Natural or Synthetic, They Are the Product of Chemical Science, Possessing Properties Which Fit Them Well for Important Communication Functions

Plastics—Their Growing Use in Telephone Plant

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THE FIRST telephone receivers to be produced in any quantity, after wooden casings were abandoned 'way back in 1877, were made of plastic material.

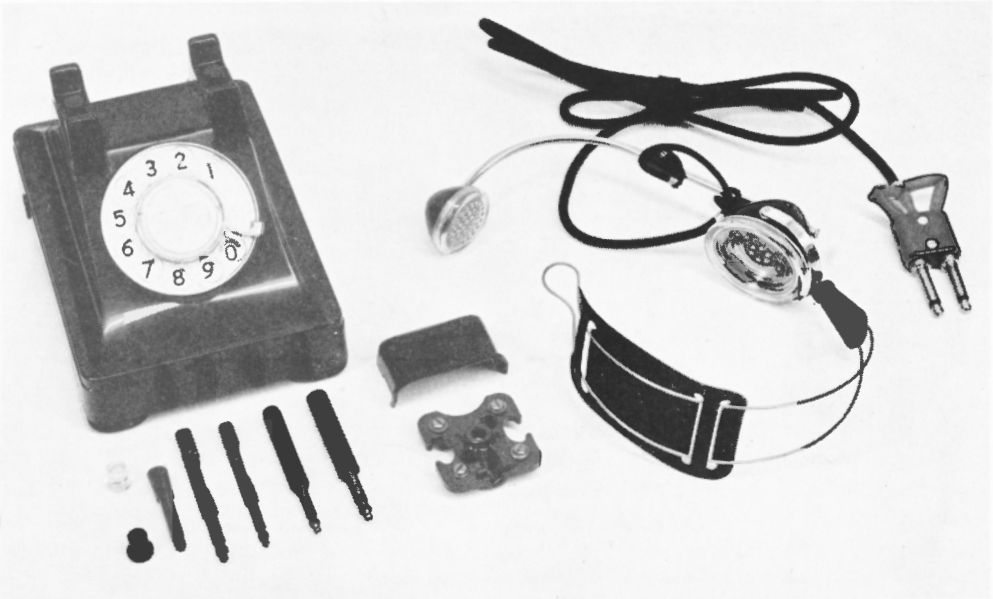
So are the operators' light-weight head sets adopted in the Bell System in 1946.

The old telephone receivers were created out of hard rubber: "hard" because Goodyear's discovery of how to vulcanize the soft latex from the trees made it possible to mold and harden *natural* rubber. The new light head sets are formed out of phenol plastic: *synthetic* (artificial) material which also can be given useful shape through the application of heat and pressure.

These are but two examples, out of many, of the Bell System's adoption and adaptation of materials and processes to special uses in the communications field. As natural materials become scarce, and as new types of synthetics are developed, plastics are playing an increasingly important part in the manufacture of many elements of telephone plant.

Lead, for example, has been the major component of telephone cable sheath since copper wires were first successfully enclosed in its protective embrace. In recent years, lead has been in scarce supply.

Are we about to produce lead synthetically then? No indeed. But what we are doing is developing combinations of synthetic materials which may turn out to do as good a job of protection as lead did, and may therefore be an alternative and a supplement to lead. Specifically, the excellent water-resisting properties of polyethylene and rubber thermoplastic give promise that, when combined in "sandwich" construction with metal tapes or thin metal sheaths, these materials will provide a workable substitute for lead cable sheath.



The adaptability of plastics is illustrated by this variety of plastic products, including the combined set housing and finger wheel; the operator head set with plastic caps on transmitter and receiver; and key buttons, plug insulation, and connector block and cover

Textile insulation for wire has also been hard to obtain in sufficient quantity, and the possibilities of using plastics here are being studied. Extruded plastic coatings on copper and aluminum wire may become of great importance in the telephone business. Drop wire jacketed with neoprene; switchboard cable jacketed with polyvinyl chloride; switchboard wire insulated with polyvinyl chloride and polyethylene; neoprene and nylon for sheathing: all these are on trial.

A rapidly growing field of use is that of the new adhesives, which are compounded of various plastics. These adhesives are very strong, permanent, water-resistant, and unaffected by fungi. They may be applied successfully to join many materials: other plastics, wood, ceramics, even metals. It is these qualities which make possible the creation of composite or "sandwich" products combining properties no single material can possess. Think of them in terms of the prefabrication of many things used in the telephone business: from movable central office partitions to portable equipment, from telephone booths to cabinets for the micro-wave repeater project. Those are, of course, for the future.

A Future—and a Past

NEW USES, new applications of plastics are developing day by day. It is a lively and growing industry. But it is by no means all new: plastics have a past as well as a future. Actually, much telephone apparatus of one sort and another—some of it entirely familiar—has long been made of plastic material. The hand tele-

phone is one example; the combined-set housing is already becoming another. From plastic materials are made dial finger-wheels, connector blocks, key button tops, plugs, vacuum-tube bases, protector mountings, and insulators of various kinds.

A plastic may be any one of a great number of materials and of both natural and synthetic origin. For example, phenol plastic, rubber, shellac, methyl methacrylate, are all plastics. Rubbers may be either natural or synthetic, shellac is natural, and phenol plastic is synthetic. Plastics are very often combined with other materials as fillers. They may be used as paints and adhesives.

The common denominator of all plastics is that at some time in their career they must be capable of being cast, extruded, pressed, formed, after which they cool or age to comprise a usable part. The flowing or plastic deformation may be carried out by heat, by pressure, or both. Some plastics are fluid to begin with and are cured or changed to a harder substance. When this happens, solidification or polymerization, or both, may take place. The former means the combination of two or more molecules with the liberation of water, hydrogen chloride, or other material, to form a new substance. Polymerization is a chemical process resulting in the formation of a new compound whose molecular weight is a multiple of that of the original substance.

For convenience, plastics may be

Combined-set bases travel by conveyor to the next process after being removed from the iniection molding machine

Vacuum tubes with plastic bases are placed in aging racks, where they are stabilized and tested

divided between thermoplastic and thermosetting materials. The former comprise those substances that can be re-softened by heat. The latter cannot be re-softened because a non-reversible chemical change has taken place. Cellulose acetate, methyl methacrylate, are examples of the former; phenol formaldehyde and urea formaldehyde are examples of the latter.

Compounds and Qualities

THE COMPOUNDING of a plastic is a highly skilled art. Fillers are added to provide bulk, strength, and electrical characteristics. Plasticizers are added to increase flow and workability. Pigments and reenforcing materials also form a part of the compound. Thousands of compounds are thus available for use.

Plastics as used in the Bell System may be grouped in three classes, each characterized by particular qualities.

One is for applications requiring mechanical strength: the ability to hold to original shape and size, and to stand up under impact, wear, battering and bending and stretching.

Another is for electrical applications where insulation and arc resistance and non-conductivity are important.

Still a third class is for general application where an economical part of pleasing appearance and reasonable strength and perfomance is desired.

These are the broad bases on which a particular plastic may be selected for a particular use or service. Any or all of these desirable qualities may be useful in practical application.

The earliest plastics in the telephone plant were insulating materials such as hard rubber, vulcanized fibre, and shellac-mica compositions. Among the first synthetic plastics was Bakelite, which came to be used in molded form and as the resin in phenol fibre.

Phenol plastic forms an insulat-

ing material used mainly where stability combined with reasonable strength is important. It is used for our telephone hand set. This particular compound consists of phenol formaldehyde resin with 50 percent filler, the latter being a mixture of wood flour or ground wood and cotton floc or linters. It is cheap, strong, mechanically stable, and chemically inert. As a rule, and this is true of most plastics, the parts come from the molding die substantially ready for use with excellent surface finish.

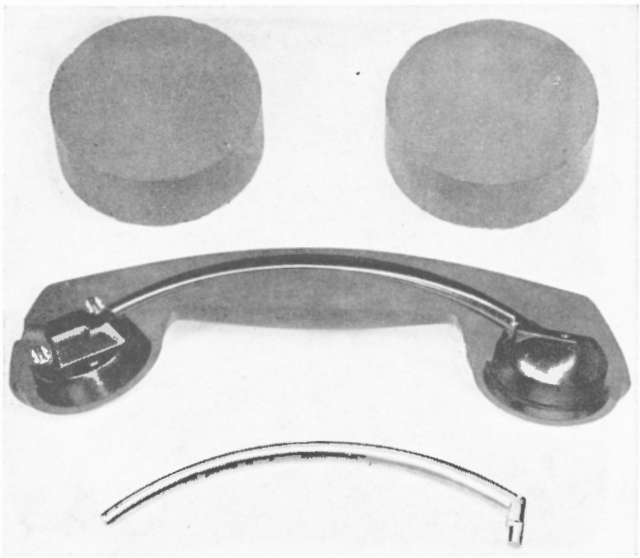
Akin to phenol plastic is phenol fibre. This is made by impregnating various types of absorbent paper with phenol formaldehyde laminating varnishes. After drying or partially curing the resins, the sheets of varnish-impregnated paper are stacked in a press and cured under a pressure of one-half to one ton per square inch at a temperature of approximately 325°F. for about one hour.

A new operator head set, with plastic caps on transmitter and receiver, gets a "talk test"

Plastics as Insulators

VARIOUS GRADES or kinds of phenol fibre are used. These vary in resin content and formulation and in the character of the surface sheet. High resin content produces good electrical characteristics; lower resin content, good mechanical strength; and for certain grades a tung oil plasticized varnish is used. Instead of paper, cloth may be employed to obtain variations in strength and appearance.

Organic plastics do not conduct electricity, and hence form insulators. These insulators must be very good, so that the telephone's comparatively feeble electric currents will not leak away or be lost in transmission. Telephone apparatus must also be stable, so that the adjustment of relays, keys, switches will be reasonably permanent. Insulators must not deteriorate chemically or affect adjacent parts nor cause corrosion or deterioration. Consequently, the properties of mechanical and chemi-



Out of these components will come a hand telephone. Top to bottom: plastic pre-forms, half section of molded handle, and core

cal stability are of predominant importance in the telephone art.

Plastic parts that are placed in the hands of the public—hand sets, for example—must not only be good insulators, but must be chemically stable and not affect the subscriber's person. Appearance, fire hazard, physical strength, and manufacturing facility are properties of considerable importance. Other qualities are, for instance, specific gravity, tensile strength, electrical characteristics, and availability.

Plastics vary greatly in price and in processing costs. The selection of the most suitable plastic for a given application is thus a complicated engineering problem.

Plastics have brought in their train several difficulties which must be dealt with in apparatus design. Age cracking or crazing can occur with some plastics in ordinary atmospheres, when flexed or strained, or in contact with solvents. The latter factor is particularly important when certain household cleaners are used.

Fastness to light, and particularly light and humidity, is a problem. This is of major importance with colored objects where a pleasing appearance is desired. Exposure tests have been carried on for years on the roof of the Bell Telephone Laboratories in New York. Tests have also been made at various locations throughout the United States:—Miami, Key West, Pittsburgh, Sandy Hook, and in the Panama Canal Zone. Thousands of specimens have been exposed and tested in natural as well as artificial environments. These have been specific telephone parts, combinations of parts, test panels, corrosion couples, etc. As new plastics appear, more tests are made. Fatigue tests by reversed flexing or by repeated impact are of great importance for dynamic uses.

New Manufacturing Arts

THE GROWING USE of plastic for telephone parts—the hand set, the operator's head set, the housing for the combined set, to mention only a few—has required the development of new manufacturing arts on the part of the Western Electric Company—the supply branch of the Bell System.

For many years, the insulation used on telephone plugs—the insulated metal end-piece attached to a connecting cord—was of hard rubber. Not infrequently, during the assembling process, metal chips would be picked up which would short-circuit the insulation. The injection molding of plastic material for insulation of the plug parts eliminated this difficulty and produced a plug with better and more stable insulation.

Originally, the connecting wires between transmitter and receiver of the hand set telephone were inserted in the mold before heating. As a consequence, it was hard to keep the wires apart during the operation, to avoid a subsequent short-circuit; and the plastic material at the center of the handle was not always fully cured. Now, the use of a metal core, which is a Western Electric development, not only keeps the wires separate, but permits the molding of a dense and very strong handle.

This can be brought about because, as a general rule, materials which are good insulators, and hence poor conductors of electricity, are also indifferent conductors of heat—since these properties tend to go hand

The hot pre-forms are dropped into the dies, the press closes, and in three minutes seven new hand telephones emerge

in hand. It has been difficult to cure heavy sections of phenol plastic because of this quality of poor heat conductivity, and thus the center of the hand set was not fully cured. A development just before the war demonstrated that the center of thick moldings could be "cooked" by the use of high-frequency electrical heating:—diathermy if you please.

For the hand set, specially compressed pellets of dry molding powder are placed betwen two plates in the output of a 14-megacycle 7-kilowatt oscillator for half a minute. This heats the pellets through by dielectric loss: the dissipation of the energy induced in them. The pellets come from the heating apparatus in a soft state, and may be quickly formed by pressure to the desired shape. This "curing" reduces the total process time, and produces a hand set of superior strength.

ANOTHER PROCESS that has become of great practical importance is that of casting resin. The resin is placed in a mold in liquid form, and is caused chemically to react by the addition of a catalyst to become a hard and infusible substance. During the war, casting resins of this type were used to make porous metal castings water and air-tight. This is possible because of their very low shrinkage.

Following the war, it was found possible to cast terminal strips in simple molds into which the terminals are inserted and the mold is filled with the casting resin compound. The particular resin used is a mixture of polystyrene monomer and a polyester plus a catalyst. In order to economize in the use of the plastic material, and also to reduce shrinkage and improve the stability of the casting, about 40 percent silica is added to the resins. Spun glass floc is also added to improve strength and some titanium dioxide to color the casting white. This is another example in pioneering by the Western Electric in a new field.

Western Electric also pioneered in the injection molding of so complicated an object as the combined telephone set.

A New Science

PLASTICS are competitive with other materials and processes, such as welding, casting, sheet metal fabrication. Good engineering must start from service needs and proceed to the selection of the best material and process from the standpoint of basic costs and adequate life. Plastics will replace some of our older materials because they will be better, and there will be instances where the molding process will provide economy over other processes in spite of higher cost of material.

Synthetic plastics are a product of modern chemical science and have no counterpart in natural materials. Practically all of these plastics are new. A large majority of them have come into commercial use since 1930, and some of the most valuable plastics from a communication standpoint, such as polyvinyl chloride and polyethylene, have been available only since 1938 and 1941, respectively. We do not have, therefore, the background of solid experience and familiarity of a great variety of service conditions with these new plastics that we have with natural and the older synthetic plastics—such as Bakelite, which appeared in 1909,

and cellulose nitrate, which appeared in 1868. Any prospective use of these new plastics requires intensive laboratory and field trials and compilation of experience data from service.

Bell Laboratories' Part

AT BELL TELEPHONE LABORATORIES, a division of the Chemical Department is indeed devoting itself to development and engineering studies of plastics. This group is primarily concerned with the application of plastics in the design of telephone apparatus, and one of its functions is to bring about developments in the plastics industry which can be used to advantage by the Bell System. Research efforts in this group have led also to the development of interesting new plastics, among which is Paracon, a synthetic rubber having valuable properties.

Plastics are not yet available for all of our needs, nor are they a panacea for all of our difficulties. But it is to be expected that their use will increase with developments in modern chemistry.

Automotive Authority

At about the time that Temple C. Smith's "Keeping Our Automotive Equipment Modern" appeared in the last (Summer) issue of this MAGAZINE, a shorter version of it, described as a "guest editorial," was published in *Fleet Owner,* a trade journal of the truck industry. Our readers may be interested in that publication's estimate of Mr. Smith and his job:

"It is fitting that Mr. Smith should be invited to be a Guest Editor. His position with the telephone system brings distinction, as this organization operates one of the largest fleets in the country. Mr. Smith also speaks with authority, based on a good technical education as the foundation for many years of practical application of engineering principles to automotive requirements.

"It is fitting also that Mr. Smith selected a subject that points to what ultimately may become the predominate post-war trend—that of engineering the vehicle to the job. His company has had much experience in this direction, for the telephone fleet is called on to perform many jobs.

"Most of us may think of the telephone truck as a piece of equipment that stops in front of our home from time to time, while the repairman inspects the instrument or strings a new line of wire from the house to the nearest pole.

"The telephone company's fleet has many other tasks to perform, involving hauling and supplying of power.

"The engineering involved in producing the right equipment must have presented Mr. Smith with many interesting problems. Out of this vast experience has come some guide posts, and these should prove of great value to other operators in rebuilding and adding to these post-war fleets."