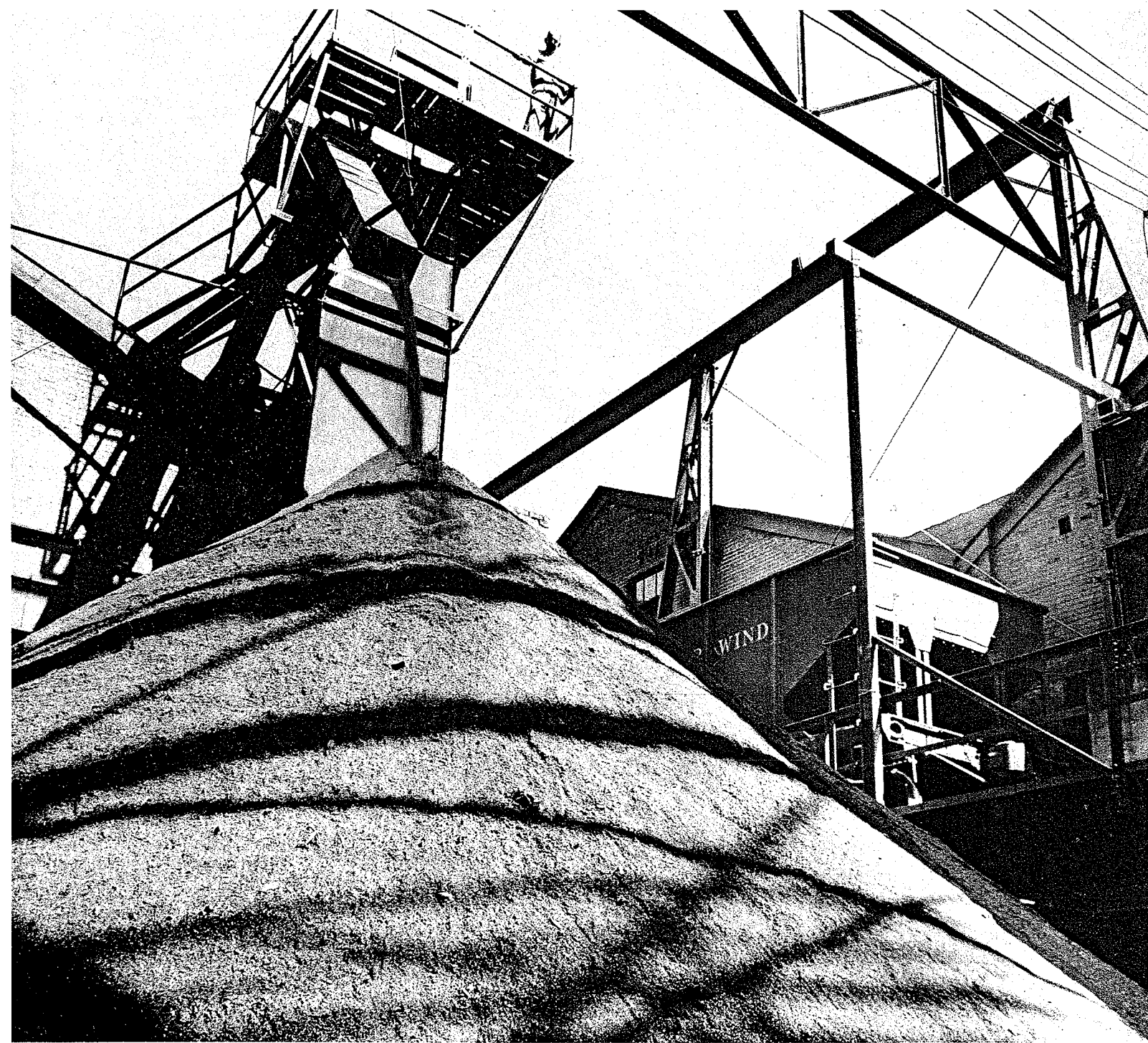


Powder Metals



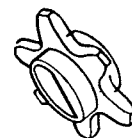
PLASTIC METALS

Division of
National-U.S. Radiator Corporation

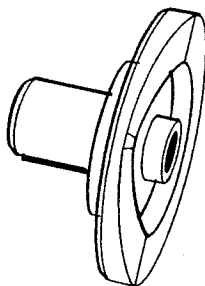




PRODUCTION of Iron Powders



PLASTIC METALS is the oldest commercial iron powder producer in the United States, having produced and sold iron powder continuously since 1933. During the years that have elapsed since the original pioneering work, *Plastic Metals* has supplied more iron powder than any other American producer, and has gained prominence as a supplier of other metal powders. The plant buildings shown in the photograph, cover a manufacturing area of almost four acres.



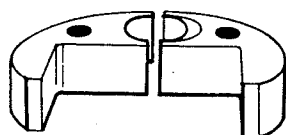
Demand for iron powder enjoyed its greatest period of growth during and following World War II. This growing demand attracted and continues to attract numerous producers, both large and small. After brief experience, however, many such firms are forced to discontinue iron powder production because their products have failed to find profitable markets.

In selecting an iron powder supplier, it is important to consider the manufacturer's performance record over a period of years. *Plastic Metals* qualifies as a sturdy and progressive pioneer that has proved its ability to offer quality metal powders for more than 20 years in this changing and growing field.

Variety of Grades

While most people know of the many applications that exist for iron powders, many do not fully realize that a wide variety of grades are needed to satisfy the complete range of end use requirements. Different production processes impart different properties to the powder. For example, electrolytic iron is characterized by high purity which in turn can be utilized in obtaining exceptional compactability or unusual magnetic properties; carbonyl iron powder is composed of small spherical particles which make it desirable for the production of certain electronic cores; reduced oxide powders offer many characteristic properties depending upon the form of oxide used and the reduction process employed. Similarly, the atomization of molten iron provides certain special properties.

It becomes obvious, therefore, that no one process is suitable for making all of the various grades of iron powder that industry requires. *Plastic Metals* is equipped to employ a number of these basically different processes for making iron powder, and as a result is in an unexcelled position to offer a great variety of grades.



Most grades of powder produced by *Plastic Metals* have been developed through close co-operation with customers and usually are designed for specific purposes. Some of these powders still have highly specialized applications, others long have enjoyed wide commercial acceptance. Details about specific grades and their uses will be furnished upon request.

In producing two of the basic types of iron powder, *Plastic Metals* employs specially developed electrolytic and reduction methods. The highlights of these two processes are described and illustrated in this bulletin.

ELECTROLYTIC IRON POWDER. Electrolytic iron powder production begins with steel plates being placed, as the anodes, in cells or tanks containing an iron salt bath or electrolyte. Cathodes, on which the powder-to-be is deposited in the process, are stainless-steel sheets roughly the same length and width as the anodes. The photograph, Fig. 2, is a partial view of our cell room showing the cells and anode and cathode arrangement. The operator in the foreground is inspecting the electrolytic iron deposit on one of the cathodes.

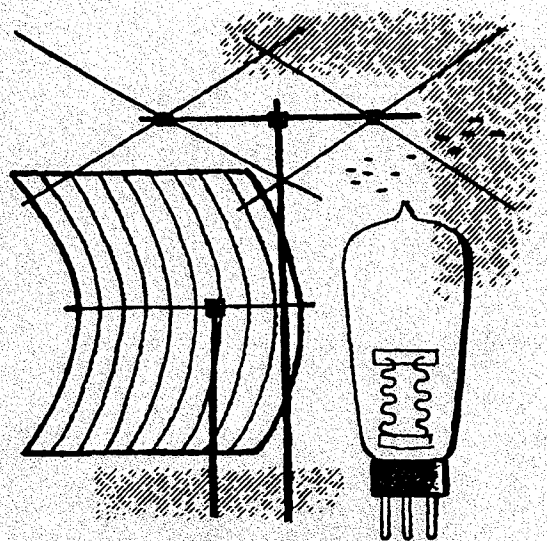
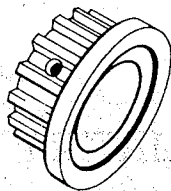
Current is supplied to the cells by two dc motor-generator sets. It takes about 48 hours to build up the iron to the thickness most economical for pulverizing. The deposit averages about $\frac{3}{32}$ in. in depth.

As shown in the background of the picture, the entire rack of cathodes in a cell is removed when the proper amount of deposition has been obtained. The now-pure iron is bright silver in color and has a fine-grained, pebbly surface. A cold-water bath, hot-water rinses and drying follow. Cell conditions must be controlled so that the deposit of iron on the cathode is not too adherent.

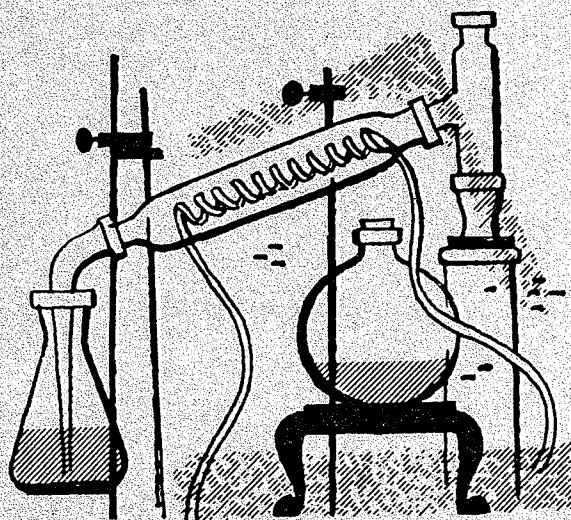
Operators then strip the electrolytic iron coating from the cathodes and the stainless-steel sheets are returned to the cells for re-use.

The electrolytic iron, as stripped from the cathodes, is brittle, consequently it can be broken into fragments, or can be pulverized to the required mesh or screen analysis. This pulverizing operation may consume from 8 to 24 hours.

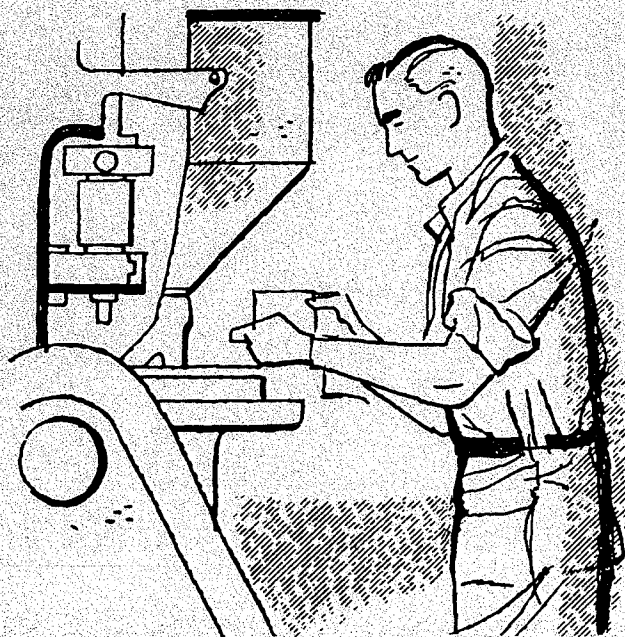
A certain amount of the electrolytic iron is sold in the fragment form prior to pulverizing.



ELECTRONICS



CHEMISTRY



POWDER METALLURGY



2—Electrolytic iron is produced in these electroplating cells.

These fragments are used as high-purity melting stock for the preparation of special alloys and closely controlled ferrous metals, some of which are produced by the recently developed vacuum melting process.

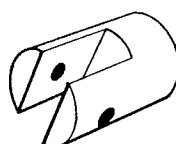
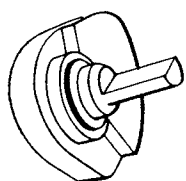
While some electrolytic iron powder produced by *Plastic Metals* is sold in the unannealed state, most powder before shipment goes through one of the annealing furnaces shown in Fig. 3. The two large furnaces in the foreground are continuous units, equipped with metal belts to convey the powder through muffles in which reducing atmospheres are maintained. Both dissociated ammonia and cracked natural gas are available as atmospheres. This annealing operation softens the powder particles so that they become plastic or compactable.

Again, depending on the end product desired, the annealed material may be subjected to further processing. Virtually all production

of powder goes through screening, or air classifying and blending equipment to assure proper particle size distribution and uniformity of the finished product.

REDUCED IRON POWDER. The source of iron in this process is mill scale, a form of iron oxide, which formerly was a waste product from steel making operations. The photograph on the front cover shows mill scale being unloaded from a railroad car.

The process starts with the production of sponge iron in a rotary kiln. Two such kilns, Figs. 4 and 5, are installed in the *Plastic Metals* plant to assure adequate production capacity and flexibility. One of these kilns is 60 feet long, and the other is 80 feet long by 8 feet in diameter. The feed ends of these kilns are somewhat higher than the discharge ends to provide for a continuous and uniform flow of material through them.



Specially selected mill scale is fed, along with crushed coke, into the kiln. The coke serves as the reducing agent in this process. The rotation of the large cylinder and the effect of gravity cause these raw materials to travel with a constantly tumbling action through the length of the kiln. As the mixture of scale and coke approach the discharge end of the kiln, it is heated by means of a gas or oil burner to a temperature of about 1900°F. Under these conditions the carbon in the coke reacts with the oxygen in the mill scale to form carbon monoxide and then carbon dioxide. These gases pass off through a stack at the feed end of the kiln. With the oxygen removed from the scale, the latter is restored to relatively pure iron having a granular, sponge-like structure, hence the term sponge iron.

It is necessary to cool the hot sponge iron before it can be discharged into the air, otherwise, re-oxidation would occur. This cooling is accomplished by means of a patented device illustrated in Fig. 4, which also shows the combination gas-oil burner at the discharge end of the larger kiln. The cooling system consists of a water-sprayed drum and coil arrangement through which the sponge iron and unconsumed coke must pass before they reach the air. Each time the kiln makes one revolution the material within the coil moves one turn toward its discharge end. When the material reaches the end of the water-sprayed tubing it is discharged at a temperature at

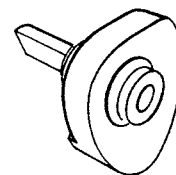
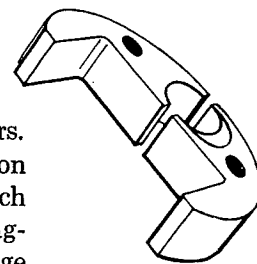
which very little iron re-oxidation occurs.

The mixture of cooled granular sponge iron which is magnetic and unburned coke which is non-magnetic then is passed over a magnetic separator. Relatively pure, clean sponge iron is thus obtained. The separated coke is used again as reclaimed material.

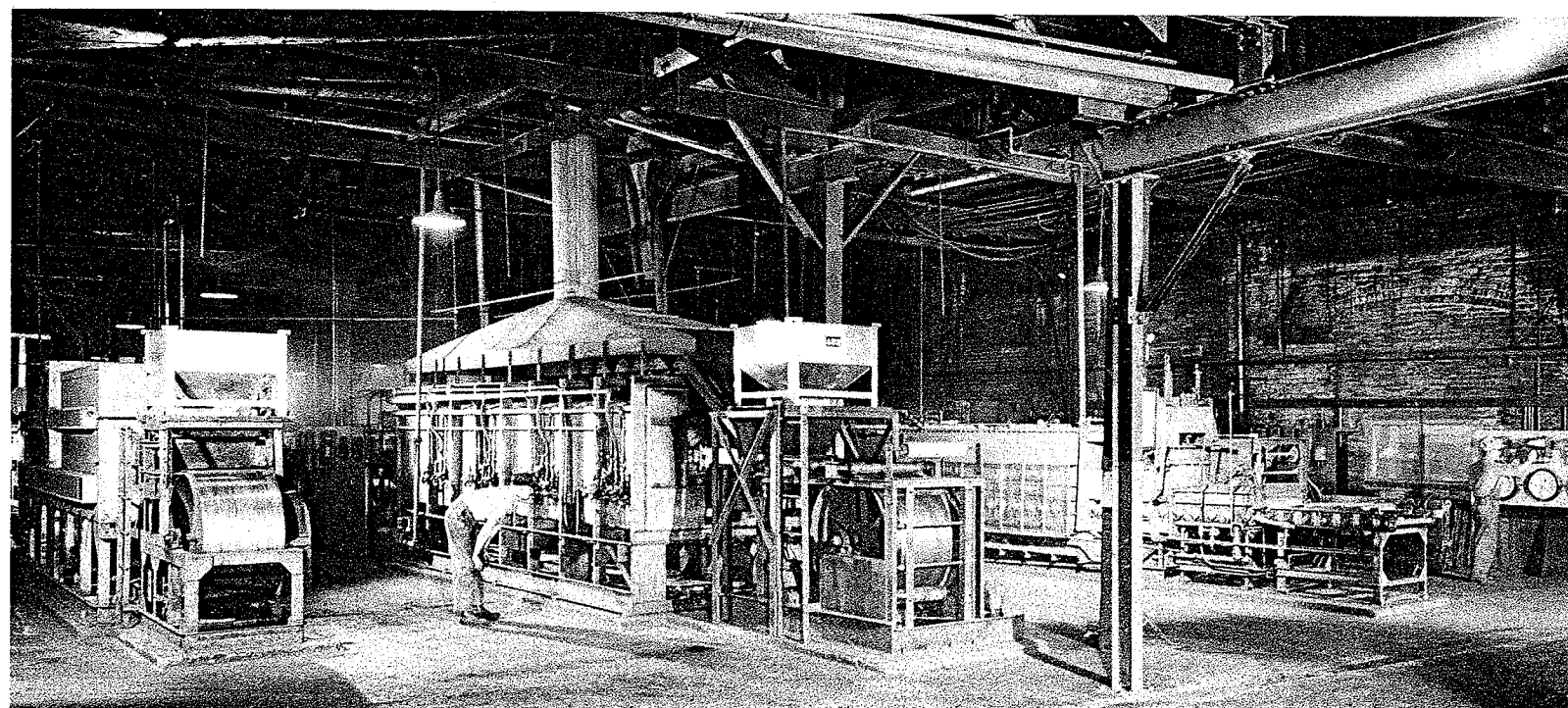
Depending on the finished product in which this sponge iron is to be used, it is ground in an attrition, hammer or ball mill. One of our large installations of continuous, grinding and screening equipment is shown in Fig. 6. Annealing of this sponge iron powder also may be required and the same furnaces used for annealing electrolytic iron powder are employed. Again, as with electrolytic iron, screening, or air classifying, blending and packing are the final steps in production. Figure 7 shows one of our large conical blenders which enables us to blend full truckloads of powder to close specifications. In this picture the powder is being packed in steel drums following a final screening operation.

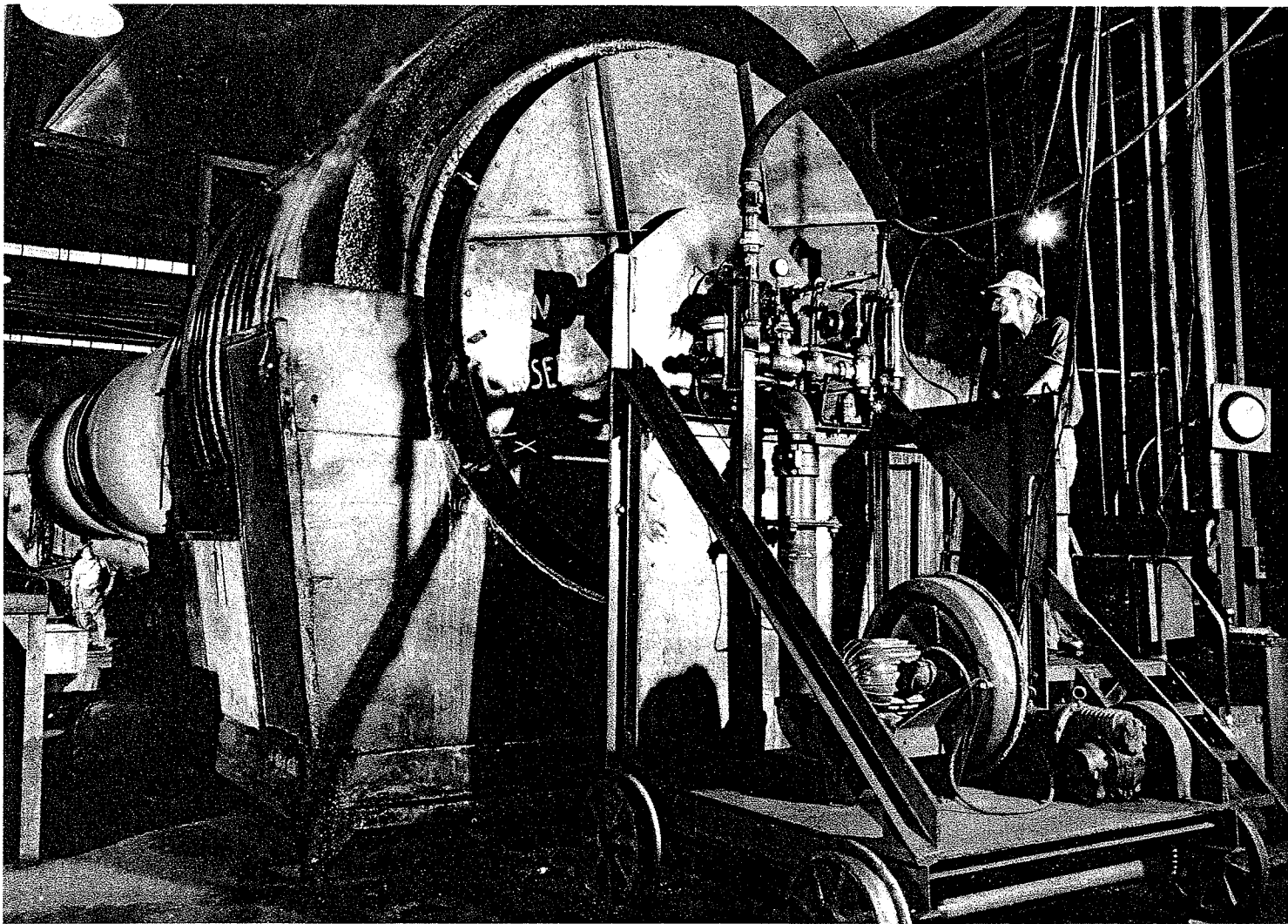
Non-Ferrous and Alloy Powders

Plastic Metals is an experienced, dependable supplier of other types of metal powders in addition to its many grades of iron powder. It is a large producer of nickel, manganese, silicon and ferro-alloy powders. These are available in certain standard grades as well as processed to customers' individual specifications to meet a variety of needs.



3—The iron powder is softened in annealing furnaces to make it more compactable.





4—Discharge end of the 80-ft. kiln showing the burner and pipe coil cooling device.

UTILIZATION of Metal Powders

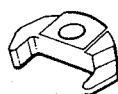
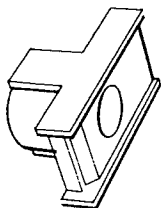
Plastic Metals does not fabricate metal powder parts commercially. Through extensive research, however, and through long experience in the production of metal powders for specific applications, *Plastic Metals* has developed many products for this field, and is in a position to cooperate effectively in the solution of fabricators' compacting and sintering problems.

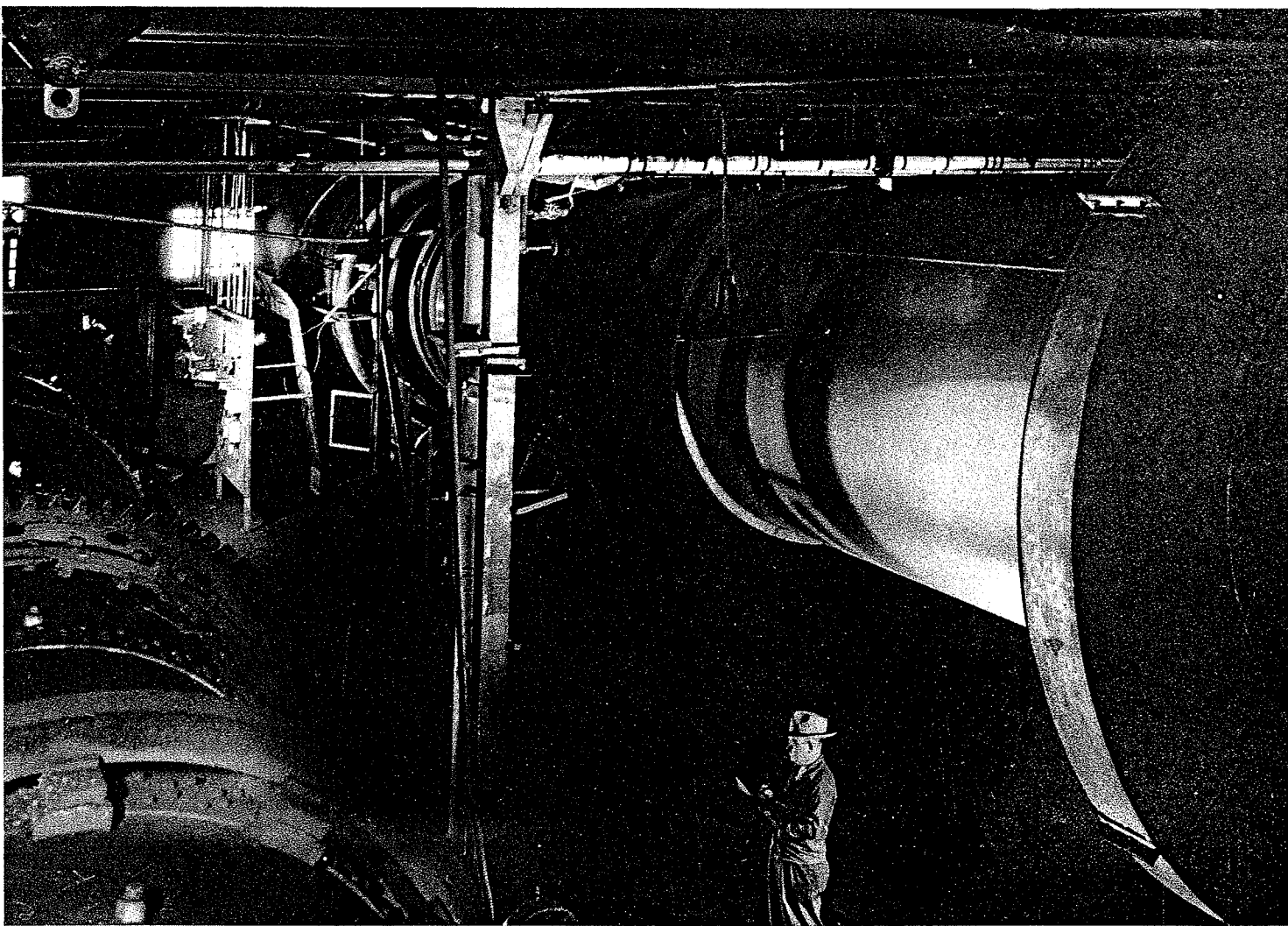
The fabrication of parts from metal powders has been covered thoroughly in many publications, but very briefly it consists of the following steps: The metal powder is mixed with a dry lubricant such as zinc stearate, is pressed at room temperature into a die at pressures which normally range from about 10 to 60 tons per sq. in. according to desired

properties. The resulting green compact is relatively weak and cannot be used in this state until it is sintered.

The compact, therefore, is heated in a furnace under protective atmosphere to the prescribed temperature. For iron powder parts this is about 2050°F. Sintering time normally ranges from about 10 to 60 minutes or more. The longer the time, the stronger the part. In many cases the sintered compact is usable without machining or further treatment. Where close dimensional tolerance or superior physical properties are required, the sintered compacts are sized or coined at die pressures equal to or sometimes exceeding the initial compacting pressure.

The process offers the advantages of low





5—Production of reduced iron powder is handled by two rotary kilns.

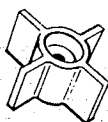
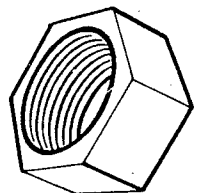
fabrication cost, speed, elimination of waste material, and special properties. It cannot be emphasized too strongly, however, that the production of parts from metal powders is not simply a matter of pouring powder into a die, exerting pressure and then after ejection from the die, sintering or heat treating the green compact. The part must be suitable in size and shape for this method of fabrication. It must be required in sufficient quantity to justify the cost of dies and special tools. It must have physical properties within the limits of economical production in competition with other methods of fabrication.

In addition, the powders must be selected carefully and if more than one powder is involved they must be mixed thoroughly along with a suitable compacting lubricant. The pressing and sintering conditions must be controlled to provide the desired physical properties and dimensional tolerances.

It should be understood also that the physical characteristics of a part produced from metal powders may not correspond to those of the part produced by other methods. It is advisable, therefore, to check physical specifications against actual service requirements rather than against standards established for other methods of manufacture.

POROUS PARTS. One of the most important applications for metal powders is in the fabrication of low-density parts in the form of oil-less bearings, bushings, and other self-lubricated items. In such parts, advantage is taken of controlled porosity by impregnating the pores with oil, graphite, or other lubricants. Such parts are widely used in automobiles, household appliances, business machines, etc.

HIGH DENSITY PARTS. During the last ten years substantial growth has developed in the



6—One of the continuous ball mills, which pulverize the iron to fine powder.

production and use of high-density parts whose physical properties approach or even exceed those of machined castings, forgings, stampings, etc. Design engineers are continuing to find new ways to use this method of fabrication. Substantial savings in cost and improvement in quality may result.

Electronic and Magnetic Parts

Many different grades of iron powder go into the production of parts used in a variety of electrical and electronic devices. Among these items are pole pieces, permanent magnets, permeability tuning cores, transformer cores, cathode ray tube deflection yokes and numerous radar and sonar parts.

Plastic Metals specializes in working with its customers to produce powders that will meet exact magnetic or electrical needs.

Friction Materials

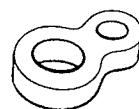
Ferrous and non-ferrous powders find extensive employment in the fabrication of brake linings, clutch facings and other friction products. *Plastic Metals* has developed iron powders especially for such applications to be used in combination with metallic, ceramic and other non-metallic compounds.

Cutting Wheels and Tools

For certain types of cemented carbide cutting tools, *Plastic Metals* nickel powder successfully replaces the conventional cobalt powder. Likewise, special grades of iron powder developed by *Plastic Metals* are serving as the bonding media in the manufacture of diamond abrasive cutting wheels. These abrasive wheels are fabricated by compacting the iron powder and diamonds, and then sintering the compact under closely controlled conditions.

Chemical Applications

Metal powders produced by *Plastic Metals* find numerous and varied applications in the chemical industry. These powders are used as reducing agents, catalysts, analytical reagents and as raw materials in the preparation of many chemical compounds. High purity metal powders, for example, are utilized in pharmaceutical applications and for closely controlled chemical reactions both in the laboratory and in production.





Flame-Cutting

A relatively new field for iron powder has been created by a development which makes it possible to flame-cut and scarf stainless steel and other metals which heretofore have resisted an oxyacetylene torch. By introducing prescribed amounts of iron powder into the oxygen stream, the flame temperature of the torch is so increased by the heat given off by the burning iron that it will melt readily many metals and alloys which formerly had to be sawed, ground, or otherwise more laboriously attacked. *Plastic Metals* iron powders for cutting and scarfing purposes are produced to the exact specifications of the oxygen and industrial gas manufacturers who supply these compounds.

Welding Rods

Another recent development is the utilization of iron powder in the coating of welding rods. This practice results in electrodes which, under many conditions, provide better quality welds at lower cost. Likewise, nickel and manganese powders are incorporated in the coatings of electrodes designed for special-purpose welding.

Pyrotechnics

Silicon and manganese powders have been developed by *Plastic Metals* for special pyrotechnic applications. These powders, along with other ingredients, are used in the manufacture of fuses, flares and various incendiary devices designed and adapted for both industrial and National defense purposes.

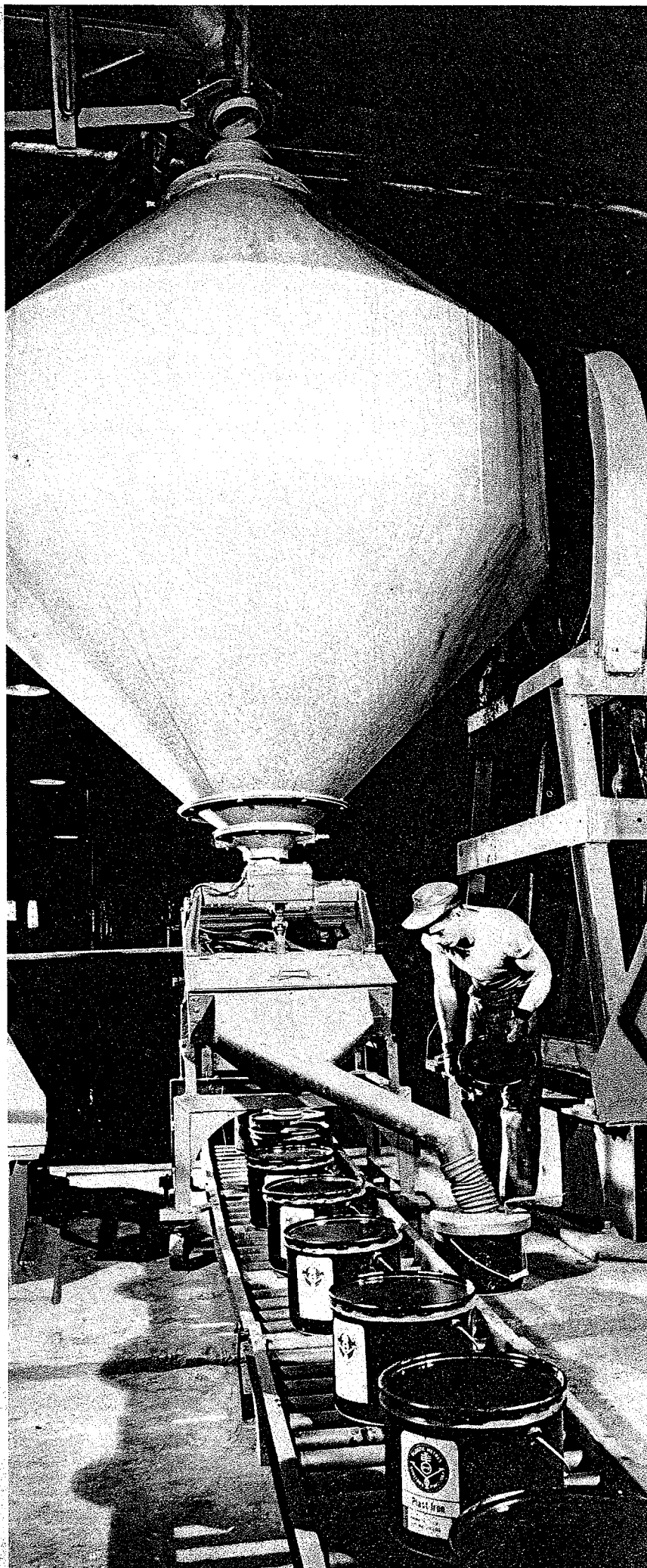
Atomic Energy

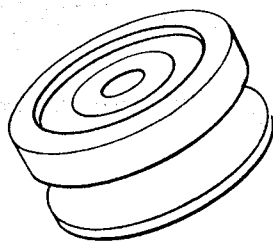
Metal powder applications also are found in the atomic energy program. Due to the many secret aspects of this program, the exact nature of these specific applications cannot be disclosed.

Engineering Services

Plastic Metals specializes in the production of superior quality metal powders for a wide variety of purposes. With its long experience in research, development and manufacture of metal powders, *Plastic Metals* is especially well-equipped to offer technical and engineering assistance in their utilization.

7—Thorough mixing of the powder provides maximum uniformity of quality.





***Standard Metal Powders
produced by
Plastic Metals***

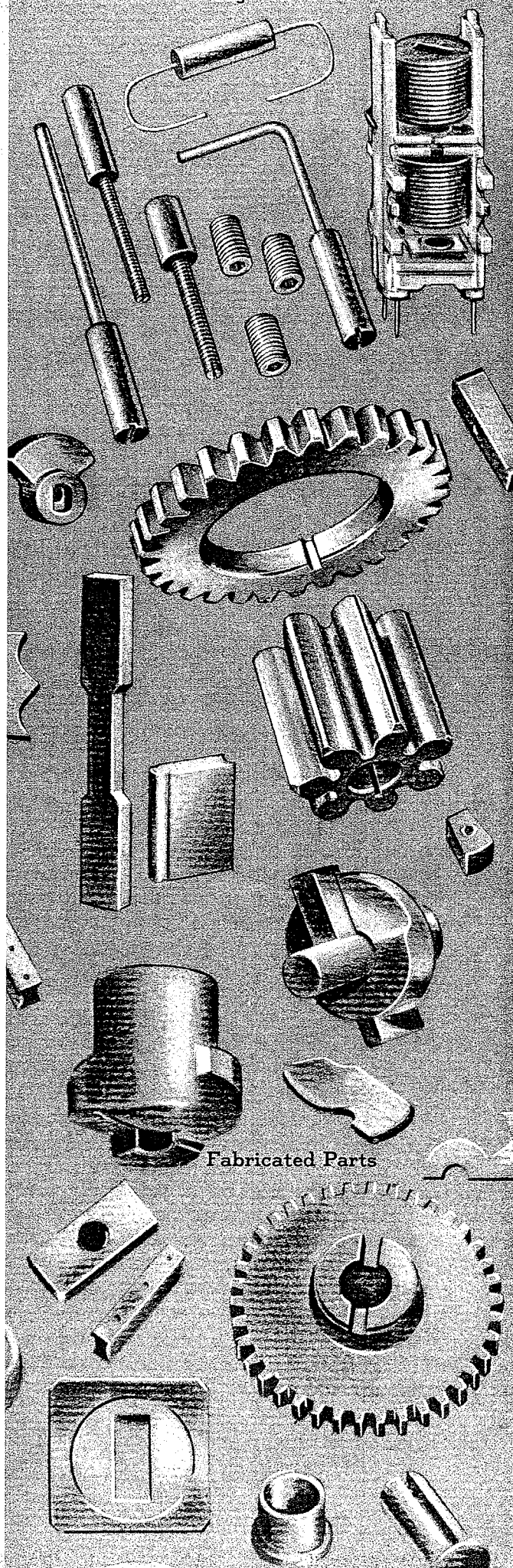
PLAST-IRON

Plast-Iron currently is available in many basically different grades. Among these is a high quality electrolytic iron powder. Its base metal is 99.9% pure. Due to its extreme purity, this type of Plast-Iron is ideally suited for electrical and magnetic applications. It has excellent compressibility, and will absorb carbon uniformly and rapidly. As a result, it is used extensively for the production of high density iron and steel parts. Its purity also makes this type of Plast-Iron suitable for many chemical and pharmaceutical applications. It is available in standard meshes from 8 to minus 325, and its apparent density can be varied from 2.0 to 2.6 grams per cc. It is also available in the form of fragments which are ideal as high purity melting stock.

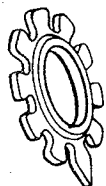
Another type of Plast-Iron is a reduced oxide form of iron powder which is produced to many different specifications. Parts made from this type of iron powder are notable for their high densities, strength and hardness. Among the grades of this type of powder are several which are characterized by closely controllable growth or shrinkage upon sintering, by exceptionally high strength without the use of copper and by a wide range of apparent densities. Many other grades are available.

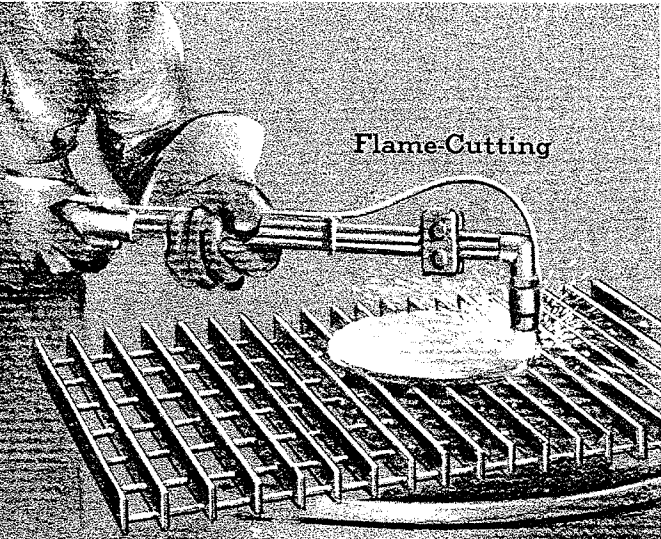
For electronic uses, *Plastic Metals* produces a number of grades of iron powder specially developed for the purpose in the frequency range of 10 to 100 KC. These types of Plast-Iron have exceptionally good permeability and "Q" values for electronic devices in the frequency range indicated.

Magnetic Cores



Fabricated Parts





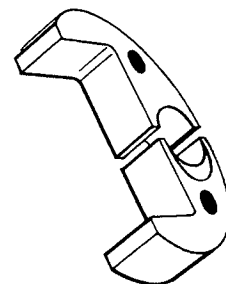
Flame-Cutting

PLAST-STEEL

Plast-Steel powders are compounded to customer specifications. Iron powders are specially processed with carbon, manganese and other elements to produce many desired steel analyses.

PLAST-NICKEL

Plast-Nickel is a high grade nickel powder with purity ranging from 97 to 99%. Both electrolytic and reduced oxide types are produced. Standard meshes are available from 12 to minus 325, and apparent densities range from 1.8 to 4.2 grams per cc. Either spherical or irregularly-shaped particles can be supplied to meet customer specifications.



PLAST-MANGANESE

Plast-Manganese is an extremely pure powder produced from electrolytic manganese having a minimum purity of 99.9%. It is available in standard meshes from 20 to minus 325, and in apparent densities ranging from 2.7 to 3.5 grams per cc.

PLAST-SILICON

Plast-Silicon powder contains from 96 to 98% silicon and is available in meshes from 4 to minus 325, and apparent densities from 0.7 to 1.5 grams per cc.

SPECIAL POWDERS

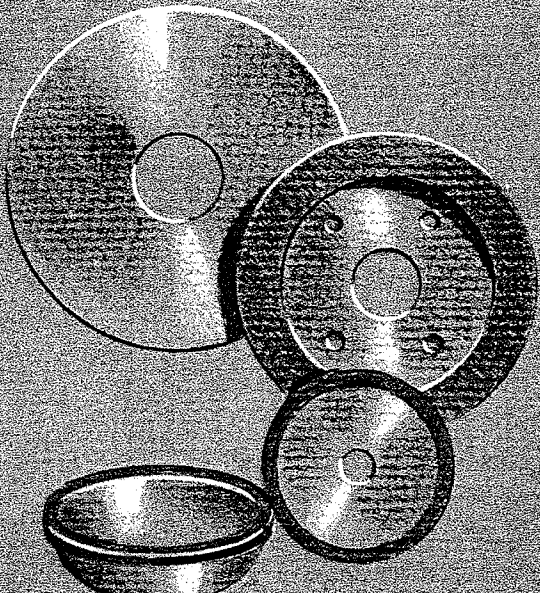
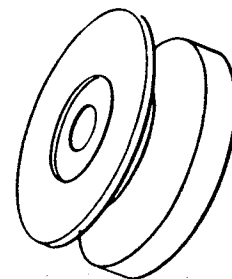
Combinations of the standard powders or of these powders with other materials will be produced to a customer's specifications. For detailed information about how metal powders can work for you, write to: PLASTIC METALS, Division of National-U.S. Radiator Corporation:

GENERAL SALES OFFICE

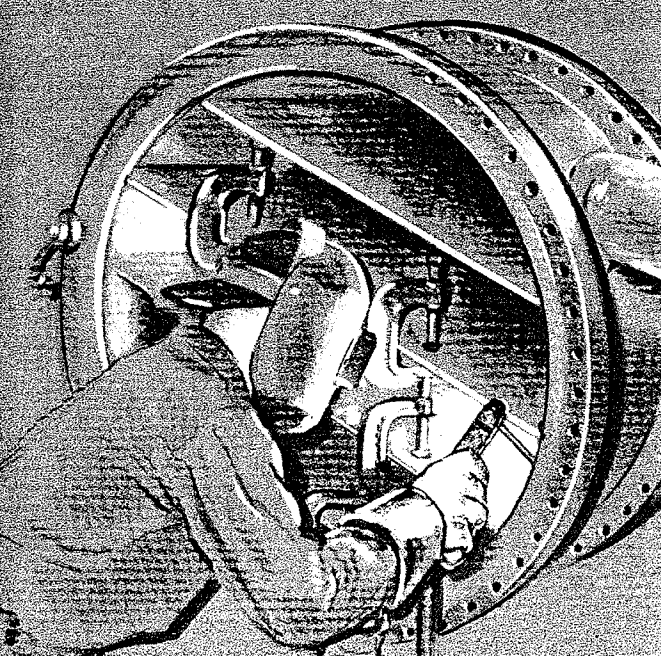
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Diamond Cutting Wheels



Welding Rods

