To all whom it may concern:

Be it known that I, Daniel H. Meloche, a citizen of the United States, residing at 2941 Gladstone Ave., Detroit, in the county of Wayne and State of Michigan, have invented certain new and useful Improvements in Processes of Producing Self-Annealed Cast-Iron Castings in Permanent Molds by the Heat of the Metal Cast, of which the following is a specification.

In order to produce homogeneous castings (i.e., castings of uniform hardness) in permanent molds I have found it necessary in addition to the precautions taken when casting in sand to protect the surface of the mold with a refractory, inert and heat insulating paint which is very adhesive, and having protected it to cover it with a thick coating of lamp black so that the casting when ejected has already been practically annealed.

In order to produce the continuous casting of grey iron castings in permanent molds a commercial success it is necessary to eject them above the critical temperature of cast iron, that is to say at a temperature of about 1650°F. which is 200°F. above the critical temperature.

In order to get clear definition the iron must be poured at a good yellow heat. That is to say it should be poured at a temperature in excess of 2200°F. These conditions are very severe and great difficulty has been experienced heretofore in commercially producing castings by continuously pouring iron into permanent molds, the chief difficulty being that the coating flaked off, volatilized or was otherwise washed off by the molten iron.

Whilst the actual casting operations must follow each other in quick succession it is necessary to avoid the sudden chilling of the iron in the mold as otherwise the castings produced thereby will be unmachinable. The effect of a sudden chill is to solidify the outer surface and leave the core liquid. Unfortunately the cooling of the interior will not provide sufficient heat to soften the skin by annealing as it has been universally found that once hard spots have been formed in the casting by chilling only prolonged annealing will remove these hard spots which render the machining unprofitable.

In order that the molds should quickly reach their working temperature when in actual use I make the molds hollow with a wall thickness of approximately 0.5".

The process I have invented consists as follows. The molds are each produced from a dry sand mold and dry sand core, the molded surfaces of the dry sand mold and core being liberally protected with graphite and dusted with lycopodium. A rib is cast around the iron molds so as to facilitate machining the surfaces which match together as set forth in U. S. patent to Phillips, No. 1,099,097, of June 16, 1914. These molds are first cleaned and faced up so that they will match together. The molds are then heated to approximately 250°F. and coated with a refractory paint which is non-volatile at any temperature at which the iron is cast.

The molds are mounted on a horizontal rotating table with their dividing planes normal to axis of rotation as set forth in co-pending application, Serial No. 504,988, of Oct. 3, 1921, De Forest W. Candler. The pressure between the molds on their matching faces is limited and determined by springs as set forth in U. S. patent to McWane, No. 1,083,122 of Dec. 30, 1913.

The iron cast in the iron mold has to be somewhat higher in silicon than many commercial cast irons, thus corresponding to the higher grade cast iron commonly known as #1 foundry iron. This iron has a silicon content greater than 2.75% and a manganese content lower than 0.40%. The total carbon content in this iron runs from 2.50% to 3.50% and the combined carbon of the pig is less than 0.7%. The sulphur and phosphorus are both held at a low figure as sulphur and phosphorus are both objectionable for the same reason that they are objectionable in sand castings.

In melting this #1 foundry iron it is preferable not to add more than 10% low carbon scrap (20% to 30% C.) and the blast is so regulated that the melting zone is confined to a few inches, so that the iron does not have an appreciable percentage of oxygen in it and also to avoid producing
combined carbon by the chilling effect of an excessively strong blast of air. I have discovered that in this connection once combined carbon is formed in molten iron the castings produced therefrom are not as soft as castings produced from iron in which the carbon is merely in solution and not chemically combined with the iron.

When pouring the iron in the mold the operations are repeated every two or three minutes when making a three to five pound casting. This rate is regulated by the heating effect of the molten iron upon the mold hence with larger castings a longer period of time would be allowed. In order to keep the temperature of the mold below 1000° F. and in order to protect the surface of the mold the refractory paint referred to above is used. The coating I prefer to use is that described in my co-pending application Serial No. 561,289, filed August 11, 1922. This coating consists essentially of fire clay with a little soluble silicate (of sodium) as a binder. A coating of 1/64" (approximately) is applied to the mold, the mold being heated so as to evaporate the water which is used as a carrier for the fire clay and a solvent for the sodium silicate. Above the coating of refractory fire clay a thick layer of lamp black is applied. This coating of lamp black or carbon black is so thick that after the casting is ejected from the mold the lamp black coating is still intact.

The result of following this procedure is that the molten iron flowing into the mold, automatically heats the molds during the continuous operation of the process to approximately 800° F. to 1000° F. and causes the carbon coating of the mold to be partially removed either by absorption or combustion. The carbon coating whilst not refractory is an excellent insulator. The combustion of the carbon coating evolves considerable heat, the combustion of even one-tenth of an ounce per casting evolving sufficient heat to raise the temperature of a 2½ pound casting no less than 280° F. The coating of carbon being polyvalent and not compact like the fire clay coating already referred to, provides in itself an easy vent for the air in the mold. This air, of course, as it escapes, causes the lamp black to burn which evolves heat as already pointed out.

The net results of the combined insulating qualities of the fire clay and the lamp black and the heat evolved by the lamp black which is consumed results in the casting remaining red hot for a much greater period of time than is the case when no lamp black is used. Further, the outer surface of the iron probably dissolves some of the carbon and hence lowers its melting point and thus still further retards the cooling rate as molten iron is a relatively poor heat conductor. By prolonging the period during which the iron is red hot or rather during the period during which it is molten more time is given to permit the silicon to complete the precipitation of the carbon in the iron and thereby produce the soft grey iron which is the object sought for in this process.

If iron is rapidly cooled a considerable proportion of carbon remains in solution when in the solid state. This solid solution increases the hardness and renders the casting brittle. Further, by prolonging the molten stage one secures complete filling of the mold.

Without the adherent refractory insulating inner coating the relatively thick outer lining of lamp black will not adhere because without the adherent insulating coating the mold becomes red hot and burns the carbon off. With the insulating refractory coating the temperature of the mold is held below 1250° F.

I have noticed that when the casting is ejected that there immediately forms on the surface of the casting a thin scale which falls off when the castings are tumbled. This scale is not formed unless an excess of lamp black is used. In other words, unless the coating of lamp black is intact when the castings are ejected from the mold.

The surface left when this scale drops off is quite soft and annealed. If no scale is formed, as happens when insufficient or no lamp black is used, then the castings are hard. Whatever may be the connection between the formation of this scale and the resulting casting the fact is that by using an excess of lamp black superimposed on an inert insulating refractory adherent coating self-annealed castings are produced which is the object of this invention.

The successful operation of this process depends upon the rate of cooling of the iron. The rate of cooling of the iron is determined by—

1. The temperature of the iron cast.
2. The temperature of the iron molds.
3. By the thickness of the walls of the iron molds.
4. The insulating qualities of the refractory lining of the molds.
5. The thickness of the lamp black coating.

In the commercial production of large quantities of two pound castings having sections varying from 1/16" to 3/8" in thickness, with a hollow iron mold operating at a working temperature of 900° F, and having a 1/2" wall thickness and a 1/64" refractory lining, together with a 1/32" coating of lampblack, will solidify this casting in twenty seconds, which is the period of time which gives the most desirable results.

With larger castings the conditions should be adjusted so that the period of time taken
to solidify does not greatly exceed this twenty seconds and with smaller castings the conditions should be varied so that the time of solidification is not much less than the period of twenty seconds.

What I claim is:

1. The process of producing self-annealed grey iron castings, which consists in casting the metal in molds coated with a smooth adherent inert insulating refractory material and having a superimposed layer of amorphous carbon sufficiently thick to considerably prolong the cooling period of the casting.

2. The continuous process of producing self-annealed grey iron castings in metal molds which consists in heating the molds then painting the surface of the mold with a wash in which a heat-resisting adhesive is dissolved and an inert refractory substance is suspended and then coating the mold with a relative thick coating of amorphous carbon, holding the molds closed by a yielding pressure, pouring iron into the molds, ejecting the castings above the critical temperature and maintaining at all times an excess of lamp black so that at all times after the ejection of the casting the coating of lamp black remains practically intact.

3. The continuous process of producing self-annealed grey iron castings, which consists in heating the molds to 400° F., then painting the mold surfaces with a permanent coating of an adherent inert insulating refractory, then applying a thick renewable coating of amorphous carbon of such a thickness that it is practically intact after the ejection of the casting, so that at all times the castings are cast in an excess of lamp black, then permitting the temperature of the molds to reach 1000° F. and ejecting the castings whilst they are still above the critical temperature of 1450° F.

4. The continuous process of producing self-annealed grey iron castings in permanent molds, which consists in melting iron having a composition of from 2.50 to 3.75% carbon and from 1.75 to 2.75% silicon and pouring at a temperature in excess of 2200° F. into metal molds having a permanent adherent refractory coating of fire clay and a renewable coating of lamp black, maintaining the coating of amorphous carbon at such a thickness that it is intact after the castings are ejected from the molds, ejecting the castings from the molds immediately they are solid and permitting the molds to become heated to a temperature above 1000° F.

5. The continuous process of producing self-annealed grey iron castings in permanent molds, which consists of first heating the metal molds to a temperature in excess of 400° F., then painting the metal molds with a refractory inert insulating coating mixed with a temperature-resisting adhesive, then applying a thick coating of amorphous carbon and maintaining the carbon coating at such a thickness that it is substantially intact at all times, second, melting iron of from 2.50 to 3.50% total carbon and from 1.75 to 2.75% silicon, pouring the iron into the molds and finally ejecting the castings from the molds the moment they have sufficiently solidified.

6. The continuous process of producing self-annealed grey iron castings in permanent molds having substantially the same composition as the iron cast therein, consisting first of heating the cast iron molds to above 400° F., then painting the molds with a refractory inert insulating wash containing a little soluble silicate in solution and a considerable quantity of a refractory powder in suspension, then coating with lamp black and maintaining the lamp black by frequent applications sufficiently thick so that it will be substantially intact after the castings are ejected from the molds, second, melting iron of from 2.50 to 3.50% total carbon and from 1.75 to 2.75% silicon, pouring the iron into the molds and finally ejecting the castings from the molds at a temperature greater than 1450° F. and permitting the molds to reach a temperature in excess of 1000° F.

7. The continuous process of producing self-annealed grey iron castings in permanent molds, which consists in pouring iron at over 2200° F. into molds protected by an adherent inert refractory insulating coating and a superimposed lining of amorphous carbon sufficiently thick so that it will be substantially intact when the casting is removed, whereby the heat of the metal cast is retained within the casting and the solidification of the casting is delayed.

8. The continuous process of producing self-annealed grey iron castings in permanent molds, which consists in pouring iron containing not over 10% low carbon scrap at a temperature in excess of 2200° F. into metal molds coated with a superimposed lining of refractory insulating coating and a superimposed lining of amorphous carbon maintained sufficiently thick so that it will be substantially intact after each casting is ejected, whereby the heat of the metal cast is maintained within the casting.

9. The continuous process of producing self-annealed grey iron castings in permanent molds, which consists in pouring iron substantially free from oxygen at a temperature in excess of 2200° F. into molds protected by an adherent inert refractory insulating coating and a superimposed lining of amorphous carbon sufficiently thick so as to be substantially intact when the casting is removed, whereby the heat of the metal cast is retained within the casting.

10. The continuous process of producing
self-annealed gray iron castings in hollow metal molds, which consists in pouring iron at over 2200° F. into the said hollow molds, the walls of which are protected by an adherent, inert, refractory, insulating coating and a superimposed lining of amorphous carbon sufficiently thick so that it will be substantially intact when the casting is removed, whereby the heat of the metal cast is retained in the casting and the solidification of the casting is delayed.

11. The continuous process of producing self-annealed gray iron castings in thin walled molds which consists in pouring iron at over 2200° F. into molds protected by an adherent, inert, refractory, insulating coating and a superimposed lining of amorphous carbon sufficiently thick so that a casting weighing two pounds will take twenty seconds to solidify so that it may be ejected from the molds.

12. The continuous process of producing self-annealed gray iron castings which consists in pouring molten iron into heated iron molds having a wall thickness of \( \frac{1}{8} \)" protected with an adherent, refractory, insulating lining of \( \frac{1}{2}'' \) with a super-imposed coating of lampblack \( \frac{1}{8}'' \) thick, whereby a casting weighing two pounds solidifies in twenty seconds.

13. The process of producing iron castings in metal molds, comprising the coating of the walls of the molds with a layer of amorphous carbon of such a thickness as to appreciably prolong the period of solidification.

14. The process of producing iron castings in metal molds, comprising the coating of the walls of the molds by means of a smoky flame so as to deposit thereon a layer of amorphous carbon of such a thickness as to appreciably prolong the period of solidification.

15. The process of producing iron castings in relatively permanent molds comprising the coating of the walls of the mold with a layer of amorphous carbon, of such thickness as to appreciably prolong the period of solidification.

In testimony whereof I affix my signature.

DANIEL H. MELOCHE.