H. GOLDSCHMIDT & F. LANGE.

PROCESS OF UNITING METALS.

APPLICATION FILED JAN. 30, 1905.

900,366. Patented Oct. 6, 1908.

Fig. 1.

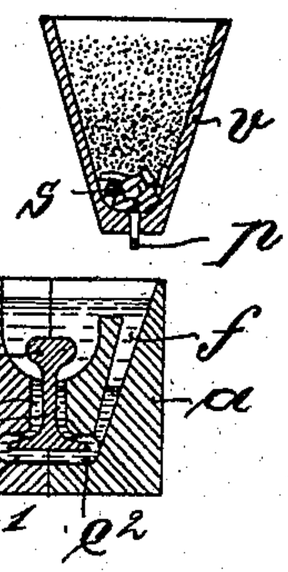
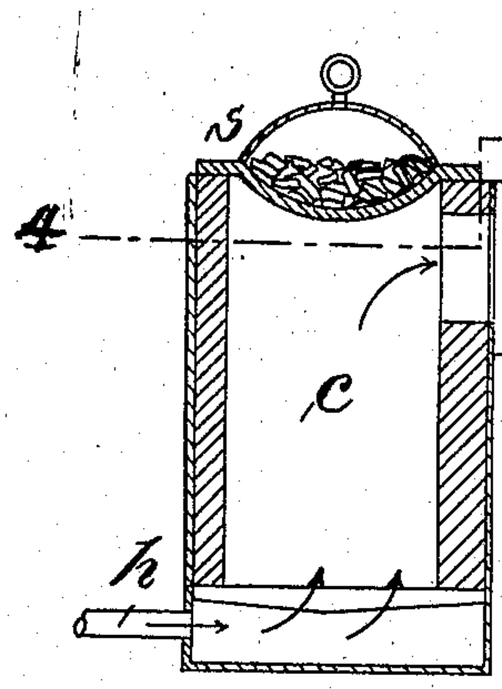


Fig. 2.



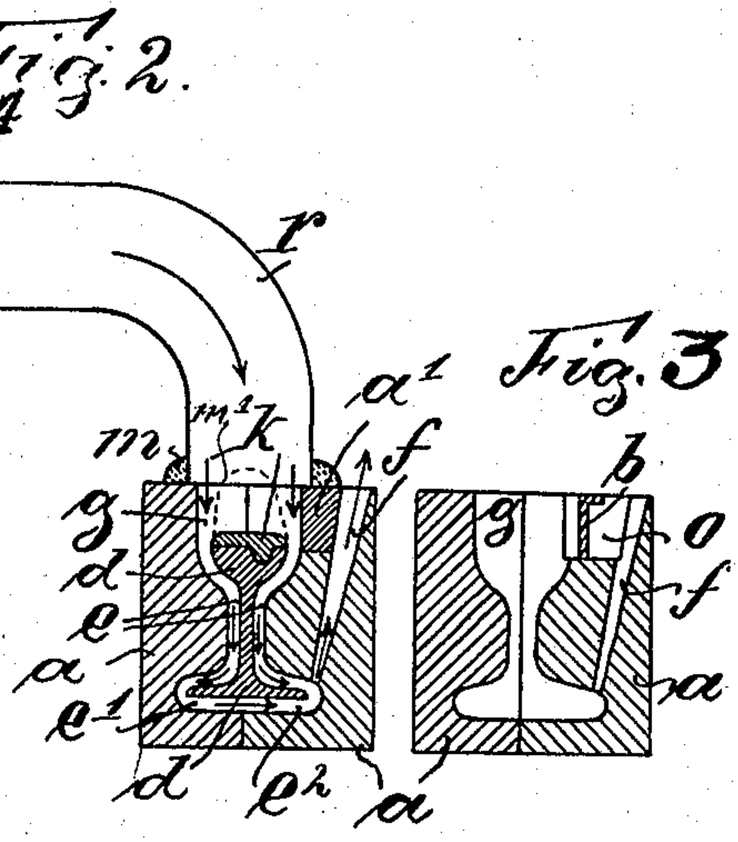


Fig. 3

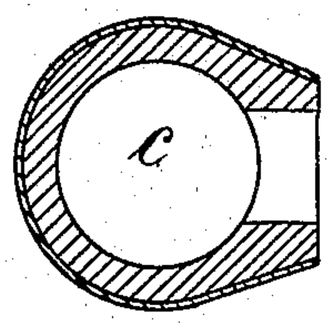


Fig. 4

Witnesses:
Arthur Scholz
Otto Scholz.

Inventor:
Hans Goldschmidt
and Felix Lange.
by Munderloh
Attorney

UNITED STATES PATENT OFFICE.

HANS GOLDSCHMIDT AND FELIX LANGE, OF ESSEN-ON-THE-RUHR, GERMANY.

PROCESS OF UNITING METALS.

No. 900,366. Specification of Letters Patent. Patented Oct. 6, 1908.

Application filed January 30, 1905. Serial No. 243,401.

To all whom it may concern:

Be it known that we, HANS GOLDSCHMIDT, manufacturer, and FELIX LANGE, architect, both subjects of the King of Prussia, German Emperor, and residents of Essen-on-the-Ruhr, in the German Empire, have invented certain new and useful Improvements in the Process of Uniting Metals, of which the following is an exact specification.

This invention relates particularly to the joining or welding of rails, girders, bars and similar articles by means of superheated molten metal, by which, in the present specification we mean metal which is brought to a superheated molten condition as the result of melting or reduction when within the zone of the reaction resulting from the ignition of a mixture of aluminum and a compound of a metal reducible by such ignition of its compound in the presence of aluminum. In welding by this alumino-thermal process it has been found in practice that the superheated molten metal is cooled considerably when brought into contact with the rail or other article and the mold, owing to the coolness of such article and mold. In order to prevent this and at the same time reduce the quantity of superheated molten metal which is necessary to produce the desired result, and in order also to make the process of joining and welding as cheap as possible, the mold spaces formed between the mold and the metallic article to which the superheated molten metal is to be connected should be as narrow as possible. When this is done, the exposed surfaces of the mold and the rail or other article are very large as compared with the quantity of superheated molten metal to be used, and therefore it is necessary to protect the superheated metal from the cooling action of these surfaces, or a larger quantity of the superheated metal will be necessary to complete the joining or welding process.

According to our invention, the metal part to which the superheated metal is to be joined has a mold placed in juxtaposition therewith, preferably in such a manner as to form a continuous narrow channel or channels, the mold preferably surrounding all of the surfaces exposed to the action of such superheated metal. This mold is preferably provided with two openings, one of which constitutes an inlet and the other an outlet, through which heated gas may be forced for the purpose of heating the walls of the mold-space and the metal part or parts inclosed thereby. The inlet opening may be connected to the blower of a blacksmith's forge or other means for causing a current of highly heated gas to pass or be forced through the channel or channels formed by the mold. These gases highly heat the metallic part or parts inclosed by the mold, and these parts and the inner surfaces of the mold both are preferably brought to a bright red heat. The connection between the mold and the source of heated gas is then broken and superheated metal, preferably soft steel produced by the alumino-thermal process, is run into the mold. This superheated metal thus run into the mold serves to connect the ends of a pair of rails or to add metal to a single rail or other part in a very perfect manner and in a very cheap way, because only a small quantity of the soft superheated steel or other superheated metal is necessary to accomplish the desired result, the cooling action of the mold and of the adjacent surface or surfaces of the metal part or parts being reduced to the minimum by such heating of the mold and metal part or parts to a bright red heat.

We are aware that in the employment of the alumino-thermal process the heating of the metal part or parts has heretofore been practiced, but our invention is distinguished therefrom in that highly heated gas is forced through the mold-space, preferably through a mold space consisting of a series of narrow channels, which are afterwards filled with superheated metal for the purpose of filling out a solid metal part or uniting two metal articles. The effect which results from the running of superheated steel or other metal into a heated mold which is in juxtaposition with or incloses the highly heated metallic surface or surfaces is very different from that which results when ordinary molten iron is run into a heated mold in juxtaposition with a heated metallic surface or surfaces. In this case the only advantage which results is that the temperature of the cast iron is not materially reduced. When a heated mold and a heated metallic surface or surfaces are used in combination with superheated molten steel produced by the alumino-thermal process, the following additional advantages result in operating upon steel rails or similar articles: first, the quality of the rails is not impaired, as has been

the case heretofore, and second, narrow channels between the mold and the rails may be employed without risk of hardening the molten steel. In addition to these important results the cost is very much reduced by the process forming the subject-matter of this invention, as compared with the cost of such work done by the process heretofore used. In the ordinary process of melting iron or steel the amount of metal to be melted for the purpose, for example of surrounding the ends of two rails with molten cast iron, is of secondary importance, because in this process it is not the quantity of molten iron which chiefly determines the cost of the process, this cost being chiefly determined only by the fact that it is necessary to melt cast iron in a furnace in order to carry out the process. This fact and the expense of working determine the cost of such process, and the quantity of cast iron used in the process affects the cost only to a very slight extent. The conditions are quite different when such rails are to be joined by the alumino-thermal process, for then the cost depends chiefly upon the quantity of the superheated metal which it is necessary to use, and it is of the utmost importance in such process to reduce the quantity of such superheated metal and the size of the space to be filled thereby to the minimum. Hence the mold space should be formed as narrow channels continuous with one another, and preferably extending in one direction.

With regard to the quality of the rails after they are subjected to the present process, we have found that the heating of the mold and such rails or other parts to a red heat before the superheated molten metal is run into the mold prevents the blistering of the steel, whereas, when this superheated molten steel or iron is run into the mold without any previous heating of such mold the steel of the rails has often suffered a great deal.

It will be obvious that in the common casting process used hitherto there is no danger of changing the quality of the steel of the rail, because the temperature of the cast-iron is too low.

Having thus clearly described the principal part of our invention, it is still necessary to describe the secondary part thereof, the object of which is to still further reduce the difference in temperature between the superheated molten metal and the highly heated rail or other article to be welded, and thus to obtain better results both with respect to the quality of the metal at the point of welding and also with respect to the cost of the joint. According to this part of our invention, not only the mold and rail or other metal article are to be heated before the superheated molten steel or other metal is run into the mold, but the mixture of aluminum and a metallic compound from which iron or steel is to be reduced also contains pieces of iron or steel which have been previously heated. When the alumino-thermal reaction takes place and the iron or steel is reduced from the mixture the excessive temperature resulting from the reaction is reduced by the presence of these pieces of iron or steel, and the volume of the molten metal resulting from the ignition of the mass is increased. These pieces of iron or steel may be heated in any suitable manner, the most obvious source of heat for such preliminary heating being the hot gases from the blacksmith's fire. Usually these pieces, which are pieces of wrought-iron or steel, are heated in a shallow vessel to a bright heat and afterward thrown into the superheated molten metal resulting from the reaction of aluminum and ferric oxid or similar compound. Said pieces may, however, be placed in the mixture of finely divided aluminum and ferric oxid after which such mixture may be ignited. There is a further difference between the old process and the present one, to wit, that it is no longer necessary to vary the quality of the steel resulting from the alumino-thermal process by the addition, for example, of silicon and manganese, which additions have been necessary heretofore in order to obtain a good connection between the superheated metal and the rail.

Our invention may be carried out by means of an apparatus such as that shown in the accompanying drawings, in which

Figure 1 is a transverse sectional elevation of a mold and a crucible or similar receptacle for the superheated molten metal; Fig. 2 is a similar view of a mold and a source of heated gas and illustrates a modification of the invention; Fig. 3 is a transverse sectional elevation illustrating another modified type of mold; Fig. 4 is a sectional plan of the source of heated gas, the section being taken in the line 4—4, Fig. 2.

Similar characters designate like parts in all the figures of the drawings.

a represents a mold which is placed in juxtaposition with and is preferably clamped to the part or parts to be welded. Here, two rails are surrounded by a mold which is made in two parts and has passages *e*, *e'*, and e^2 constituting portions of the mold space. The ingate of the mold is shown at *f*, and is a channel communicating with the channel e^2. Between this ingate and the rail a barrier, such as *a'*, (see Fig. 2) is placed so that there is a complete separation between the mold and the outlet therefrom when the mold is to be heated. The ingate *f* of the mold is such only when metal is to be run into the mold, and during the heating of the mold constitutes in the present instance the outlet for the heated gas, the main mold-space con

stituting the inlet at such time. When the mold and the rails are to be heated, a pipe, such as *r*, leading from a smith's forge, such as *c*, is connected with the opening *m'*, that is, with the main mold-space formed by interposing the barrier *a'* between the ingate *f* and the other channels of the mold. The connection between the mold and the pipe *r* is preferably made air-tight, as by a ring of clay *m*, and afterward a current of hot gas is forced into the mold through the channel *e*, *e'*, *e*² and *f*. When the rails or other parts to be joined have reached a bright red heat and the mold is of a corresponding temperature the pipe *r* and the barrier *a'* are removed and the mold assumes the form shown in Fig. 1. Instead of the barrier *a'* a piece of sheet-iron, such as *b* (see Fig. 3) may be used, this being afterward melted by the superheated slag resulting from the alumino-thermal process.

At the same time that the mold and metal parts are heated a crucible should be filled with a mixture of granulated aluminum and oxid of iron. In this mixture a quantity of wrought-iron or steel (for example thirty per cent. of the weight of such mixture) may be placed. If this iron or steel is strongly heated before it is placed in the crucible the quantity used can be still further increased. The mixture thus made is then ignited in the well-known manner and a regulus of molten iron or steel sinks to the bottom of the crucible and the mass of molten slag remains in the upper part of the crucible. The soft steel reduced by the alumino-thermal process and resulting from the melting of the wrought-iron or steel by the superfluous heat of the reaction is then run into the ingate *f* of the mold to fill such mold. This may be effected by pushing up an iron stopper *p*, which may be a wire nail filling a tap-hole in the bottom of the crucible *v*. The whole mass of the molten steel will then flow through this tap-hole into the ingate *f* and fill the same, and will flow over this ingate through the passages *e*², *e'*, and *e* into the mold. The free spaces of the mold are of such size that the rail or other metal part is almost or entirely surrounded by the molten steel or metal, and such metal part or parts will be heated up by the molten metal to such an extent as to form therewith a weld or joint. When two rails are placed end to end, and the molten metal is run around or between the ends thereof, a continuous rail having a homogeneous weld at the point of connection results. The alumina slag which runs out of the crucible *v* after all the molten steel has made its exit runs over the opening *o* from which the barrier *a'* has been removed, flows over the top of the rail or rails, and covers the top of the same so as to prevent any loss of heat.

When pieces of iron or steel heated to a red heat are mixed with the welding compound a very high percentage of the same can be used, for example, fifty per cent. or more by weight of such compound. Because of this the quantity of superheated iron or steel produced by the present process is doubled, as it is well known that the mixture of alumina and oxid of iron ordinarily reduces about fifty per cent. of its weight to metallic iron. When highly heated wrought iron or steel is added to the mixture premature solidification of the alumina slag, which results when cold pieces of metal in the same quantity are added, is prevented, and the whole mass of molten metal and slag in the crucible will remain and run out of the crucible in a molten state.

We deem it desirable to cover the top of the metal article or rail with a shield *k* while the hot gases are being forced through the mold from the furnace *c*, in order to prevent the hot gas from impinging directly upon the top of the rail.

It will be evident that the welding compound or mixture and the crucible *v* containing the same may also be pre-heated if desired. By doing so considerable heat is saved, which is utilized later in welding or melting the bars or other parts operated upon.

One of the principal advantages which results from this improved process is that by its means it is possible to unite bars which it has hitherto been impossible to weld, that is, to join together along their sides or other large surfaces bars of considerable cross section or length of cross section.

It was formerly impossible to produce flawless welds in forgings or the like when the surfaces to be joined were of considerable extent, even when very large quantities of the welding compound were used in doing so. By this method of welding, in which the mold is formed with narrow channels the large surfaces of which, and of the rail or other part, are heated by hot gas forced through the mold, it is practicable to weld pieces having a welding surface of great length without excessive expense.

An important feature of that part of our process which relates to the addition of pieces of wrought-iron or steel to the welding compound, is that when such pieces are heated sufficiently they can be introduced into the welding compound in the crucible in large pieces. These large pieces when so heated will melt almost immediately, either while the alumino-thermal reaction is taking place or immediately after the action is complete. In practicing the alumino-thermal process heretofore, when cold wrought-iron or steel was introduced into the crucible containing the welding compound it was necessary to introduce such iron or steel in a finely divided state. This improved process can be utilized in various ways, to remove

blemishes in forgings, castings, etc., or to add parts to them, or to complete their outlines. For example should it be desired to weld a broken tooth onto a cog-wheel or to make any other addition of superheated iron or steel where no direct union of solid metal parts takes place, but where such part is merely strengthened by the addition of the superheated steel or metal, this process can be employed in the manner described. In addition to this it will be noted that the means employed for obtaining the desired result is very simple, there being only the work and the mold, the channels of which serve at first as flues for the hot gas, and are then filled up by the molten metal.

Having thus fully described the nature of our invention, what we desire to secure by Letters Patent of the United States is:—

1. The improvement in the art of uniting metals, which consists in placing a mold in juxtaposition to solid metal with a mold-space therebetween, then forcing a current of heated gas through the mold space, and then running superheated molten metal into said mold-space and thereby partly fusing said solid metal, said superheated molten metal and the partly fused portion of the solid metal forming when solidified a uniform weld.

2. The improvement in the art of uniting solid pieces of metal, which consists in placing a mold in juxtaposition to adjacent portions of said pieces of metal with a mold-space therebetween, then forcing a current of heated gas through the mold-space, and then running superheated molten metal into said mold-space and thereby partly fusing said solid pieces of metal, said superheated molten metal and the partly fused portions of the solid pieces of metal forming when solidified a uniform weld.

3. The improvement in the art of uniting metals, which consists in placing a mold in juxtaposition to solid metal with a mold-space therebetween, then forcing a current of heated gas through the mold-space, and then running into said mold-space a mixture of molten metals, one of which is a superheated molten metal and thereby partly fusing said solid metal, said superheated molten metal and the partly fused portion of the solid metal forming when solidified a uniform weld.

4. The improvement in the art of uniting metals, which consists in placing a mold in juxtaposition to solid metal with a mold-space therebetween, then forcing a current of heated gas through the mold-space, and then running into said mold-space a mixture of superheated molten metals and thereby partly fusing said solid metal, said superheated molten metals and the partly fused portion of the solid metal forming when solidified a uniform weld.

5. The improvement in the art of uniting metals, which consists in placing in juxtaposition to solid metal a mold of such construction as to form therewith a mold-space having narrow channels, then forcing a current of heated gas through the mold-space, and then running superheated molten metal into said mold-space and thereby partly fusing said solid metal, said superheated molten metal and the partly fused portion of the solid metal forming when solidified a uniform weld.

6. The improvement in the art of uniting metals, which consists in placing a mold in juxtaposition to solid metal with a mold-space therebetween, igniting a mixture of finely divided aluminum and a reducible compound of a metal together with relatively large heated pieces of such metal and reducing to a superheated molten state the metal of such compound and also such large pieces of metal, and then running the superheated molten metal into said mold-space and thereby partly fusing said solid metal, said superheated molten metal and the partly fused portion of the solid metal forming when solidified a uniform weld.

7. The improvement in the art of uniting metals, which consists in placing a mold in juxtaposition to solid metal with a mold-space therebetween, igniting a mixture of finely divided aluminum and a reducible compound of metal together with relatively large heated pieces of metal and reducing to a superheated molten state the metal of such compound and also such large pieces of metal, forcing a current of heated gas through the mold-space, and then running the superheated molten metal into said mold-space and thereby partly fusing said solid metal, said superheated molten metal and the partly fused portion of the solid metal forming when solidified a uniform weld.

8. The improvement in the art of uniting metals, which consists in placing in juxtaposition to solid metal a mold of such construction as to form therewith a mold-space having narrow channels, igniting a mixture of finely divided aluminum and a reducible compound of a metal together with relatively large pieces of such metal and reducing to a superheated molten state the metal of such compound and also such large pieces of metal, forcing a current of heated gas through the mold-space, and then running the superheated molten metal into said mold-space and thereby partly fusing said solid metal, said superheated molten metal and the partly fused portion of the solid metal forming when solidified a uniform weld.

9. The improvement in the art of uniting metals, which consists in placing a mold in juxtaposition to solid steel with a mold-space therebetween, then forcing a current

of heated gas through the mold-space, and then running superheated molten steel into said mold-space and thereby partly fusing said solid steel, said superheated molten steel and the partly fused portion of the solid steel forming when solidified a uniform weld.

10. The improvement in the art of uniting metals, which consists in placing a mold in juxtaposition to solid steel with a mold-space therebetween, then forcing a current of heated gas through the mold-space, and then running into said mold-space a mixture of different kinds of molten steel one of which is superheated molten steel and thereby partly fusing said solid steel, said superheated molten steel and the partly fused portion of the solid steel forming when solidified a uniform weld.

11. The improvement in the art of uniting metals, which consists in placing a mold in juxtaposition to solid steel with a mold-space therebetween, then forcing a current of heated gas through the mold-space, and then running into said mold-space a mixture of different kinds of superheated molten steel and thereby partly fusing said solid steel, said superheated molten steel and the partly fused portion of the solid steel forming when solidified a uniform weld.

12. The improvement in the art of uniting adjoining ends of a pair of solid metal bars or rails, which consists in placing a mold in juxtaposition to the adjacent ends of such solid bars or rails with a mold-space therebetween, then forcing a current of heated gas through the mold-space, and then running superheated molten metal into said mold-space and thereby partly fusing the adjoining ends of said solid rails or bars, said superheated molten metal and the partly fused portions of the rails or bars forming when solidified a uniform weld.

In witness whereof we have hereunto set our hands in the presence of two witnesses.

HANS GOLDSCHMIDT.
FELIX LANGE.

Witnesses:
WILLIAM ESSENWEIN,
PETER LIEBER.