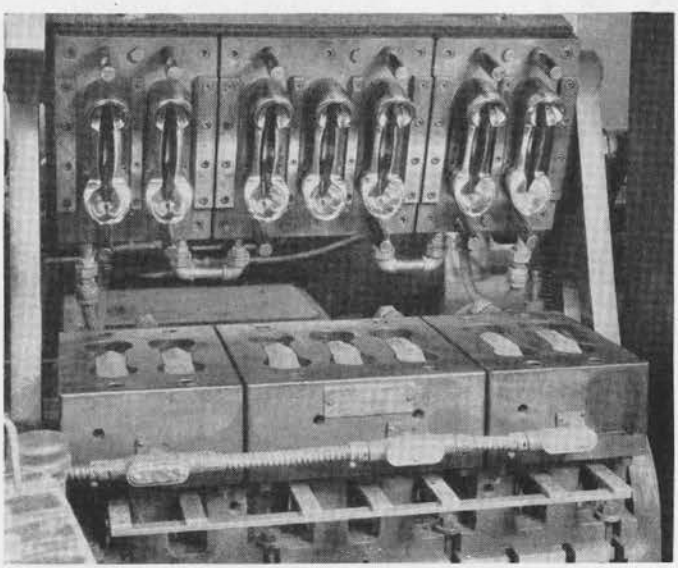

Fig. 1—Several handset handles are molded simultaneously in a hydraulic press

line in a position perpendicular to the direction of pressure and form so-called "horizontal" fin lines which introduce another appearance problem. The handset handle, which is molded as shown in Figure 1, has such a fin line and required careful grinding and buffing of a large area to produce the necessary surface smoothness. The development of an ingenious method of removing the fin automatically by machining a groove at the fin line is an outstanding improvement from the standpoints of both appearance and economy. Involved with appearance, although not strictly related to it, is heat conductivity. In apparatus such as the handset, which comes in contact with the face and hands, the use of exterior metal parts or other materials which conduct heat rapidly and feel cold is not generally favored.

Although many plastics were originally developed as electrical insulating materials, they are much more generally employed now because they provide an economical method of manufacturing irregularly shaped assemblies completely finished. However, in telephone apparatus certain dielectric properties of plastics are of importance to the designer and insulation resistance is of great interest in parts which carry closely spaced conductors. Arc resistance also requires the attention of the designer in certain types of apparatus. Some materials will continue to conduct over their surfaces after the original arc breaks. Others such as hard rubber and cellulose acetate do not form a conducting surface when burned by moderate arcing. An interesting example is the successful use of cellulose acetate molded compositely with phenol plastic so as to form an arc resistant front face for a test strip with two hundred inserts. The use of a thermo-setting material for the basic structure is mandatory to withstand the temperature rise resulting from extensive soldering operations required on the terminals.

Thermal and climatic effects require considerable attention in design of molded apparatus because practically every organic plastic is adversely affected to some extent by variations of these conditions. Most thermo-plastics "cold flow," some excessively at summer temperatures. Obviously this results in distortion which might loosen screws or other parts which stress the material. When operating temperatures do not exceed 120 degrees Fahrenheit the problem may frequently be solved by reinforcement or by other means of relieving or distributing the stress.

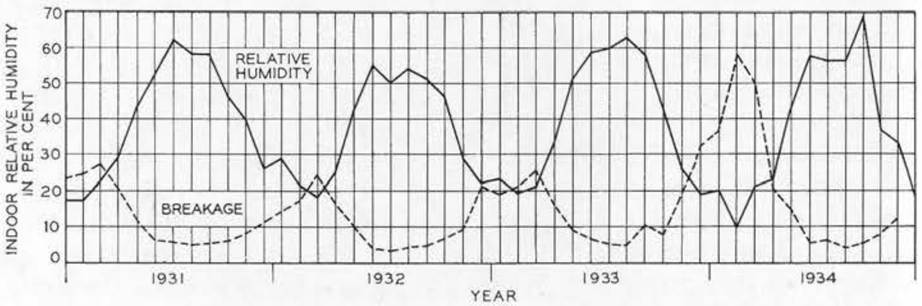

Fig. 2—Breakage of molded telephone apparatus increases during the winter months when humidity is low

Humidity has a disturbing influence upon the mechanical characteristics of many plastics and field experience with telephone apparatus has clearly indicated that impact resistance decreases with decrease of humidity. This is demonstrated in records of breakage over long periods, which show a substantial increase in failures of molded phenol-plastic parts located indoors during the winter months when the humidity is extremely low due to artificial heating. The breakage of such parts is plotted in Figure 2, where it will be noted that the strength of phenol plastics is restored by an increase of humidity. Certain cellulose acetate plastics on the other hand are subject to permanent shrinking and warping, when exposed to alternate humidifying and drying. This appears to be caused by the loss of a constituent which is volatilized with the moisture during the drying stage. The smoothness of molded phenol plastic surfaces is generally more difficult to preserve in humid atmospheres when materials of higher impact resistance are employed. Use of a cellulose filler with long wick-like fibers to improve impact resistance may allow moisture to be more readily drawn into the material with consequent roughening of the surface finish caused by the moisture swelling the fibers. Subsequent drying does not restore the original smoothness of the molded surface.

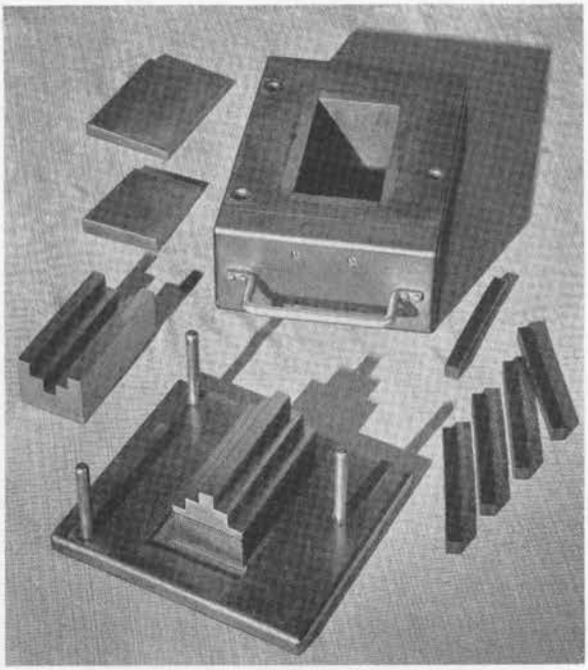

Fig. 3—A mold with step-like pistons is used where a large number of test pieces of the type shown are required for experimental purposes

To accumulate first-hand information on the characteristics of molded plastics, suitable molds and molding equipment for preparing test pieces have been provided. In addition a variety of molds for preparing round and rectangular blocks is required to supply material which may be subsequently machined into working models of proposed apparatus parts. Often by preparing simple modifications of standard molds it is possible to form in the molding operation designs which are subsequently completed by machining.

For tests of impact and transverse strength, cold flow, insulation resistance, and certain other determinations of materials, standard test bar samples can be employed. When one type of specimen is used for a variety of test purposes a large number of pieces are required and they must be molded to conform to the widely varied characteristics of the materials. A mold which satisfactorily fulfills these requirements for most plastics has been designed in a step-like form of upper and lower pistons which operate in a rectangular box having wedges on one side and end. This gives a five-impression mold with a single cavity as shown in Figure 3. Opening of the mold is facilitated by first loosening the two wedges.

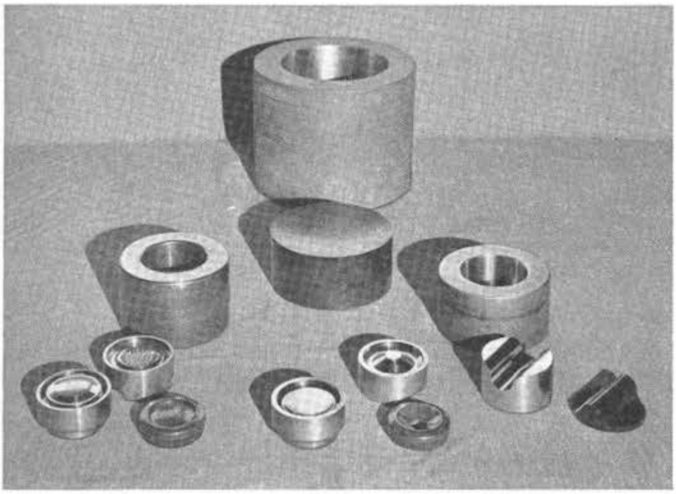

Fig. 4—Transmitter and receiver caps and certain test specimens are made in round molds with special pistons

For testing the surface finish of molded materials a specimen of rather unusual shape has been designed which provides curved and flat surfaces as well as thick and thin sections. The variation of surfaces and section thicknesses which sometimes occurs in a single molded part, such as a handset handle, has suggested this type of specimen for appearance tests. For a large variety of electrical measurements a six-inch-diameter disc of variable thickness is employed according to the requirements.

Several molds for producing round parts with boxes which have varying amounts of filling space are shown in Figure 4. Frequently one or more special pistons are used with these molds to prepare partially molded designs which occasionally carry inserts and which may be subsequently machined. Several of these special pistons together with some of the resulting molded parts are shown. This system of actual molding of questionable features of design is not only economical but of great value because it permits a variety of materials to be studied in a specific application and demonstrates the feasibility of novel features of design whether from an engineering or manufacturing standpoint.

Certain molded parts for telephone apparatus, intended for manufacture either in large numbers or with exacting requirements, justify the construction of experimental molds to produce completely molded working models of the proposed design. These can also be used for trial installations. In such cases the molds are usually made to permit molding several proposed modifications and thus give the maximum flexibility in molding methods and material selection. One of these molds is illustrated in the photograph that is shown on page 212.

All of this work, however, is merely indicative of a fund of information which during the last ten years has been gathered in a coördinated investigation of molded materials. It was part of a program to accumulate pertinent information through a group of engineers and from that source to supply information for the use of designers. The wisdom of the policy is attested by the service history of the molded parts in the telephone plant.