Automatic and Semi-Automatic Furnaces

for the

Continuous Heat-Treatment of Metals

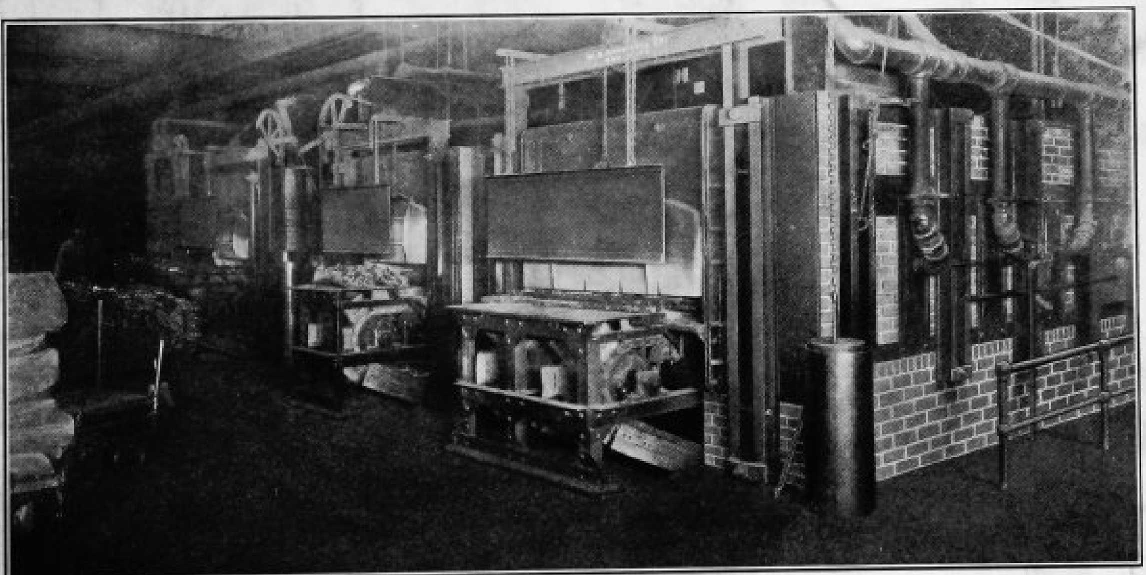

Fig. 1. AUTOMATIC FURNACES FOR HEAT-TREATMENT OF CRANKSHAFTS, ETC. CHARGING ENDS

Matter and Arrangement
Copyrighted 1920

W. S. ROCKWELL COMPANY

FURNACE ENGINEERS AND CONTRACTORS

50 CHURCH STREET NEW YORK
(Hudson Terminal Building)

BRANCHES: CHICAGO — CLEVELAND — DETROIT

June, 1920

No. 217

QUANTITY production of quality product involves consideration of many factors frequently overlooked in those manufacturing operations which include the heat-treatment of metals.

It is generally assumed, for instance, that the uniform heat-treatment of large quantities of steel shapes of similar size requires merely a uniformly heated product, and that a uniformly heated product requires nothing more than a uniformly heated furnace. Nevertheless, variations in metallurgical quality of the finished product are likely to exist even tho the product has been uniformly heated, and variations in the uniformity of heating are likely to occur even with an ***indicated*** uniform temperature in the furnace chamber. The real test is the degree of uniformity of the finished product, which is determined not only by the manner in which the heat is applied to each individual piece, but also by the manner in which it is cooled.

Uniform heating PREPARES the metal for uniform heat-treatment, but it is the final set or adjustment of the structure that actually DETERMINES the uniformity of the heat-treatment and the quality of the product.

To heat the charge uniformly it is necessary that each piece be subjected to the heat in the same manner, at the same temperature and for the same length of time, which requires something more than a uniformly heated furnace.

If a large quantity of material is piled in a furnace chamber, it is certain that the outside pieces will be heated to, and finally cooled from, a higher temperature than the pieces at the center or at the bottom of the mass. When a large, cold charge is introduced into a hot chamber at the same time, there is a natural drop in chamber temperature, which is recovered only as the charge absorbs heat. The temperature variation is in proportion to mass; the time element in proportion to mass, surface and

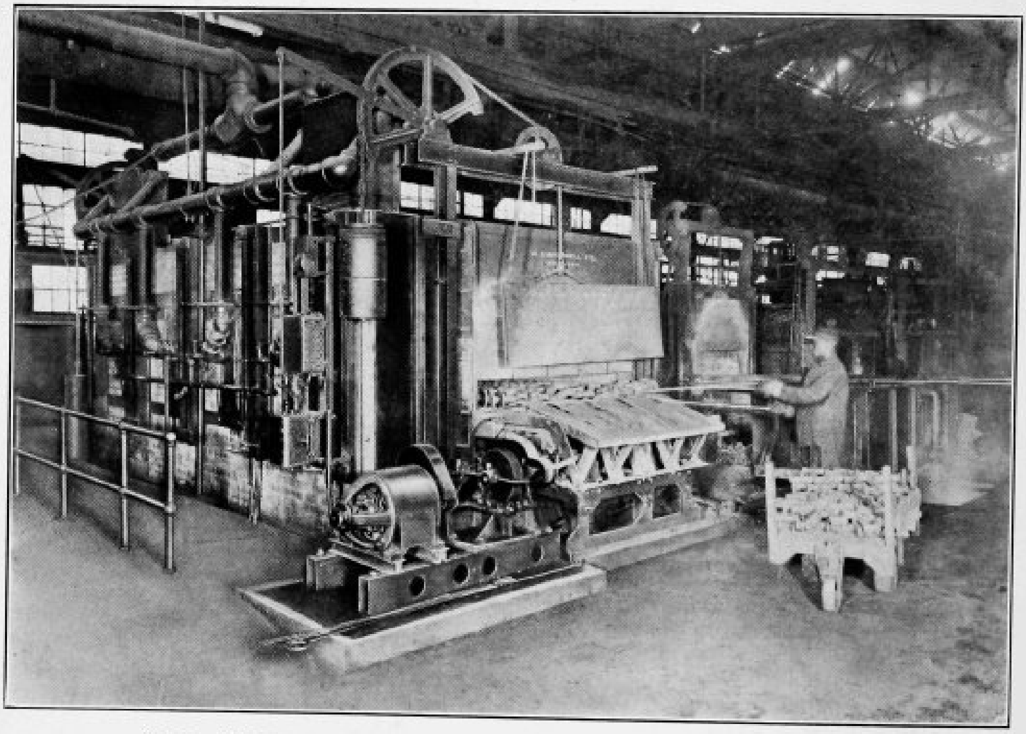

Fig. 2. AUTOMATIC FURNACE FOR HEAT-TREATMENT OF CRANKSHAFTS DISCHARGING END

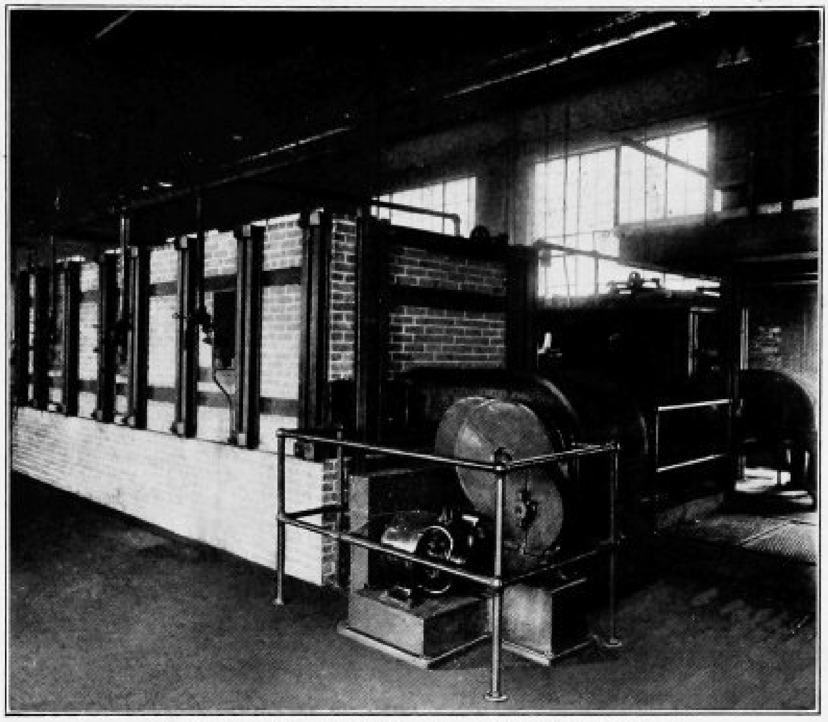

Fig. 4. HARDENING FURNACES—DISCHARGING ENDS
After reaching the final temperature the pieces are removed thru an opening in the side of the furnace and quenched in a tank partly buried in the floor. A conveyor in the tank removes the material from the oil and delivers it to the charging ends of the tempering furnaces, Fig. 5.

temperature; and the variations in proportion to the number of charges, all other conditions being equal.

Similarly, if a large number of uniformly heated pieces are plunged into a quenching bath at the same time, there is a tendency for the bath to become irregularly heated and the outside of the mass to cool at a lower temperature and in less time than the center. Thus, the good effect of uniform heating is partly negatived by subsequent unequal cooling, and to the extent of such disparity the product is inferior in quality.

With such mass methods of heating and cooling it is unreasonable to suppose that each piece receives the same treatment. It is immaterial what the furnace pyrometer reading or the temperature of the quenching bath may be, for, unless all pieces are both heated and cooled exactly alike, the indication of uniform temperature in the furnace or quenching bath serves merely as evidence, not as proof, of a final uniformly heat-treated product.

The ideal heating condition is approached when the heat is applied to each piece in the same manner, for the same time and at the same temperature; and is most accurately, conveniently and economically accomplished when the furnace operates with a continuous input and output of material, a continuous input of fuel and discharge of spent gases, and a grad-

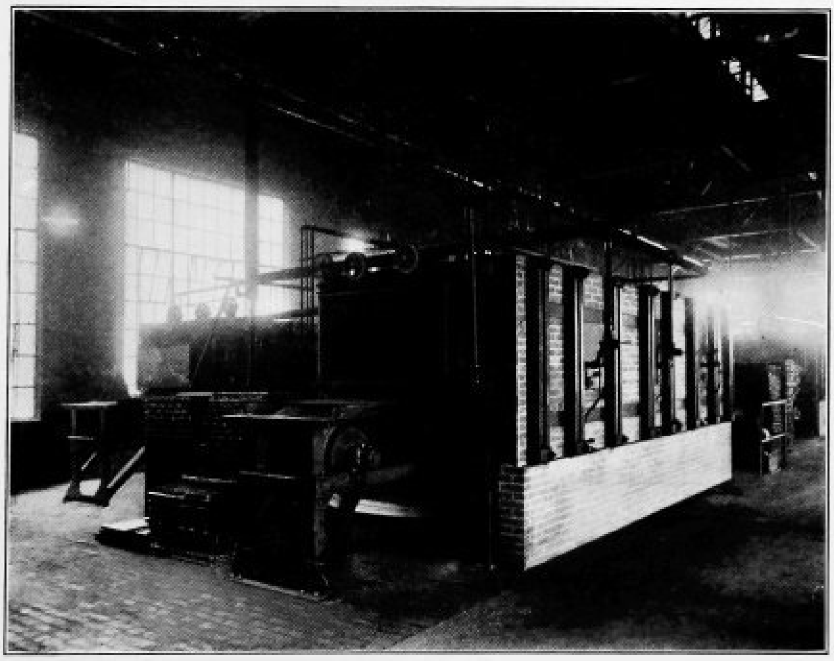

Fig. 3. HARDENING FURNACES—CHARGING ENDS
Material is laid on slow-moving conveyor chain and delivered into the heating chamber. Each piece is kept separate from the others in its passage thru the heating zone.

ual heating of the material to the final and determinative temperature.

The principle of treating each piece individually when heating applies equally to cooling, whether it be quenching for hardening, rapid air cooling for normalizing, or slow, prolonged cooling as for annealing.

The automatic furnace most easily meets these conditions by insuring the gradual heating of each piece in the same manner, to the same temperature, for the same length of time. It also has the advantage of increasing output in proportion to labor and fuel, as one man with an automatic furnace may do more work, at less cost, than two or three men with a furnace operating on the batch principle. Further than this, the automatic furnace requires less floor space for a given output. With these advantages the automatic type of furnace is entitled to consideration whenever the manufacturing conditions are in harmony with this method of heating.

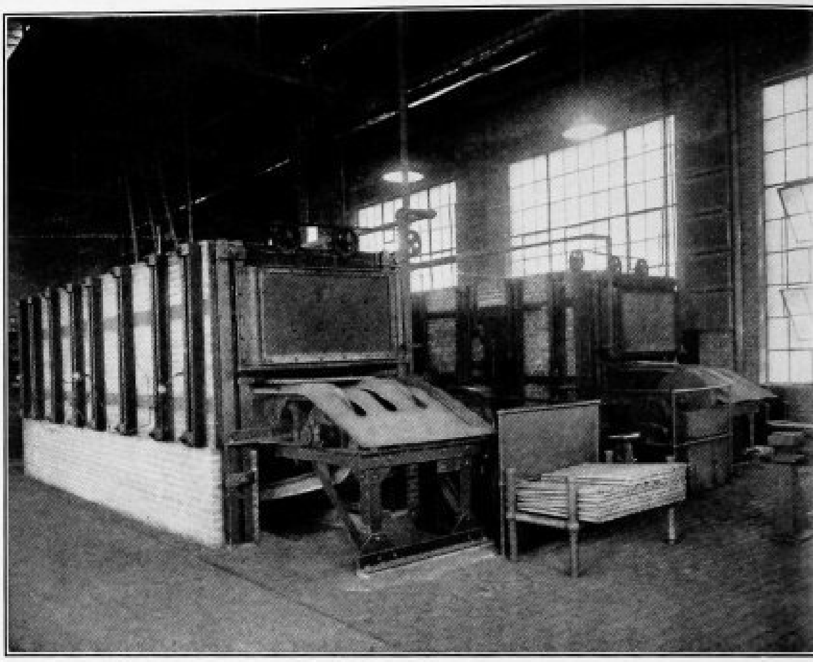

Fig. 6. TEMPERING FURNACES—DISCHARGING ENDS
After the pieces have been slowly brought up to heat they are automatically discharged on the apron shown in front of the furnaces.

It should be borne in mind, however, that the automatic type of furnace has its limitations as well as its field of usefulness. It performs to best advantage when the supply of material is regular and the heating operation continuous; when the size and shape of the pieces to be heated are fairly uniform; when the temperatures to be maintained are not unduly high, and when there is a sufficient quantity of material to keep the furnace going at full capacity thruout the day.

Its field of usefulness is narrowed when the sup-

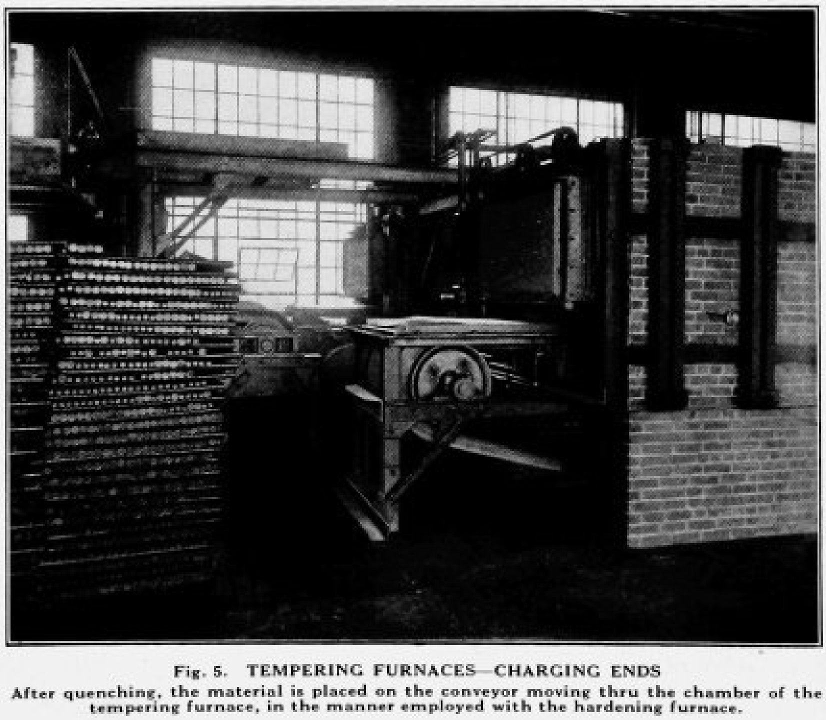

Fig. 5. TEMPERING FURNACES—CHARGING ENDS
After quenching, the material is placed on the conveyor moving thru the chamber of the tempering furnace, in the manner employed with the hardening furnace.

ply of material is irregular and the operation intermittent; when there is a wide variation in the size and shape of the pieces to be heated; or by other conditions that do not make the operation as a whole strictly continuous and in harmony with the factory product.

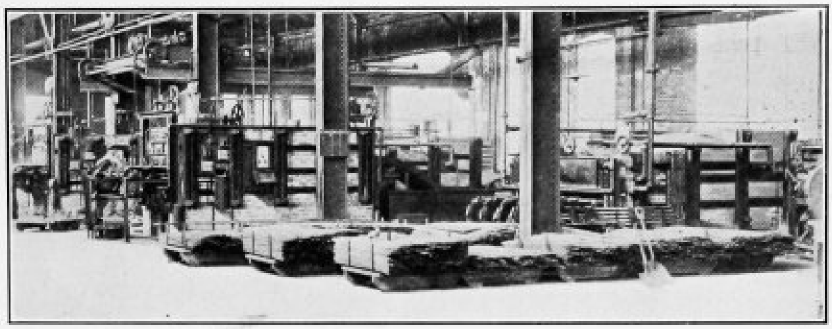

Fig. 8. GENERAL LAYOUT OF AUTOMATIC FURNACES FOR CONTINUOUSLY HEATING, HARDENING AND TEMPERING ROD STOCK

Just as an automatic machine must be set up differently to accommodate pieces of different size and shape, and is unsuited to the handling of small batches of work, just so is the usefulness of the automatic furnace confined to the heat-treatment of particular kinds and quantities of material.

It is generally more difficult to adapt an automatic furnace to a wide range in shape and size of pieces to be heated than, for instance, to adapt a turret lathe or automatic screw machine to the varying demand for product within their limitations. With the furnace, a marked variation in the shape and size of pieces generally necessitates a difference in construction of conveyor, also provision for changing its speed to allow for any variation in heating time required by the difference in mass and surface of the pieces and the variation of fuel input and discharge of spent gases. There is a very great difference between the operation of mechanism when subjected to heat and when cold. The necessity for difference in design to meet the conditions of expansion, contraction and comparative weakness of material when heated must be considered.

With the automatic type of furnace, the advantages from the standpoint of quality, denoting good heating, should be as evident as the advantages from the standpoint of production.

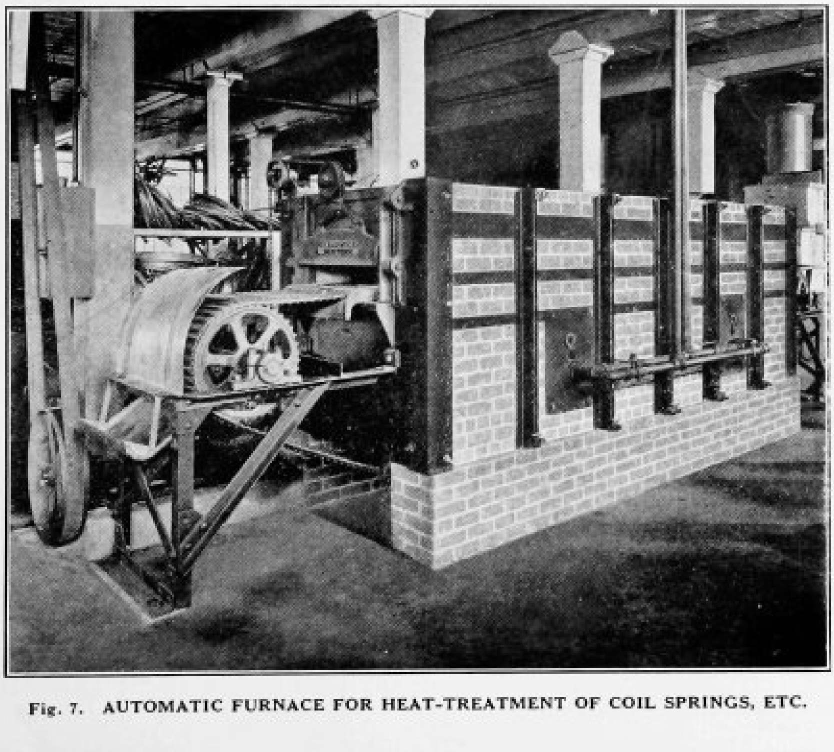

Fig. 7. AUTOMATIC FURNACE FOR HEAT-TREATMENT OF COIL SPRINGS, ETC.

The necessity of producing a quality product is more important than the necessity of producing a product in large quantities. Unless this relationship is properly considered in the design and operation of an automatic furnace, the results fall short of what is actually required. This important point is frequently overlooked in the consideration of such furnaces. It is not only necessary to provide the mechanical features incident to the continuous movement of material thru the furnace, the combustion features necessary to transform the energy of the fuel into hot gases, but to properly deliver and apply the heat in these gases to as much of the surface of the individual piece as possible. Of equal importance is the conservation of the heat in the gases after they have been in contact with the material, in order that the fuel used for the operation may be held to a minimum.

The metallurgist will recognize the advantages of a method of heating by which the material is gradually brought up to the final temperature; utilization of heat in spent gases to preheat material; the exposure of each piece to the heat in the same manner, to the same temperature,

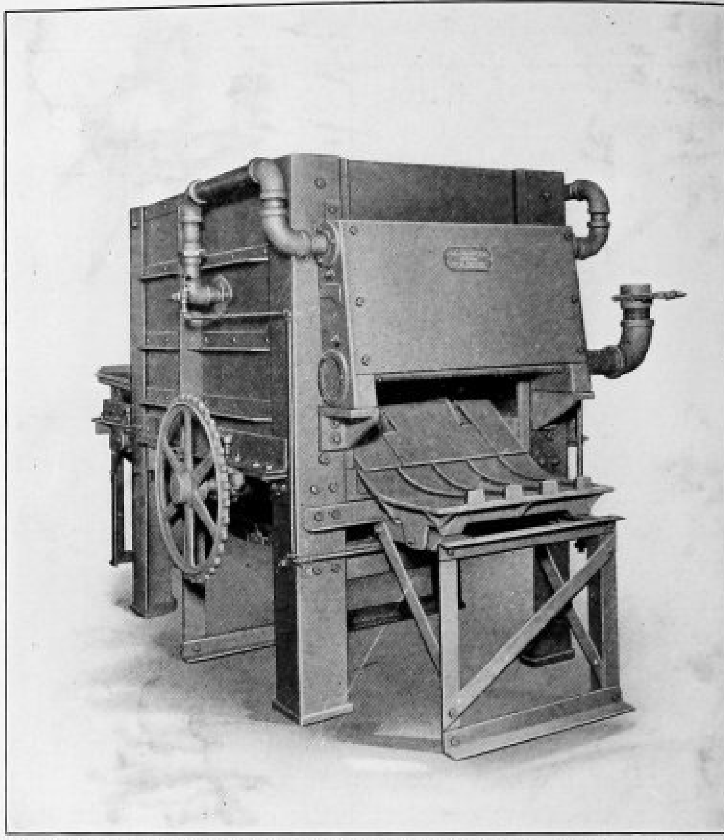

Fig. 10. AUTOMATIC FURNACE FOR LIGHT ROD STOCK – DISCHARGING END
After being heated, the material is discharged on the apron, from which it is removed to the forming machine.

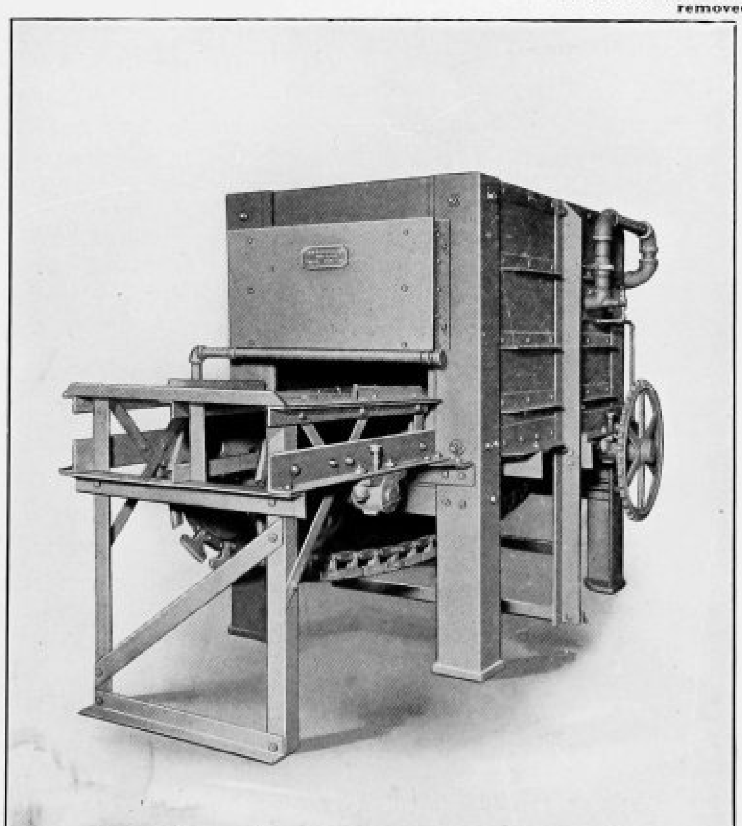

Fig. 9 SMALL AUTOMATIC FURNACE FOR LIGHT ROD STOCK CHARGING END

for the same length of time; the uniformity not only of the individual pieces but of the sections thereof as compared with the corresponding sections of other pieces; in short, the advantages that naturally follow what is virtually a method of continuously preheating, heating, cooling and handling each piece the same as all others.

The production manager will appreciate the advantages of increased production per unit of floor space; the reduction in manual labor per unit of production; the uniformity of product, resulting in decreased scrap, following less dependence upon the human element; the fuel economy that naturally follows the direct transfer of the heat in the spent gases to the incoming cold material; the improvement in working conditions as a result of the lesser amount of heat, in proportion to output, thrown off into the room by the automatic furnace; in short, the saving in the cost of the finished product due to economy in labor, time, fuel, floor space, decreased rejections, etc.

TYPICAL AUTOMATIC FURNACE INSTALLATIONS

The illustrations herein cover some of the applications of this method of heating and cooling which is coming more and more into favor. Owing to the great variety in working conditions it is impracticable to fully standardize the design or sizes of these furnaces, as the individual requirements warrant consideration of each case on its merits, in order that the heating cycle may be properly adapted to the given manufacturing conditions. However, the illustrations afford an idea of the manner in which typical heating problems are handled and of the opportunity of effecting further improvement in industrial heating operations.

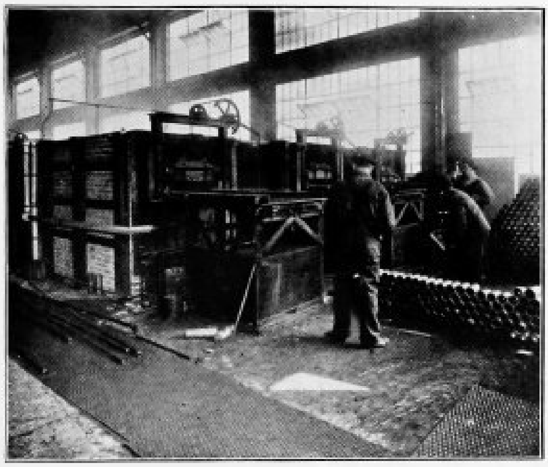

Fig. 11. HARDENING FURNACES—CHARGING ENDS
Pieces to be heated are placed on the charging table, from which they are continuously delivered into the chamber by a motor-driven mechanism.

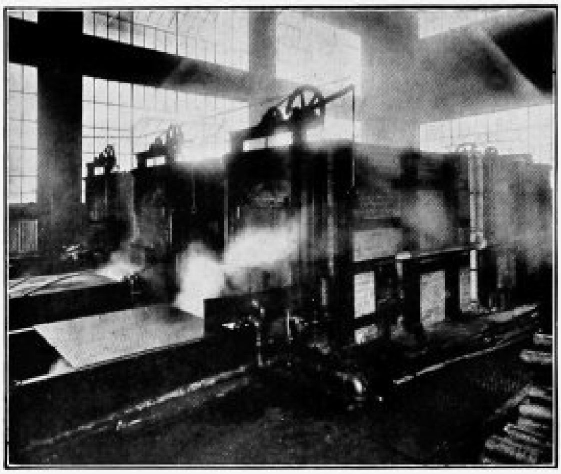

Fig. 12. HARDENING FURNACES—DISCHARGING ENDS
After passing thru the heating chamber, the pieces are discharged by gravity into the quenching tank.

HEAT-TREATMENT OF AUTOMOBILE CRANKSHAFTS

Continuous furnaces for the heat-treatment of automobile crankshafts, camshafts and the like are illustrated by Figs. 1 and 2.

The shafts are carried thru the furnace on a slow-moving conveyor driven by the motor shown at the front of the furnace, Fig. 2. Each piece is heated individually. The spent gases are not only employed to preheat the incoming material, but also to preheat the air for combustion.

The furnaces illustrated by Figs. 3, 4, 5

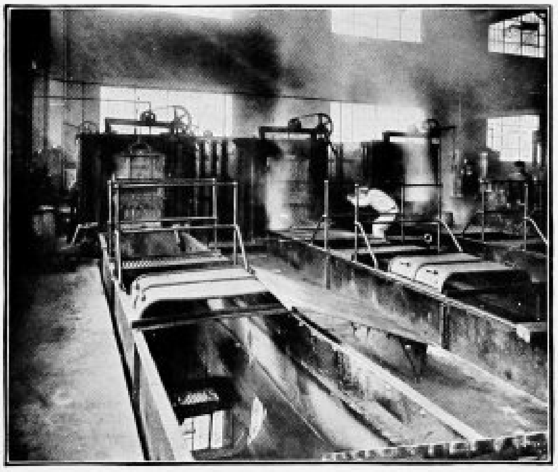

Fig. 13. QUENCHING TANKS IN FRONT OF HARDENING FURNACES
Each tank is provided with a conveyor on which the pieces are cooled separately and delivered to the tempering furnaces.

and 6 are well suited for heat-treatment operations, such as the annealing, normalizing, hardening, tempering, etc., of such material as crankshafts, axles, shafts, springs, tubes, bars, rods, cylinders, etc. They are often arranged in series so that two or more operations, such as annealing, hardening or tempering, may be conducted continuously and in sequence. Frequently, by simply adjusting the temperature or heating time, one furnace may be used for hardening, tempering, annealing or normalizing.

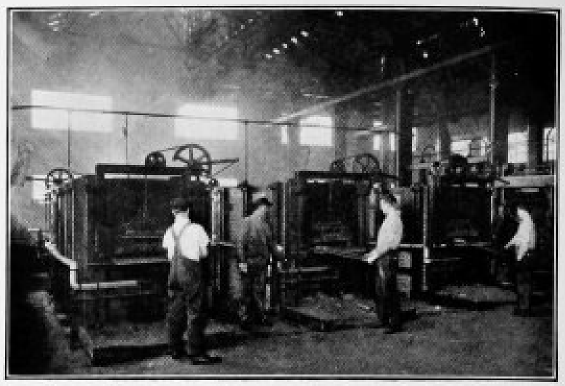

Fig. 15. TEMPERING FURNACES—DISCHARGING ENDS

HARDENING AND TEMPERING OF LIGHT BAR STOCK, ETC.

A hardening furnace of the automatic type, arranged in series with a quenching tank and tempering furnace, is illustrated by Fig. 3. The material to be heated is laid on slow-moving conveyor chain at the charging end and delivered into the furnace chamber. Special insulated shields and arrangement of blast provided over the working openings protect the operator from the heat.

The pieces are brought up to heat by being slowly passed thru the furnace, from a low temperature at the charging end until they reach the maximum temperature at the discharging end, Fig. 4. They are then removed from a working opening at the end or at the side of the furnace, as the size and shape of the material requires, and quenched in a tank partly buried in the floor. A conveyor in the quenching tank removes the material and delivers it to the charging end of the tempering furnace chamber, Fig. 5. After the pieces have been brought slowly to the tempering heat they are discharged on the apron at the discharging end of the tempering furnace, Fig. 6.

In the passage thru the chamber of each furnace the pieces are kept separate and suspended in the heat, with practically point contact on the hot conveyor chains.

COIL SPRINGS, ETC.

The furnace illustrated by Fig. 7 is adapted to the continuous tempering of such material as coil springs and similarly formed products that may be conveniently handled on the type of conveyor shown.

The conveyor is provided with a pocket for each piece, to afford the advantage of individual heating, with no piece in contact with another. The construction of the conveyor is adapted to the size and shape of the material to be heated. The

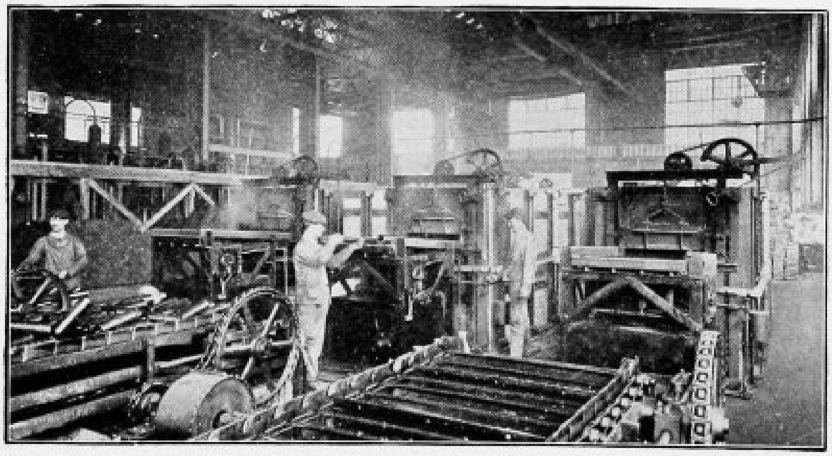

Fig. 14. TEMPERING FURNACES—CHARGING ENDS
The pieces are removed from the conveyor of the quenching tank and charged into the tempering furnaces in the manner employed for the hardening furnaces.

size of the chamber and arrangement of working openings may be adapted to the quantity to be handled and the related shop conditions.

LIGHT ROD STOCK

Light rod stock may be continuously heated for forming, hardening and tempering with the type of furnace illustrated by Fig. 8, arranged in series as shown. The rods in the foreground, cut to length, are placed on the conveyor and automatically pass thru the heating furnace on the right, from which they are removed thru an opening in the side wall near the opposite end of the heating chamber. They are then passed thru the shaping machine, thence to the oil hardening bath (visible between the first two columns), from which they are automatically conveyed into and thru the tempering furnace (on the left of the second column). As discharged from the tempering furnace they are inspected and adjusted, if necessary, and made ready for final fitting.

The progress of the rods is continuous from start to finish. The heating and cooling of each piece individually is clean, rapid and systematic. Pyrometers are provided to record the temperature of each heating operation.

This type of furnace and arrangement of units, while advantageous from the standpoint of quality and cost of heated product, should be considered only when the manufacturing conditions are such as require the continuous production of large quantities of material.

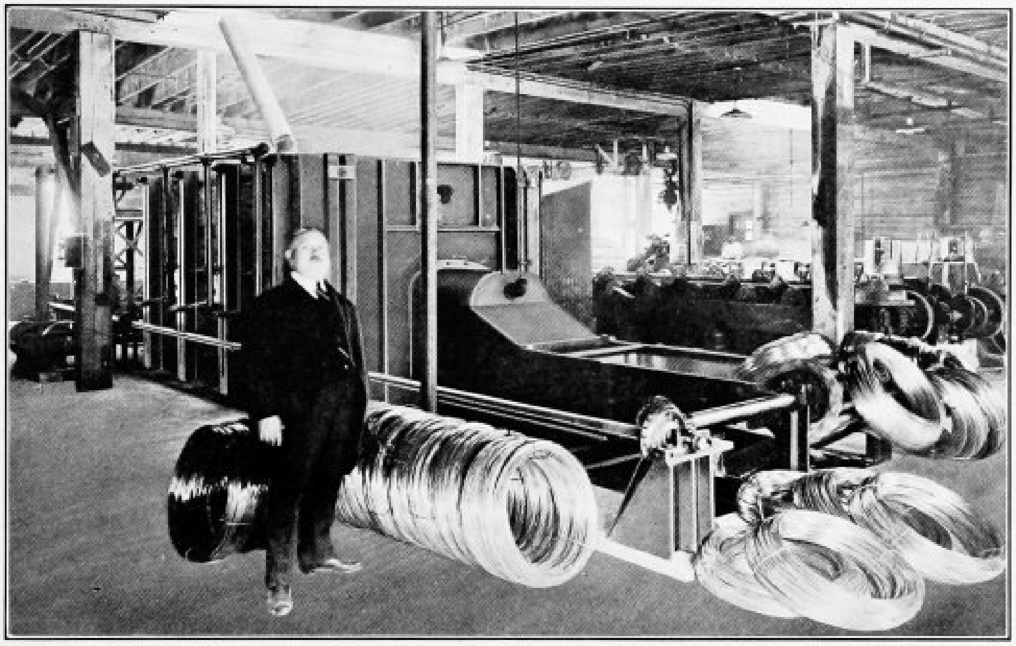

Fig. 16. SINGLE-MUFFLE BRIGHT ANNEALING FURNACE—CHARGING END

The continuous heating of light rod stock for bending, shaping, etc., on a moderate scale may be conducted with the type of furnace illustrated by Figs. 9 and 10. The rods, after being heated individually, are discharged on an apron, Fig. 10, at a point convenient to the operator and forming machine.

A special economizer hood is placed over the discharge opening to protect the operator from the heat of the spent gases. These gases are deflected upward by a novel arrangement of downward blast, and circulate around a preheater thru which the air for combustion is supplied to the burners.

The economizer hood is applicable to a wide range in variety and size of furnace.

This type of furnace may also be used for hardening operations, for which service a quenching tank should be located at the discharging end.

TUBES, BILLETS, ETC.

For the continuous heat-treatment of comparatively short material, such as tubes, billets, etc., which do not necessitate the use of a chain conveyor, there may be employed, either individually or in series, the types of furnaces illustrated by Figs. 11, 12, 13, 14 and 15.

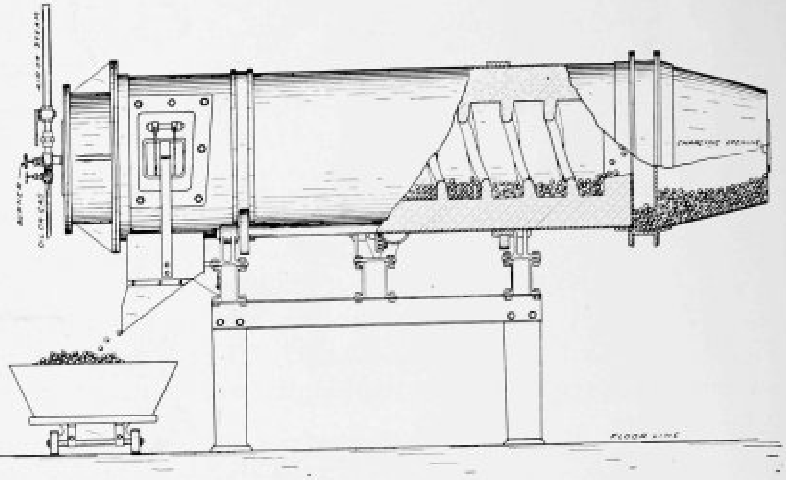

Fig. 18. SECTIONAL VIEW OF ROTARY FURNACE SHOWING HELICAL LINING

At the charging ends of the hardening furnaces, Fig. 11, the material is placed on a table and delivered into the furnaces by an automatic motor-driven mechanism (enclosed beneath the table). The charging mechanism is employed to deliver the material continuously into the furnace and to fix the position, movement and time of exposure of each piece. The automatic movement begins immediately after the piece is placed on the table and is regulated by a controller convenient to the hand of the operator. To obtain the advantages of individual heating and cooling, the charging mechanism is so arranged that but one or two pieces are charged and discharged at the same time. This eliminates the disadvantages in heating and cooling common to any method that would involve the charging or discharging of a batch at one time. The charging mechanism is so arranged that the pieces are charged in proper rotation of heating and cooling.

At the discharging ends of the hardening furnaces, Fig. 12, the pieces are plunged into the quenching bath one or two at a time at regular intervals, so that there is no opportunity for bunching of the material or irregular heating of the bath itself. It is but a matter of a second or two from the final heating in the chamber to the cooling in the bath, and as there is practically no exposure to the atmosphere the steel is quite clean and free from scale.

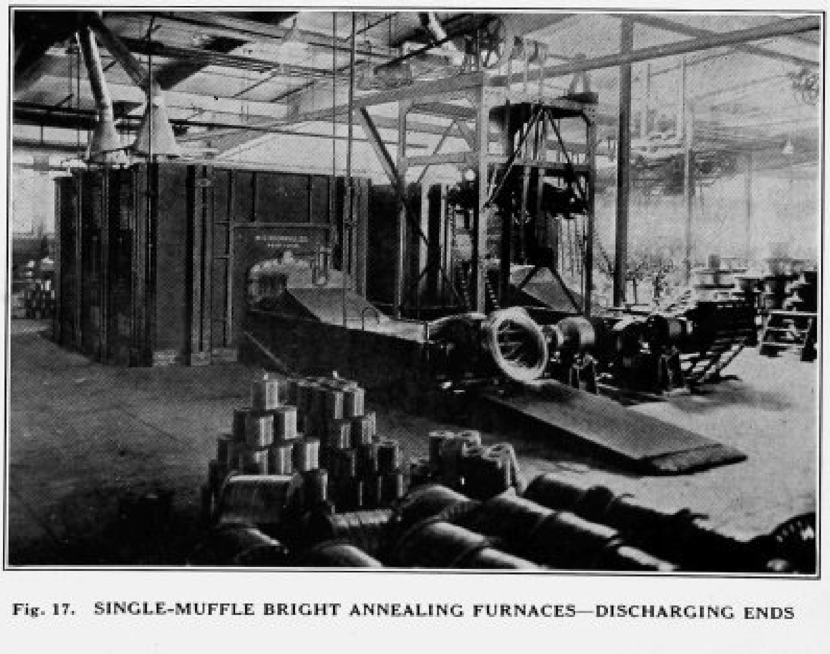

Fig. 17. SINGLE-MUFFLE BRIGHT ANNEALING FURNACES—DISCHARGING ENDS

The quenching tanks in front of the hardening furnaces, Fig. 13, are each provided with a conveyor and means for circulating the quenching fluid. The initial movement and sequence of the pieces as they are plunged into the bath is continued by the movement of the conveyor, which with the circulation of the fluid insures a uniform cooling of each individual piece.

Covers are provided to protect the bath, and protected footwalks facilitate passage between the tanks.

The conveyors in the quenching tanks, Fig. 13, carry the pieces out of the bath direct to the charging ends of the tempering furnaces, Fig. 14, where the pieces are removed from the conveyor to the charging table of the tempering furnace, passing thru this furnace in the same manner as thru the hardening furnace.

At the discharging ends of the tempering furnaces, Fig. 15, the pieces are continually discharged, one or two at a time, in the order as charged. They may be removed by hand, as shown, or delivered to a conveyor to facilitate the uniform cooling of each piece individually and the transfer of the pieces to the point of the next operation.

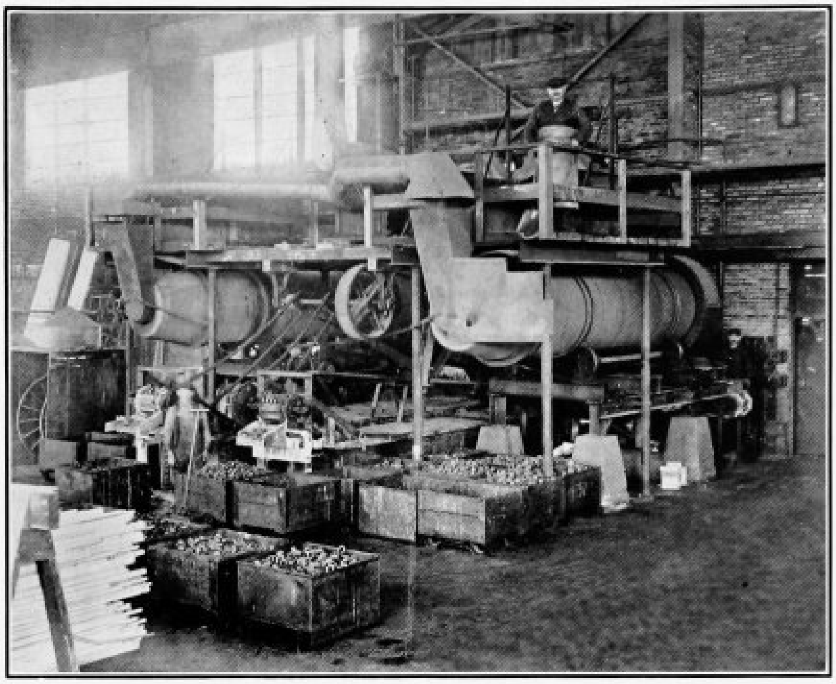

Fig. 20. ROTARY FURNACE FOR ANNEALING BOLTS, RIVETS, CUPS, ETC.

When the product is to be annealed only, the procedure is the same as that described for the tempering operation.

ADVANTAGES OF AUTOMATIC HEATING

When the product is heat-treated in this manner, with ordinary care and attention on the part of the operators the chances for error are minimized and the percentage of rejections greatly reduced. The individual pieces have been charged automatically and gradually brought up to the final temperature; the time of exposure has been determined identically for all pieces; the quenching has been performed rapidly with practically no fall of temperature between the final heating and cooling operations and without

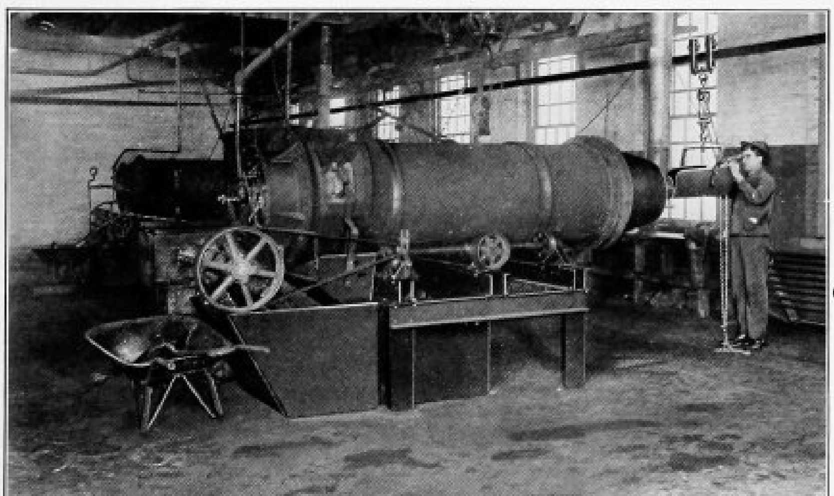

Fig. 19. ROTARY HARDENING FURNACE FOR AUTOMATICALLY HEATING AND QUENCHING SMALL STEEL PARTS

material exposure to the air. The delivery of each heated piece separately into the quenching bath and the sustained movement on the conveyor thru the bath in the order of their discharge from the furnace, together with the circulation of the quenching liquid itself, insures individual and uniform cooling.

Such individual and uniform heating and cooling results in a high-grade product, serves to decrease the cost of labor and fuel for the heat-treatment itself, the cost of subsequent machining operations, and the loss of product rejected as the result of poor heat-treatment.

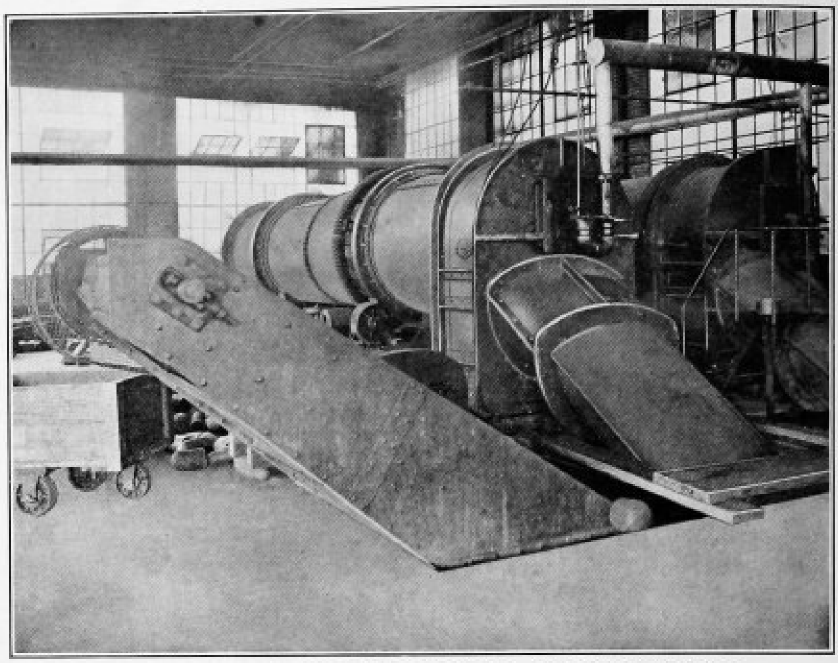

Fig. 22. ROTARY ANNEALING FURNACES—DISCHARGING ENDS
The pieces are discharged into a quenching bath thru an enclosed chute, to prevent oxidation, and are removed from the quenching bath by the conveyor shown at the left.

BRIGHT ANNEALING OF NON-FERROUS METAL

It is frequently desired to anneal ***non-ferrous*** metal in a manner that will leave it clean or bright or both so as not to require pickling at the end of the heating operation. To accomplish this result with material in the form of wire and miscellaneous punched, drawn, spun, stamped or rolled parts, the type of furnace illustrated by Figs. 16 and 17 may be employed to advantage.

The material to be heated is placed on the conveying chain at one end of the furnace, travels downward thru a water seal and thence upward into a closed muffle. In this muffle the metal is gradually brought up to the required temperature as it progresses to the discharge end of the furnace, at which point it is carried downward thru another water seal and is delivered clean and bright at the discharge end of the conveyor.

The determination of furnace size and the details of chamber arrangement and conveyor construction are dependent almost entirely upon the manufacturing and plant conditions. The furnace may be built with a single muffle, Fig. 16, or with twin muffles.

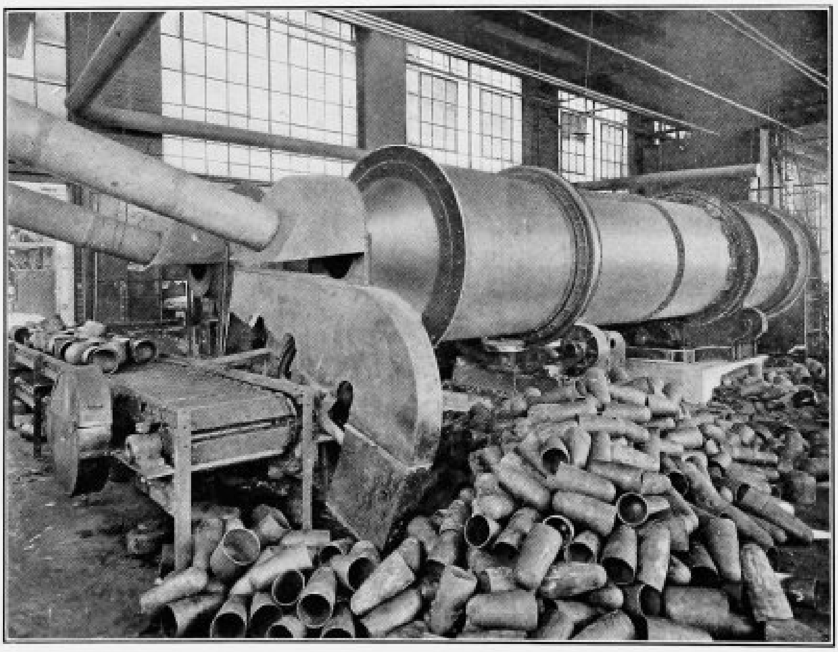

Fig. 21. ROTARY FURNACES—CHARGING ENDS
For annealing pressed steel parts.

This type of furnace, particularly in the larger sizes, should be considered only when the composition of the metal permits, when the size and shape of the material to be annealed are more or less uniform and the quantity sufficient to permit the maintenance of heat both day and night. Expansion and contraction, following irregular heating and cooling, and the tendency of operators to rush the firing operations when starting, would unduly shorten the life of the muffle.

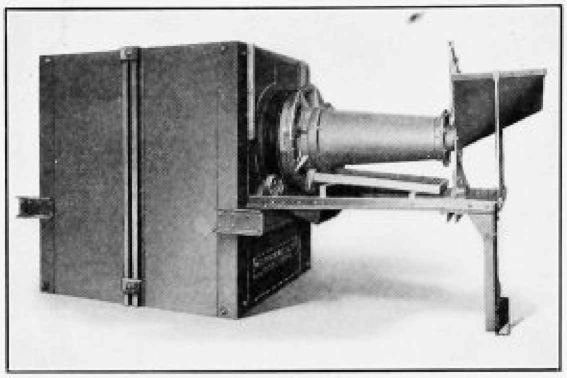

Fig. 24. ROTARY DRYER FOR AUTOMATICALLY DRYING SMALL METAL PARTS

ROTARY FURNACES

For the heat-treatment of comparatively small pieces, the size and shape of which will permit of continuous stream movement, the internally-fired rotary type of furnace, with helical lining, as illustrated by Fig. 18, may be employed for annealing, normalizing, hardening, tempering, bluing and miscellaneous heating operations on ferrous or non-ferrous metal products, such as bolts, nuts, rivets, balls, saw teeth, buttons, cups, shells, etc.

Recent modifications of this type of furnace, which has been used extensively for years, widen its field of usefulness to a point heretofore considered impracticable with this method of heating and handling.

While a great variety in methods is employed for conveying material to or from the furnace, details of which are determined largely by the size, shape and quantity of material to be heated and the general manufacturing conditions, the principle of heating and movement thru the furnace remain substantially unchanged.

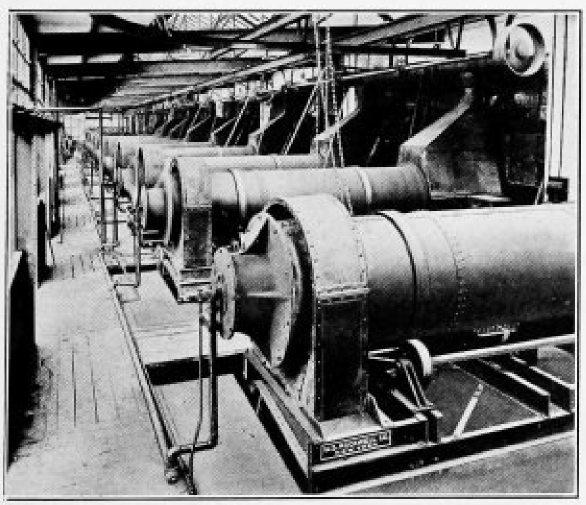

Fig. 23. ROTARY FURNACES FOR ANNEALING PRESSED STEEL PARTS OR FORGINGS

The material to be heated is charged into the charging drum in bulk, and a definite quantity is taken from the drum into the furnace at each revolution. The material is gradually and automatically wormed thru the furnace, at a fixed speed, to the discharge end, where it reaches the desired temperature and is automatically discharged.

It is not only brought up to the desired temperature from the cold state gradually so as to afford time for the heat to penetrate its mass without overheating its surface parts, but each individual piece is constantly exposed to the heat in the chamber and to the ever-changing surface of the evenly heated spiral runway, being finally discharged at the time it reaches the desired temperature and degree of saturation.

The spiral runway permits a definite amount of material to pass from the charging drum into the furnace. Each charge is kept separate from the others, and each individual piece is continually turned over and moved forward in the spiral runway.

The horizontal position of the cylinder and the spiral runway are essential features of the furnace. Together with the variable speed regulator they determine the length of travel and time of exposure thru the furnace, which is the same for each individual piece. This would be impossible in an inclined cylindrical furnace with a smooth lining and without provision to regulate the movement of the pieces. In such a furnace some of the material is bound to run ahead of the rest, causing a difference in time of exposure, resulting either in underheating or overheating. The horizontal position also permits of convenient charging and discharging and simpler driving mechanism.

Liquid or gaseous fuel, the control of which is practically the only manual part of the operation, is introduced into a combustion chamber at the discharge end where the heat is at the desired degree. As the hot gases of combustion pass onward toward the charging end they meet the incoming cold material, which absorbs the heat in the gases, leaving their temperature comparatively low at the outlet on the charging end.

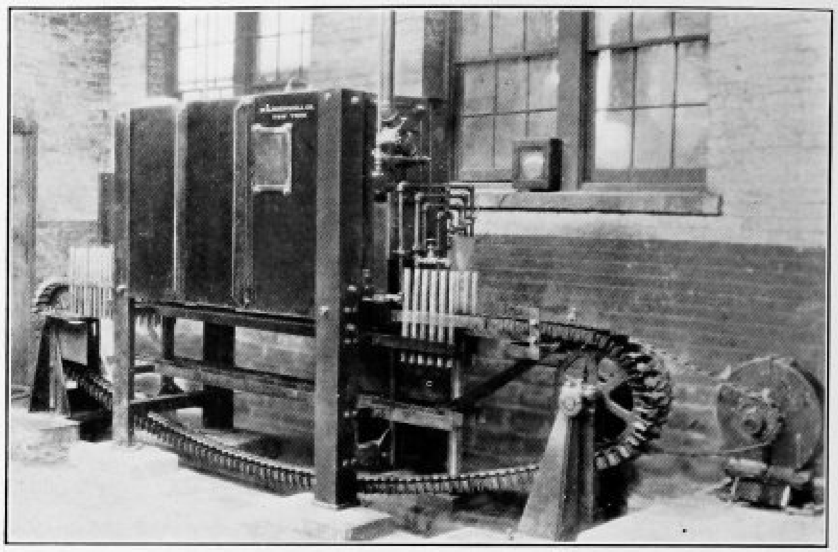

Fig. 26. AUTOMATIC TUBE HEATING FURNACE—DISCHARGING END
Tubes are placed in holders forming part of a conveyor. Length of tube exposed to heat is automatically fixed.

The temperature is continuously indicated, while the furnace is revolving, by pyrometer equipment adapted to the rotary motion of the furnace.

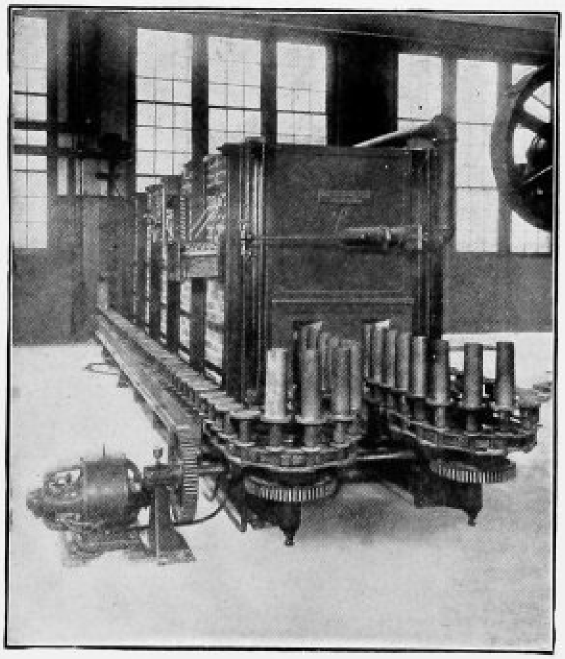

Fig. 25. AUTOMATIC FURNACE FOR END HEATING DISCHARGING END

The lining, which is adapted to the temperature requirements and the nature of the material being handled, may be of refractory material or metal or a combination of both. In either case the principle of the spiral runway to move the material is retained.

The speed may be varied, according to the shape, size and quantity of material being heated, by means of a variable speed driving mechanism. When a conveyor is employed to deliver material to or remove it from the furnace, the speed of the conveyor may be synchronized with or maintained independently of the speed of the furnace.

For heat-treating operations in which quenching is not desired, the furnace may be arranged substantially as indicated by Fig. 18. When it is desired to quench immediately after heating, the furnace is generally provided with a quenching tank and conveyor as illustrated by Figs. 19 and 20. With such construction, the material, in comparatively small lots, is discharged from the furnace into the quenching tank, being caught on the conveyor and discharged over the end of the tank.

ANNEALING PRESSED STEEL PARTS

The successful adaptation of this type of furnace, in the larger sizes, to the annealing of pressed steel parts in large quantities has indicated the possibilities of improving the quality and decreasing the cost in this line of manufacture. In the operation shown by Fig. 21, the heavy drawn steel cups are charged into the furnace hoppers directly from a conveyor carrying the cups from the press room. The cups are wormed thru the furnace to the discharging end, where they are automatically discharged thru a large covered chute to protect them from the atmosphere until they reach the quenching bath, from which they are automatically carried up and dumped into the mill trucks shown in Fig. 22.

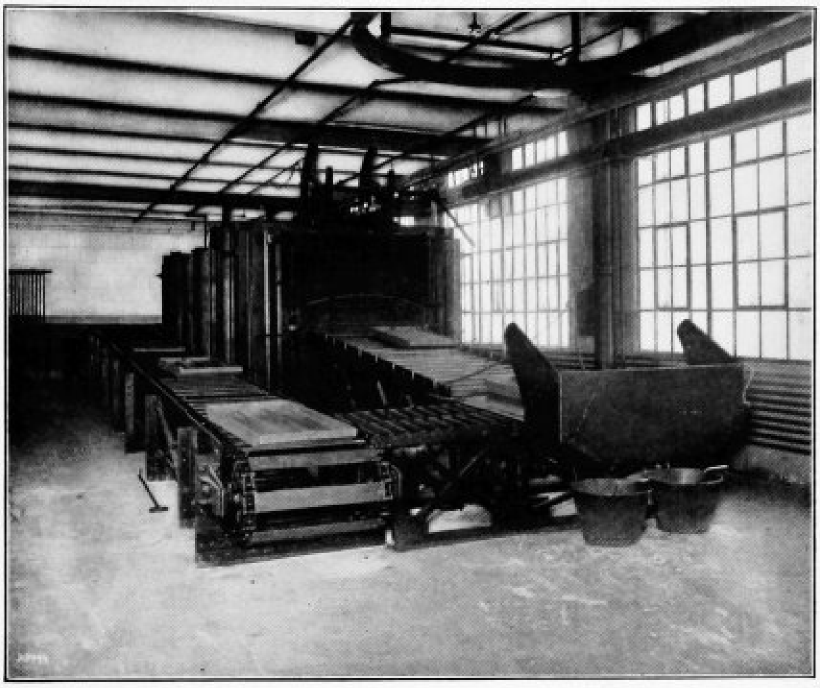

Fig. 28. SEMI-AUTOMATIC FURNACE—DISCHARGING END
Showing discharging chute, unloading table and conveyor for carrying the pans back to the charging end of furnace.

By this method of protecting the material in its passage from the furnace to the quenching bath, it has been found in practice that the pickling operations usually employed in connection with low-carbon pressed steel parts have been very materially reduced and in some cases entirely abandoned.

The furnaces illustrated by Figs. 21 and 22, having a capacity ranging from 5,000 to 10,000 pounds per hour, are larger than those illustrated by Fig. 23. The latter are suitable for handling large quantities of medium sized pressed steel parts or forgings. In Fig. 23, the furnace in the immediate foreground is not moving, but the others are in operation.

In an installation of this kind, when the volume of work handled is sufficient, a furnace may be employed for handling the output of each press, thus keeping the press and annealing operations in step and main-

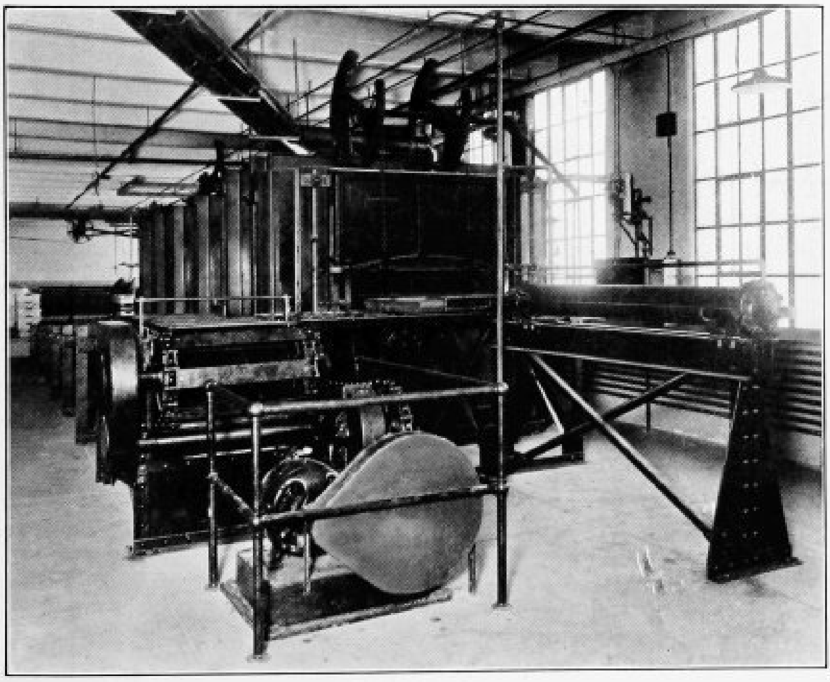

Fig. 27. SEMI-AUTOMATIC FURNACE—CHARGING END
Loaded pans of metal to be annealed are brought up by the conveyor at the side of the furnace. The pans are then charged by a pneumatic pusher.

taining a steady and continuous output.

ROTARY FURNACES FOR THE HEAT-TREATMENT OF DROP FORGINGS

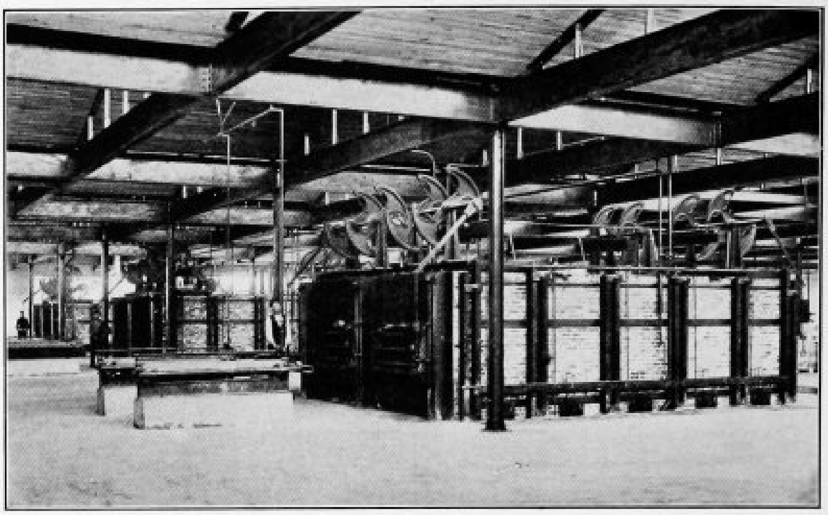

Fig. 30. TWIN-CHAMBER DOUBLE-END SEMI-AUTOMATIC FURNACES
With pushers at charging ends of furnaces.

The heat-treatment of large quantities of small and medium sized drop forgings, ranging up to 8 or 10 lb. each, is successfully accomplished with these rotary furnaces arranged in series for normalizing, hardening and drawing. The sequence of operations and method of handling material from one furnace to another are similar to those described on pages 9 and 10. The advantages of this method from the standpoint of uniformity and cost per unit of output, are in marked contrast to the uncertain functioning of heating and handling equipment generally employed in this line of manufacture.

ROTARY DRYER

For drying small metal parts after washing operations, a modification of the rotary furnace may be employed.

In this design, Fig. 24, the material, charged into the hopper, is conveyed automatically into the perforated revolving drainage drum, in which the greater part of the moisture is removed, the liquid discharging into a drip pan. The material is then conveyed thru the dryer, in which it is thoroughly dried, finally passing out thru a chute.

Fig. 29. TWIN-CHAMBER SEMI-AUTOMATIC FURNACE
CHARGING END

This type of dryer may be employed in the handling of chemical products which require a very thorough drying, for which operations the drainage drum is omitted.

The method of applying heat to the material is practically the same as that employed in the rotary heat-treatment furnaces previously described. The charge is divided into a number of small lots, each separated from the others and continually agitated, with a consequent uniform exposure of all surfaces to the heat, assuring a very thorough drying process.

SPECIAL AUTOMATIC FURNACES

The great variety in manufacturing processes and plant conditions frequently calls for automatic furnaces of novel design adapted to the individual requirements. One of these, shown by Fig. 25, is employed to heat the end or a portion of the body of hollow cylinders without overheating the base, in order to facilitate the subsequent crimping, tapering or other forming operation. Such operations are delicate and require very thorough annealing so that the structure of the metal may permit of forming without fracture or uneven surface.

This method of heating illustrates a departure from long-established heating practice, resulting in a very material improvement in quality and production cost. The practice for years on this operation had been to revolve the individual piece and play gas flames against the section to be annealed. Fairly satisfactory results could be obtained by this method provided the metal were a good conductor of heat and the walls of the cylinder comparatively thin, but more especially if the operator were careful not to prolong the time of exposure. As a low temperature is usually required in the metal and the temperature of the flame was nearer to the melting point than to the annealing point, there was great danger of overheating, heating unevenly or underheating, which danger was lessened only by the skill of the operator.

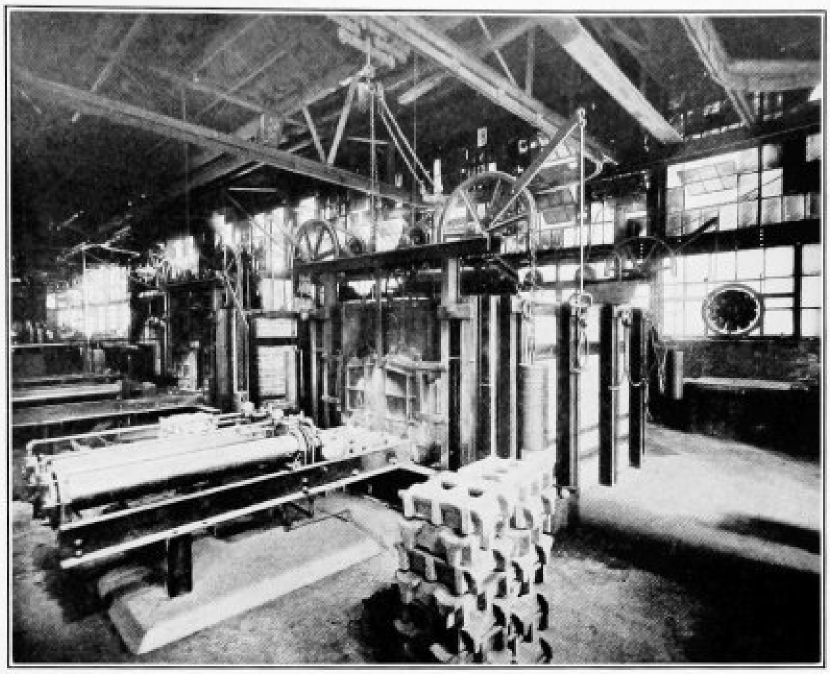

Fig. 32. SINGLE-CHAMBER SEMI-AUTOMATIC DIE HEATING FURNACES, EACH ARRANGED FOR TWO ROWS OF DIES
Carriages for dies are shown in foreground.

Another method was to suspend the pieces in a heating chamber or bath, the temperature of which approximated the temperature desired in the metal. While this method was better than the other from the standpoint of uniform heating, both were open to the added objection that the output was limited and the cost high.

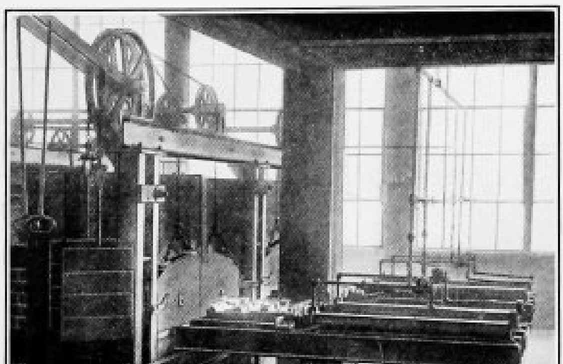

Fig. 31. TWIN-CHAMBER SEMI-AUTOMATIC FURNACE
Each chamber arranged for two rows of material.

To eliminate these disadvantages on large quantities of material, the operation is made continuous with the type of furnace illustrated by Fig. 25, which is built with single or twin conveyors to suit conditions. The type of conveyor used on this furnace makes possible the continuous employment of practically the entire length of the conveyor for handling material. In practice the operators are kept busy in loading and unloading the furnace, the output per man is increased hundreds of per cent over the previous practice, and the loss due to improperly heated product is practically nil.

Another furnace of this type, designed to heat the ends of tubes for bending, is illustrated by Fig. 26.

With this continuous furnace the tubes are placed in holders forming part of a conveyor. Provision is made at one end to automatically fix the length of tube exposed to the heat, and at the other end to automatically strip the tubes from the conveyor. Means are provided to cool by water such parts of the conveyor as are exposed to the heat and to localize the heating of the tubes as desired. The tubes are brought up to heat gradually, and each is subjected to the same temperature, for the same length of time and in the same manner. The results in practice have shown a marked decrease in rejections due to improperly heated material, an increase in output due to the automatic method of charging, heating and discharging, and decreased fuel consumption.

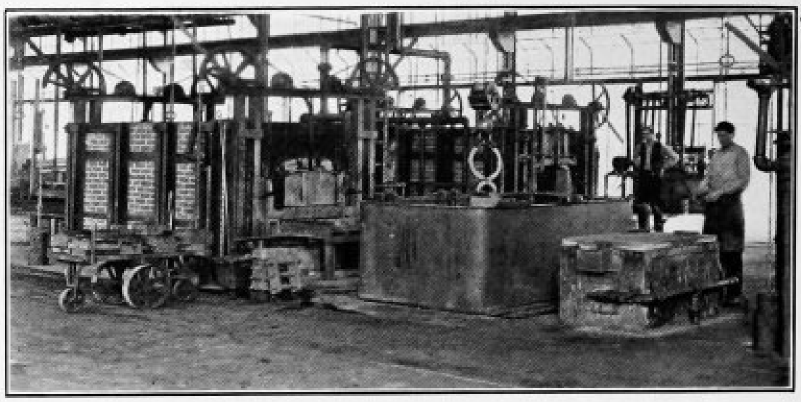

Fig. 34. SEMI-AUTOMATIC FURNACES FOR HEAVY DIES DISCHARGING ENDS
Quenching tank and tempering plate in foreground.

SEMI-AUTOMATIC METHODS

When the manufacturing conditions prohibit the use of a strictly automatic type of furnace, it is frequently possible to modify the method of handling without materially departing from the principle of continuous operation. Whenever a furnace is required to meet variable manufacturing conditions, it is preferable to consider a type of furnace that is practically continuous tho not strictly automatic in operation.

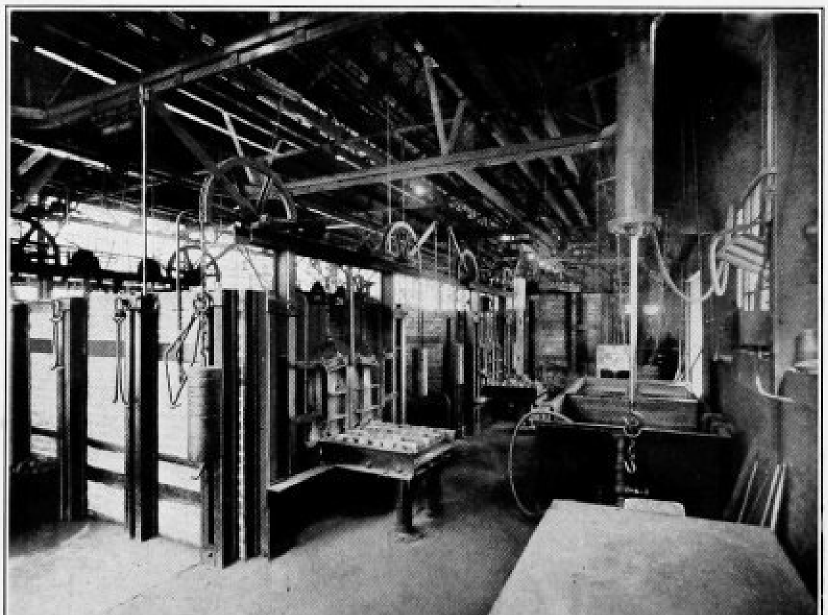

Fig. 33. SEMI-AUTOMATIC FURNACES FOR HEAVY DIES DISCHARGING ENDS
Showing hoist and quenching tank.

ANNEALING METAL PARTS OF IRREGULAR SHAPE AND SIZE

In the manufacture of small punched, stamped, drawn, and other formed parts, it is frequently necessary to anneal between operations and to have a quantity of given pieces follow others materially different in size, shape or weight. As the factor of temperature must always be considered with the factor of time exposure, which differs according to the mass and surface of the pieces exposed to the heat, it is desirable that the furnace be readily adaptable to such changing conditions. In such cases the material may be placed on shallow trays or pans and charged into a furnace of the type illustrated by Fig. 27. The trays are pushed thru the furnace to the opposite end and discharged from a table in front of the furnace as shown by Fig. 28. The empty trays are then returned to the charging end of the furnace on the conveyor shown at the side. Altho the delivery of material is intermittent, the operation is practically a continuous horizontal movement, the furnace chamber occupying one section of the circuit. The provision made for handling the trays mechanically decreases the labor and time and contributes to the efficiency of the operation.

A modification of this furnace is illustrated by Fig. 29. Here the material to be heated is delivered to the furnace in trays carried on a truck. As a loaded tray is pushed from the truck into the chamber a heated tray of material is discharged at the opposite end of the chamber, the doors being arranged to open simultaneously. The chamber is thus kept fully loaded and the operation is practically continuous, tho, of course, the temperature drop at the charging end, due to the entrance of the comparatively large cold charge, is somewhat greater than with the automatic furnace, in which the pieces would be handled individually.

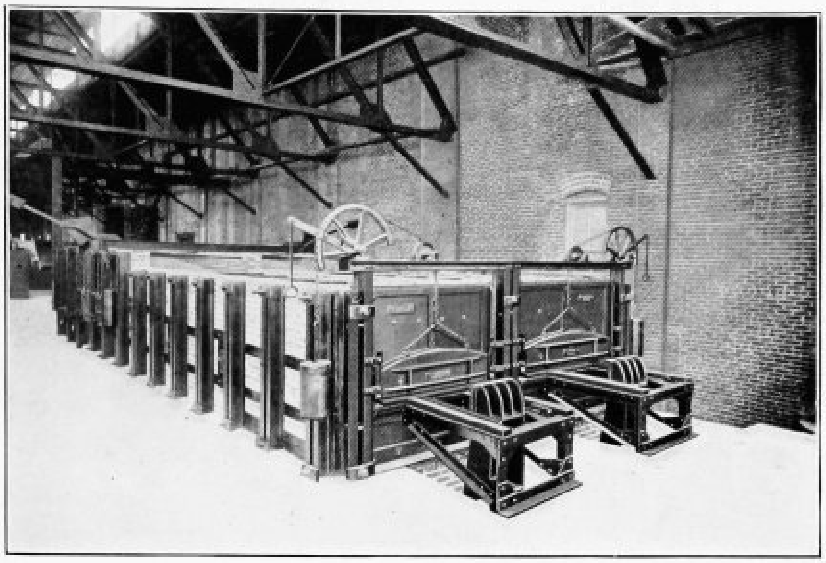

Fig. 36. TWIN-CHAMBER "L" TYPE BAR HEATING FURNACE

The heat is applied directly to the bottom of the charge as well as to the top and the sides, and is uniformly and constantly maintained on all these surfaces whether the charge consists of one small piece or of one the full area of the working opening. The charge is virtually suspended in a heated zone, as the principle of underfiring and perforated floor admits hot gases and radiant heat direct to the bottom of the charge and eliminates the possibility of uneven heating common to furnaces with solid and comparatively cold hearths.

The application of this principle on a larger scale is illustrated by Fig. 30; while Fig. 31 illustrates another modification involving two pans to each chamber of a double-chamber furnace, making four rows, any of which may be moved independently of or in conjunction with the others.

This method of continuous heating, embodying the advantages of bringing the material slowly up to the required temperature, is applicable to the heat-treatment of larger individual pieces, such as dies, which by reason of the mechanical and metallurgical requisites must be handled very carefully.

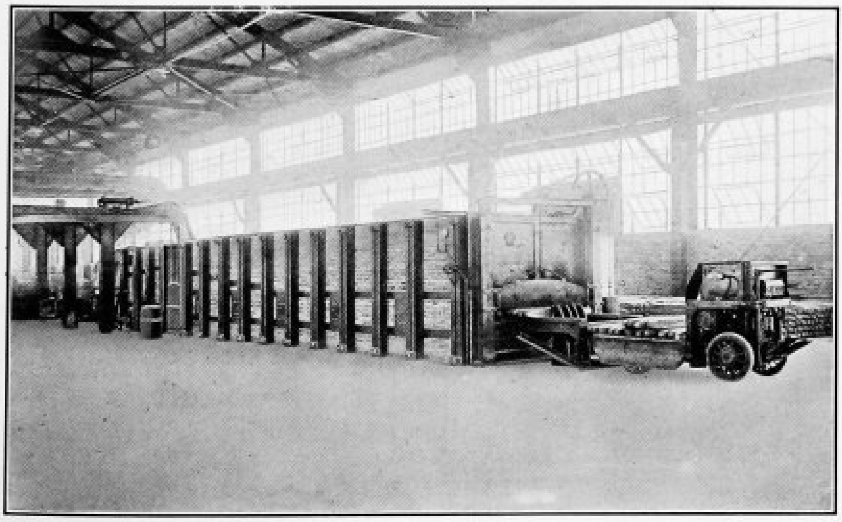

Fig. 35. "L" TYPE BAR HEATING FURNACE—CHARGING END
Pusher for charging mechanism located below mill floor.

HEAT-TREATMENT OF DIES

In heating large dies it is desirable that they be thoroughly saturated at a temperature slightly below the final temperature before the formed corners or edges on the face reach the final temperature. As the life of a die is no greater than the life of its corners or edges, it naturally follows that every possible effort should be made to prevent overheating these corners or edges or exposing them to the final temperature any longer than is absolutely necessary. The corners and edges of the die are the first to heat and the first to cool, and it is at these sections that the ruinous effects of unequal contraction are manifested. These corners and edges heat and cool more rapidly because the surface in proportion to the mass of these sections is much greater than that of the body of the die, which naturally reveals a difference in time of heating and cooling. Obviously, it is essential to consider the difference in time required to reach a given temperature in heating or cooling, due to the difference in surface and mass of the sections embodying the outline of the piece and the body of the die itself. Improper heating or cooling, resulting from a disregard of these factors, is responsible for a great deal of the limited die service with consequent loss of production, material and labor. Such loss greatly offsets any saving in time or fuel by heating the die quickly without due regard to all the factors involved.

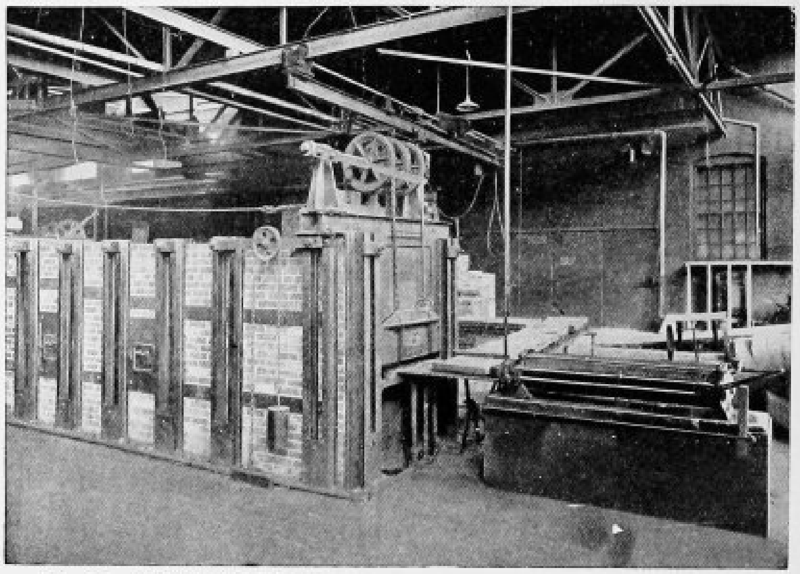

Fig. 38. "STRAIGHT-LINE" CAKE HEATING FURNACE—CHARGING END
Cakes are delivered to working opening by conveyor.

The type of furnace illustrated by Figs. 32 and 33 affords a practically continuous method of heating and cooling, with every facility for bringing the dies up to the final heat thru a slow, soaking process. The dies to be heated are placed upon carriages and slowly conveyed from one end of the furnace to the other. They are withdrawn one at a time, quenched, and tempered on the small plate furnace as shown in Fig. 34.

SEMI-AUTOMATIC FURNACES FOR HEAVY PIECES

This semi-automatic principle may be employed in heating heavy pieces, such as bars, billets, ingots, axles, shafts, etc., for annealing, hardening or tempering, or for miscellaneous heating operations preparatory to forging, pressing, rolling or extruding. The construction of the floor, arrangement of chambers and working openings, and the method of delivering material to, thru and from the furnace, vary with the nature of the operation, the size, shape and

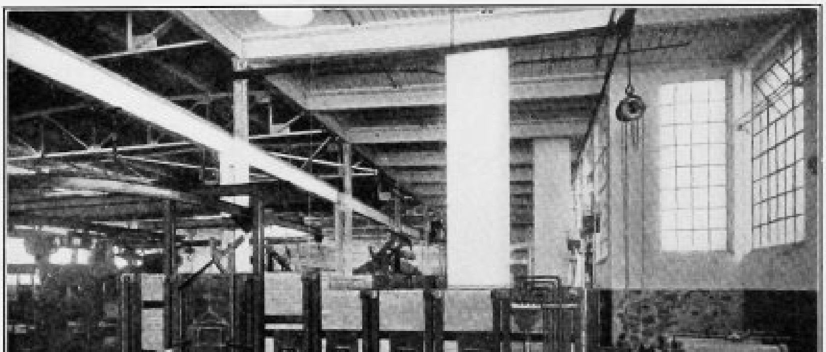

Fig. 37. SINGLE-CHAMBER DOUBLE-ROW "L" TYPE BAR HEATING FURNACE
Showing discharge opening and monorail. Charging mechanism is located above mill floor.

number of pieces to be handled, and the local manufacturing conditions.

As a rule the furnaces for this class of work are divided into two types: the "L" and the "straight-line." In the "L" type the pieces are charged into one end, pushed thru to the opposite end and taken out of an opening located in one or both of the side walls. Furnace is often arranged with openings on both sides to serve a machine located on each side of the furnace.

This furnace may be built in single-chamber form, with openings on one or both sides as illustrated by Fig. 35, or in twin-chamber form as illustrated by Fig. 36. Provision may be made to handle two rows of material in a single chamber as illustrated by Fig. 37. On account of the advantages of this type of furnace in the application of heat and decreased area of exposure in working openings, it should be given preference over the "straight-line" type whenever the manufacturing conditions will so permit.

In the "straight-line" type the material is charged in one end of the furnace and pushed or rolled straight thru and out at the opposite end.

This type is to be preferred whenever the size or weight of the individual piece heated renders difficult its removal thru a side door, or when it is desirable to discharge direct to a machine or quenching tank located substantially in line with the furnace chamber. It has the disadvantage of greater area of exposure incident to the wider working opening, which is apt to react somewhat on the uniformity of the material, the comfort of the operators and the furnace structure.

Fig. 38 shows a furnace of the "straight-line" type with a conveyor delivering material to the charging end, and a pusher arranged to deliver it into the heating chamber and discharge it at the opposite end. A modification of this type is illustrated by Fig. 39, where the pieces to be heated are placed upon an elevating plat-

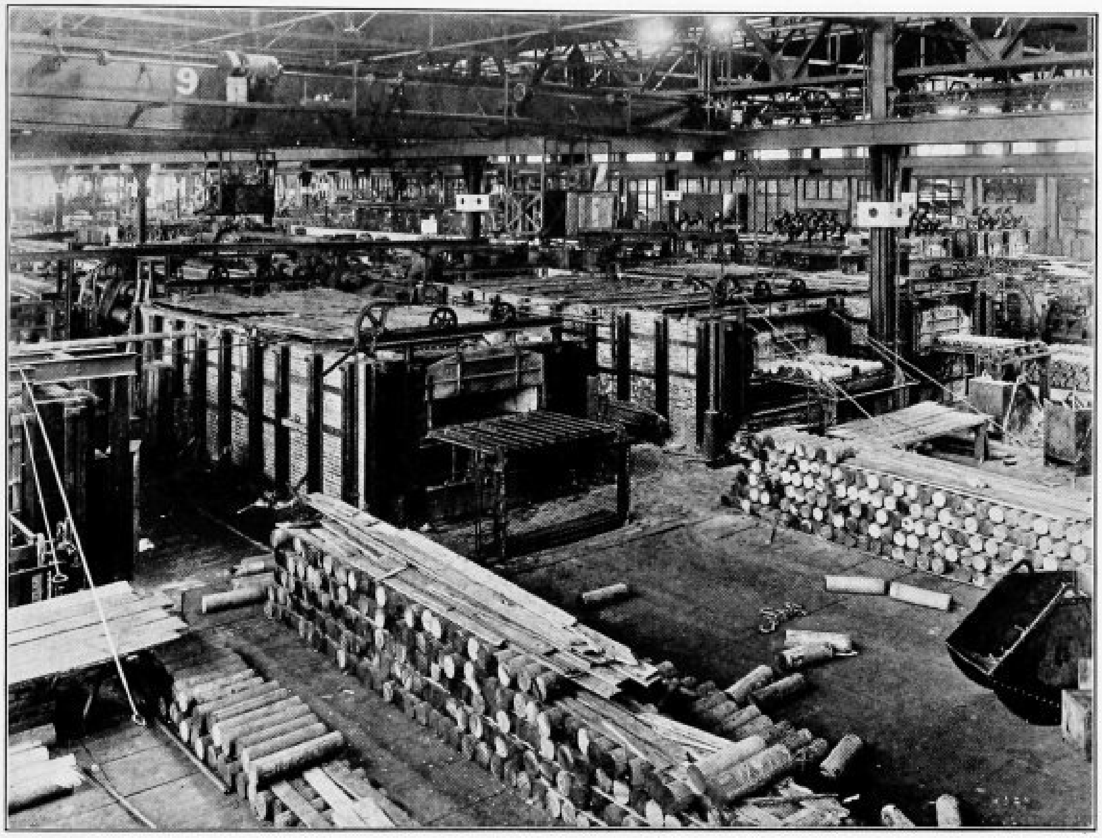

Fig. 39. "STRAIGHT-LINE" BILLET HEATING FURNACES—CHARGING ENDS
Billets are charged in one end and passed straight thru and out the other end. Suitable for heating billets for extruding, piercing or rolling.

form to raise the charge to the hearth level. The material is then pushed thru the chamber and delivered direct to machines located at the opposite end of the furnace.

SELECTION OF FURNACE

Determination of the type and size of furnace, number and position of working openings, and number of chambers, is governed entirely by the individual manufacturing conditions. The controlling factors are the quantity, shape and size of material to be heated; temperature; position of furnace with reference to adjacent machinery; floor space; facilities for moving material to, thru and from the furnace; fuel to be used; location of stacks, vents, etc. These factors, different in each plant, make a study of each individual case necessary, in order that the type and size of furnace selected may be adapted to the manufacturing conditions.

CONTINUOUS ROD HEATING

The continuous method of heating rods for the manufacture of bolts, spikes, rivets, and the like, may be conducted in furnaces of the type illustrated by Fig. 40. The rods are charged at one end of the furnace and pushed out at the opposite end directly into an automatic machine that completely disposes of the rod.

Over each working opening of these furnaces there is a special type of economizer hood. A novel arrangement of downward blast serves to deflect the waste gases upward, where they circulate around a preheater in the hood and preheat the air supplied to the burners for combustion. This not only saves fuel by utilizing the heat in the waste gases, but, as will be seen by referring to Fig. 41, induces a current of cool air past the operator toward the furnace, instead of permitting the discharge of hot gases from the furnace.

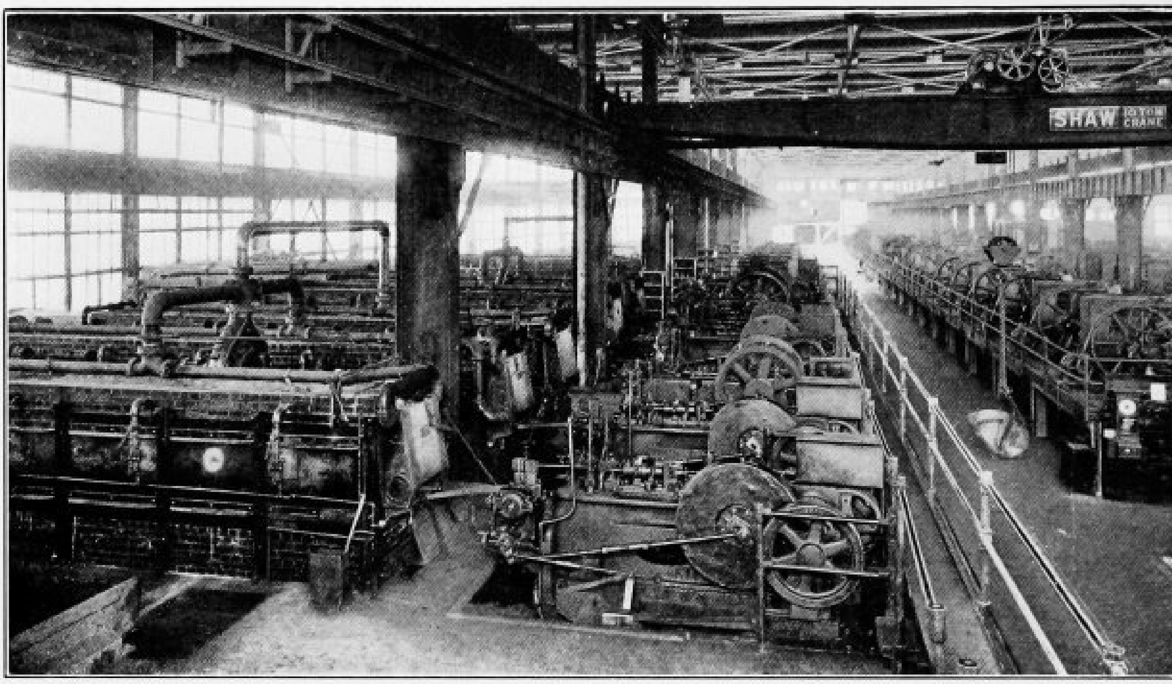

Fig. 40. CONTINUOUS RIVET ROD FURNACES AND MACHINES

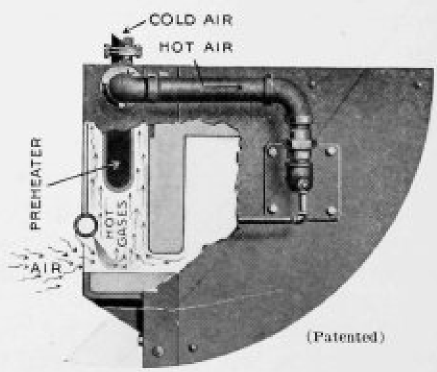

Fig. 41. SECTION SHOWING DEFLECTION OF HOT GASES, WITH INDUCED AIR *TOWARD* THE FURNACE, AND THE PREHEATING OF AIR FOR COMBUSTION.

The Relation of Indicated Uniform Temperature to Uniformly Heated Product

THE pyrometer charts, Figs. 42 and 43, illustrate the temperature variation during one day's operation of two furnaces of the type illustrated by Figs. 28 and 29, in use in two separate factories under the same management.

The irregularities in the lines are the natural result of the periodical charging and discharging of comparatively large panloads of material and the consequent opening of the chamber doors. It will be noted, however, that the variation is quite uniform and indicates a good heating condition. This is due primarily to the relationship of the combustion chambers and construction of the floor to the zone in which the heat is applied to the material, and to the heavy construction of the furnace itself.

It may be assumed that material heated in a furnace from which these readings were taken was heated uniformly. It probably was; but the charts themselves serve merely as evidence, not as proof, of the fact.

Equally good records of temperature control may be secured in other types of furnaces in which the manner of applying heat to the material would be entirely different. If, for instance, one type of furnace had a hot hearth and the other a comparatively cold one, it is reasonable to suppose that there would be a marked difference in the quality of the heated product, regardless of the indication of uniform temperature at some point in the chamber.

It is not merely the indication of uniform temperature but, rather, the use made of the potential energy so indicated that really counts.

The pyrometer does not necessarily indicate the temperature of the material, but merely the temperature of that part of the chamber in which the couple is located. Like the gauge on the steam line, it indicates the existence of heat energy, but it does not necessarily indicate the use made of that energy. The indicated temperature must be considered with the element of time, and with the influence that the factors of mass and surface and composition of the metal have upon the time.

While indication of uniform temperaature is an essential element in the production of uniformly heated material, it should be borne in mind that, for reasons given, this indication in itself is not proof of a uniformly heated product.

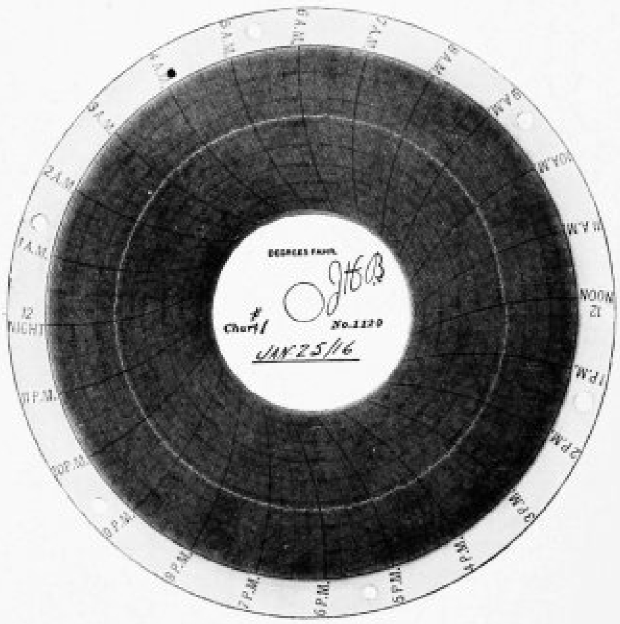

Fig. 42. PYROMETER CHART SHOWING UNIFORMITY OF TEMPERATURE DURING 24-HOUR RUN.

It is possible to maintain an indication of uniform temperature at some point in almost any furnace, but unless the heat is applied uniformly to the surfaces of each piece to be heated, and to all pieces alike, there is very apt to be a variation in heated product despite evidence in the form of pyrometer records to show that no variation should exist.

CARNEGIE LIBRARY OF PITTSBURGH
3 1812 04050 8609

THE real test in heating is the uniformity with which the heat is applied to all surfaces of each individual piece of a charge when the furnace is loaded to maximum capacity, and not when the chamber is empty or but partially filled. The element of time required for saturation must be considered with the temperature to which the piece is to be heated, and the mass and surfaces of the individual piece must be considered with reference to the elements of temperature and time.

Indication of uniform temperature is, like the cost of fuel or the tons of output, but one factor in the heating operation. Such factors, no matter how favorable they may appear, are inconclusive unless considered with the uniformity of the finished product from the metallurgical point of view.

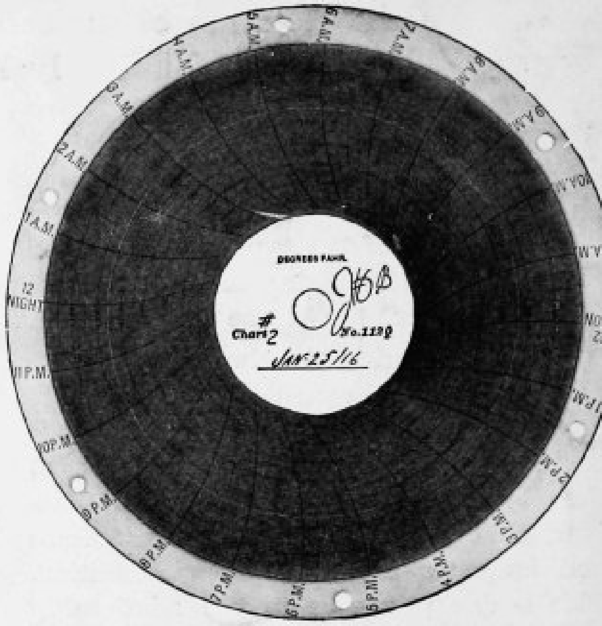

Fig. 43. INDICATION OF UNIFORM TEMPERATURE DOES NOT NECESSARILY PROVE THAT THE MATERIAL IN THE FURNACE HAS BEEN UNIFORMLY HEATED.

It is not the cost of fuel, the cost of labor, the tons of output, or the indication of uniform temperature; but, rather, the good quality and total cost of the finished product which are the determinative tests of industrial heating operations.

We solicit inquiries for better heating methods and equipment, irrespective of purpose or fuel.

Our aim is to furnish industrial heating service in quantity production of quality product.

"FURNACE AND FUEL TO SUIT THE WORK"—is the rule governing our consideration of new or improvement of existing furnace equipment to suit **your** needs under **your** plant conditions.

Our practice is to deal with each case on its individual merits, recommending changes in methods, equipment or fuel only when it is apparent that these will be productive of better results.

LET US HANDLE YOUR HEATING PROBLEMS

We make inspection of plant, devise methods of heating and handling material, furnish complete industrial furnace equipment adapted to the individual plant conditions, and guarantee results, using coal, gas or oil, as the best interests of our patrons require.

W. S. ROCKWELL COMPANY

Furnace Engineers and Contractors

50 CHURCH STREET NEW YORK

(Hudson Terminal Bldg.)

BRANCHES: CHICAGO—CLEVELAND—DETROIT

No. 217