

[54] METHOD AND APPARATUS FOR
 EXTRUDING METAL POWDER TO
 PRODUCE A CONTINUOUS ROD

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 264/111, 425/78

[51] Int. Cl. B22f 3/24

[58] Field of Search 264/111; 29/420,
 29/420.5, DIG. 47, DIG. 31; 425/78

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[57] ABSTRACT

There is disclosed an apparatus for the continuous extrusion of copper rod from copper powder in a manner which prevents harmful deterioration of the compacting cylinder and requires the expenditure of less power to operate.

8 Claims, 6 Drawing Figures

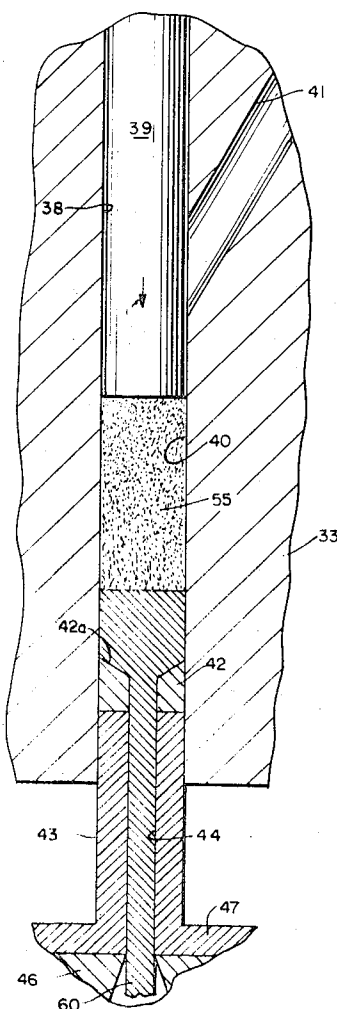


FIG. 1

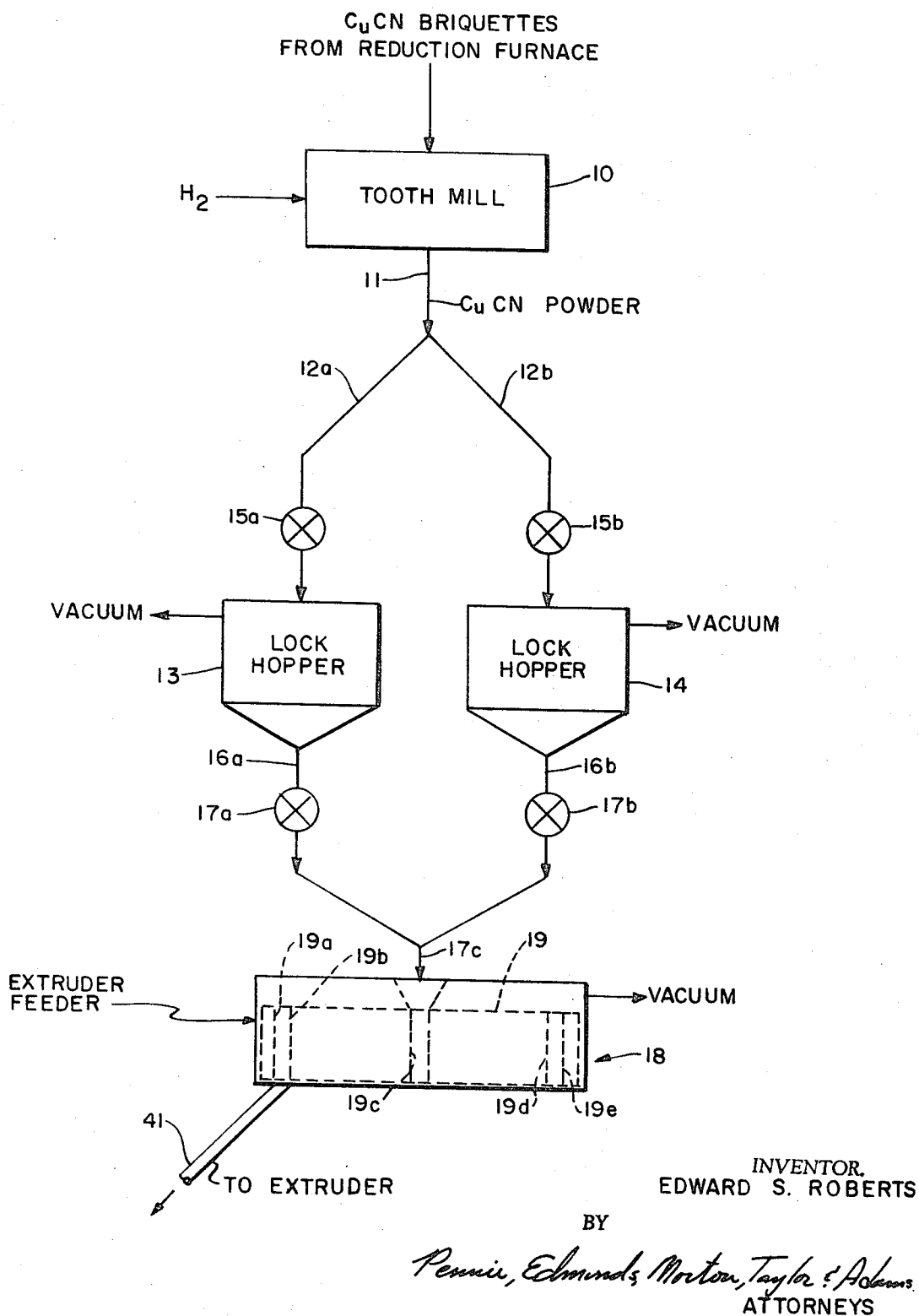
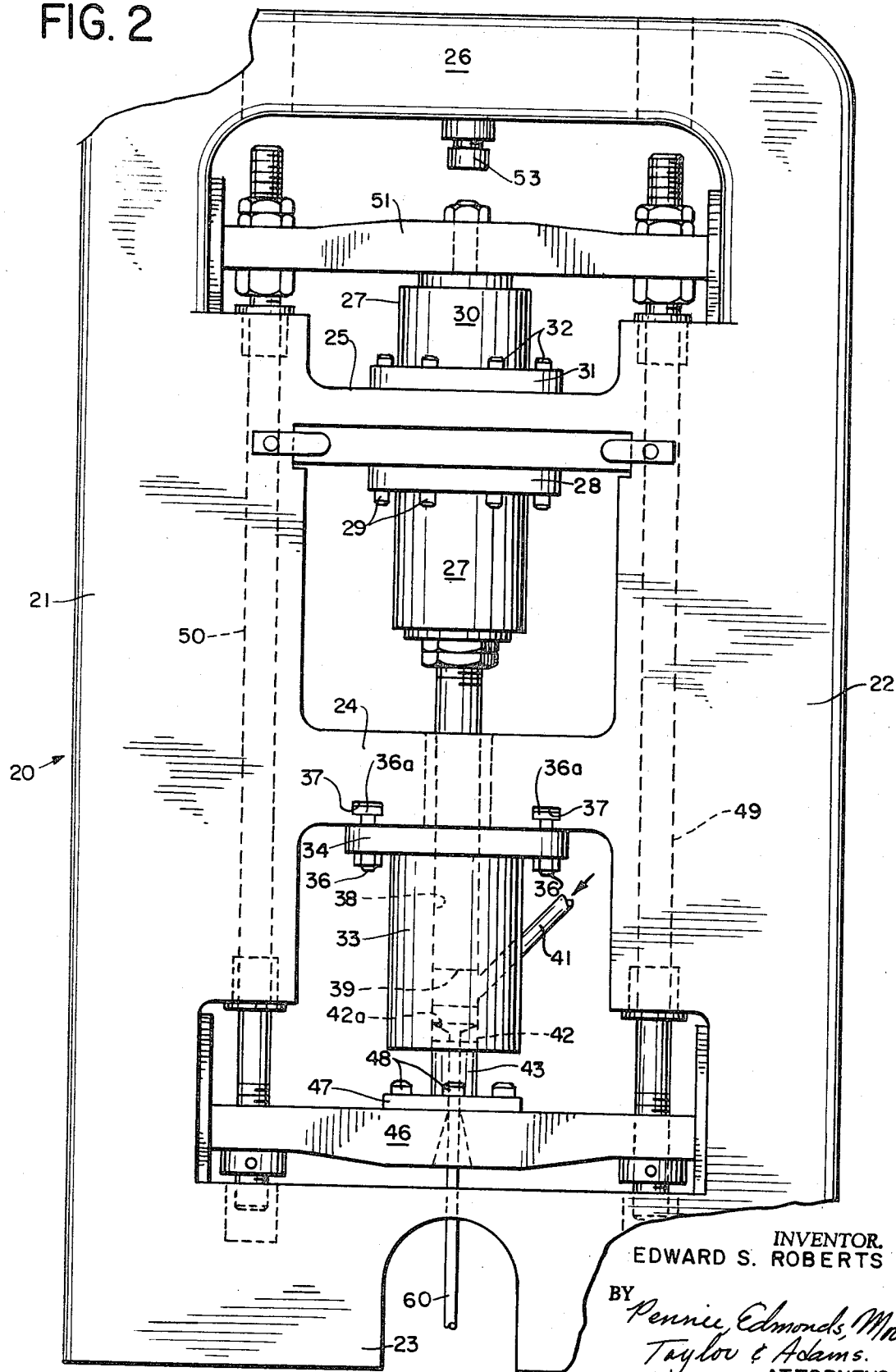


FIG. 2



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FIG. 3

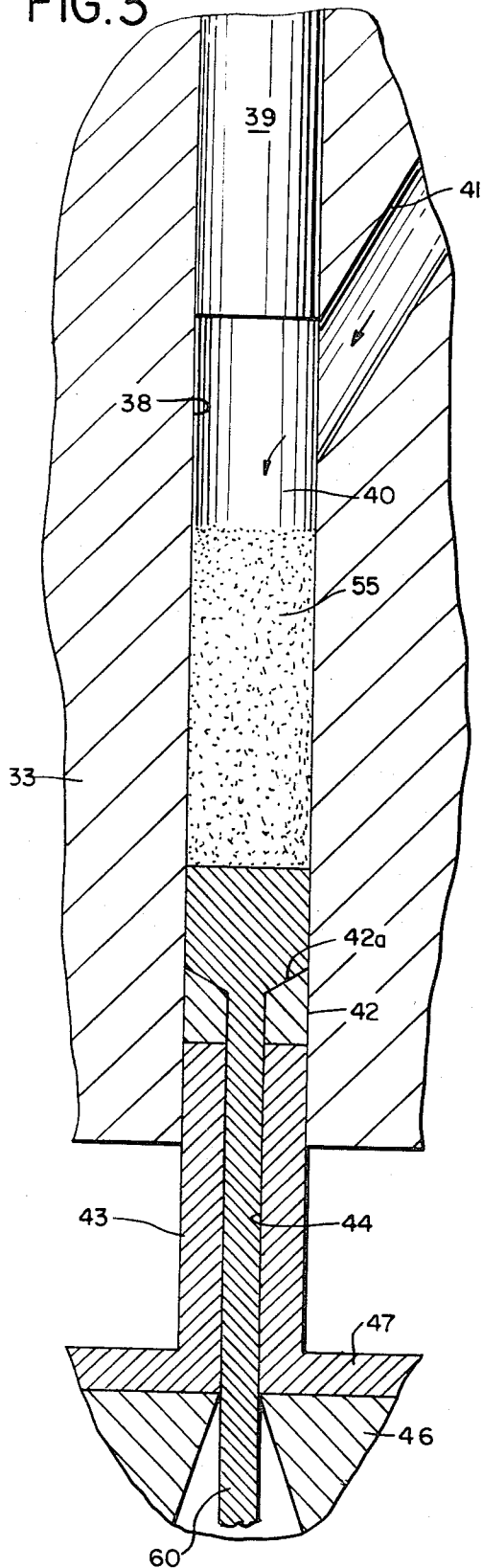
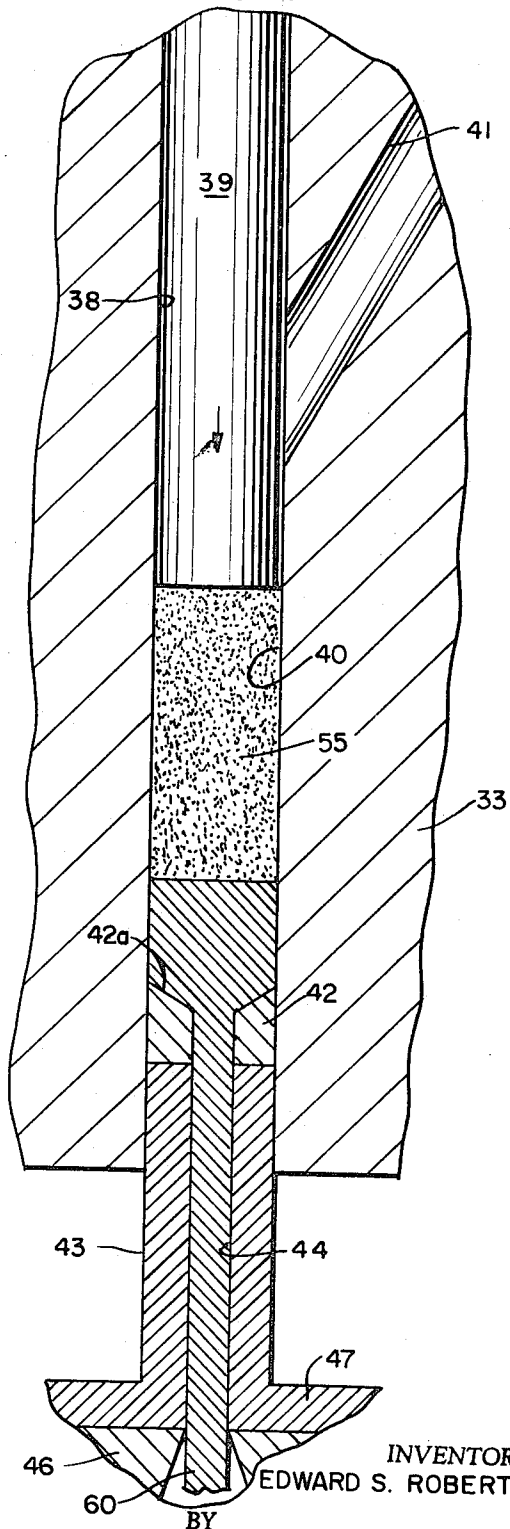


FIG. 4



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FIG. 5

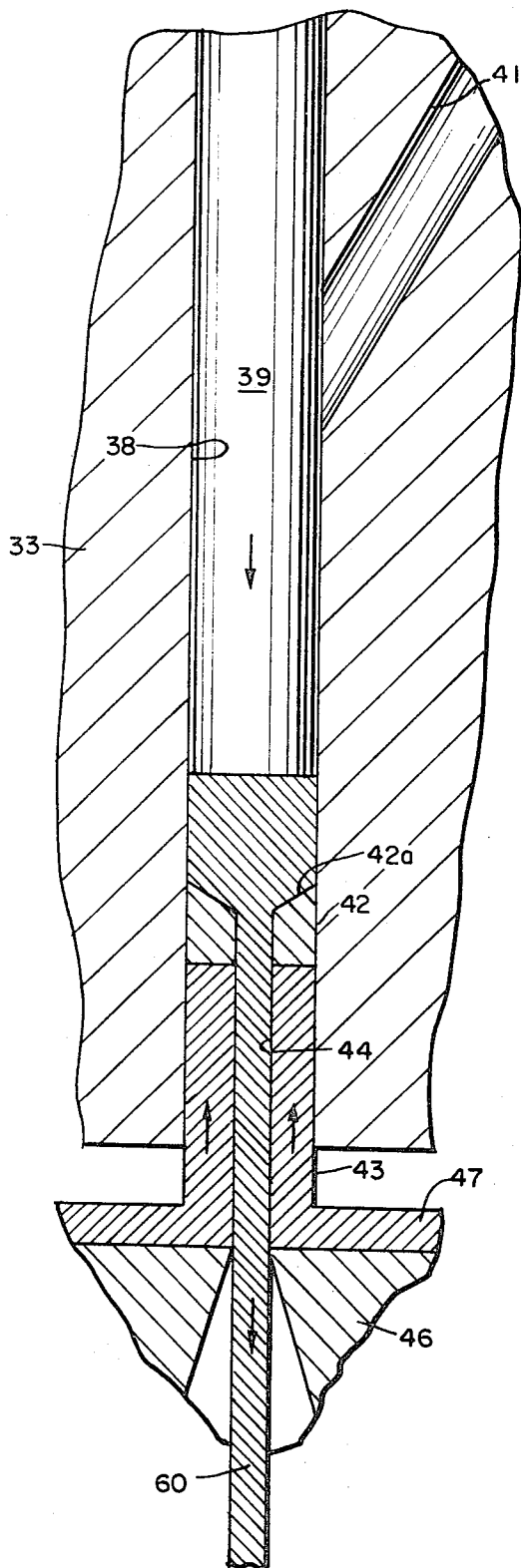
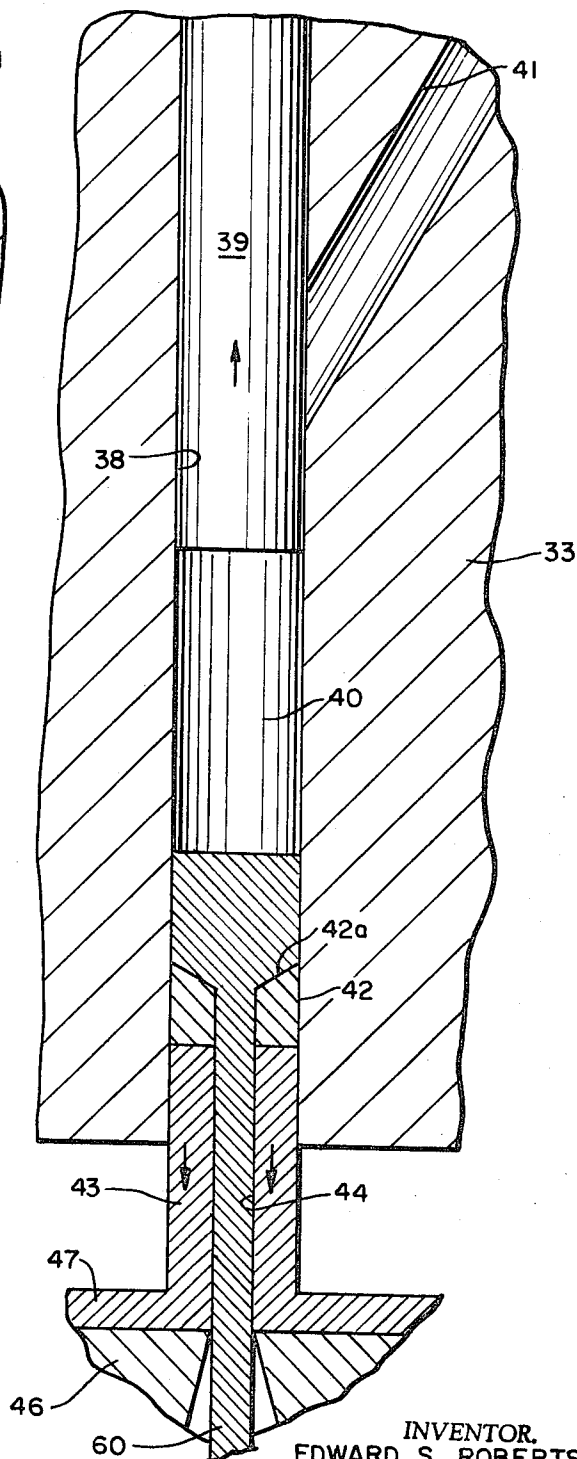


FIG. 6



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METHOD AND APPARATUS FOR EXTRUDING METAL POWDER TO PRODUCE A CONTINUOUS ROD

BACKGROUND OF THE INVENTION

It is known to extrude metal powders by successive compacting and extruding. However, successful operations have required canning of the metal powders to permit the outside of the can to be lubricated. This helps to prevent metal powder from being caught between the extrusion ram and the compacting cylinder wall which would cause galling. This method of extrusion, however, permits only batch operation and is limited by the amount of metal that can be loaded into a can and which can be placed in the extrusion cylinder and finally expressed through a die.

It would be highly desirable to extrude copper powder into the form, say of a 5/16 inch diameter rod which can easily be drawn into wire. Moreover, it would be desirable to extrude a rod long enough to weight up to 10 to 20 tons. This would permit coiling the rod into a bundle for annealing, if need be, before drawing into any desirable length of wire. Such an operation is impossible with canned material.

It is the purpose of the present invention to provide unique means for processing metal powder which will solve the above problem.

SUMMARY OF THE INVENTION

In accordance with the present invention, apparatus is provided for receiving a measured quantity of metal powder, such as copper in a compacting cylinder. During transmission of (under vacuum) the powder to the chamber a rarefied hydrogen atmosphere is maintained to prevent oxides from forming and to inhibit the suspension of particles in the atmosphere. Such oxides or particles would be likely to cause galling of the cylinder wall during subsequent compacting. A first ram means is provided for compacting the powder to a sufficient density for extruding. Thereafter second ram means forces an extruding die through the compacted powder in a direction opposite to the compacting direction to cause extrusion of copper rod in any suitable length. This two state arrangement reduces the overall power requirements of the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow diagram of a compacting extrusion apparatus constructed in accordance with the present invention;

FIG. 2 is an elevational view of an extruder in accordance with the present invention;

FIG. 3 is an enlarged cross-sectional detail of a portion of the apparatus of FIG. 2 wherein metal powder is admitted to the compacting cylinder;

FIG. 4 is similar to FIG. 3 showing the action of the compacting ram;

FIG. 5 is similar to FIG. 3 and shows the action of the extrusion ram and die; and

FIG. 6 is similar to FIG. 3 and shows the return of the ram cylinder to its initial position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing and initially to FIG. 1, an apparatus constructed in accordance with the principles of the invention has been illustrated. The apparatus

tus includes a tooth mill 10 adapted to receive briquettes or other consolidated or partially consolidated masses of copper or other metal powder from a production source. Such briquettes or lumps of consolidated powder are ground in the mill into powder. A reducing hydrogen atmosphere is advantageously maintained in the mill to prevent the possible formation of oxides which would otherwise occur in the presence of normal atmosphere.

From the mill 10 the metal powder (hereinafter referred to as copper powder) may proceed through conduits 11, 12a and 12b to lock hoppers 13 and 14. Fluid-tight valves 15a, 15b control the admission of powder to the hoppers. Conduits 16a, 16b having fluid valves 17a, 17b therein further control the admission of powder to a conduit 17c which leads to a feeder 18. The latter has a thick horizontal disk 19 provided with vertical passages 19a, 19b, 19c etc. As the disk rotates each passage 19a etc. becomes filled with a measured quantity of powder and further rotation causes the powder to be discharged through a conduit 41 leading to the extruder of the invention. Means (not shown) are provided for exhausting most of the hydrogen from hoppers 13 and 14 and from feeder 19 for a reason which will be explained.

An extruder 20 constructed according to the principles of the invention has been illustrated in FIGS. 2-6. The extruder 20 comprises a main frame having two upright side members 21 and 22 joined by a base 23 and intermediate across members 24, 25, 26. The side members 21 and 22 define a centrally located well for the mounting of hydraulic compacting and extrusion means.

Accordingly, a first hydraulic cylinder 27 is secured by mounting plate 28 and peripheral bolts 29 to the underside of cross arm 25. A second hydraulic cylinder 30 is similarly secured by mounting plate 31 and bolts 32 to the upper portion of cross arm 25. A cylindrical container 33 is secured beneath cross arm 24 by mounting plate 34 and bolts 36. The latter have ends 36a which engage in T-slots 37 permitting some lateral adjustment.

The container 33 defines a cylindrical bore 38 which receives a compacting ram 39 extending from and actuated by hydraulic cylinder 27. Bore 38 forms a compacting chamber 40 which connects with a conduit 41 leading from feeder 19. The lower end of bore 38 is closed by an extrusion die 42 having in its upper end an orifice 42a. Die orifice 42a connects with an extrusion passage 44 in the die support 43 which is peripherally mounted to a yoke 46 by a plate 47 and bolts 48. The yoke 46 in turn is secured to rods 49, 50 which extend through side members 21 and 22 to be connected to an upper yoke 51. The latter yoke 51 and thus the lower yoke 46 are driven by hydraulic cylinder 30. Stop means 53 limits the uppermost travel of yokes 51 and 46.

Referring now to FIGS. 3 to 6, it will be seen that a measured quantity of metal powder 55, such as copper will first be charged within the compacting chamber 40 through conduit 41 connected to feeder 18 of FIG. 1. The powder 55 will be admitted to the chamber 40 in a near vacuum containing a residual hydrogen atmosphere. The hydrogen atmosphere is mostly evacuated in order to prevent the creation of a cloud of metal powder during charging of chamber 40 and during compacting by ram 39 in order to prevent particles

from entering between the cylindrical wall of chamber 40 and the ram 39 and also to avoid having to compress a gas atmosphere to high pressure during the compaction operation.

FIG. 3 is an enlarged detail of the compacting cylinder 40 formed within the container 33 wherein a measured quantity of copper powder 55 has been deposited through conduit 41. FIG. 4 shows the movement of the ram 39 to effect partial compaction of the metal powder 55. FIG. 5 shows the die support 43 and die mount 42 thrust upwardly by actuation of cylinder 30 and upward movement of yoke 46 to extrude compacted powder through die orifice 42a and to form a copper rod 60. FIG. 6 shows the return movement of ram 39 preparatory to permitting chamber 40 to be recharged.

The reasons for the above described inverted extrusion may be stated as follows:

In the compaction of metal powder in a cylinder with a ram there is a gradient pressure downward from the face of the moving ram toward the face of the fixed die on the opposite side of the metal powder billet. For the prior art method of direct extrusion there would be an orifice in this fixed die opposite to the ram. To extrude the compact through this orifice it is necessary to exert a pressure on the ram which is the pressure for compaction in addition to the pressure which is required for extrusion.

According to the present invention the feature of inverted extrusion is achieved by placing the extrusion orifice within an extrusion ram which is activated, as described above, after the compacting ram has substantially completed its compaction stroke. As the extrusion ram is moved into the metal billet the pressure gradient is in the direction opposite to that during compaction so that the maximum pressure is at the extrusion orifice. The length of the extrusion stroke can be kept small to keep all ram travel distances to a minimum.

By way of comparison, the design of "direct" extrusion is based on:

$$F = KA \ln R$$

where:

F = force on the ram in lbs.

K = extrusion constant in psi.

A = area of the cylinder in sq. ins.

R = extrusion ratio = A/a

where: a = area of the extruded rod in sq. ins. For copper:

Temp. °F	K psi
1800	10,000
1400	20,000
1000	30,000
800	35,000
600	42,000
400	48,000
200	54,000
100	57,000

F/A = cylinder pressure. It is desirable to keep this value less than 200,000 psi. R should be greater than 8 to 9 to give 100 percent compaction. For inverted extrusion the value of K would be considerably smaller than for direct extrusion.

The additional force required by direct extrusion over inverted extrusion represents the force required to slide the billet along the cylinder under pressure. This

force may represent friction between the billet and the cylinder, or, if the metal to be extruded welds to the cylinder wall, it represents the shearing force required to shear the metal of the billet. The metal of the billet can also weld to the ram surface. If the billet metal slides in the cylinder the force required to slide the billet, F is linearly proportional to the product of the surface area A and the unit pressure at the surface P : $F = u AP$. If P is constant then $F = RA$. If the billet metal welds to the cylinder F would also be proportional to A above.

In direct extrusion of a billet the force required on the ram generally decreases as the billet is extruded, the decrement being roughly proportional to the reduction in cylindrical surface area of the billet remaining in the cylinder, until the billet length is reduced to some fraction of the cylinder diameter at which time the force for extrusion alone apparently mounts. This decrease in force as extrusion of a billet proceeds is not found with inverse extrusion and the force required on the ram is lower than in direct extrusion and remains constant as extrusion proceeds.

From these relations it would appear that if we compact with the top ram 39 and extrude inversely with the bottom die 42 extrusion will not occur between the top ram and the cylinder wall. Moreover, if the clearance between the ram and the cylinder and between the die and the cylinder is 0.001 inch then the ratio of this clearance area to the extrusion area of the 5/16 inch dia. hole in the die is 19.53 and $\ln R$ would be 5.74 instead of 2.77 requiring a cylinder pressure 2.07 times as high to extrude copper directly through the clearance space as would be the case invertedly through the die.

It will be apparent therefore that the present invention provides for successful continuous rod extrusion from compacted metal powder because of certain unique features which have been described. Firstly, by maintaining a rarefied hydrogen atmosphere in the compacting cylinder, the formation of oxides are prevented as well as the suspension of copper particles which might with oxides cause galling of the cylinder wall. This is a very important feature since the powder need not in any way be lubricated. Secondly, the amount of power necessary to compact and extrude is made optimum by the inverted extrusion technique. Much greater power would be required if the compacting ram had to accomplish also the extrusion of the rod. The invention thus provides a method and means for producing high quantity metal rod continuously under optimum power consumption.

It will be understood that the foregoing description is of a preferred embodiment of the invention and is therefore representative. In order to appreciate fully the scope of the invention reference should be made to the appended claims.

What is claimed is:

1. An apparatus for extruding a continuous solid metal rod and the like from metal powder comprising a frame, means defining a compacting chamber, valve controlled conduit means connected to said chamber, means for passing through said conduit and into said chamber a measured quantity of metal powder, means for maintaining a protective atmosphere in said chamber whereby said atmosphere is rarified prior to compacting said powder, means for compacting said powder in said chamber to a density suitable for subsequent

extrusion and means for extruding said powder from a compacted state comprising a die, first ram means for compacting said powder in a direction toward said die during its compaction stroke and second ram means containing said die for extruding said rod in a direction opposite to said compacting direction, said second ram means being activated after the first ram means has substantially completed its compaction stroke.

2. The apparatus of claim 1 wherein said atmosphere is hydrogen gas and wherein the apparatus further includes mill means for receiving briquettes and like consolidated masses of metal powder for conversion in the presence of hydrogen gas into powder form, and feeder means for receiving said powder and for discharging a measured quantity of metal powder into said compacting chamber.

3. A method of extruding a metal powder in the form of a continuous dense solid elongated shape which comprises flowing a charge of metal powder in a protective gaseous atmosphere into an extrusion chamber, the gaseous atmosphere being substantially completely evacuated from said chamber, compacting the powder by compressing it towards an extrusion die and then extruding the compacted mass from said chamber through said die by pressing the extrusion die into the mass.

4. The method according to claim 3 wherein the residual gaseous atmosphere in the evacuated extrusion chamber is non-oxidizing.

5. The method according to claim 4 wherein the gas is hydrogen.

6. The method of extruding a metal powder in the form of a continuous dense solid elongated rod which comprises the steps of: maintaining an atmosphere which is substantially inert with respect to a metal to be converted to powder in a mill, converting said metal into a powder in the presence of said atmosphere, accumulating said powder in a collector in continued presence of said atmosphere, evacuating said collector and extrusion chamber connected thereto to leave only a residual atmosphere, flowing a charge of metal powder into said extrusion chamber, compacting said powder by compressing it towards an extrusion die and then extruding the compacted mass from said chamber through said die by passing the extrusion die into said mass.

7. The method according to claim 6 wherein the residual gaseous atmosphere in the evacuated extrusion chamber is non-oxidizing.

8. The method according to claim 7 wherein the gas is hydrogen.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,757,410 Dated September 11, 1973

Inventor(s) Edward S. Roberts

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 21, "weight up to 10 to 20" should read --weigh up to 10 to 20--;

Column 2, line 14, "tr the hoppers" should read --to the hoppers--

Column 2, line 15, "17b therin further" should read --17b therein further--;

Column 6, line 9, "whch is substantially" should read --which is substantially--;

Signed and sealed this 1st day of January 1974.

(SEAL)
Attest;

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

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(SEAL)
Attest:

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RENE D. TEGTMEYER
Acting Commissioner of Patents