Aug. 10, 1943. M. E. EVANS 2,326,629

METAL ATTENUATING PROCESS AND APPARATUS

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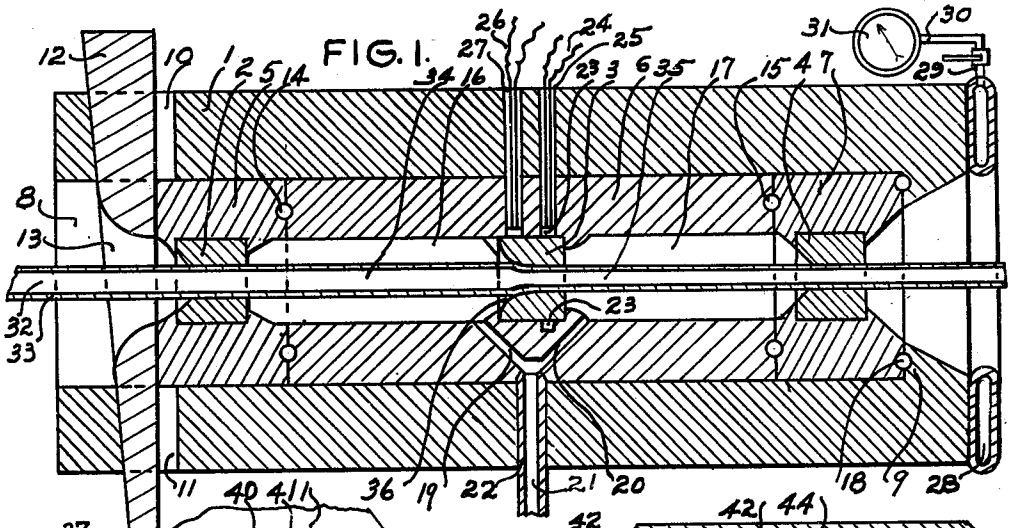


FIG. 1.

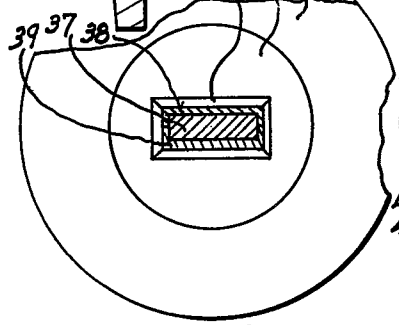


FIG. 2.

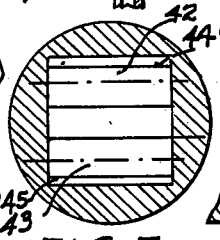


FIG. 3.

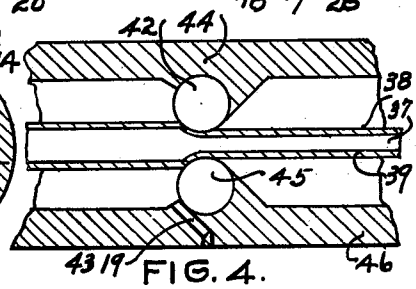


FIG. 4.



FIG. 12.

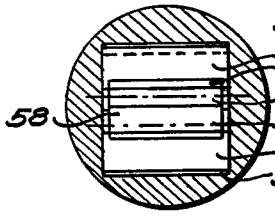


FIG. 5.

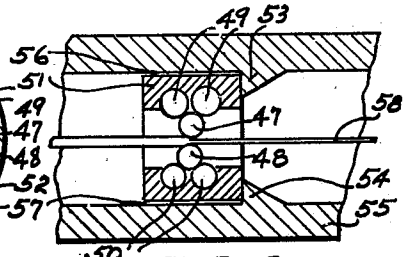


FIG. 6.

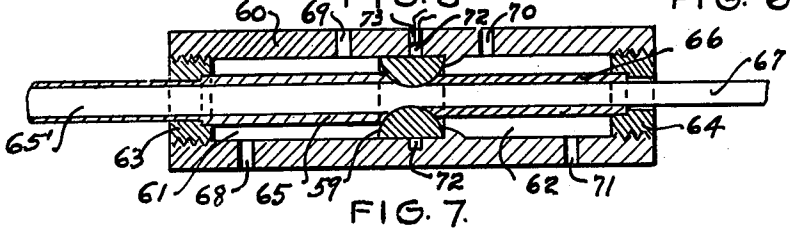


FIG. 7.

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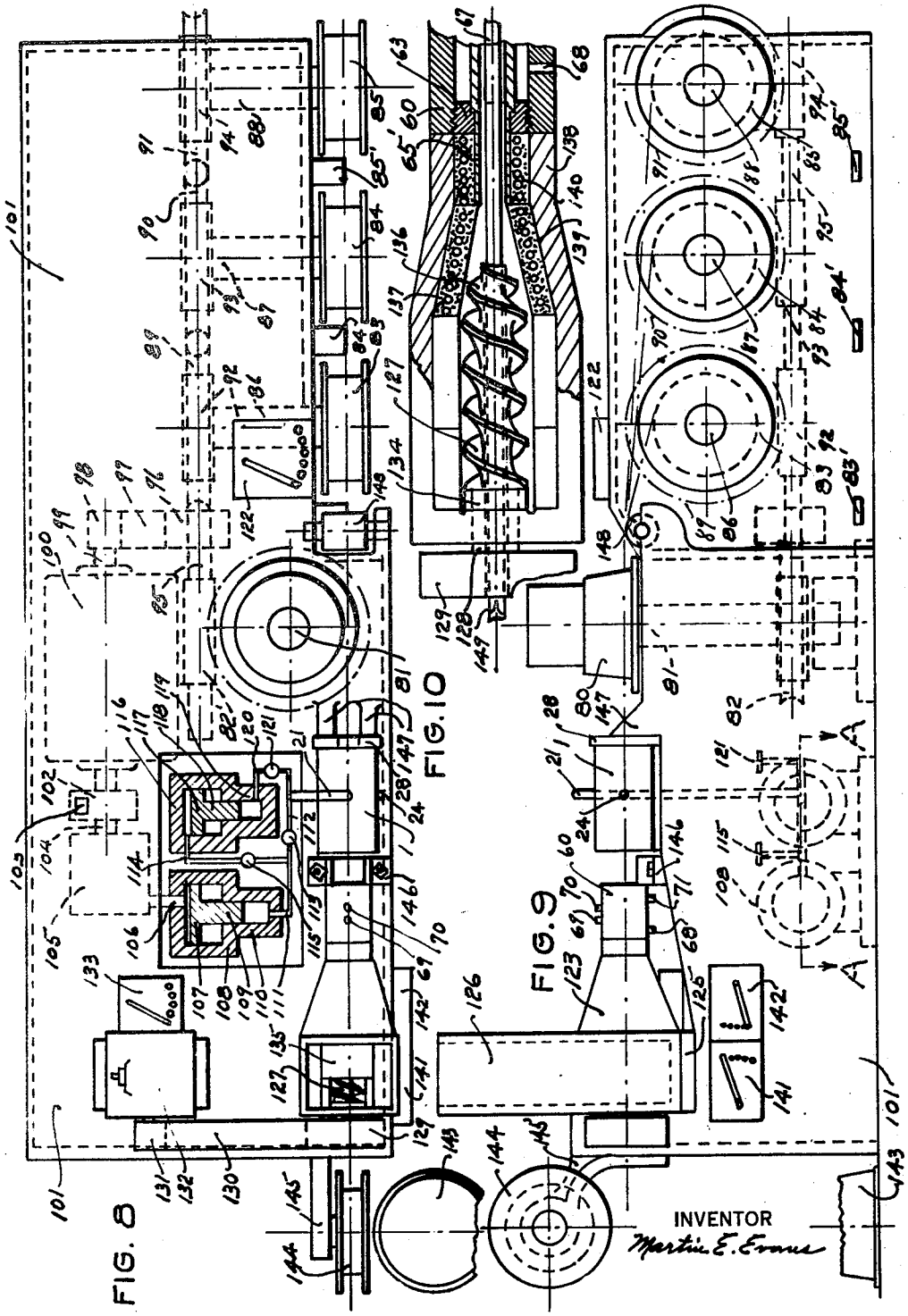


FIG. 8

FIG. 10

FIG. 9

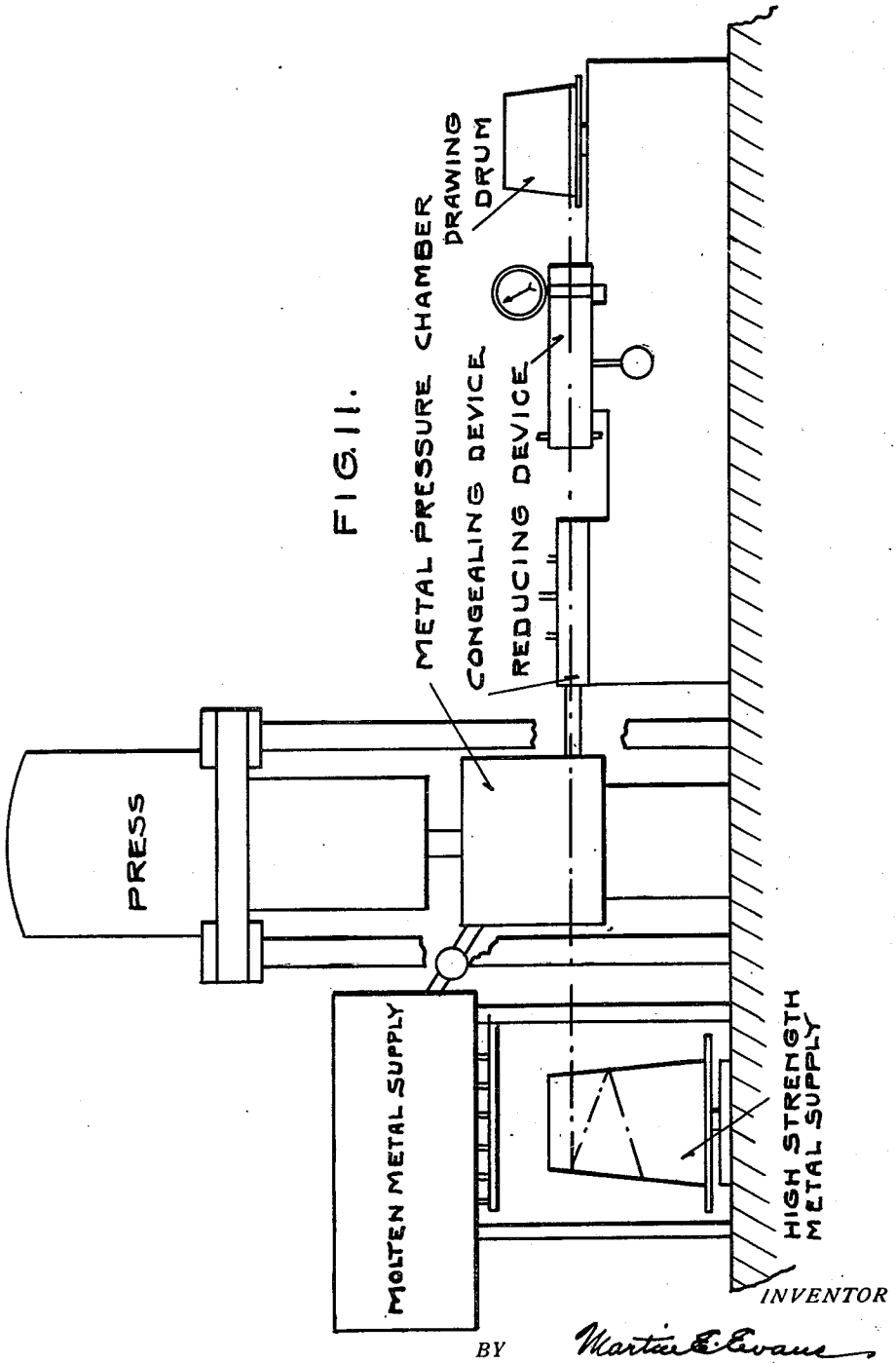
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METAL ATTENUATING PROCESS AND APPARATUS

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FIG. 11.



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UNITED STATES PATENT OFFICE

2,326,629

METAL ATTENUATING PROCESS AND APPARATUS

Martin E. Evans, Pittsburgh, Pa.

Application March 4, 1939, Serial No. 259,833

24 Claims. (Cl. 29—33)

This invention relates to an attenuated metal article and to the production thereof, and particularly to a duplex metal attenuated article comprising a relatively high melting temperature metal and a relatively low melting temperature metal and the method of assembling these metals whereby new and useful metal combinations are attained and new and useful production methods and apparatus are added to the art of attenuating metals.

It is proposed to produce a base metal strip of relatively high melting temperature and of relatively high tensile strength and to control its surface condition suitably to provide traction or attachment to another metal or alloy of relatively lower melting temperature positioned longitudinally therewith. The traction mentioned would be utilized to propel the surface metal through a die in a subsequent operation with the base metal strip.

In another aspect this invention relates to the working of a cast metal or congealed metal of small tensile strength with a metal work piece of relatively high tensile strength to impart pliability to the former.

In another aspect this invention relates to the production of an attenuated metal work piece adapted to receiving an addition alloyed thereto of a different analysis of metal and to the methods and apparatus specially adapted to this purpose.

As an example of base metals, steel or copper may be mentioned with aluminum or zinc or Babbitt and bearing metals as metals to be worked in contact with the former.

The surface condition of the base metal strip is controlled by new steps in the art of producing the strip from billets by heating, rolling and cold working. The surface of both metals in a combination is controlled as to chemical composition and shape. The art has repeatedly set forth the problem of providing an adherent coating of or containing aluminum on a ferrous workpiece for heating, rolling and cold working. As an example of the chemical control to meet this problem, the surface aluminum is initially limited to less than 17 per cent. An iron aluminum alloy with 16 percent aluminum appears to be the maximum aluminum content permitting hot working while a 5–6 percent content approximates the limit for cold working. These percentages are altered by the presence of another metal such as chromium with the iron or with the aluminum to provide desired characteristics.

The control of the base metal surface may be initiated with the casting thereof into a workpiece by mixing granulated material with a binder and coating the casting mold therewith to a thickness by way of example of 1/8" to 3/8". Granules sized 40 to 100 to the inch mixed with liquid silicate of soda are dried on the mold. The hot poured metal in contact with the granules welds to them as a layer adapted to further working. Granulated ferrochromium or ferrotungsten or high carbon steel are desirable to unite to low carbon steel to control penetration of the base metal by the low melting metal such as aluminum or zinc to be applied later. When the outer part of the workpiece is to carry the aluminum alloy and penetration of the work piece by the aluminum is to be somewhat prevented by another alloy such as ferrochromium, a layer arrangement of the granulated material with the binder is desirable to provide an intermediate position for the ferrochromium relative to the aluminum alloy and the poured metal. The base metal workpiece having the ferrochromium aluminum combination provided by the steps herein outlined has utility other than for the duplex metal attenuation. Ferrochromium, commonly referred to as stainless iron or steel has low wear resisting qualities. With aluminum present the well known wear resisting qualities of aluminum nitride are provided by nitriding at a temperature around 720° C. and upwards. This is feasible since the base metal melting temperature is well above this point. Obviously, nitriding is a finishing operation after attenuation into wire, cutlery or other forms.

Considered in detail, the granulated ferrous material to be mixed with the binder preferably has an aluminum content of not over 17 per cent. The aluminum may be a mechanical mixture with or an alloy content of the ferrous granulated material. The range of 5 to 17% aluminum and preferably 12% is adapted to hot attenuation operations while the 5% range is suitable for cold attenuation.

The first layers of granulated material applied to the mold contain the aluminum. The last layers may be the granulated ferrochromium which may act as a barrier to the aluminum penetration. This method of manufacturing an alloy powder is illustrative and by suitable choice of powder mixtures and heating temperatures the granulated aluminum-ferrous alloy previously referred to may be provided for mold coating.

The work piece is usually cut up into lengths and transported to various points for further working. Reheating this work piece being necessary, preliminary thereto and for the protection

therefrom, the work piece surface is freed from scale by sandblasting or other means and then coated at 200 or 300° C. with a paint of 3 parts powdered aluminum, 5 parts resin and 5 parts petroleum tar at 200 to 350° C. Or the coating may be of 70 parts powdered aluminum, 23 parts sal ammoniac and 7 parts zinc. In reheating to the rolling temperature, the base metal alloys with the paint forming a protection against surface deterioration. The subsequent working and attenuation of the alloy with the heated base give it a degree of pliability. Obviously the attenuated base workpiece with such surface preparation is adapted to uniting with aluminum or zinc subsequently placed thereon in much less time than when the surface is free from such preliminary alloy. Since the iron zinc alloy is brittle and becomes thick and stiff in proportion to the time of heating above the melting point of zinc, this control factor is important. Further, the penetration of the zinc by the iron and of the iron by the zinc is controlled to a degree by the character of the surface given the work piece in the mold and by subsequent working. The attenuated work piece may be given an alloyed coating at other points in the reducing process than as outlined. Thus, after hot rolling, the workpiece may be cleaned and alloyed with zinc, the said alloy attaining a degree of pliability with further working. With a suitable alloy surface on the workpiece it is proposed to unite thereto a second metal such as aluminum or zinc in strip form or by congealing progressively. Economy in manufacture whereby handling and processing are reduced to a minimum requires that the metal be progressively congealed upon the support strip to provide the combination workpiece for further attenuation to impart pliability to the congealed metal.

However, aluminum powder or flakes mixed with zinc powder and heated in a retort to a temperature 20 to 60° F. below the melting point of zinc by virtue of the vapor pressure of the zinc, forms an aluminum zinc powder alloy suitable for union with the alloy on the work piece. After formation of this powdered alloy, the zinc and aluminum zinc alloy are separated mechanically and the alloy powder is drawn with the work piece through a heated die and therein united to the work piece by residual zinc powder in the alloy powder, thereby forming the finished metal combination.

The characteristic mobility of the coating metal provided by the molten condition or the powdered condition of the metal is utilized to provide the distribution of the coating metal around the core strip.

In the process of attenuating to a uniform cross section a duplex metal workpiece having a relatively low strength surface layer of metal over a relatively strong support strip, the surface layer has a tendency to spread and depart from the support strip under the pressure necessary to attenuate the support strip. To overcome this tendency it is essential to provide means to restrain the movement of the low strength metal from more than its proportional movement with the support strip. To this end it is proposed to apply circumferential pressure to the low strength surface metal to restrain its lateral movement and to govern its longitudinal movement by engagement either frictional or bonded with the support strip. The circumferential restraint may be variously provided. Hydraulic pressure directly upon the workpiece is a preferred form; engagement with an enveloping casing is another form in which instance the casing is close fitting and of a length that bonded metal cannot be sheared from the base strip but must travel with the strip through the casing and receive its proportionate reduction in a die and emerge from the die into a restraining casing and travel therein jointly with the base or support strip. Thus it is seen that the frictional or bonded engagement with the support strip should be of a length and intensity at the approach to the attenuating device sufficient to advance the weaker metal through the attenuating means and after the exit therefrom sufficient to restrain the weaker metal from longitudinal movement greater than that of the support strip. It is therefore evident that the restraint on the low strength material should be complete circumferentially and longitudinally.

The apparatus, chosen to effect the attenuation of the duplex strip comprises dies or rolls or a combination preferably mounted in a chamber adapted to withstand hydraulic pressure therein of an order up to 100,000 pounds per square inch. The passage of the workpiece through the chamber is effected by tension thereon, but it is intended that adaptations having driven rolls for duplex sheets are within the scope of this application, since the principle of restraint herein set forth is advantageously applicable therto. The medium for applying the hydraulic pressure obviously may be of a lubricating character.

The material worked upon involves preferably a support strip that has received the special operations previously outlined to provide a suitable surface condition which is progressively advanced with the molten duplex metal thereabout through a congealing and working device for the duplex metal to an attenuating die or rolls. It is apparent that duplex metal in strip form may be advanced with the support strip and unattached thereto to a die or rolls.

Referring to the drawings,

Fig. 1 shows a sectional view of a die in a casing arranged to apply hydraulic pressure on strip material passing through the die.

Fig. 2 shows an end view of the entrance die and the casing arranged for receiving a rectangular shaped duplex metal strip section of Figure 1.

Fig. 3 shows an end view of an arrangement of rolls to replace the central die of Figure 1.

Fig. 4 shows a sectional view of the rolls of Figure 3 with a duplex strip between the rolls and subjected to hydraulic pressure.

Fig. 5 shows reducing rolls supported in backing rolls mounted in a pressure ring adapted to hydraulic pressure.

Fig. 6 shows a sectional view of rolls and mounting of Figure 5.

Fig. 7 shows another modification of the invention adapted to apply pressure upon strip material passing through the central die and to congeal (from a source not shown) metal upon a strip passing therethrough.

Fig. 8 shows a plan view and partial sectional view along line A—A of Figure 9 of a wire drawing machine embodying the various novel elements of the invention.

Fig. 9 shows a view in elevation of the machine shown in Figure 8.

Fig. 10 shows an enlarged sectional view in plan of the coating metal supply means for wire.

Fig. 11 shows a diagrammatic layout for coating and drawing strip.

Figure 12 is an end view of one form of product.

Referring to Figure 1, within a cylindrical casing 1 is mounted a number of dies 2, 3 and 4 held in pressure rings 5, 6 and 7 respectively, in alignment in a central cylindrical chamber 8 of the casing 1. On the casing 1 a shoulder 9 at the exit end thereof and tapered passages 10 and 11 at the entrance end thereof accommodating a tapered key with central eyelet 13 restrain the dies and pressure rings against axial movement within the central chamber 8. Between the respective pressure rings 5, 6, 7, gaskets 14 and 15 form seals for chambers 16 and 17 formed on either side of the central die 3 by longitudinal extension of the central die pressure ring 6. A gasket 18 on the shoulder 9 of the casing adds a further seal to exit chamber 17 of the central die 3. In the pressure ring 6 of the central die 3 are provided passageways 19 and 20 leading from chambers 16 and 17 and converging to a common conduit 21 screwed into the pressure ring 6 through a radial opening 22 in the casing 1. Liquid introduced through the conduit 21 and passageways 19 and 20 is given a pressure from a source not shown that may attain 100,000 pounds per square inch and in order that the walls of the chambers may not be unduly thick to withstand this pressure the diameters of the chambers are kept small, and the seals 14 and 15 may be of relatively low melting temperature metal adapted to unite under moderate heat with the walls forming a solid barrier. Around the central die 3 an electrical heating element 23 is provided in the central pressure ring 6 with detachable connection 24 through a continuous passage 25 in the casing 1 and the central pressure ring 6. A thermocouple thermostat 26 extends through a continuous passage 27 in the casing 1 and the pressure ring 6 to contact the central die 3.

At the exit end of the casing 1 is positioned a flexible hollow metal ring 28 connected by a valve 29 and a pipe 30 to a dynamometer gage 31, a liquid filling the passages of the members outlined.

Extending through the registering dies 2, 3 and 4 is shown a cylindrical duplex metal strip comprising a core 32 and a covering 33 and having a large section 34 and a reduced section 35 in chambers 16 and 17 respectively.

The large section 34 of the duplex strip contacts with the tapered entrance 36 to the central die 3 and is progressively reduced therein while hydraulic pressure in the chamber 16 introduced through passages 19 and 21 forces the covering 33 against the core 32 and insures the proportionate reduction of each.

Referring to Figure 2, a cross section of a rectangular strip 37 with thinner rectangular strips 38 and 39 on the respective sides thereof is shown entering a die 40 fitting into a pressure ring 41 positioned in the entrance of the central chamber 8 of the casing 1.

Referring to Figures 3 and 4, an embodiment of the invention substituting rolls for dies is shown. A pair of co-operating rolls 42 and 43 are held in bearings 44 and 45 respectively in the pressure ring 46 which is a counterpart of the shrinkage ring 6 and adapted to replace the latter in the chamber 8 in the casing 1 shown in Figure 1.

Referring to Figures 5 and 6, an embodiment of the invention is shown having a pair of reducing rolls 47 and 48 provided with backing rolls 49 and 50 respectively mounted in cages 51 and 52 respectively and positioned against shoulders 53 and 54 respectively in a pressure ring 55 adapted to fit in the mid portion of the central chamber 8 of the casing 1. The cages 53 and 54 are held in position by liners 56 and 57 respectively against radial movement, and the distance between the rolls 47 and 48 is adjusted in accordance with the thickness of said liners. Changes in the thickness of the liners 56 and 57 changes the position of the reduction rolls and the consequent reduction of the strips 58 between the rolls.

Referring to Figure 7, an embodiment of the invention is presented showing a die 59 mounted in a pressure ring 60 having chambers 61 and 62 in the extensions of said ring with screwed plugs 63 and 64 respectively serving to position sleeves 65 and 66 respectively which isolate the chambers 61 and 62 from the strip material 67 passing through the die 59. The entering chamber 61 of the die 59 has passages 68 and 69 thereto and likewise the exit chamber 62 has passages 70 and 71 thereto, said passages being adapted to accommodate the flow of fluid therein in accordance with operating conditions. Around the die 59 an electrical heating element 72 is positioned in the pressure ring 60 detachably connected through a passage 73 in the pressure ring to a source of electricity.

Referring to Figure 12, a core of strip metal 74 has hereabout a close-fitting envelope of metal 75 with an alloy of the same or different metals along the line of contact 76 adapted under operative conditions hereafter set forth to bond the combination into a solid body.

Referring to the dual purpose device illustrated in Figure 7, a support strip 67 progressively advanced by means not shown with molten duplex metal from a pressure source not shown through the outwardly extending entrance tube, 65' is sufficiently cooled in the entrance casing 65 by liquid circulating in the entrance chamber 61 through openings 68 and 69 to be definitely shaped and worked by the variable temperature die 59 heated by the electrical coil 72. Further cooling the exit casing 66 by liquid circulating in the exit chamber 62 through openings 70 and 71 lowers the temperature sufficiently to permit the coiling of the combined strip without damage for transport to the attenuating apparatus. The dual purpose device of Figure 7 and the attenuating device such as shown in Figure 1 may be in tandem so that the strip material may be attenuated directly without coiling. Transporting the round duplex strip 67 to the attenuating device preferably illustrated in Figure 1, and identifying the strip as support strip 32 and surface strip 33, the end thereof is specially shaped by means not shown to fit through the registering dies 2, 3 and 4 with an extension to a device not shown adapted to provide traction through the dies. The first and last dies, 2 and 4 respectively, act as glands to seal the chambers 16 and 17 divided by the central attenuating die 3 and supplied with liquid under pressure through pipe 21 and passages 19 and 20. The chambers 16 and 17 are of a length and the liquid therein of a pressure to restrain the surface strip 33 from undue lateral motion or accumulation in the reducing die entrance 36 regardless of the bond between the support strip and the surface strip. With the combined strip tapered in accord with

the attenuating die entrance 36 and backed out therefrom so that the taper bears against the confined fluid then the fluid acts as a die and the taper pressing thereagainst maintains a pressure in the chamber 16. The heater coil 23 regulated in accord with the thermostat 26 may be adjusted to heat the die 3 to a temperature effecting a bond between the support strip and the surface strip, the die and pressure ring preferably being made of tungsten carbide to resist heat and abrasion.

The beforementioned pressure source of molten duplex metal may be of a character employed in die casting and particularly die casting of zinc and zinc alloys and aluminum to a thickness of as thin as one one-hundredth of an inch. Obviously a pressure sourcefor such molten metal is not essential but preferable because of the density of the congealed product thereof.

The heater ring temperature adjusted in connection with the dynamometer 31 recording the pressure by the casing 1 on the flexible tube 28 and transmitted by liquid through valve 29 and tube 30 in consequence of the tension on the support strip may give most favorable attenuating operation.

Instead of the liquid means in the pressure ring 6 for restraining the metal on the support strip from lateral movement, the device shown in Figure 7 with the tube 65' eliminated may be substituted in the casing 1 and aligned therein by a simple casing not shown to fit around the ring 60 and within the chamber 8 of the casing 1. In that instance the die 59 performs the attenuation and the sleeves 65 and 66 restrain metal on the support strip against the lateral movement and accumulation in the die entrance. The inside passages of the sleeves 65 and 66 are of a length and relative diameter in contact with strip therein adapted to insure the proportional flow of metal of the strip through the die 59. Where wide support strips are involved it is desirable in order to reduce friction and tension load to use rolls instead of dies and to this end the embodiment shown in Figures 2, 3 and 4 may be used advantageously. The support strip 37 grouped with outside strips 38 and 39 passes through an entrance die 40 in a pressure ring 41 mounted in a casing 1, then through rolls 42 and 43 in a pressure chamber 46 and then through an exit die the counterpart in reduced section of the entrance die shown in Figure 2. The two dies act as glands to retain the liquid within the pressure ring. The entrance die, the rolls and the exit die are mounted with registering orifices. The liquid pressure within the shrinkage ring 46 is exerted over sufficient area on the outside strips 38 and 39 to provide traction to them through frictional engagement with the support strip 37 for attenuation in the rolls. This pressure also governs the rate of departure of the outside strips from the rolls.

In the passage of a strip through a reducing die, experiments show approximately 31% of the tension on the strip is due to friction and that if the strip is placed in tension approximating the elastic limit on both sides of the die and such tension maintained as relative motion between the die and strip is produced, the force against the die during attenuation is very materially reduced. Utilization of this principle in attenuating duplex metal strip very materially reduces the pressure of the attenuating die or rolls upon the metal and consequently reduces the tendency of the weaker metal to depart from proportionate reduction. Thus the congealing apparatus shown in Figure 7 operated on a duplex strip in tandem with the apparatus in Figure 1 employs the respective dies 59 and 2 as back tensioning means on the strip being attenuated by die 3. This tension reduces the pressure of the die 3 upon the covering 33 and the core 32, and the tendency of the covering metal 33 to depart from proportionate entrance with the core into die 3 is materially reduced. This important feature is equally exemplified in the application of rolls to reduction of duplex strip. Thus copper and aluminum or steel and aluminum or other combinations of metals not alloyed together may be reduced in cross section and separated, with the advantage of subjecting the weaker metal to pressing action in joint attenuation greater than the tensile strength of such weaker metal alone would provide—an economy in handling and a superior product because of greater density thereof resulting. Thus Babbitt metal worked on a metal strip and separated therefrom is a new product.

Babbitt metal of the following parts is representative:

1–7 per cent antimony, 4 per cent copper, 89% tin.

2–11 per cent antimony, 5 per cent copper, 84% tin.

Preference is given to a lead bearing metal having a $\frac{1}{10}$ per cent tellurium content, the tellurium conferring upon the lead resistance to fatigue incident to vibration, and a so-called marine babbitt of the following analysis is added to the art:

Antimony 7%, lead 72%, tin 20.9%, tellurium $\frac{1}{10}$ of one percent. The discovery of the utility of tellurium is included within the scope of this invention.

To control the angle of contact between the rolls and material and to provide the necessary support bearing, the embodiment shown in Figures 5 and 6 provides changeable attenuating rolls 47 and 48 with backing rolls 49 and 50 respectively. The use of a confined liquid atmosphere around the various embodiments precludes the expansion of the workpiece beyond specified limits, limits which are prescribed by the uniformity of cross section in the work piece.

Referring to Figure 7, the combination of die 59 and casings 65 and 66 is in effect a die having a confined approach and exit, thus providing the restrained atmosphere. The liquid substitute in chambers 16 and 17 of Figure 1 for elements 65 and 66 is in effect a non-compressible atmosphere.

Referring to Figures 8 and 9, a vertical drawing drum 80 on a drive shaft 81 carrying a worm gear 82, and horizontal drawing drums 83, 84 and 85 on drive shafts 86, 87 and 88 respectively carrying worm gears 89, 90 and 91 respectively are driven by worms 82, 92, 93 and 94 respectively on a common drive shaft 95. The drums 83, 84 and 85 are controlled by clutches 83', 84' and 85' respectively. The drive shaft 95 carries a gear 96 driven by a chain 97 and a pinion 98 on one end of a motor shaft 99 of a motor 100 housed within the frame 101 of the machine. The opposite end of the motor shaft 99 connects to a speed reducing mechanism 102 having exterior control handle 103 and a power shaft 104 connecting to a hydraulic pump 105 adapted to supply liquid at a pressure up to 1000 pounds per square inch through a connection 106 to a relatively large piston 107 in a cylinder 108. The

piston 107 is connected to a rod 109 which acts as a piston in a small cylinder 110 to step up the pressure on a liquid therein to the order of 10,000 pounds per sq. in. From the small cylinder 110 a connection 111 branches out in one course 112 through a valve 113 to the casing 1, mounted exteriorly of the frame 101, and in another course 114 through a valve 115 to a relatively large cylinder 116, so that the liquid at 10,000 pounds per square inch may act within the casing 1 or within the cylinder 116 upon a piston 117. The piston 117 carries a rod 118 which acts as a piston in a small cylinder 119 to step up the pressure upon a liquid therein to the order of 100,000 pounds per square inch. A connection 120 from the small cylinder 119 extends through a valve 121 to the casing 1 uniting with the connection thereto from valve 113 so that a number of liquid pressures are made available to casing 1.

The motor 100 is controlled and regulated by an exteriorly positioned rheostat box 122. Upon the frame 101 the previously described casing 1 and the pressure ring 60 are mounted in coaxial alignment with each other and with a duplex metal supply device 123, so that the supply device provides an entrance for a strip that passes on through the ring and casing to any of the drawing drums, vertical or horizontal. A support roll not shown on frame 101 guides the strip to the horizontal drums.

The duplex metal supply device comprises a base 125 from which extends upwardly a hopper 126 in the bottom of which is a screw 127 having a central hollow passage in alignment with the ring 50 and casing 1. One end of the screw 127 is mounted in the wall of the base 125 and on a hollow shaft 128 carrying exteriorly of the hopper a gear 129 driven by a belt connection 130 from a pinion 131 on the shaft of a motor 132. The motor 132 is controlled by a controller box 133 conveniently located. A thrust collar 134 on the screw mounting assists in maintaining the screw in position. The screw 127 has a tapered section 136 co-operating with a tapered element 137 to compact powdered duplex metal by reason of their pressure and wedge action. Forward of the tapered section is a cylindrical section 138 into which fits the tube 65' of the device illustrated in detail in Fig. 7. The tapered element 137 and cylindrical element 138 carry insulated heating elements 139 and 140 respectively controlled by rheostats 141 and 142 respectively.

A floor reel 143 supplies round strip material to the passageway through screw 127. A mounted reel 144 on bracket 145 on frame 101 supplies flat strip. When flat strip is operated on, the upright drum 80 may be removed to provide maximum passage to the horizontal drums. The usual fastenings are employed in starting the strip through the line of action. The cooling water connections 68, 69, 70 and 71 on the pressure ring 60 are made operative as procedure may require.

The ring 60 is held in engagement with the supply metal member 123 by brackets 146. The thrust from casing 1 is taken up by the lugs 147 on the frame 101.

In operation, after a pointed wire is passed through the duplex metal supply device, the pressure ring and casing 1 and attached to the drawing drum, the metal supply screw 127 is revolved forcing powdered metal into tapered element 137 and cylindrical element 140 which by adjustment of rheostats 141 and 142 heat the metal to the desired temperature, even melting it in element 140 when such action is desired. The forward movement of the wire 67 and the screw action advance the duplex metal into the tube 65' where the cooling action congeals the metal, if it is molten, on the wire 67. Continued rotation of the screw 127 forces duplex metal laterally against the element 137 and wire 67 sufficiently to act as a brake or back tensioning device on the wire. With the wire extending through the gland dies 2 and 4 of casing 1 and bearing against mid die 3 forward movement of the wire registers pressure through casing 1 on ring 28 which shows in gage 31. Regulation of resistance 133 regulates screw action of screw 127 and thus the braking force on wire 67 which is at once shown on gage 31. The resistances 141 and 142 may be connected to the terminals 24 of casing 1 to control the temperature of ring 23.

Through manipulation of valves 115, 113 and 121, and controller 103, suitable lateral pressures may be established in casing 1 upon the duplex metal on the wire passing therethrough.

The aluminum and zinc powder (that is electro positive to steel) in the metal supply device acts as a brake on the wire, acts to force foregoing molten like particles ahead and absorb heat preparatory to becoming molten when the molten condition is desired. Obviously under the effect of pressure and heat, suitable discrete particles will bond together without reaching a molten condition.

To roll or draw steel and lead or steel and aluminum or steel and zinc with more than a moderate dipped coating heretofore has not been commercially feasible because of the lack of restraint of the lower tensile strength metals mentioned. The new product from the steps outlined is a high tensile strength support strip and a lower strength surface strip jointly attenuated to a uniform cross section. As an example of a new individual product Babbitt metal may be taken as congealed on a strip, attenuated with the strip to confer pliability thereon and then separated from the strip to be handled independently.

Further, the discrete particles or congealed metal around a high tensile strength strip may be used solely as a lubricant of a thickness to facilitate the passage of the strip through a greater number of dies than any coating heretofore available. Thus as shown in Figure 1, the outer metal 33 on the strip 32 may serve as a lubricant through an exceptional number of reductions in dies.

Substantially, as set forth, the preparatory step in protecting the surface of a relatively high strength metal against deleterious accumulations during heated attenuation as preparation for a work strip, accumulations that would tend to abrade drawing dies and prevent alloying action with subsequently applied covering metal, the steps of applying a covering metal, the joint attenuation of the work strip and covering metal to a uniform cross section, the instrumentalities restraining the flow of metal to determined limits, and the product of these steps come within the scope of my invention.

Obviously this invention is not limited to the specific embodiment of instrumentalities, but is capable of many variations and applications without departing from its spirit and scope as outlined in the following claims. As an example, it is intended to include the formation of a tube of ferrous metal properly shaped and supported, the ferrous metal being alloyed with aluminum

content from 5 to 17 percent, and the pouring into the tube of molten ferrous metal, and the utilization of the heat of casting to join the tube and poured metal. Treatment thereafter to be as previously outlined, hot rolling and or cold attenuation.

I claim:

1. In the process of producing an attenuated metal work strip the steps consisting of congealing molten metal in a mold coated with a binder and granulated ferrous aluminum alloy metal thereby providing a workable surface of said granulated metal on said congealing metal attenuating said ferrous aluminum alloy metal by rolling while hot, progressively congealing aluminum or other metal on said rolled metal to a uniform thickness, and attenuating said rolled and congealed metal.

2. In the process of producing an attenuated metal work strip, the steps consisting of coating a congealing ferrous metal workpiece with a workable ferrous aluminum alloy thereby protecting said metal from oxidation during rolling, attenuating said metal by rolling while hot, progressively congealing metal on said rolled metal to a uniform thickness, and attenuating said rolled and congealed metal to a uniform thickness.

3. In the process of producing an attenuated metal workpiece the steps consisting of congealing molten ferrous metal in a mold coated with silicate of soda and ferro chromium granules passing 40 to 100 mesh to the inch thereby providing a surface of said granules on said congealing metal, coating said congealed metal with 70 parts aluminum, 23 parts sal ammoniac and 7 parts zinc made adherent by heat incident to hot rolling, and attenuating said metal by rolling while hot under the protection against oxidation by said coating.

4. In the process of producing an attenuated metal workpiece, the steps consisting of utilizing a workable ferro-aluminum metallic coating on an attenuated ferrous metal workpiece as protection against oxidation during the hot rolling thereof, hot rolling said workpiece, coating said workpiece with metal a second time, and utilizing said first metallic coating to bond said second coating to said workpiece.

5. The method of making a ferrous metal article having an aluminum alloy stainless steel surface which comprises casting molten ferrous metal against chromium steel metal carrying not over 17 percent and preferably 12 percent of aluminum supported in a mold and utilizing the heat of casting to unite said cast metal and said supported metal and attenuating said united metal by hot rolling said aluminum content adapting said article to hot working and conversion to resist wear.

6. The method of making a ferrous metal article having an aluminum alloy stainless steel surface which comprises casting molten ferrous metal against chromium steel metal carrying not over 5 percent of aluminum supported in a mould and utilizing the heat of casting to unite said cast metal and said supported metal, attenuating said united metal by hot rolling and then attenuating said metal further by cold rolling or drawing, said aluminum content adapting said article to cold working and conversion to resist wear.

7. The method of making a ferrous metal article having an aluminum alloy stainless steel surface which comprises casting molten ferrous metal against chromium steel metal carrying not over 17% and preferably 12% of aluminum supported in a mold and utilizing the heat of casting to unite said cast metal and said supported metal attenuating said united metal by hot rolling, cleaning the surface of said hot rolled metal and forming thereon a coating of aluminum, said aluminum content adapting said article to hot working and conversion to resist wear.

8. The method of making a ferrous metal article having an aluminum alloy surface which comprises casting molten ferrous metal against ferrous metal carrying not over 17 percent of aluminum supported in a mold and utilizing the heat of casting to unite said cast metal and said supported metal, attenuating said united metal by hot rolling, cleaning the surface of said rolled metal, and drawing said article through heated granulated aluminum under pressure thereby uniting said aluminum to said article.

9. The method of making a ferrous metal article having an aluminum alloy surface which comprises coating a surface in a mold to a depth of from ⅛" to ¼" with a mixture compound of metal particles comprising ferrous metal with not over 17 percent aluminum and a binder for said particles, hardening the resulting coating, introducing into said mold molten ferrous metal and utilizing the heat of casting to unite said cast metal with said coating metal, hot rolling said metal combination, cleaning said hot rolled metal and coating said alloyed surface with aluminum.

10. The method of making a ferrous metal article having an aluminum surface which comprises coating a surface in a mold to a depth of from ⅛" to ¼" with a mixture composed of metal particles comprising ferrous metal with not over 5 percent of aluminum and a binder for said particles, hardening the resulting coating, introducing into said mold molten ferrous metal, utilizing the heat of casting to unite said coating metal, hot rolling said metal combination, coating said metal combination with aluminum and cold attenuating said coated combination.

11. The method of making a ferrous metal article having a non-ferrous surface which comprises coating a surface in a mold with a mixture of ferrous metal with aluminum and a binder for said particles, hardening said coating, coating said coating with a mixture of ferro chromium particles, hardening said coating, introducing into said mold molten ferrous metal, utilizing the heat of casting to unit said coating metal, hot rolling said metal combination, cold attenuating said metal combination, and coating said article with non-ferrous metal.

12. A coating for molds adapted to form an aluminum alloy-containing surface on a ferrous alloy base metal cast in the mold, which comprises a ferro-aluminum stainless steel granulated alloy containing aluminum but not more than enough aluminum to permit hot working of said alloy, said aluminum providing one element of an alloy formed later to protect said stainless steel against wear.

13. An aluminum coated iron or steel article, comprising a stainless iron or steel body; and a plurality of separately applied coatings thereon, including a coating of aluminum; and a coating of workable aluminum-iron alloy interposed between the aluminum coating and the said body and of relatively low aluminum content said aluminum being adapted to conversion to an alloy giving wearing qualities to said stainless body.

14. In the process of making an attenuated metal article the steps consisting of making a

ferrous aluminum alloy with an aluminum content low enough to allow mechanical working, contacting a stainless ferrous base metal with said ferrous aluminum alloy, and utilizing the heat from one of said contacting metals in a molten state to effect a union between said alloy and said base metal, said aluminum being adapted to conversion to an alloy giving wear qualities to said stainless metal.

15. An article of manufacture comprising an iron or steel body; and a plurality of separately applied coatings thereon including a coating of stainless steel with an aluminum content not over 17% and preferably 12%, said second coating comprising an alloy with said aluminum adopted to protect said stainless steel.

16. In attenuating apparatus, the combination comprising pressure means progressively supplying granulated coating metal circumferentially of a metal work piece; means to attenuate said work piece; means to heat said granulated metal and work piece jointly; means to progressively pull said granulated metal and work piece jointly through said attenuating means, and means to regulate the heat provided by said heating means, whereby said work piece is progressively attenuated and coated.

17. In the process of providing an aluminum alloy surface on a metal article, the steps consisting of forming a relatively thin body of aluminum ferrous alloy; casting and congealing metal against one surface of said body thereby bonding said alloy and metal; and against the heated other surface of said aluminum alloy, providing any heated material adapted to penetrate and alloy with said heated alloyed aluminum and allowing said alloying action to occur whereby said relatively thin body is utilized to unite said penetrating material to said congealed metal of said article.

18. In the process of producing an attenuated metal work strip the steps consisting of congealing molten metal in a mold coated with a binder and granulated ferrous aluminum alloy metal, thereby providing a workable surface of said granulated metal on said congealing metal; attenuating said surfaced metal; and utilizing the said heated aluminum of said ferrous aluminum to attach to said combination any heated material which has the property of penetrating and uniting with said heated ferrous aluminum alloy, thereby providing said penetrating material as a part of said surface metal when cold.

19. In the process of producing a metal article by congealing molten metal in a mold lined with metal, utilizing the heat of said congealing metal to bond said metals together, and attenuating said combined metals, the steps consisting of including aluminum on the outer surface of said lining metal and utilizing said aluminum in a heat treating operation subsequently to performing said attenuating operation.

20. In the process of producing a metal article by congealing molten metal in a mold lined with metal, utilizing the heat of said congealing metal to bond said metals together, and working said combined metals, the steps consisting of including aluminum and chromium on the outer portion of said lining metal and subsequently utilizing said aluminum in an alloying operation.

21. In apparatus comprising a frame, a die, and a capstan for drawing a work piece through said die, the combination of a casing, a screw within said casing, a passage in said casing and screw through which a work piece is moved by said capstan, means to heat discrete particles of material and means to rotate said screw whereby said discrete particles are compressed and bonded together around said work piece below the melting temperature of said particles as said work piece is actuated by said capstan.

22. In apparatus comprising a frame, a die, and a capstan for drawing a work piece through said die, the combination of a casing, a screw in said casing, a passage in said casing, a screw through which a work piece is moved by said capstan, and means to rotate said screw whereby discrete particles are compressed around said work piece thereby providing back tension on said work piece as it approaches said die for attenuation.

23. In apparatus comprising a frame, a die, and a capstan for drawing a work piece through said die, the combination of a casing, means for pressing discrete particles in said casing around said work piece, and electrical means for quickly heating said particles thereby making said pressing means progressively effective to bond said particles below their melting point around said work piece as it approaches said die.

24. In apparatus comprising a frame, a die, and a capstan for drawing a work piece through said die, the combination of a casing, means for pressing coated discrete particles in said casing around said work piece similarly coated, and heating means effective on said coatings whereby said particles are bonded together and to said work piece progressively as said work piece is actuated by said capstan.

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