July 10, 1934. M. LOW 1,965,603

METHOD OF AND APPARATUS FOR SHAPING PLASTIC MATERIALS

Filed May 28, 1932 5 Sheets-Sheet 1

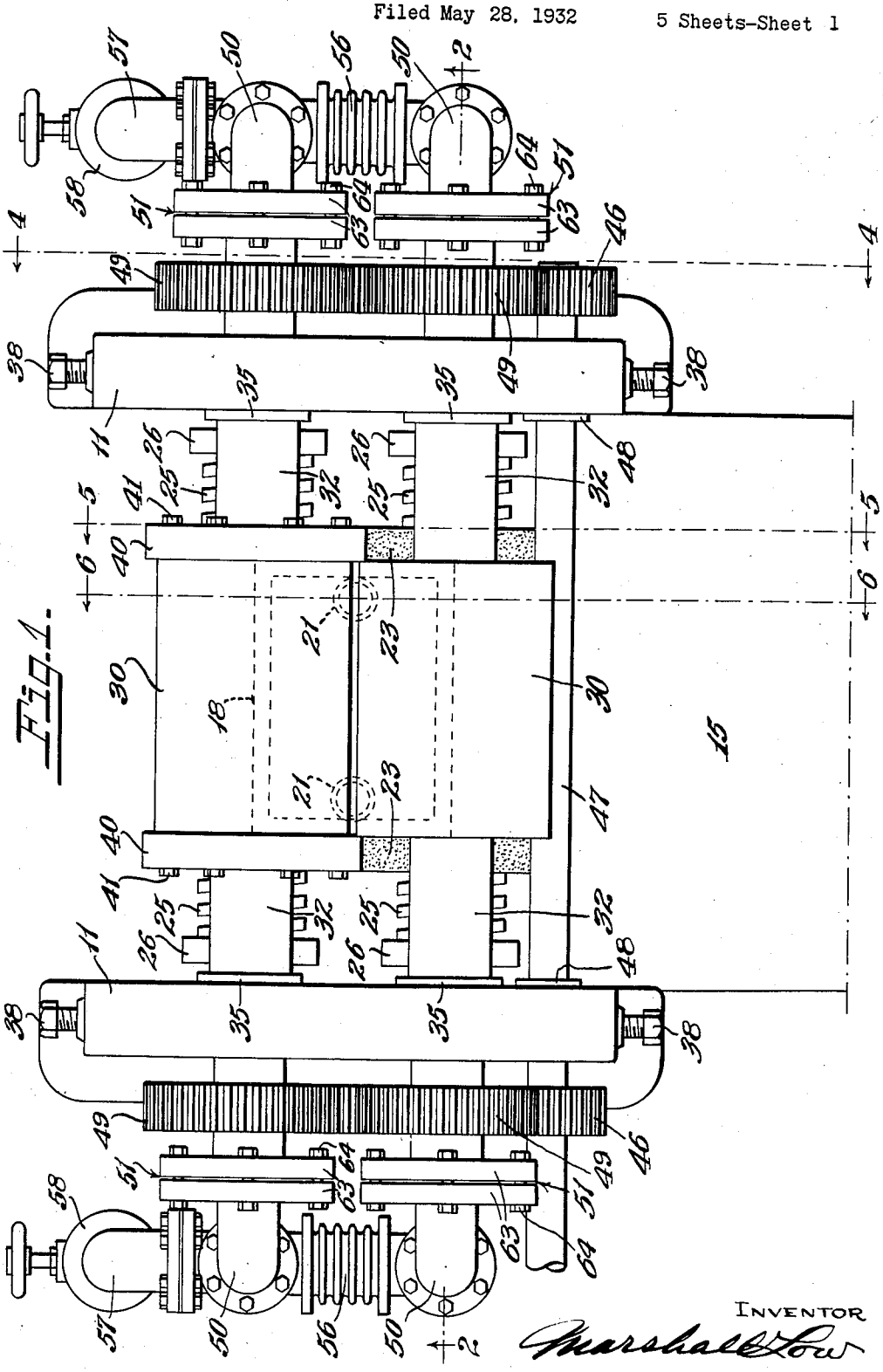


Fig. 1.

INVENTOR

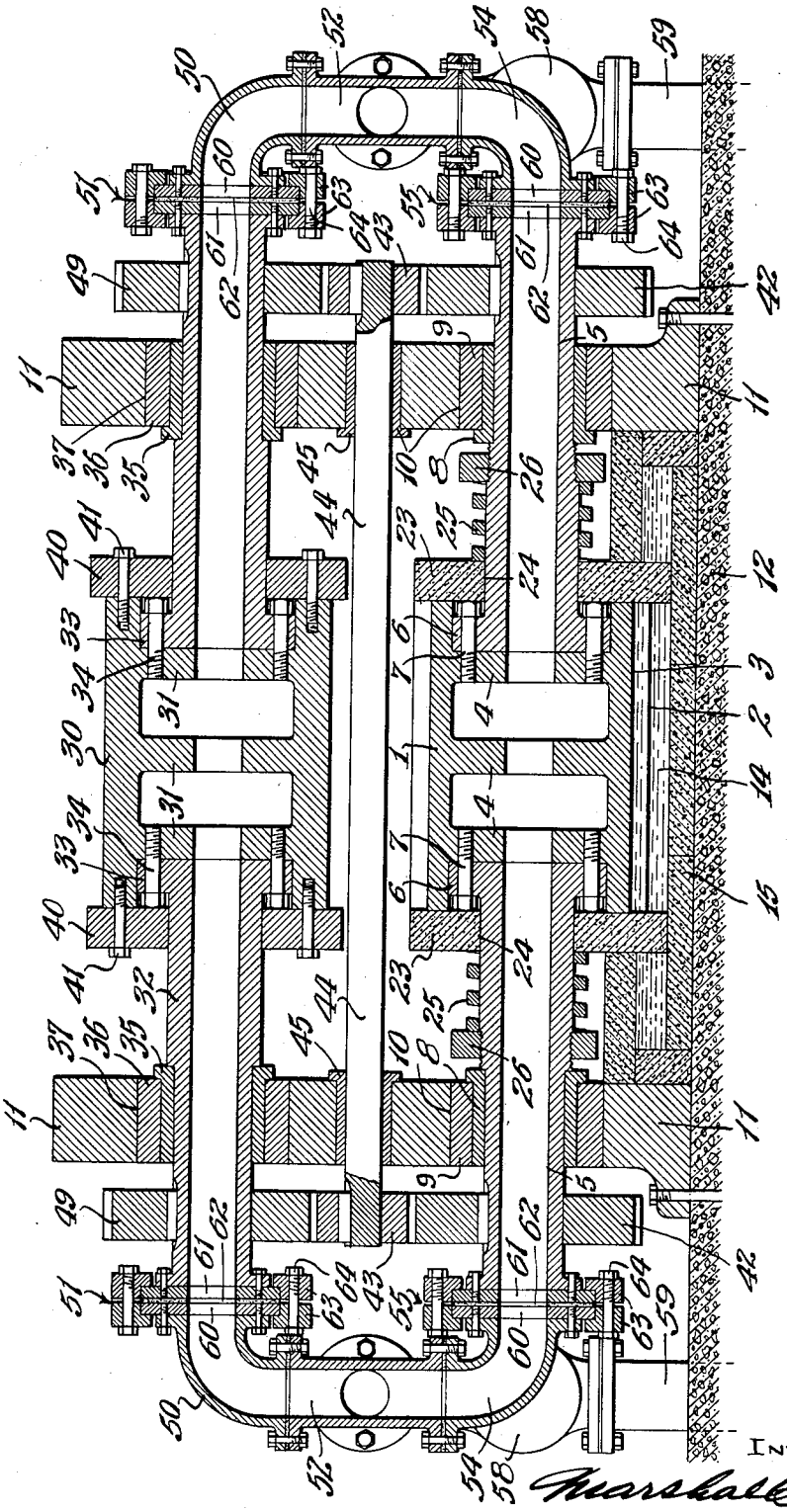
Marshall Low

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METHOD OF AND APPARATUS FOR SHAPING PLASTIC MATERIALS

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Fig. 2.



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Fig. 3.

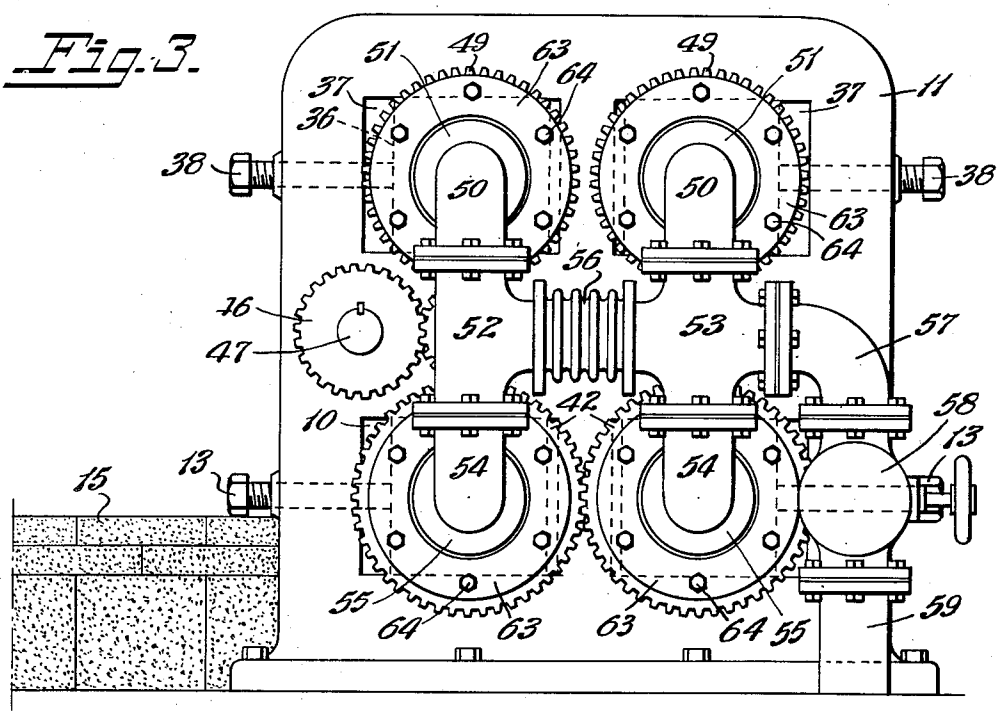
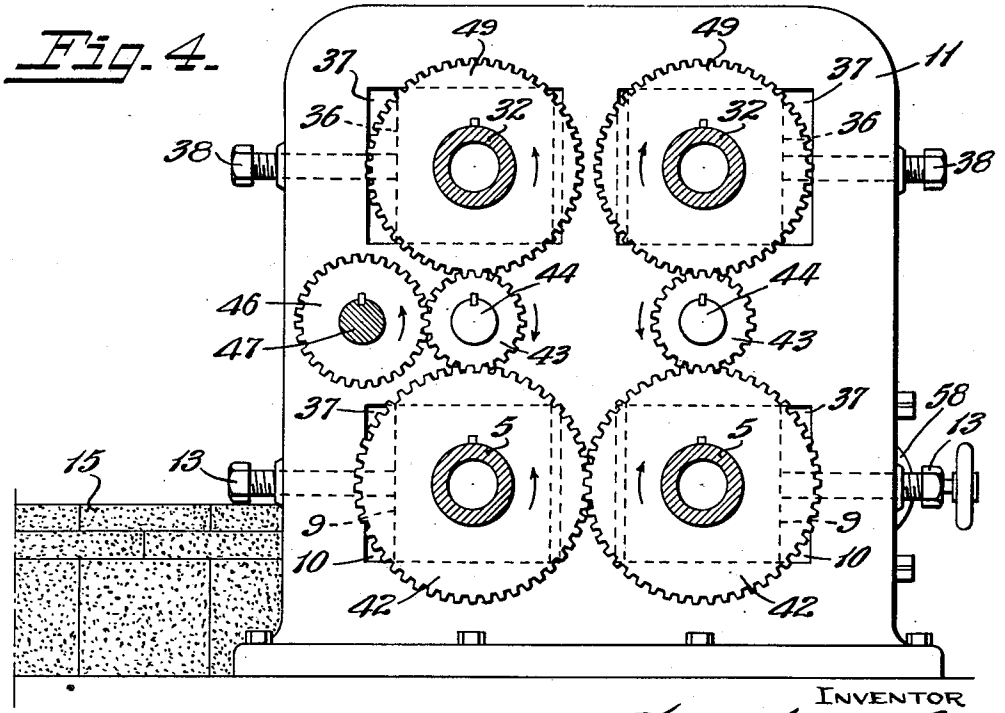


Fig. 4.



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Fig. 5.

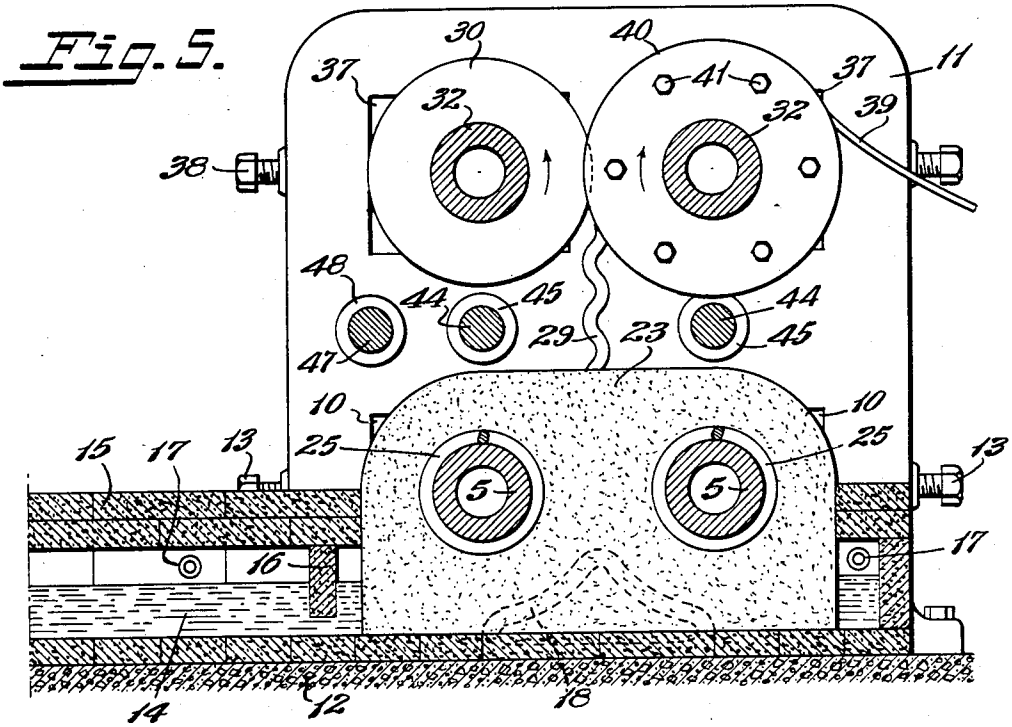
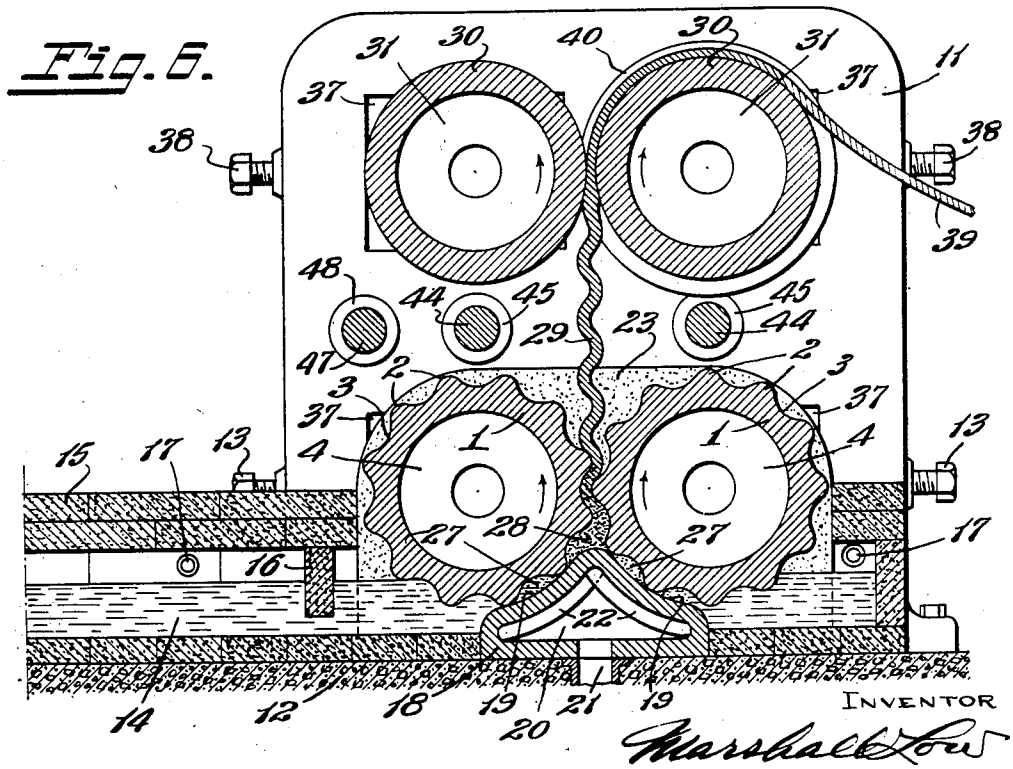


Fig. 6.



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METHOD OF AND APPARATUS FOR SHAPING PLASTIC MATERIALS

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Fig. 7.

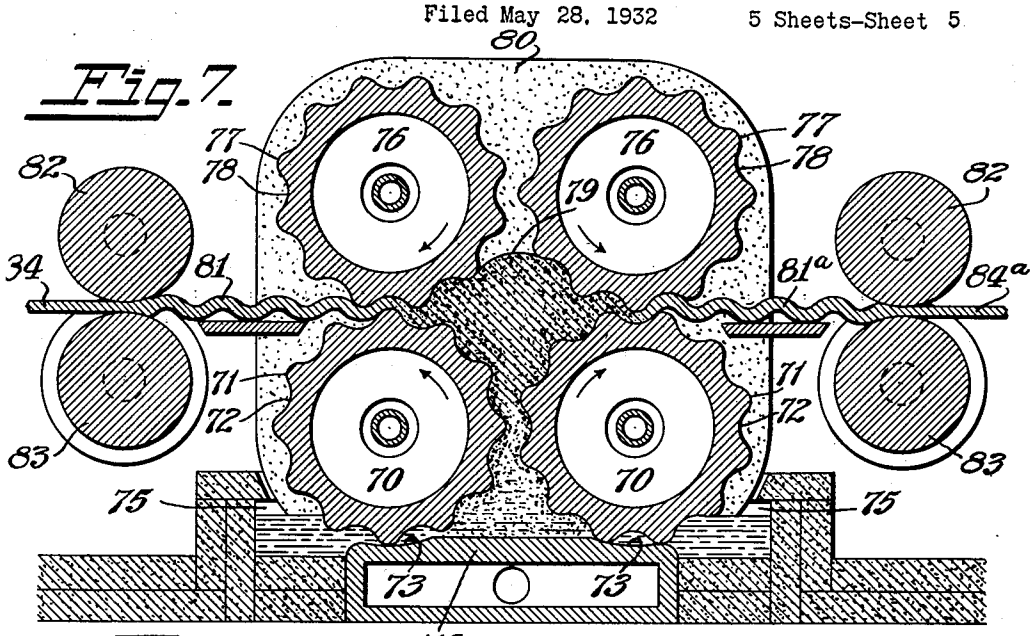
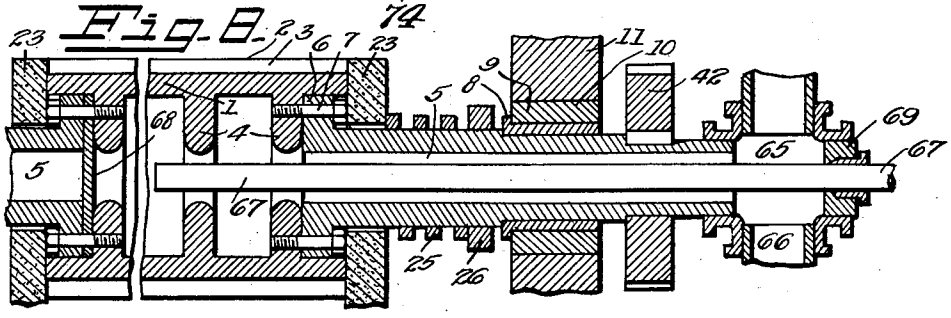


Fig. 8.



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Patented July 10, 1934 1,965,603

UNITED STATES PATENT OFFICE

1,965,603

METHOD OF AND APPARATUS FOR SHAPING PLASTIC MATERIALS

Marshall Low, Washington, D. C., assignor to Harry N. Low, Washington, D. C.

Application May 28, 1932, Serial No. 614,239

20 Claims. (Cl. 207—14)

This invention relates to a method of and apparatus for shaping plastic material and it has particular relation to a method of and apparatus for continuously solidifying and shaping material which is fluid when subjected to heat.

Heretofore, efforts have been made to roll iron and steel continuously from a body of molten metal by introducing the metal while in a molten state, between a pair of rotating rolls but such efforts have thus far been unsuccessful commercially by reason of certain inherent difficulties encountered in this type of apparatus. It has been experienced, among other things, that when such an apparatus was initially placed in operation it was necessary to close the space between the rolls either by moving the rolls toward one another or by obstructing the space therebetween by a gate or plug so as to prevent the hot metal from flowing downwardly therebetween before it had time to become solidified by contact therewith. Also, the fluid level of the pool of metal between the rolls would fluxuate, with the result that the metal flowed unevenly between the rolls in accordance with the hydrostatic head. Also, when the hot metal was poured into the pool its inertia would penetrate the body of the metal to a point adjacent a line of tangency between the rolls and melt the metal already solidified which, resulted in flaws and soft spots in the rolled sheet or bar. Also, if the metal near the line of tangency between the rolls became solidified beyond a certain degree it would not be carried between the rolls but on the contrary, it would be extruded upwardly thereby. Also, the rate of solidification of the metal in contact with the rolls was greatly retarded by reason of the fact that this metal was also in direct molecular contact with the parent body of molten metal thereabove and subject to the transfer of heat therefrom. And lastly, the only force tending to cause the metal to pass between the rolls was that exerted by gravity as the coefficient of friction between the metal and the relatively smooth surfaces of the rolls was negligible.

One of the objects of the present invention is to avoid all of the difficulties hereinabove mentioned, by positively feeding the molten metal upwardly by a pair of cooling and shaping rolls partially immersed in a body of molten metal, at a uniform and constant rate irrespective of the influence of gravity or the hydrostatic level of the molten metal in the pool, thereby resulting in a rolled strip or bar of metal of greater and more uniform density.

Another object of the invention is to provide a device of the character described by means of which bodies of metal of predetermined size are segregated from the parent body of metal in the pool and subjected to uniform cooling while entirely out of contact with such body, thus materially accelerating the rate of solidification of the metal.

With such objects in view, as well as other advantages which may be incident to the use of the improvements, the invention consists of the parts and combinations thereof hereinafter set forth and claimed with the understanding that the several necessary elements constituting the same may be varied in proportion and arrangement without departing from the nature and scope of the invention as defined in the appended claims.

In order to make the invention more clearly understood there are shown in the acompanying drawings, means for carrying the invention into practical effect, without limiting the improvements in their useful application to the particular construction, which for purpose of explanation have been made the subject of illustration.

In the accompanying drawings:

Figure 1 is a plan view of a rolling mill constructed in accordance with the present invention.

Figure 2 is a vertical transverse sectional view taken on line 2—2 of Figure 1.

Figure 3 is a side view of the structure illustrated in Figure 1.

Figure 4 is a vertical longitudinal sectional view taken on line 4—4 of Figure 1.

Figure 5 is a vertical longitudinal sectional view taken on line 5—5 of Figure 1.

Figure 6 is a vertical longitudinal sectional view taken on line 6—6 of Figure 1.

Figure 7 is a diagrammatic vertical sectional view through another form of the invention, and

Figure 8 is a fragmentary longitudinal sectional view through a cooling and shaping roll and directly associated parts showing another construction for introducing the cooling medium into the roll.

Referring to the drawings, an apparatus constructed in accordance with the present invention is shown as comprising a pair of shaping and cooling rolls 1 which are mounted for rotation in opposite directions about spaced horizontal axes and which are each provided with a plurality of alternately arranged longitudinally extending elevations and depressions 2 and 3 respectively, the elevations in one of said rolls registering with the depressions 3 of the adjacent roll at the line of

nearest approach therebetween (Fig. 6). Each of the rolls 1 is of hollow cast construction and is provided with a plurality of internal spaced annular flanges 4 cast integrally therewith which not only serve to reinforce the roll but which function as cooling fins for radiating heat.

Each of the rolls 1 is carried by a pair of axially alined tubular stud shafts 5 having collars 6 at their inner ends which are secured to the flanges 4 at the ends of the rolls 1 by means of bolts 7. These shafts are mounted for rotation in bushings 8 provided in slide bearings 9 which are mounted in ways 10 provided in a pair of side frame members 11 anchored to a suitable concrete base 12. The rolls may be adjusted horizontally toward and away from one another to vary the distance between the rolls and the thickness of the sheet rolled thereby, by means of jack screws 13 which are threaded into the frame members 11 for abutting engagement with the slide bearings 9.

The lower portions of both of the rolls 1 are adapted to be immersed in a pool 14 of molten metal which is contained in a receptacle or forehearth 15 which may be supplied with molten metal directly from an open hearth or induction furnace or from a converter, not shown. A baffle element 16 is provided within the forehearth 15 adjacent to the rolls 1 and functions as a skimmer for excluding dross from the metal delivered to the rolls and which effectively prevents surges of metal in the vicinity of the rolls which might be produced if the molten metal is supplied to the forehearth 15 from a ladle, converter or other extraneous source. Burners 17 are provided in the side walls of the forehearth 15 for maintaining the metal in the pool 14 at the desired temperature and also for minimizing the oxidation of the metal by rendering the atmosphere within the forehearth inert through the consumption of the oxygen therein.

Mounted in the forehearth 15 and directly between the rolls 1 beneath the axis of rotation thereof, is a bridging member or abutment 18, preferably of cast iron construction, which is formed with curved surfaces 19 having a radius of curvature conforming substantially to the maximum radius of the rolls 1. These surfaces 19 constitute a continuation of the bottom of the forehearth 15 and are adapted to be frictionally engaged by the elevations 2 of the rolls 1 when the latter are rotated. The bridging member 18 is formed with a chamber 20 through which a cooling medium such as water or steam is circulated through inlet and outlet pipes 21 in the bottom thereof, and is also formed with a plurality of reinforcing ribs 22 for strengthening the surfaces 19 and for accelerating the dissipation of heat therefrom.

Mounted adjacent to the ends of the rolls 1 and cooperating both with the rolls and with the bridging member 18, is a pair of end members 23 of a refractory material such as firebrick or lava rock, which prevents the escape of metal from the depressions 3 in a longitudinal direction. These members 23 are provided with a pair of openings 24 through which the stud shafts 5 extend and are maintained in yieldable frictional engagement with the ends of the rolls by means of coil springs 25 surrounding the shafts 5 intermedate the end members 23 and adjusting nuts 26 threaded onto the shafts 5.

It will be apparent from the foregoing that the rolls 1 function similar to a gear pump in that the elevations 2 and depressions 3 segregate bodies of molten metal, indicated at 27, from the pool 14 and subjects these bodies to the cooling effect of the rolls and bridging member 18, at points remote from the parent body of metal. The continued rotation of the rolls 1 carries these segregated bodies of metal upwardly into a chamber or space 28 located above the bridging member 18 and directly below the line of nearest approach between the rolls, where the same are united under pressure while plastic to form a homogeneous mass which is then carried upwardly between the rolls and further compressed thereby, the elevations of one roll displacing a portion of the material contained in the depressions of the other roll and distributing the same over the adjacent elevations and into molecular union with the material similarly displaced from the adjacent depressions so as to form a sheet of metal of sinuous cross-section, indicated at 29.

Mounted directly above the rolls 1 is a pair of flattening rolls 30 which are also of hollow cast construction and are formed with a plurality of internal annular flanges 31. Each of these rolls is carried by a pair of axially alined tubular stud shafts 32 having collars 33 at their inner ends which are secured to the flanges 31 at the ends of the rolls 30, by means of bolts 34. These shafts are mounted for rotation in bushings 35 provided in slide bearings 36 which are mounted in ways 37 formed in the side frame members 11. The rolls 30 may also be adjusted horizontally toward and away from one another by means of jack screws 38 which are threaded into the frame members 11 for abutting engagement with the slide bearings 36. From the rolls 1 the strip of metal 29 passes upwardly and between the flattening rolls 30 which removes the sinuous configuration thereof and which also reduces its thickness to form the finished flat strip, indicated at 39. End flanges 40 may be secured to the opposite ends of one of the rolls 30 by means of bolts 41 so as to guide the sheet of metal laterally between these rolls and impart a smooth uniform edge thereto. After passing between the rolls 30 the strip may be passed to other instrumentalities for further shaping or treatment if so desired.

The rolls 1 are rotated in unison and are maintained in proper relative angular positions by means of a pair of intermeshing gear wheels 42 which are keyed to the outer ends of the tubular stud shafts 5 and which mesh with intermediate pinions 43 keyed to the outer ends of two parallel jack shafts 44 which are journaled in bearings 45 provided in the side frame members 11. The gear wheels 42 are rotated in unison by means of drive pinions 46 which are fixed to the ends of a horizontally extending drive shaft 47 which extends parallel to the shafts 44 and which is journaled in bearings 48 also provided in the side frames 11. This shaft may be driven at the desired rate of speed by any suitable prime mover, not shown. Gear wheels 49 are also fixed to the outer ends of the tubular stud shafts 32 for intermeshing engagement with the intermediate pinions 43 on the opposite sides thereof from the gear wheels 42 whereby the flattening rolls 30 are rotated in unison with the cooling and shaping rolls 1. By means of this particular construction when power is applied to the drive shaft 47 the rolls 1 are rotated in opposite directions with their inner portions moving upwardly so as to extract metal from the pool 14 in the forehearth 15. By reason of the fact that the strip of metal is attenuated when flattened by the rolls 30 it is necessary to rotate these rolls at a slightly faster

rate than are the cooling and shaping rolls 1 in order to prevent an excess quantity of metal from accumulating between the shaping rolls 1 and the flattening rolls 30. This is accomplished by constructing the gear wheels 49 with a pitch diameter slightly less than that of the gear wheels 42.

The cooling and shaping rolls 1 and also the flattening rolls 30 are cooled by a cooling medium such as water or steam which is circulated therethrough in regulable quantities sufficient to dissipate rapidly the heat transferred thereto from the hot metal and to cause the molten metal in contact with the rolls 1 to crystallize and form a relatively plastic mass capable of retaining a shape imparted thereto. To this end elbows 50 are provided which are communicably connected at the upper ends with the tubular stud shafts 32 by packing members 51 so as to permit of the free rotation of these shafts and at the same time prevent leakage. As viewed in Figure 3 of the drawings, the forward elbows 50 communicate at their lower ends with T pipe fittings 52 while the rear elbows 50 communicate at their lower ends with cross pipe fittings 53. Also, elbows 54 are provided which are communicably connected at their lower ends with the tubular stud shafts 5 by packing members 55 similar in construction and operation to the packing members 51. With reference still to Figure 3 of the drawings, the forward elbows 54 communicate at their upper ends with the lower ends of the T pipe fittings 52 while the rear elbows 54 communicate at their upper ends with the lower ends of the cross pipe fittings 53. The T fittings 52 and cross fittings 53 are communicably connected by yieldable bellows devices 56 so as to permit of a slight amount of adjustment of the distance between the rolls 1 and 30 without interfering with the circulation of the cooling medium through the system. The rear ends of the cross fittings 53 communicate through elbows 57 with the upper ends of manually operable valves 58 which, in turn, communicate at their lower ends with pipes 59. By means of this arrangement either of the pipes 59 may lead to the source of supply of the cooling medium and either of those pipes may be employed as an over-flow or outlet according to the particular requirement incident to the installation. Thus, the cooling medium introduced into the system from either side of the apparatus will separate into four independent streams each passing through one of the several rolls 1 and 30 and after extracting heat therefrom will join and pass from the system at the other side of the apparatus.

The packing members 51 and 55 each preferably comprises a pair of annular members 60 and 61 which are bolted to the ends of their associated elbows and stud shafts with an intermediate packing element 62 disposed therebetween. The members 61 are maintained in close proximity to one another by means of a pair of clamping members 63 which are secured together by means of bolts 64. Thus, it will be apparent that when the stud shafts are rotated the annular members 61 will rotate therewith with the inner face thereof frictionally engaging the packing member 62. Any heat which may be generated through friction will be quickly dissipated by the cooling medium passing through the system. By means of this construction an effective seal is provided for preventing the leakage of cooling medium where the several conduits communicate with the rotating stud shafts.

In Figure 8 there is shown another form of construction which may be employed for introducing the cooling medium into each of the rolls through one end only thereof and for permitting the same to escape from the roll through the same end. As illustrated in this figure, the outer end of one of the tubular stud shafts of one of the rolls, for example, the shaft 5 of a lower cooling and shaping roll 1, is rotatably mounted in one arm of a cross pipe fitting 65 which communicates with a discharge pipe 66 leading to a drain, not shown. The cooling medium is admitted through an inlet pipe 67 which extends through the cross fitting 65 and coaxially through the associated stud shaft 5 in radially spaced relation thereto, and into the roll 1 to a point intermediate the ends thereof. The opposite end of the roll 1 is closed by an end wall member 68 which is secured in position between the end flange 4 and the abutting end of the other stud shaft 5. Leakage of the cooling medium at the point where the inlet pipe 67 enters the cross fitting 65 is prevented by a packing gland 69 which is threaded into the cross fitting 65 for sealing engagement with the inlet pipe 67. The cooling medium thus introduced into the roll 1, doubles back upon itself and escapes through the tubular shaft 5, around the inlet pipe 67, and through the cross fitting 65 to the discharge pipe 66. This form of construction is very efficient and simplifies the installation of the apparatus and the necessary supply and discharge mains.

In Figure 7 there is illustrated another form of apparatus which is designed to produce a pair of sheets or bars simultaneously. In this construction, a pair of laterally spaced lower rolls 70, each having a plurality of longitudinally extending elevations 71 and intervening depressions 72, are mounted for rotation about horizontal axes and with the elevations 71 thereof in substantially contiguous relation with arcuate surfaces 73 formed on a hollow bridging member 74 which is disposed within a forehearth 75 and between the rolls 70, and through which a cooling medium also is circulated. A pair of rolls 76 similar to the rolls 70 are rotatably mounted directly above the rolls 70 with the elevations and depressions 77 and 78 thereof in intermeshing spaced relation with the elevations and depressions 71 and 72 respectively of the rolls 70. The circumferential surfaces of the rolls 70 and 76 cooperate to define an upper chamber 79 for receiving the material delivered thereto upwardly between the lower rolls 70. End members 80 of suitable construction and material, are provided to prevent the escape of material from the depressions 72 of the rolls 70 and from the chamber 79 in a longitudinal direction.

The rolls 70 and 76 are suitably driven in unison in the direction indicated by the arrows in Figure 7, so as to move the relatively plastic metal from the chamber 79 horizontally outwardly in opposite directions between the rolls 70 and 76 in order to produce two sheets 81 and 81^a simultaneously. In this embodiment of the invention a pair of upper and lower flattening rolls 82 and 83 may be provided on each side of the apparatus for removing the corrugations in the sheets 81 and 81^a so as to form two flat sheets 84 and 84^a.

This construction is more particularly claimed in a copending application, Serial No. 636,080, filed Oct. 3, 1932, which constitutes a continuation in part of this application.

The apparatus has thus far been described for

use in connection with rolling metallic sheets and bars from metal delivered thereto in a molten state but it will be readily apparent to those skilled in the art that the apparatus with slight changes is adaptable for use in connection with the fabrication of plate and sheet glass. When the apparatus is employed in connection with molding or rolling plate glass the rolls 1 and 30 may be constructed of a refractory composition containing a relatively high proportion of graphite or these rolls may be constructed of cast metal with their surfaces impregnated or otherwise treated with graphite in order to prevent sticking.

From the foregoing it will be apparent that an apparatus is provided in which material delivered thereto in a fluid state may be segregated into separate relatively small bodies and subjected to uniform cooling action entirely around such bodies thus greatly increasing the rate of solidification and that the bodies being thus rendered plastic are united with one another under pressure and further cooled and compressed to form a relatively self supporting strip which may thereafter be further reduced in thickness and cooled to provide a sheet of material requiring little or no additional fabricating operations. It will also be apparent that not only is the speed of operation materially increased by the accelerated cooling above referred to but that the feed of the material rendered plastic by cooling is positive and uniform in its action irrespective of the level of the supply of fluid material in the pool.

It will be understood that in practice the cross-sectional area of the pipes and fittings 52, 53, 56, 57, 58 and 59 in the several figures will be large enough to deliver cooling medium to the rolls in accordance with the maximum capacity of the tubular stud shafts 5 and 32, thus rendering it possible to obtain the necessary cooling effect. Also, if the forehearth 15 is connected directly to an open-hearth or induction furnace cooling means may be provided within the forehearth, in addition to the bridging member 18, for reducing the temperature of the molten metal before it is delivered to the rolls 1.

It will be understood that petcocks may be provided where necessary for permitting the escape of steam and air which may become trapped in the system and also for draining the system when not in use and for permitting the escape of steam condensing in the lower portions of the system. Also, safety valves may be provided at appropriate points so as to eliminate the danger of an explosion in the event that the operation of the apparatus should, from any cause, be discontinued or interrupted when there is molten metal within the forehearth 15 and water trapped within the cooling system.

What is claimed is:

1. The method of fabricating sheets or bars from plastic material which consists in successively segregating quantities of fluid material from a supply of such material, reuniting the segregated quantities of material to form a homogeneous plastic mass, by rotating a pair of spaced corrugated rolls adjacent to an abutment, and subsequently shaping said plastic mass into sheet or bar form by passing the same through the space between said rolls.

2. The method of fabricating sheets or bars from plastic material which consists in successively segregating and elevating quantites of fluid material from a pool of such material, reuniting the segregated quantities of material to form a homogeneous plastic mass, by rotating a pair of spaced corrugated rolls adjacent to an abutment; and subsequently shaping said plastic mass into sheet or bar form by passing the same upwardly through the space between said rolls.

3. The method of fabricating metallic sheets or bars from metal delivered in a molten condition which consists in successively segregating quantities of molten metal from a parent body of such metal, reducing the temperature of the metal thus segregated to render the same relatively plastic, reuniting the segregated quantities of plastic metal to form a homogeneous mass, by rotating a pair of spaced corrugated rolls adjacent to an abutment, and subsequently shaping said plastic mass into sheet or bar form by passing the same through the space between said rolls.

4. The method of fabricating sheets or bars from metal delivered in a molten condition which consists in successively segregating and elevating quantities of molten metal from a pool of such metal, reducing the temperature of the metal thus segregated to render the same relatively plastic, reuniting the segregated quantities of plastic metal to form a homogeneous mass, by rotating a pair of spaced corrugated rolls adjacent to an abutment, and subsequently shaping said plastic mass into sheet or bar form by passing the same upwardly through the space between said rolls.

5. A method of continuously rolling metallic sheets and bars which comprises the steps of segregating and elevating successive quantities of molten metal from a parent body in a pool of such metal by rotating a pair of spaced corrugated rolls adjacent to an abutment, cooling the metal thus segregated to accelerate the rate of solidification thereof and to render the same relatively plastic, reuniting the segregated quantities of metal under compression to form a homogeneous mass, kneading the metal to expell trapped gases and to reduce the crystalline structure thereof; and passing the metal thus treated between said rolls while still plastic under its original heat to fabricate the same into a continuous sheet or bar, all of said steps occurring in sequence and in timed relation with respect to one another.

6. A method of continuously rolling metallic sheets and bars which comprises segregating and elevating successive quantities of molten metal from a parent body in a pool of such metal by rotating a pair of spaced corrugated rolls adjacent to an abutment at a substantially uniform rate, extracting heat from opposite sides of the metal thus segregated to accelerate the rate of solidification thereof and to render the same relatively plastic, reuniting the segregated quantities of metal under compression to form a homogeneous mass, subsequently passing the metal thus united between said rolls, while still plastic under its original heat, to fabricate the same into a continuous sheet or bar, and varying the rate of cooling in accordance with the temperature of the metal and the rate of said segregation, all of said steps occurring in sequence and in timed relation with respect to one another.

7. In a plastic-material-shaping apparatus having a compression chamber with a sheet-shaping outlet therefrom and means for feeding plastic material in segregated quantities successively to said chamber, a rotatable corrugated roll forming a portion of said feeding means, one wall of said compression chamber and one wall of said outlet.

8. In a plastic-material-shaping apparatus

having a compression chamber with a sheet-shaping outlet therefrom and means for feeding molten metal in segregated quantities successively to said chamber, a rotatable corrugated roll forming a portion of said feeding means, one wall of said compression chamber and one wall of said outlet, and means for cooling said segregated quantities of metal while being fed to said chamber.

9. In a plastic-material-shaping apparatus having a compression chamber with a sheet-shaping outlet therefrom and means for feeding molten metal in segregated quantities successively to said chamber, a rotatable corrugated roll forming a portion of said feeding means, one wall of said compression chamber and one wall of said outlet, and means for cooling opposite sides of said segregated quantities of metal while being fed to said chamber.

10. In a plastic-material-shaping apparatus having a compression chamber with a sheet-shaping outlet therefrom and means for feeding plastic material in segregated quantities successively to said chamber, a rotatable corrugated roll forming a portion of said feeding means, one wall of said compression chamber and one wall of said outlet, and a receptacle for containing a supply of plastic material, said roll extending into proximity to a material confining surface of said receptacle.

11. In a plastic-material-shaping apparatus having a compression chamber with a sheet-shaping outlet therefrom and means for feeding plastic material in segregated quantities successively to said chamber, a rotatable corrugated roll forming a portion of said feeding means, one wall of said compression chamber and one wall of said outlet, and means disposed in yieldable engagement with the ends of said roll for preventing the escape of material from said chamber longitudinally of said roll.

12. In a plastic-material-shaping apparatus having a compression chamber with a sheet-shaping outlet therefrom and means for feeding plastic material in segregated quantities successively to said chamber and for feeding said material therefrom through said outlet in sheet form, a rotatable corrugated roll forming a portion of said feeding means, one wall of said compression chamber and one wall of said outlet, said roll acting on said material to form the sheet with an undulatory surface, flattening rolls associated with said corrugated roll for removing the undulations from said sheet, and means for rotating said flattening rolls in synchronism with said corrugated roll and at an increased rate of speed to prevent material from accumulating between said corrugated roll and said flattening rolls occasioned by the attenuation of said sheet when the undulations therein are removed.

13. Apparatus of the character described comprising a pair of opposed rolls, each having a plurality of circumferentially arranged longitudinally extending elevations and depressions, and both of said rolls being mounted for rotation in unison with the elevations of one of said rolls in constantly registering spaced relation to the depressions of the other of said rolls at the line of nearest approach therebetween to provide a sheet forming pass; bridging means disposed in proximity to the elevations of both of said rolls and cooperating with the circumferential surfaces of said rolls to define a chamber adjacent to the entrance of said pass; and means for rotating said rolls to cause the elevations and depressions of both of said rolls to cooperate with said bridging means and move a succession of substantially segregated quantities of plastic material into said chamber from a source of such material located exteriorly thereof, and thence through said pass to be shaped by said rolls into a sheet of substantially corrugated configuration.

14. Apparatus of the character described comprising a pair of opposed rolls, each having a plurality of circumferentially arranged longitudinally extending elevations and depressions, and both of said rolls being mounted for rotation in unison with the elevations of one of said rolls in constantly registering spaced relation to the depressions of the other of said rolls at the line of nearest approach therebetween to provide a sheet forming pass; bridging means disposed in proximity to the elevations of both of said rolls and bridging the depressions between such elevations to define a plurality of compartments adjacent to the entrance of said pass for receiving and confining substantially segregated quantities of plastic material; and means for rotating said rolls to convey the material contained in said compartments through said pass and to compress and unite the same to form a sheet of substantially corrugated configuration.

15. Apparatus of the character described comprising a receptacle for containing a supply of material fluid when heated; a pair of opposed rolls, each having a plurality of circumferentially arranged longitudinally extending elevations and depressions, and both of said rolls being mounted for rotation in unison with the elevations of one of said rolls in constantly registering spaced relation to the depressions of the other of said rolls at the line of nearest approach therebetween to provide a sheet forming pass, and with both of said rolls extending into said material and into proximity to a material confining surface of said receptacle and cooperating with such surface to define a chamber below said pass; and means for cooling said rolls to reduce the temperature of the material in proximity thereto and render the same relatively plastic, both of said rolls being operable when rotated to cooperate with said surface and move a succession of substantially segregated quantities of material into said chamber from said receptacle and thence upwardly through said pass to be shaped by said rolls into a sheet of substantially corrugated configuration.

16. Apparatus of the character described comprising a receptacle for containing a supply of material fluid when heated; a pair of opposed rolls, each having a plurality of circumferentially arranged longitudinally extending elevations and depressions, and both of said rolls being mounted for rotation in unison with the elevations of one of said rolls in constantly registering spaced relation to the depressions of the other of said rolls at the line of nearest approach therebetween to provide a sheet forming pass, and with both of said rolls extending into said material in said receptacle; means disposed within said receptacle in substantially sealing relation to the elevations of both of said rolls and bridging the depressions therebetween to define a plurality of compartments adjacent to the entrance of said pass; means for cooling said rolls to reduce the temperature of the material in contact therewith and render the same relatively plastic, both of said rolls being operable when rotated, to cooperate with said bridging means and successively segregate successive quantities

of material from said supply and to convey the same upwardly through said pass and to compress and unite the same to form a sheet of substantially corrugated configuration.

17. Apparatus of the character described comprising a pair of opposed rolls, each having a plurality of circumferentially arranged longitudinally extending elevations and depressions, and both of said rolls being mounted for rotation in unison with the elevations of one of said rolls in constantly registering spaced relation to the depressions of the other of said rolls at the line of nearest approach therebetween to provide a sheet forming pass; bridging means disposed in proximity to the elevations of both of said rolls and bridging the depressions between such elevations to define a plurality of compartments adjacent to the entrance of said pass for receiving and confining substantially segregated quantities of molten metal; means for rotating said rolls to convey the material contained in said compartments through said pass and to compress and unite the same to form a sheet of substantially corrugated configuration; and means for circulating a cooling medium through said rolls and said bridging means to extract heat from opposite sides of the metal contained in said compartments, thus to accelerate the solidification thereof.

18. Apparatus of the character described comprising a pair of rolls, each having a plurality of peripherally arranged longitudinally extending elevations and depressions, mounted for rotation in opposite directions with the elevations of one of said rolls registering with the depressions in the other of said rolls at the line of nearest approach therebetween and in spaced relation with respect to one another; stationary bridging means disposed in substantially sealing relation with the elevations of both of said rolls and cooperating with the circumferential surfaces thereof for defining a closed chamber adjacent the entrance side of said rolls, said elevations and depressions being operable when said rolls are rotated to convey successive quantities of plastic material into said chamber from points exterior thereof, and thence outwardly therefrom between said rolls to be compressed and united thereby prior to delivery from said rolls to form a continuous strip of substantially corrugated configuration; flattening rolls cooperating with said first mentioned rolls for removing the corrugations in said strip to form a substantially flat sheet; and means for rotating said flattening rolls in synchronism with said first mentioned rolls and at an increased rate of speed.

19. Apparatus of the character described comprising a receptacle for containing a lake of plastic material; a pair of rolls disposed in spaced relation and mounted for rotation in opposite directions about parallel axes located in a plane extending at an angle to the vertical, each of said rolls having a plurality of peripherally arranged longitudinally extending elevations and depressions, and with both of said rolls extending into the lake of material in said receptacle; means located between said rolls and having arcuate surfaces disposed in sealing relation with the elevations of said rolls and cooperating therewith to form a chamber located below the plane of the axes of said rolls; and means for rotating said rolls to cause the elevations and depressions of said rolls to cooperate with said member to successively segregate separate quantities of said material from the parent body of said lake and to carry the same into said chamber and thence upwardly between said rolls to be compressed and united thereby prior to delivery from between said rolls to form a continuous strip.

20. Apparatus of the character described comprising a receptacle for containing a lake of molten metal; a pair of hollow rolls disposed in spaced relation and mounted for rotation in opposite directions about parallel axes located in a substantially horizontal plane, each of said rolls having a plurality of peripherally arranged longitudinally extending elevations and depressions, and with both of said rolls extending into the material of said lake; a hollow confining member located between said rolls and having arcuate surfaces disposed in sealing relation with the elevations of both of said rolls and forming therewith a chamber located below the plane of the axes of said rolls; and means for rotating said rolls to cause the elevations and depressions of said rolls to cooperate with said member to successively segregate separate quantities of said material from the parent body of said lake and to carry the same into said chamber and thence upwardly between said rolls to be compressed and united thereby prior to delivery from between said rolls to form a continuous strip; and means for circulating a cooling fluid through said rolls and said confining member to extract heat from opposite sides of the material contained in said depressions, thus to accelerate the solidification thereof.

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