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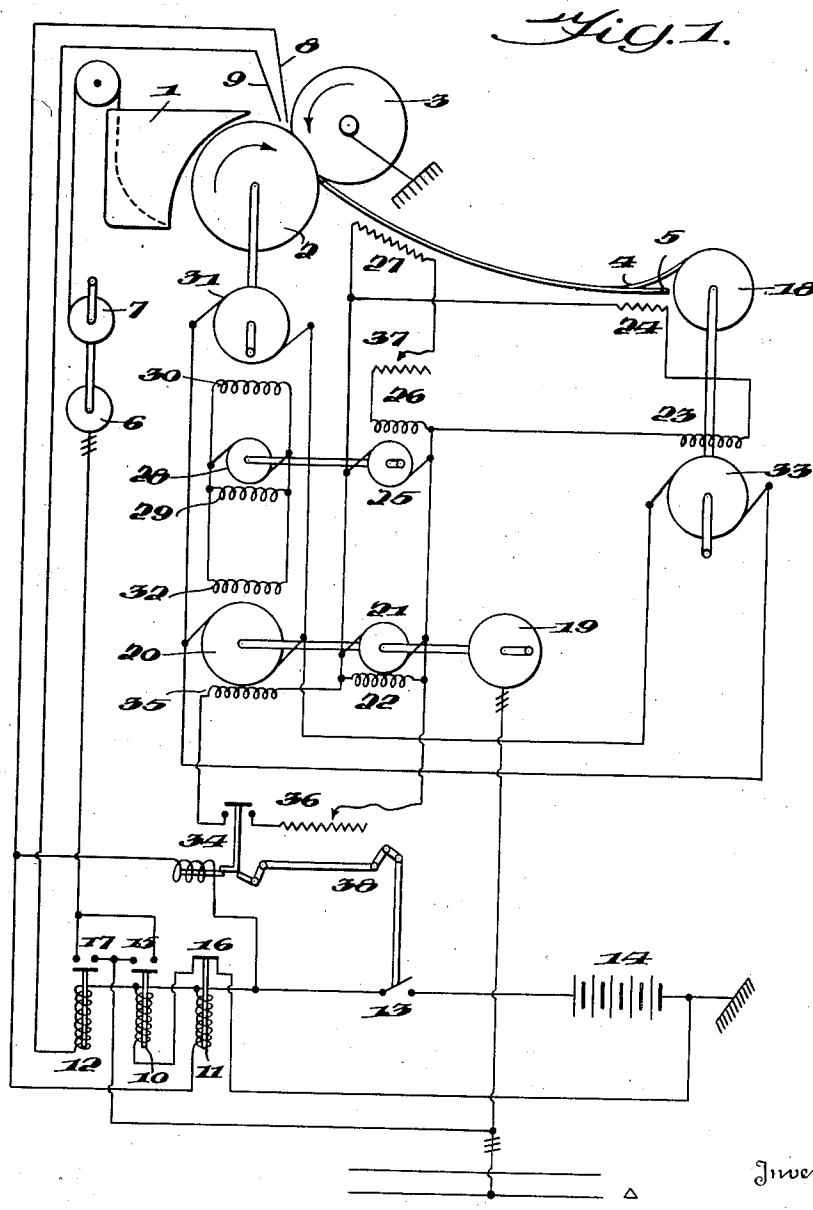
A. SCHWARZ

2,332,759

METHOD OF AND APPARATUS FOR ROLLING MOLTEN METALS

Filed June 5, 1940

5 Sheets-Sheet 1



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Fig. 2.

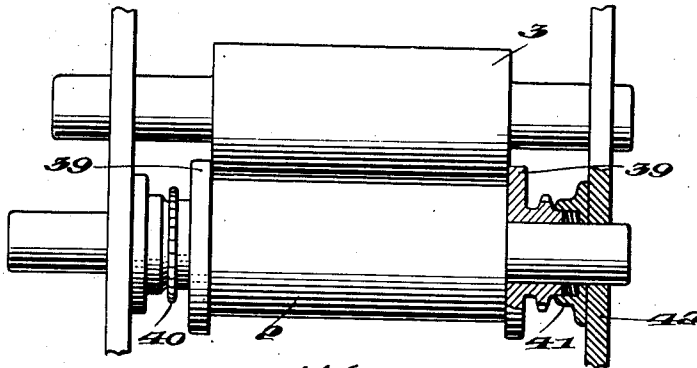


Fig. 3.

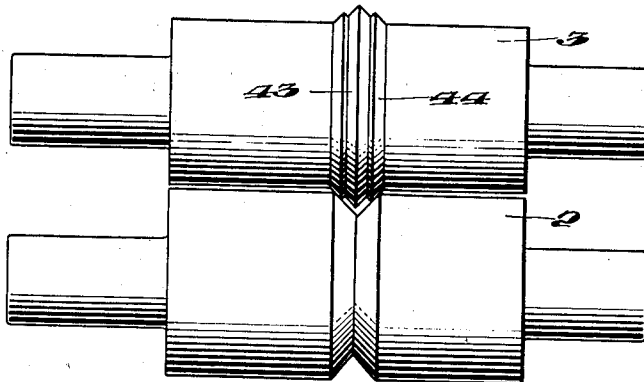
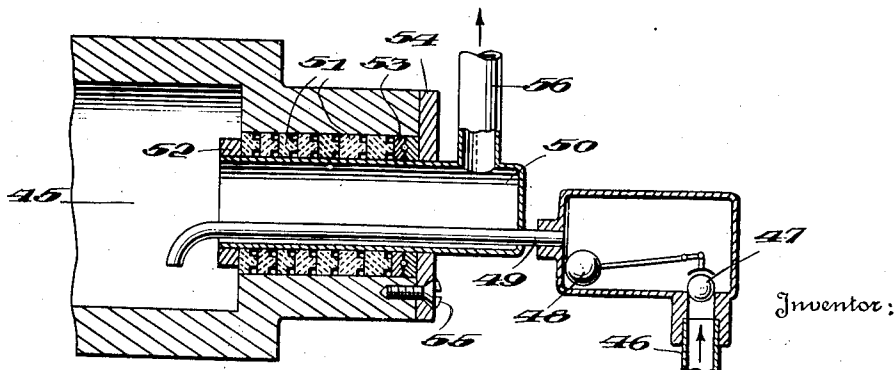


Fig. 4.



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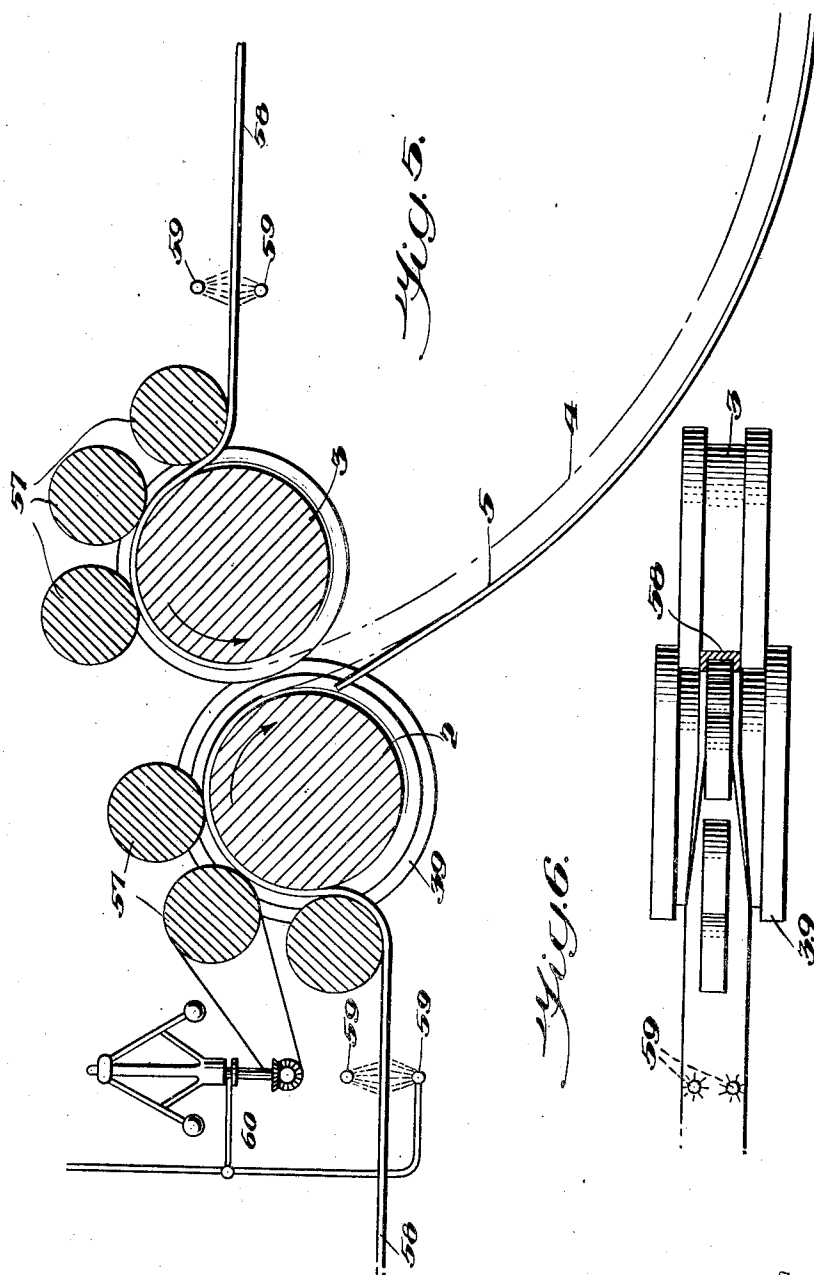
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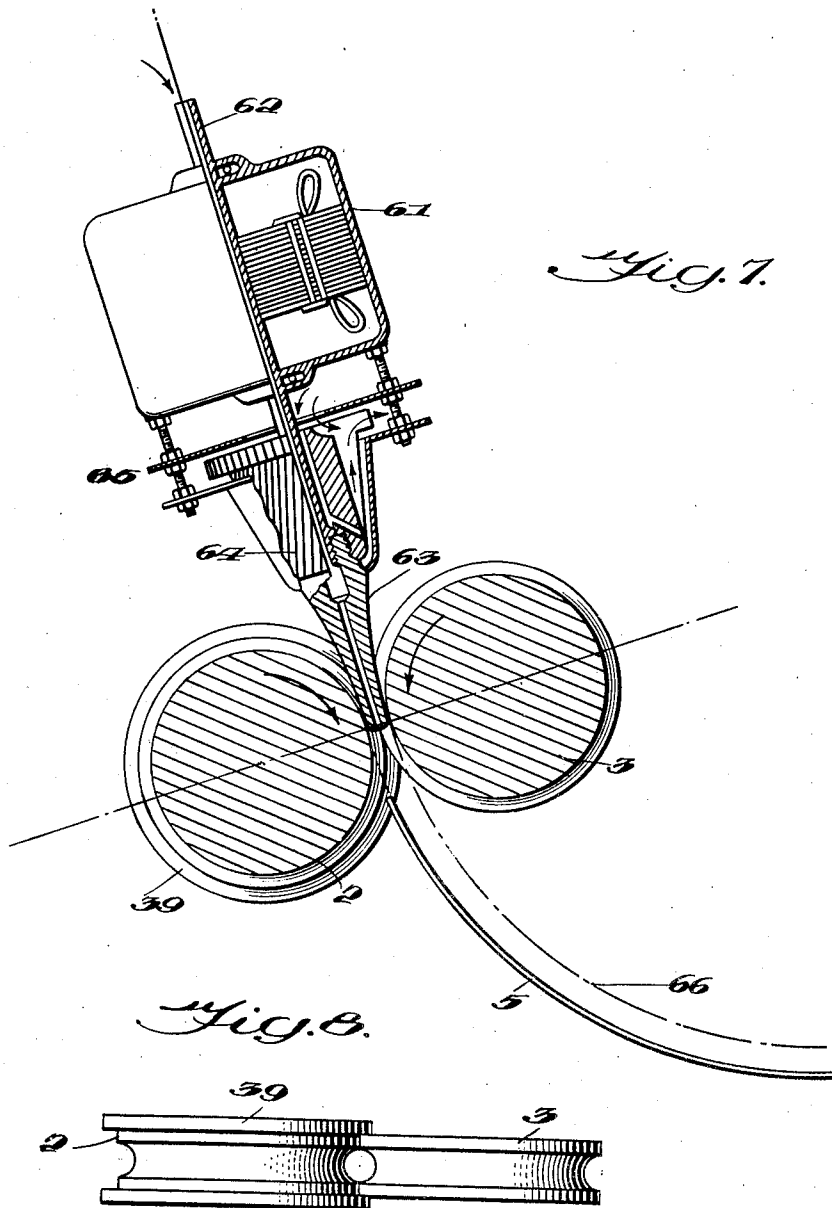
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METHOD OF AND APPARATUS FOR ROLLING MOLTEN METALS

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5 Sheets-Sheet 4



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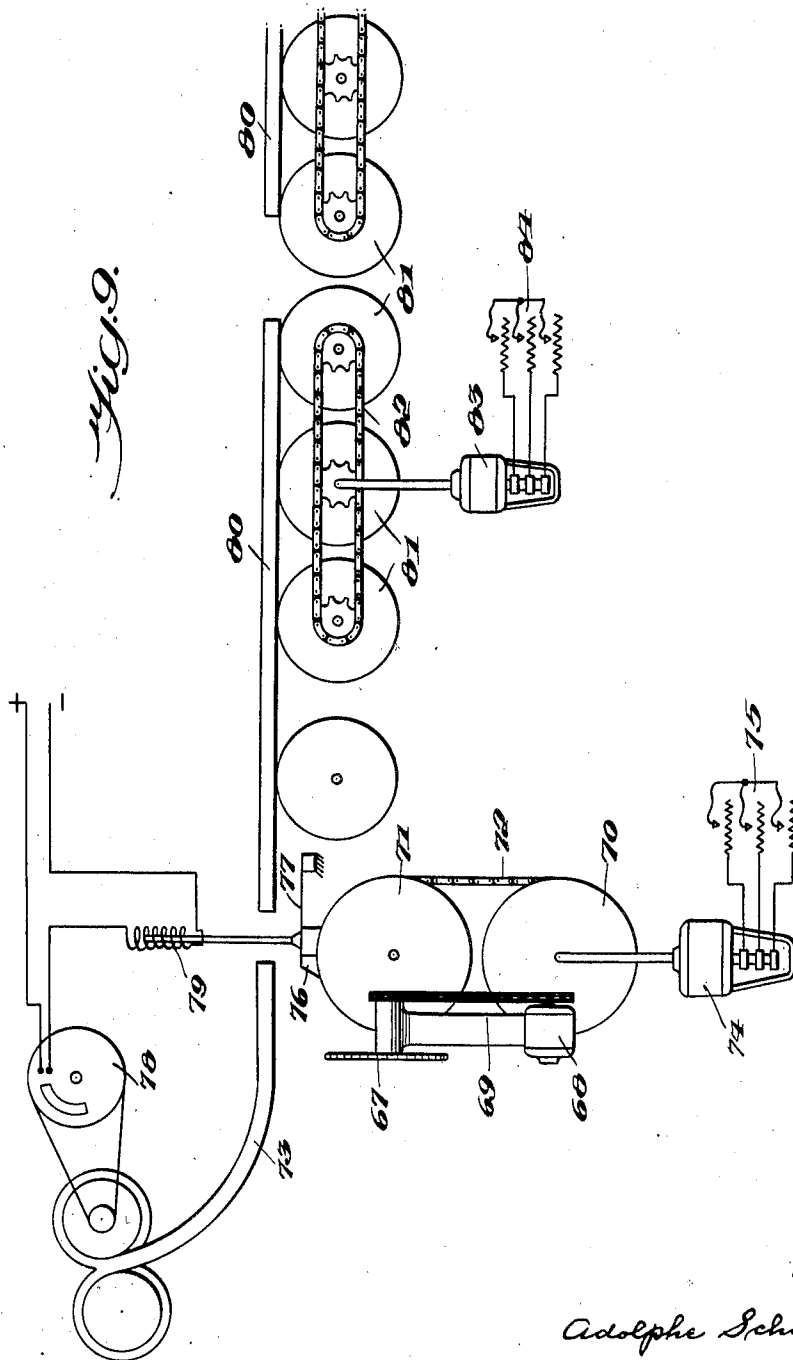
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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

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METHOD OF AND APPARATUS FOR
ROLLING MOLTEN METALS

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7 Claims. (Cl. 22—57.5)

The process universally used for the manufacture of all kinds of metal profiles such as sheets, flats, corners, beams, rails, tubes, etc., requiring the casting of blooms or slabs and their successive heating and rolling in large and expensive plants until the final profile and dimensions are attained, is very long and difficult and involves considerable capital expenditure.

Many proposals have been made for rolling metals in their molten state directly into the desired profiles. This process considerably lessens the installation and production costs, reduces the operating time, saves labour and reduces the capital required. The results are however not satisfactory because the profiles produced are not homogeneous throughout their length, or may not attain the necessary thickness, and principally because metals with melting points as high as steel cannot be rolled.

According to the invention it is proposed to employ limiting working speeds in order that the available roll materials may resist the temperatures to which they are exposed, the rolls having to eliminate only the quantity of heat corresponding to the melting heat of the treated metal which escapes upon solidification and which may be eliminated subsequently from the rolls by a gaseous or liquid refrigerant, so that continuous working is possible.

By pouring molten metal at a temperature approaching its solidification temperature between rolls rotating in opposite directions that part of the molten metal which comes into contact with the cooler surfaces of the rolls immediately freezes enough to support the doughy core, so that by the compressive action of the rolls, this metal is pressed out of the space between the rolls, or calibre, in the form of a delicate incandescent profile of the same form and dimensions as this calibre and of minimum strength. This strength increases gradually, due to the cooling effect of the surrounding air, until the profile reaches its normal strength at a certain distance from the rolls, being supported by a smooth slide, whose inclination and form are so chosen as to obtain a friction which avoids any accelerating or braking of the profile which might cause its deformation.

When the pass of the rolls is continuously fed with enough molten metal, so that it is certain to be filled during the entire production time, the profile obtained will have the full dimensions of the roll opening throughout its length. On the other hand the profile must be discharged at

production velocity in order to avoid any deformation after leaving the rolls.

The objects and advantages of the invention will be apparent from the following specification when read with the accompanying drawings in which:

Fig. 1 shows the arrangement of the whole installation, consisting of the rolls, slide and winder with their driving motors and electrical connections,

Fig. 2 shows straight rolls with discs for avoiding the lateral flow of molten metal,

Fig. 3 shows the rolls with calibre-grooves and conical grooves to avoid the lateral flow of molten metal,

Fig. 4 shows the internal cooling of the rolls,

Figs. 5 and 6 show the profile rolls with forming rolls and strips for the production of thick profiles,

Figs. 7 and 8 show the profile rolls with mandrel and driving motor for the production of tubes,

Fig. 9 shows the circular saw with parallel guiding device and accelerating rollgangs.

The molten metal contained in the pouring pan 1 shown in Fig. 1, is poured directly or by means of a rill, at a temperature approaching its solidification temperature, between horizontal rolls 2 and 3 installed one above another at a suitable angle, to facilitate the supporting of the profile at its weakest point. These rolls are provided with grooves on their surfaces, forming at their junction lines a closed calibre of the desired form and dimensions, or their surfaces are smooth and the distance apart can be regulated for rolling sheets of various thicknesses. By rotating the rolls in the direction indicated, the frozen metal layers with the doughy layer enclosed between them are pressed through the pass of the rolls 2 and 3 and delivered from these rolls as an incandescent and delicate profile 4 of the same form and dimensions as the pass. The profile 4 has its minimum permissible strength when leaving the rolls 2 and 3, but enough to maintain its acquired form and dimensions until the smooth slide 5 receives it. The slide 5 has a suitable profile and an inclination and form to cause friction, avoiding however any accelerating or braking effect that could cause any stressing of the profile 4, capable of deforming it. The length of the slide 5 is enough to enable the profile 4 passing along it to have sufficient time to acquire the needed strength for its further manteling, by the cooling effect of

the surrounding air or by means of artificial refrigeration.

In order to obtain an uninterrupted profile of constant dimensions throughout its full length, the amount of molten metal poured between the rolls 2 and 3 must be enough to fill the whole section of the pass during the full production time; to achieve this purpose the pouring pan 1 is provided with a motor 6 and a mechanical coupling 7, controlled by the two electric contacts 8 and 9 through the relays 10, 11 and 12. By closing the switch 13, a source of current 14 energises the closing relay 10 whose contacts 15 bring the motor 6 into the "pouring" position. The molten metal accumulates in front of the two rolls 2 and 3 until it reaches the contact 8 installed at a suitable distance above the pass of the rolls 2 and 3 thus closing the current of 14 on the opening-relay 11 through the earth. The contact 16 of the opening-relay 11 breaks the current of the closing relay 10 and contacts 15, thus stopping the motor 6. The level of the molten metal at the rolls 2 and 3 employed for the production of the profile 4 sinks and interrupts the contact at 8 so that the opening-relay 11 closes its contacts 16 to energise the closing relay 10 whose contacts 15 again place the motor 6 in the "pouring" position. By these means a minimum of molten metal is required at the rolls 2 and 3 in order to ensure an adequate supply for the whole section of their pass and over the full length of the profile 4, this being determined by the distance between the pass and the contact 8. In order to avoid a large amount of metal accumulating at the rolls 2 and 3, and causing them to become overheated, a second electric contact 9 is installed at a suitable distance over the contact 8 which energises the closing-relay 12 as soon as it is reached by the ascending level of molten metal; the contacts 17 of the closing-relay 12 cause the motor 6 to reverse so that the pouring is interrupted, and the motor 6 stops as soon as the contact 9 is interrupted with the result that the maximum permissible amount of molten metal collecting in front of the rolls 2 and 3 is limited.

Knowing the dependence of the mechanical strength of the metal to be rolled on its temperature up to its melting point and also the time necessary to affect the roll surfaces by the molten metal treated, the rolling speed can be regulated so that the surfaces of the rolls will not be affected and the profile 4 which is produced will have enough strength to maintain its acquired form and dimensions, so that its strength will increase sufficiently on the slide 5 due to the cooling effect of the surrounding air, to permit its being wound on the winder 18 at its production velocity. For this purpose the rolling speed is regulated at a constant temperature corresponding to the chosen strength of the profile 4, by a temperature regulator of known construction or by the following system: The motor-generator set consisting of the motor 19, the main generator 20 and the auxiliary generator 21, upon being set into operation causes the auxiliary generator 21 to attain its normal voltage, due to its own excitation 22. This generator supplies current for the separate excitation 23 in which is inserted the temperature sensitive rheostat 24 consisting of material with a high temperature coefficient, and also to the exciter-motor 25, which then runs at minimum speed, due to its excitation 26 in which is also inserted a temperature sensitive rheostat 27, whose electrical resistance is at its minimum,

so that the exciting current of the motor 25 is at its maximum. The exciter 28 coupled with the exciter-motor 25 running at minimum speed, and being excited by its own excitation 29, gives a minimum voltage to the separate excitation 30 of the rolls-driving motor 31 and also to the counter-excitation 32 of the main generator 20, which latter gives a low voltage in opposition to its normal voltage and feeds the armature of the rolls-driving motor 31, running at relatively low speed against its normal running direction. By closing the switch 13, the metal-pouring pan 1 is kept in the "pouring" position by the motor 6 as described above and the molten metal accumulates in front of the rolls 2 and 3 until it reaches the contact 8 which stops the pouring of molten metal and simultaneously closes the excitation switch 34 so that the auxiliary generator 21 feeds the main-excitation 35 of the generator 20 at constant voltage; therefore, the voltage of this generator 20 reverses its direction and attains its maximum value, also reversing the rotational direction of the roll-driving motor 31, beginning with the rolling of the molten metal at maximum speed. As soon as the profile 4 passes close to the temperature-sensitive rheostat 27, the temperature of the latter rises and proportionally increases its electrical resistance, the resulting drop in current in the excitation 26 increasing the speed of the exciter motor 25. The voltage of the exciter 28 increases more than proportionately with its speed rise, due to the current rise in its own excitation 29, so that the current rise in the excitation 30 of the motor 31 and in the counter-excitation 32 of the generator 20 causes a notable reduction in the speed of the motor 31 or of the rolling speed. The incandescent profile 4, now remaining longer in contact with the rolls 2 and 3, leaves them at a lower temperature, the temperature and the electrical resistance of the rheostat 27 are also lower so that the speed of the exciter-motor 25 and the voltage of the exciter 28, as well as the currents in the excitation 30 and in the counter-excitation 32 are lower, with the result that the rolling speed increases until the temperature of the profile 4 corresponds to the chosen conditions of temperature in the winding of the rheostat 27, thus maintaining a strong dependency of the rolling speed on the temperature, which is synonymous with the strength of the profile 4. In order to avoid too great a difference of speeds before and after the incandescent profile 4 heats the temperature-sensitive rheostat 27, its winding section may be preheated by a suitable rheostat to a temperature approaching the minimum allowable temperature of the profile 4, so that the rheostat 27 will regulate from this temperature upwards. To adjust the rolling speed to the temperature of the profile 4, a hand-controlled rheostat 36 is provided for the regulation of the voltage of the main generator 20 and the controllable rheostat 37 for the regulation of the speed of the exciter motor 25, that is of the voltage of the exciter 28. By opening the switch 13, the pouring of molten metal is interrupted and through the mechanical connection 38 the switch 34 is simultaneously opened; this latter interrupting the current in the main excitation 35 of the main generator 20, so that the remaining counter-excitation 32 reverses the polarity of this generator and therefore also the running direction of the roll driving motor 31, so that any molten metal remaining between the rolls 2 and 3, will not solidify and set hard there. This system permits the amount

of heat to be eliminated by the rolls 2 and 3 to be reduced to a minimum and also lessens the demand of rolling energy without fragile movable apparatus.

The incandescent profile 4 continues its way along the slide 5 over the temperature-sensitive rheostat 24 embedded in it, to the winder 18 which rotates at a minimum speed for winding up the profile 4. During this time the rheostat 24 becomes heated by the profile 4, and due to the high temperature-coefficient of its active material, its electrical resistance increases, reducing the current in the excitation 23 and consequently the speed of the motor 33, that is the winding velocity increases. The top of the winder 18 being higher than the slide 5 lifts the hot profile 4 a certain distance over the rheostat 24 when the winding velocity increases, so that this rheostat will become cooler, its electrical resistance falls and in consequence the speed of the winder-motor 33 decreases, until the rheostat 24 reaches the temperature corresponding to the electrical resistance needed for the given motor speed, and a constant distance between hot profile 4 and rheostat 24 will be maintained, securing the same winding velocity as the production velocity of the profile 4, apart from the diameter variation of the winder. The armature of the winder driving-motor 33 may be fed by a separate generator, by the auxiliary generator 21 or by the main generator 20, in which case the voltage change of this generator also partly regulates the winding speed by changing the production speed of the profile 4.

To avoid a lateral flow of molten metal at the ends of the rolls 2 and 3, see Fig. 2, one of them is provided with discs 39 of greater diameter than that of the rolls; these discs may be rotated at relatively low speed in comparison with the roll speed by a chain-wheel 40 and they are pressed against the roll ends by the springs 41, supported against the frame 42; they may also be attached elastically to the rolls, or to the frame 42. Sometimes it is preferable, especially in the case of closed calibres, to provide parallel to the grooves 43 forming the closed pass of the rolls 2 and 3, conical ones 44 as indicated in Fig. 3, in the case of a corner; these two conical grooves 44, being pressed together, close the pass and the molten metal cannot escape. In both cases, any different elongation of the rolls 2 and 3 cannot cause any harmful constraint on these rolls or an abnormal rise in the power required.

In order that the rolls 2 and 3 may resist the high temperatures of molten metals such as steels, except when rolled at high velocity, the rolls must have an active cooling surface sufficient to enable them to transmit the quantity of heat they receive from the molten metal, to a gaseous or liquid refrigerant. For this purpose the outside surface of the rolls 2 and 3 will be of appropriate dimensions and each roll will be provided with an axial hollow space 45 (see Fig. 4) to which cooling water is supplied through the tube 46, the return-valve 47, the constant-level valve 48 and the tube 49 passing through the tube 50. This tube 50 is kept tight in the bore of the roll for instance by several labyrinth rings 51 held at one end of the tube 50 by the nut 52 and at the other end by the ball-bearing 53 abutting against the plate 54 held by the screws 55. The vapour produced in the space 45 escapes through the tubes 50 and 56 and is employed for the refrigeration of the outside surface of the

rolls 2 and 3, or of the molten metal between the pouring-pan 1 and the pass of the rolls 2 and 3, or of the incandescent profile 4, the vapour serving at the same time as an anti-oxidising atmosphere or for other purposes. The outside of the rolls may be cooled by water-baths or jets, or by jets of cold gas or by other means.

When rolling thick profiles there will be a limiting thickness, at which the rolls 2 and 3 are no longer able to eliminate the quantity of heat necessary to obtain a profile of sufficient consistence, even when an intensified cooling is adopted, so that the rolling velocity must be reduced below the velocity at which the molten metal affects the surfaces of the rolls. In this case, each roll 2 and 3, as shown in Figs. 5 and 6, is provided at its upper periphery with one or more forming rolls 57, pressed centrally on to the rolls 2 and 3 and of suitable form and dimensions to fit the grooves of the rolls 2 and 3 forming the calibre with metallic strips 58 of the desired quality and dimensions, so that the roll opening will be lined with them, only their edges being larger than the depth of the grooves. The two strips 58 which thus form two half envelopes attain their welding temperature by pouring molten metal between them, so that by the compressing action of the rolls 2 and 3, these half-envelopes weld with the poured metal, forming the core of the profile 4, and their edges also weld together to form a closed envelope strong enough to maintain the form and dimensions of the profile 4 leaving the rolls 2 and 3 until it acquires the needed strength on the slide 5, which supports it during the time it solidifies. An additional rolling immediately afterwards will assure the complete welding between the envelope and the core of the profile 4, its own heat being used for this purpose. Thick strips, which may not attain their welding temperature quickly enough, are previously heated in convenient furnaces or by burners 59, regulated in dependence on the rolling speed, for instance, by a centrifugal governor 60 or the like. The lateral flow of molten metal is again prevented by the discs 39 or by the conical grooves 44, shown in Figs. 2 and 3. By choosing suitable materials for the strips 58 and the molten metal of the core, it is possible to obtain profiles the surfaces of which have different properties to those of their core; such as great mechanical hardness, stainlessness, etc.

For rolling seamless tubes, the rolls 2 and 3 are each provided with semi-circular grooves which form at the contact line of the rolls 2 and 3 a circular closed pass of the same diameter as the outside diameter of the tube to be produced (see Figs. 7 and 8). Above the rolls 2 and 3 a motor 61 is arranged with its axis perpendicular to the centre of the circular pass. At the lower end of the hollow motor shaft 62 there is an axially perforated mandrel 63 having the same diameter as the inside diameter of the tube to be produced. A radiator 64 of good heat-conducting material is fixed on the mandrel 63 and has a good thermal contact with the latter. The outside of the radiator 64 is provided with ribs which form a fan for sucking in cooling air through the space between the shaft 62 and the bore of the radiator 64 and pass it through holes in the lower part of the radiator and between these and the diffuser 65, which latter protects the radiator 64 and the motor 61 from the heat radiated by the molten metal between the rolls 2 and 3, the air being finally discharged by the wings on the upper part of the radiator 64. The lateral flow of molten

metal is again prevented by the discs 39 or by the supplementary conical grooves 44 (see Figs. 2 and 3). When molten metal is poured between the rolls 2 and 3, these latter and the mandrel 63 rotating, the inner and outer frozen metal layers with the doughy metal between them are discharged by the rolls 2 and 3 in the form of an incandescent seamless tube 66 supported by the slide 5 during its solidification. The motor shaft 62 and the mandrel 63 are cooled by a gaseous or a liquid refrigerant passed through the holes of shaft 62 and mandrel 63 and blown from there into the inside of the tube 66 to accelerate its solidification. The rolls are cooled in the manner already described.

In order to be able to remove rolled profiles which cannot be wound, such as corners, beams, big sections, tubes, etc., these must be piled up in fixed lengths. The cutting of the profile must take place without influencing its running velocity; for this purpose, the circular saw 67 shown in Fig. 9, together with its driving motor 68 is mounted by means of a common baseplate 69 on two horizontal wheels 70 and 71, coupled together by the chain 72 which forms a parallel guide. For each turn of the wheels 70 and 71, the saw describes a path parallel to the profile 73 and at the same time perpendicular to it, and therefore cuts the profile 73 into a length depending on the diameter of the wheels 70 and 71. In order to be able to cut any desired length with one diameter of wheels 70 and 71, these are geared by the asynchronous motor 74 connected to its slip-regulator 75, allowing a slip of about 100% for several torques of the motor 74; the wheel 71 is provided with a stop 76 retained in position by the brake-arrester 77 which is controlled by the contact-disc 78, this latter being moved at a velocity corresponding to the desired profile length to be cut, by means of the electro-magnet 79. The motor 74 may rotate as soon as the contact-disc 78 energises the electro-magnet 79, which lifts the brake-arrester 77, and releases the stop 76; the saw 67 upon coming into contact with the profile 73, adopts its own longitudinal velocity, cuts through the profile and comes back at an accelerated velocity until the contact-disc interrupts the current of the electro-magnet 79, and the disc 71 being braked by the brake-arrester 77, stops at a low velocity when the stop 76 reaches the brake-arrester 77.

To facilitate piling up of the cut profiles 80, a clearance must be left between them; for this purpose, the profile 73 lies on the rolls 81 connected together by the chains 82 and coupled with the asynchronous motor 83 connected to its slip-regulator 84, so that the speed of the motor 83 will be reduced by the profile 73 and adopts its velocity, due to the slip regulator 84. As soon as the cut profile 80 is detached from the profile 73, the motor 83 accelerates the cut profile 80, thus gaining a free space between it and the profile 73. A series of such rolls installed one behind the other will enable the desired clearance between succeeding profile lengths 80 to be obtained.

The profiles produced may be employed as an ordinary saleable product or as raw material for high quality goods that must be subjected to further treatment, such as a supplementary rolling process or heat treatment, in which latter event the heat of the profile itself may be used.

I claim:

1. Method which comprises pouring molten metal into the laterally and upwardly extending

throat between two horizontally disposed oppositely rotating rolls, the axis of one of said rolls being positioned above and laterally of the axis of the other roll, automatically regulating the rate of pouring of the molten metal into the throat in accordance with variations in the depth of the body in said throat to maintain a substantially constant depth of said body, and automatically regulating the speed of the rolls to maintain a substantially constant temperature of the profiled metal passed by said rolls at a fixed distance therefrom.

2. Method which comprises pouring molten metal into the laterally and upwardly extending throat between two horizontally disposed oppositely rotating rolls, the axis of one of said rolls being positioned above and laterally of the axis of the other roll, automatically regulating the speed of the rolls to maintain a substantially constant temperature of the profiled metal passed by said rolls at a fixed distance therefrom, and supporting the profile leaving said rolls by a slide which is so adjusted as to permit longitudinal movement of the profile thereon without substantial longitudinal pressure or tension.

3. Method which comprises pouring molten metal into the laterally and upwardly extending throat between two horizontally disposed oppositely rotating rolls, the axis of one of said rolls being positioned above and laterally of the axis of the other roll, automatically regulating the speed of the rolls to maintain a substantially constant temperature of the profiled metal passed by said rolls at a fixed distance therefrom, winding the profile upon a winder and automatically regulating the rate of turning of the winder in accordance with the degree of sag of the profile in the horizontal span thereof.

4. Apparatus for rolling molten metal comprising two horizontally disposed reversely turning rolls, the axis of one of said rolls being disposed above and laterally of the axis of the other roll thereby forming a laterally and upwardly extending throat between the rolls capable of holding a quantity of molten metal, a temperature sensitive device positioned to respond to changes in the temperature of the profile leaving said rolls, said device associated with means for regulating the speed of the rolls to maintain a substantially constant temperature of said profile and a downwardly sloping slide associated with the rolls and adapted to receive the profile therefrom, said slide being so adjusted as to permit the profile to slide thereon without substantial longitudinal tension or pressure.

5. Apparatus for rolling molten metal comprising two horizontally disposed reversely turning rolls, the axis of one of said rolls being disposed above and laterally of the axis of the other roll thereby forming a laterally and upwardly extending throat between the rolls capable of holding a quantity of molten metal, a temperature sensitive device positioned to respond to changes in the temperature of the profile leaving said rolls, said device associated with means for regulating the speed of the rolls to maintain a substantially constant temperature of said profile, a winder receiving said profile at a point remote from said rolls, a temperature sensitive device positioned so that variations in the sag of the profile between said rolls and winder will vary the amount of heat radiated to said device, and means associated with said device to vary the speed of the winder and thereby to maintain a substantially constant sag of said profile.

6. Apparatus for rolling molten metal comprising two horizontally disposed reversely turning rolls, the axis of one of said rolls being disposed above and laterally of the axis of the other roll thereby forming a laterally and upwardly extending throat between the rolls capable of holding a quantity of molten metal, means for pouring molten metal into said throat, means for varying the rate of pouring of the molten metal to maintain a substantially constant depth thereof in the throat, a temperature sensitive device positioned to respond to changes in the temperature of the profile leaving said rolls, said device associated with means for regulating the speed of the rolls to maintain a substantially constant temperature of said profile.

7. Apparatus for rolling molten metal com-

prising two horizontally disposed reversely turning rolls, the axis of one of said rolls being disposed above and laterally of the axis of the other roll thereby forming a laterally and upwardly extending throat between the rolls capable of holding a quantity of molten metal, one of said rolls being hollow and provided with means for introducing a vaporizable cooling liquid into the interior thereof and means for discharging vapors of said cooling liquid therefrom, a temperature sensitive device positioned to respond to changes in the temperature of the profile leaving said rolls, said device associated with means for regulating the speed of the rolls to maintain a substantially constant temperature of said profile.

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