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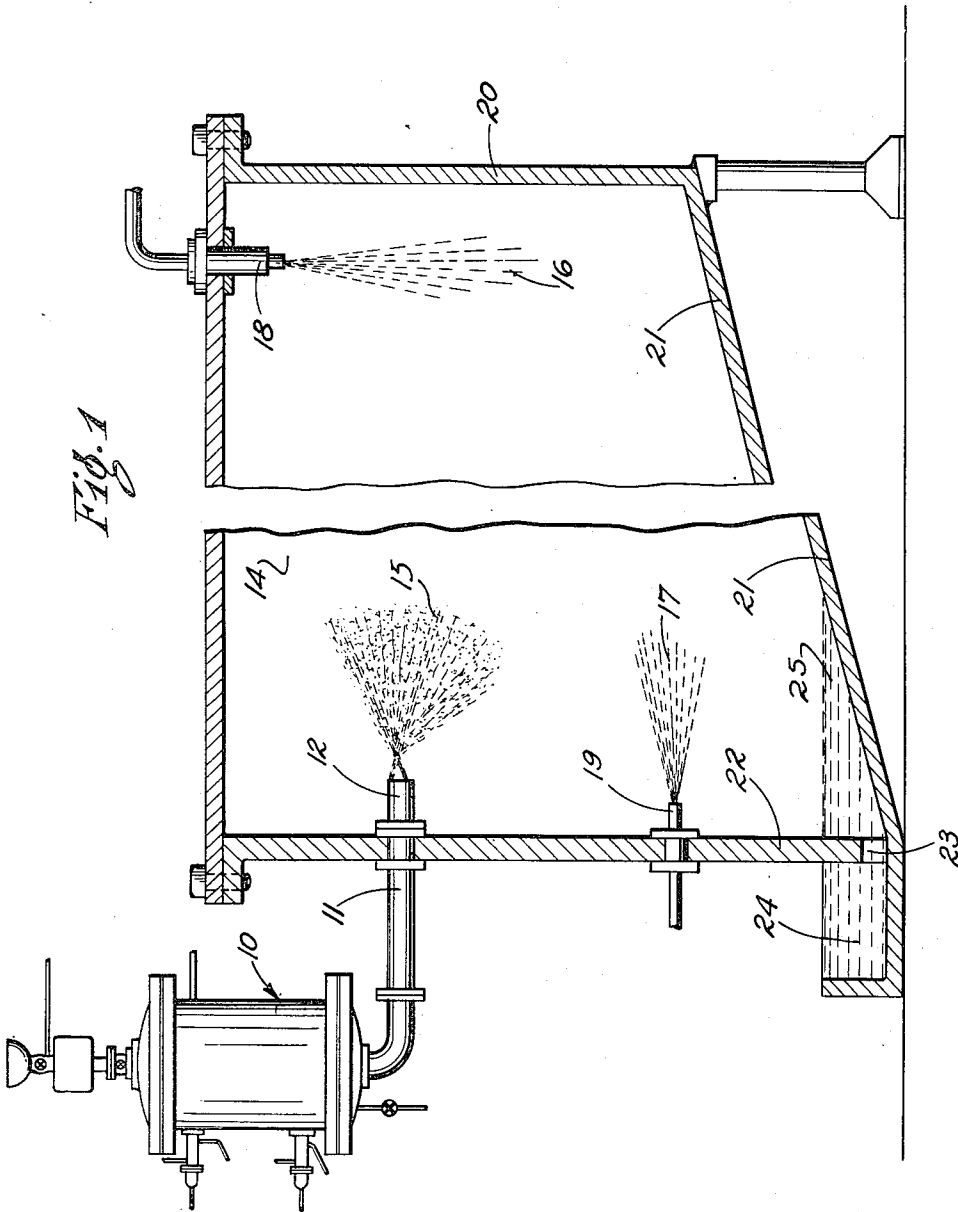
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METHOD FOR SPRAYING METAL

Original Filed Aug. 4, 1944

2 Sheets-Sheet 1



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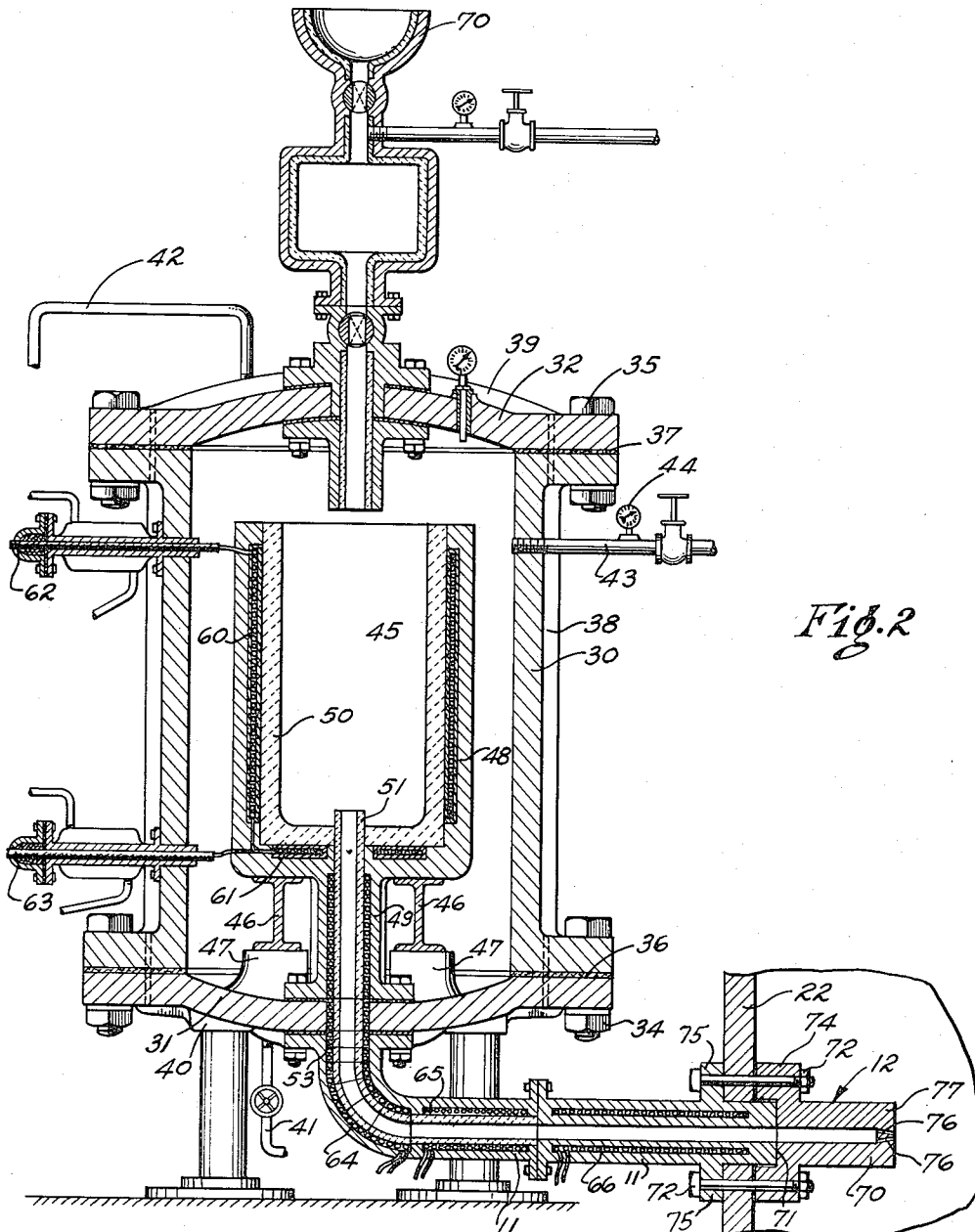
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METHOD FOR SPRAYING METAL

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Continuation of application Serial No. 548,023, August 4, 1944. This application March 22, 1950, Serial No. 152,412

7 Claims. (Cl. 117—46)

This invention pertains to method and apparatus for spraying metal and producing metal strip thereby, and is a continuation of my application, Serial No. 548,023, filed August 4, 1944, and now abandoned.

This invention relates to a method of and apparatus for spraying molten metal, and more particularly to a method of and apparatus for making finely divided metallic particles or powders suitable for use in the manufacture of electrolytic cell electrodes, and in the manufacture of other articles composed of sintered metal powders.

It has heretofore been proposed to produce spray deposited coatings consisting of finely divided metallic particles which cohere to each other when projected against a suitable base by melting the metal and atomizing the molten metal by a gaseous blast. Ordinarily the melting of the metal and atomization of the metal are carried out in the same apparatus, the metal being supplied in the form of a rod or wire being fused by an oxy-acetylene flame, for example, and projected and atomized by a blast of a gas such as compressed air.

For some purposes, the above described apparatus, which is known as a metallizing gun, is quite satisfactory. However, where quantities of metal are to be atomized, the operation is expensive because the metal is supplied in the form of wire and because of the cost of the gases used in fusing and atomizing the metal. The operation is also unsatisfactory for many purposes because the metals may be contaminated or oxidized by the gases furnishing the flame for melting the metal, or by the atomizing and propelling gas or both. The heat of the flame also imposes limitations on the materials upon which coatings can be sprayed. Furthermore, the atomization effected by the blast of gas is not uniform and the size and shape of the particles cannot be accurately controlled (1–20 microns in size).

According to my present invention I eliminate the difficulties noted above and provide a method and apparatus whereby large quantities of finely divided metal powders can be produced economically, and in which the metallic particles can be made of more uniform size than heretofore possible, with the size being readily controllable. Furthermore, all danger of contamination of the metals is eliminated. These results I preferably accomplish by melting the metal in a crucible maintained under a relatively high pressure, for example, on the order of 450 lbs. and up per square inch, discharging the molten metal through a nozzle in which it is mechanically atomized solely by the flow of the metal itself, without the use of any atomizing gas, and projecting the spray so produced by the fluid pressure alone. The spray may be directed against a suitable base to be coated if it is desired, to provide a spray-deposited coating or layer composed of coherent particles, or the spray may be directed into a chamber, room or tower, preferably so proportioned and arranged that the metallic particles will solidify before they fall to the floor of the tower or room. The solidified particles may then be collected and used in the manufacture of electrolytic condensers, for example, or in the production of articles by powder metallurgy. By this method large quantities of metal may be fused, atomized and sprayed rapidly and economically, and contamination and oxidation may be avoided, for if desired, the metal particles may be sprayed into an atmosphere composed of a gas which is inert with respect to the metal being sprayed. Furthermore, by controlling the pressure of the molten metal and the design of the nozzle, very fine

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particles can be produced, and the particles are of more uniform and more accurately controlled size than can be obtained with apparatus wherein the metal is atomized by a gaseous blast.

Referring now to the drawings: Figure 1 somewhat diagrammatically illustrates the general arrangement of an apparatus for atomizing and spraying molten metal, producing metal coated articles and producing powdered metal according to my invention; and Figure 2 illustrates a preferred form of apparatus for melting and discharging the molten metal under pressure. As shown in Figure 1, an apparatus for carrying out my method preferably comprises a crucible indicated generally at 10 for melting metal under pressure and preferably constructed in accordance with my prior Patent No. 2,322,787, issued June 29, 1943, and my copending application Serial No. 407,199, filed August 16, 1941, now Patent No. 2,371,604.

From the crucible 10, which will be described in greater detail below, the molten metal is conducted under pressure through the conduit 11 to the discharge nozzle or spray nozzle 12, which is disposed within the chamber, tower, or room 14. The pressure of molten metal in the nozzle is such that the metal passing through the nozzle is mechanically atomized into very minute particles, producing a spray of finely divided molten particles indicated diagrammatically in the drawing at 15. If it should be desired to produce spray-deposited coatings, or to "metallize" the articles, suitable base materials or the articles to be metallized would be disposed within the chamber 14 in the path of the spray 15 close enough to the nozzle 12 so that the particles when they impinged upon the base or article to be coated would still be in a plastic, if not fluid, state. Upon impingement the particles would therefore adhere to the underlying surface and cohere to each other in the usual manner of spray-deposited particles. This operation may be carried out in a reducing atmosphere and preferably the metal surfaces to be spray-coated are cleaned by the action of a reducing flame before they are placed in the chamber. Oxides are thus removed from the surfaces of the base metal and are prevented from reforming by the presence of the reducing atmosphere. The absence of oxides on the metal surfaces insures good adhesion of the sprayed metal to the underlying surfaces.

If it is desired to produce finely divided metallic particles to be utilized in powder metallurgy, for the manufacture of electrolytic condensers, or other purposes, then the spray is directed into the chamber which is preferably sufficiently large to permit the cooling and solidifying of the individual particles during their travel through the chamber and before they impinge upon any interior surface thereof. When the particles are permitted to cool in such manner the individual particles remain separate and retain their generally spherical form, producing particles which are ideally suited for subsequent use in powder metallurgy and in electrolytic electrodes where the great area of the spherical particles is of best advantage.

It will be appreciated that the atmosphere within the chamber 14 may be composed of any suitable gas, and may be maintained at pressures above or below atmospheric, depending upon the particular requirements. Reduced pressures of gas within the chamber 14 will result in slower cooling of the particles. The temperature of the gas may also be controlled to vary the rate of cooling. Various inert gases may be employed to prevent corrosion or contamination of the finely divided particles. For some metals such as aluminum and magnesium, an atmosphere of carbon monoxide will be satisfactory. Carbon monoxide may also be employed in spraying ferrous materials, or other reducing or non-oxidizing atmospheres of conventional compositions may be used. For some materials such as copper and other metals which are not corroded by air, no particular precautions need be observed, and the chamber may merely contain air at atmospheric pressure. Also by providing chambers of sufficient size, the powdered metal being permitted merely to settle to the floor of the chamber and either removed therefrom continuously as by belt conveyors or scrapers substantially covering the floor, or periodically removed therefrom.

As noted above, I preferably employ an apparatus such as described in my Patent 2,371,604 for producing the

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supply of fluid metal under pressure required by the nozzle 12. As shown in Figure 2, such an apparatus preferably comprises a cylindrical pressure chamber 30, having a bottom portion 31 and a top closure member 32 securely bolted thereto as by bolts 34 and 35, respectively, gaskets 36 and 37 being employed to provide tight joints. To prevent the pressure chamber from becoming overheated, it is preferably water-jacketed as indicated at 38, 39 and 40, or other suitable cooling means may be employed. Water or other cooling liquid may be supplied to the water jacket members through an inlet pipe 41 and discharged through the pipe 42. By this means excessive heating of the pressure chamber and consequent weakening thereof may be eliminated. This construction is particularly advantageous in conjunction with metals or alloys of higher melting points, such as ferrous materials, for example, but is not as important in conjunction with aluminum or other metals or alloys of relatively low melting points.

The molten metal is discharged under pressure by a suitable gas within chamber 30, which exerts pressure on top of the body of metal, the gas being supplied through conduit 43, which is provided with a suitable valve and a pressure gage 44, or the pressure may be developed or increased by the pressure of metallic vapors or gases from the metal to be discharged. The metal is contained in a crucible indicated generally at 45 and supported within the pressure chamber in any convenient manner as by rails 46 resting on upstanding bosses 47 extending from the bottom member 31 of the chamber. Thus the gas pressure acts on the surface of the molten metal, furnishing the discharge pressure, and also acts on the exterior of the crucible, so that the crucible is not subjected to any destructive forces, even though the gas may be at a pressure of several hundred pounds.

The crucible preferably includes a metallic shell portion 48, having a depending neck portion 49 extending to the bottom of the container. The crucible is provided with a lining 50 of refractory material which is preferably selected so that it will have little, if any, damaging effect upon the quality of the metal, even though it may be dissolved therein to a slight extent; for example, in conjunction with the melting of aluminum, a lining of aluminum oxide is preferred. The depending neck portion is similarly provided with a lining 51 of the same material, the refractory material preferably projecting slightly above the bottom of the crucible as indicated at 42 to prevent foreign matter which may accumulate in the bottom of the crucible from being discharged therefrom. The molten metal is discharged through the refractory lining 51 of the depending neck portion and the opening 53 through the bottom member 31 to the conduit 11 which leads to the nozzle 12.

The crucible may be heated by any convenient means, such as by induction heating, or the resistance heating coils indicated diagrammatically at 60 and 61 and disposed between the refractory lining 50 and the metallic shell 48. The lead-in wires 62 and 63 pass through the wall of the pressure chamber 30, arrangements such as shown and described in greater detail in my aforesaid application being employed to prevent the escape of gas under pressure around the lead-in wires. To control the temperature of the metal during its passage through the discharge conduits, separate heating coils 64, 65 and 66, each provided with individual lead-in wires, are employed. Preferably the heating current for these coils is independently controllable so that the temperature of the crucible can be controlled by the coils 60 and 61, and the temperature of the various portions of the discharge conduit may be controlled by the coils 64, 65 and 66. The heating effect of the several coils may be regulated by means of conventional rheostats or other similar devices, not shown.

While the metal may be melted in the crucible, it is more convenient to melt the metal in another furnace and supply the molten metal to the crucible. I preferably construct the crucible so that it can be intermittently charged with molten metal without interrupting the discharge of metal under pressure therefrom. Preferably the charging mechanism is arranged as shown herein and as described in detail in my aforesaid application, and comprises a funnel shaped member 70 adapted to receive molten metal from another furnace or ladle, and suitable valves, chamber and conduits to permit charging the crucible without loss of pressure or interruption of flow.

With such an arrangement, molten metal under accu-

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ately controlled pressure and temperature may be supplied continuously to the nozzle 12. As shown in Figure 2, the spray nozzle 12 may comprise a member 70 provided with an enlarged opening 71 to receive the end of conduit 11, the nozzle being secured to the conduit by suitable bolts 72 extending through the flange 74, flange 75 of conduit 11 and wall 22, upon which the nozzle is mounted. The spray is produced by a plurality of minute orifices in the end wall 77 of the member 70, the axes of the orifices being arranged so the jets from the orifices intercept each other, producing a finely divided spray. The fineness of the atomization may be controlled by controlling the discharge pressure and by changing the diameter of the orifices. Generally speaking, with higher pressures and smaller orifices, smaller particles will be produced. Increasing the temperature of the molten metal also reduces the size of the particles.

While the nozzle may be of any conventional configuration to produce the desired finely divided spray, the materials of the nozzle must be carefully selected with respect to the work which the nozzle is called upon to do. For example, in spraying aluminum of high purity, it is desirable to employ a nozzle composed of aluminum oxide, or lined therewith, to prevent contamination of the aluminum. As noted above, the crucible and conduit are also preferably lined with aluminum oxide so as to prevent contamination of the metal. For some metals carbon nozzles may be satisfactory. For other purposes, nozzles of porcelain or glass, or quartz or platinum may be employed. For some purposes nozzles made of steels which will retain their strength at high temperatures are satisfactory. If desired, the inner surfaces of such nozzles may be protected with fused ceramic materials such as porcelain enamel, or the like. In any event, where purity of product is essential, the material of the nozzle should be carefully selected to prevent contamination of the fused metal by the nozzle, and ordinarily the lining of the crucible and the conduits may be made of the same material that is employed in the nozzle.

From the foregoing description of a preferred form of my invention, it will be evident that I have provided a method of and apparatus for spraying molten metal whereby relatively large quantities of metal can be fused and sprayed economically and rapidly without risk of substantial contamination of the sprayed particles. The apparatus is such that the pressure and temperature of the spraying operation can be controlled with a high degree of accuracy, and the operation can be carried out continuously for long periods of time, thus insuring the production of sprayed particles of uniform characteristics and of the desired particle size. Various molten materials can be sprayed with my apparatus without danger of contamination. The production of pure metals and alloys of the desired, accurately controlled particle size provides metal powders which will insure the production of high quality articles by subsequent molding and sintering operations. The metal may be discharged from the nozzle at very high velocity in such a finely divided state as to constitute, in effect, a metallic fog or mist. The apparatus may be employed in the production of spray deposited coatings of high quality. In such operations the apparatus is particularly advantageous because of the absence of any flame at the spray nozzle.

Those skilled in the art will appreciate the various changes and modifications that may be made in my invention both as to the method and apparatus, without departing from the spirit and scope thereof. It is therefore to be understood that my patent is not limited to the preferred form described herein, or in any manner, other than by the appended claims when given the range of equivalents to which my patent may be entitled.

I claim:

1. The method of making finely divided metallic particles which includes the steps of fusing metal, conducting the fused metal under pressure of at least several hundred pounds per square inch to a spray nozzle, forcibly discharging the fused metal from the spray nozzle and mechanically atomizing the metal issuing therefrom solely by directing portions of the molten metal in converging directions to cause the particles of molten metal to collide and divide into particles of very fine size.

2. The method of making finely divided metallic particles which includes the steps of fusing metal, conducting the fused metal under pressure substantially in excess of atmospheric pressure to a spray nozzle, forcibly dis-

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charging the fused metal from the spray nozzle and atomizing the metal issuing therefrom solely by directing portions of the molten metal in converging directions to cause the particles of molten metal to collide and divide into particles of very fine size and directing the spray so produced into an atmosphere which is substantially inert with respect to the molten metal, and allowing the molten particles making up the spray to solidify individually, and collecting the solidified particles.

3. The method of making finely divided metallic particles which includes the steps of fusing metal, conducting the fused metal under pressure substantially in excess of atmospheric pressure to a spray nozzle, forcibly discharging the fused metal from the spray nozzle into a region at a substantially lower pressure and atomizing the metal issuing therefrom solely by directing portions of the molten metal in converging directions to cause the particles of molten metal to collide and divide into particles of very fine size.

4. The method of spray depositing metal which includes the steps of fusing metal, conducting the fused metal under pressure substantially in excess of atmospheric pressure to a spray nozzle, forcibly charging the fused metal issuing therefrom from the spray nozzle, and atomizing the metal issuing therefrom solely by directing portions of the molten metal in converging directions to cause the particles of molten metal to collide and divide into particles of very fine size, directing the metallic spray so produced into a chamber containing an atmosphere which is substantially inert with respect to the sprayed metal, and directing the spray against an object to be coated, the particles composing the spray impinging on the object while still in a molten or plastic state.

5. The method of spray depositing metal which includes the steps of fusing metal, conducting the fused metal under pressure substantially in excess of atmospheric pressure to a spray nozzle, forcibly discharging the fused metal issuing therefrom from the spray nozzle, and atomizing the metal issuing therefrom solely by di-

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recting portions of the molten metal in converging directions to cause the particles of molten metal to collide and divide into particles of very fine size, and directing the spray against an object to be coated, the particles composing the spray impinging on the object while still in a molten or plastic state.

6. The method of spray depositing metal which includes the steps of fusing metal, conducting the fused metal under pressure substantially in excess of atmospheric pressure to a spray nozzle, forcibly discharging the fused metal issuing therefrom from the spray nozzle, the metal being atomized solely by the pressure of the metal itself and by directing portions of the molten metal in converging directions to cause the particles of the molten metal to collide and divide into particles of very fine size, directing the metallic spray so produced into a chamber containing a reducing atmosphere, cleaning a surface to be metallized by subjecting the surface to the action of a reducing flame, thereafter placing said surface within said chamber and directing the spray against said surface, the particles composing the spray impinging on the surface while in a molten or plastic state.

7. A method of making finely divided metallic particles according to claim 1 further comprising directing the atomized metal particles into an atmosphere substantially inert with respect to the molten metal.

References Cited in the file of this patent

UNITED STATES PATENTS

200,376	Daughtrey	Feb. 19, 1878
1,582,668	Dreifuss	Apr. 27, 1926
1,834,687	Davis	Dec. 1, 1931
2,197,274	Menke	Apr. 16, 1940
2,235,258	Jones	Mar. 18, 1941
2,402,441	Paddle	June 18, 1946

FOREIGN PATENTS

548,630	Great Britain	Oct. 19, 1942
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