United States Patent [19]

Lauener

[11] **3,769,826**

[45] **Nov. 6, 1973**

[54] **APPARATUS FOR ROLLING METAL STRIP**

[75] Inventor: **Wilhelm Friedrich Lauener,** Rikon, Switzerland

[73] Assignee: **W. F. Lauener AG,** Rikon, Switzerland

[22] Filed: **May 4, 1972**

[21] Appl. No.: **250,343**

[30] **Foreign Application Priority Data**

May 6, 1971 Switzerland 6693/71

[52] **U.S. Cl.** **72/191,** 72/249

[51] **Int. Cl.** **B21b 21/00,** B21b 35/00

[58] **Field of Search** 72/191, 194, 249, 72/190, 199, 189

[56] **References Cited**

UNITED STATES PATENTS

2,811,060	10/1957	Sendzimir	72/190
2,710,550	6/1955	Sendzimir	72/191 X

Primary Examiner—Milton S. Mehr
Attorney—Robert E. Burns et al.

[57] **ABSTRACT**

The disclosed apparatus for rolling metal strip comprises a driven rotary roller system on both sides of the strip to be worked. Each roller system comprises a mainshaft and at least two rollers rotatably mounted on this mainshaft parallel to the latter and rotatable from a special drive through the agency of friction clutches. The rollers in each system are uniformly distributed around the respective mainshaft and at the same radial distance from the latter. The mainshafts and roller systems are synchronously driven in relatively opposite directions, and the rollers in the two systems are so arranged that they meet the strip in pairs, one from each system, on the two sides of the strip. The strip is fed between the two roller systems by two driven feed rollers having a weight sufficient to absorb vibrations which are set up in the metal strip by the action of the roller systems.

1 Claim, 3 Drawing Figures

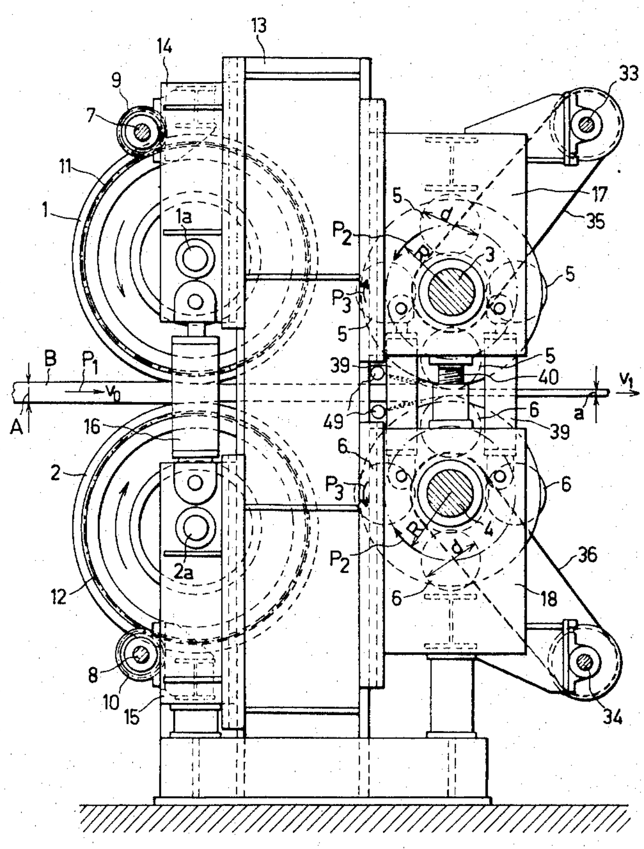


Fig. 1

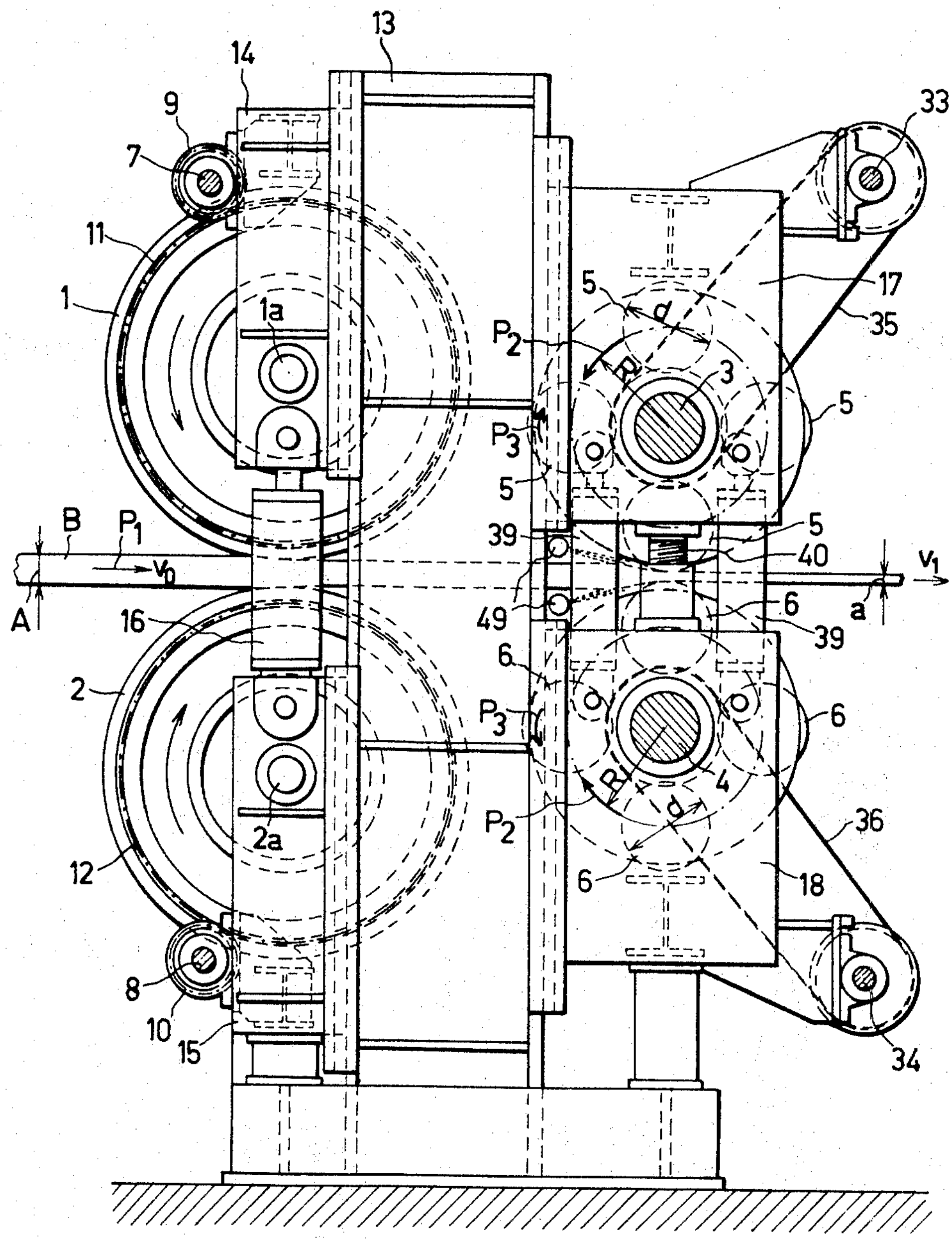

13
14
9
7
33
11
1
1a
5
d
17
35
P2
R
3
5
P3
5
B
P1
v0
39
5
40
v1
A
49
6
a
39
16
6
2
P3
6
R
4
d
P2
36
2a
12
6
18
8
10
15
34

Fig. 2

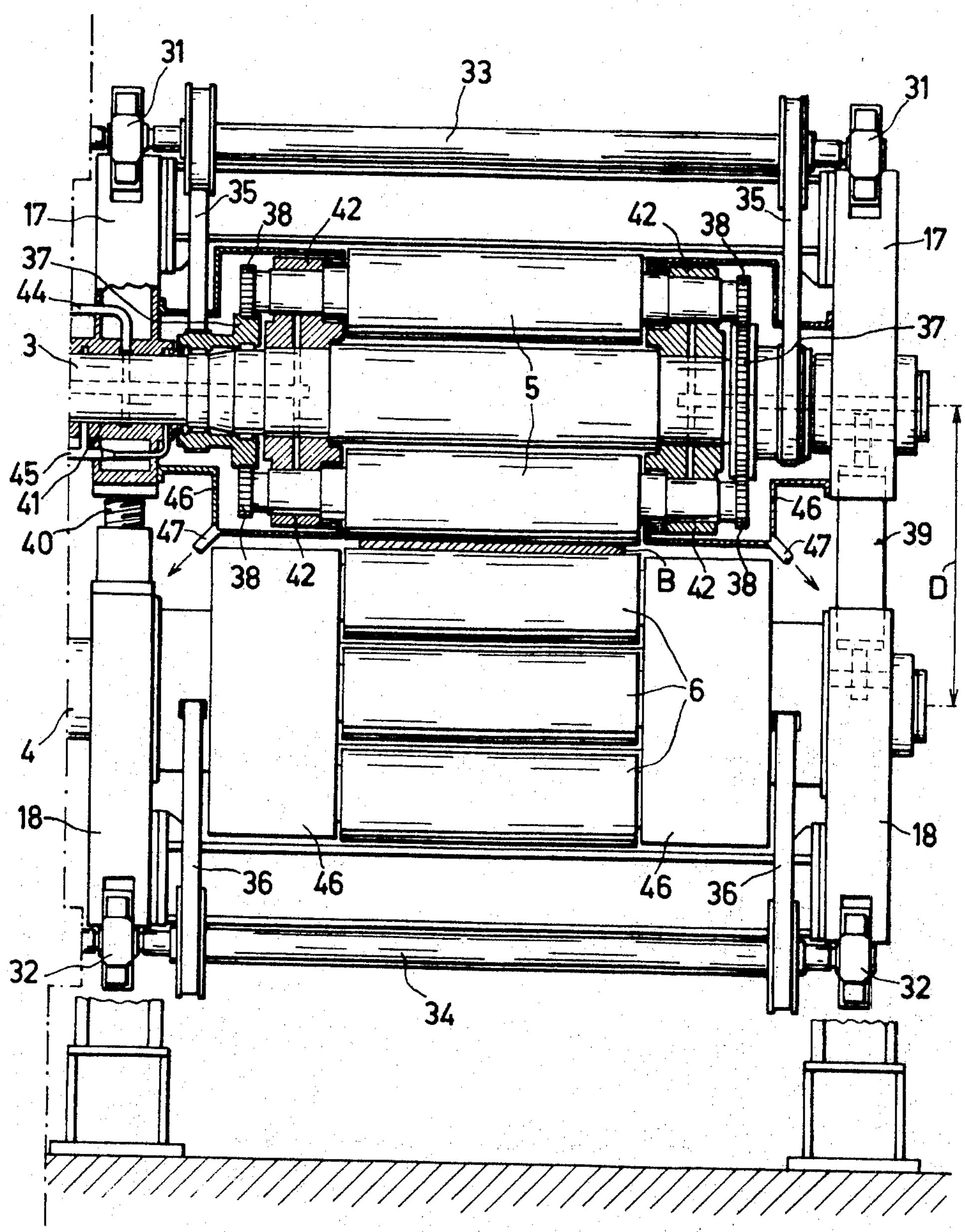
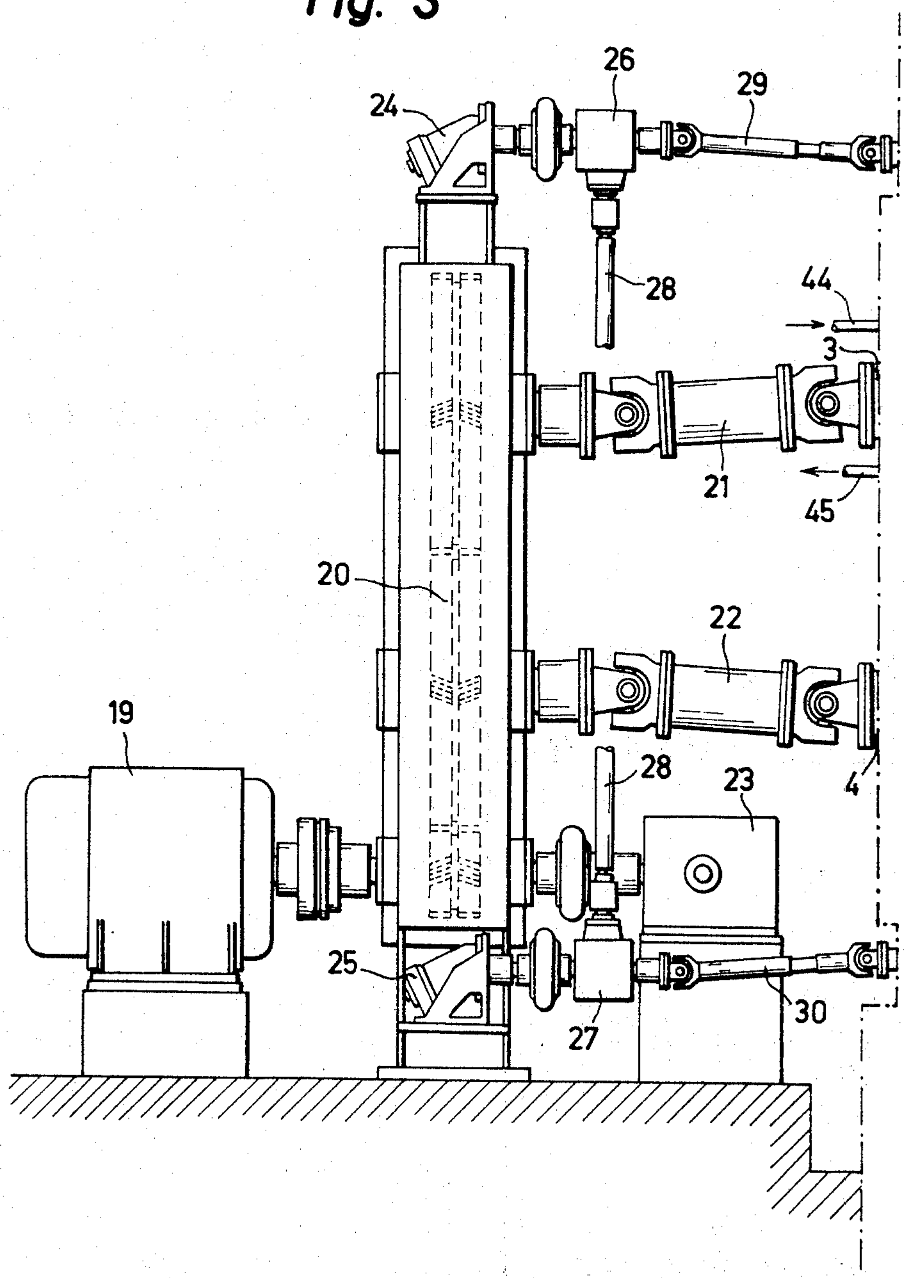

31
33
31
35
38
42
42
38
35
17
17
37
44
37
3
5
45
41
46
46
40
47
47
39
38
42
B
42
38
D
6
4
18
18
36
46
46
36
32
34
32

Fig. 3



APPARATUS FOR ROLLING METAL STRIP

The invention relates to apparatus for rolling metal strips.

There exists a requirement for forming cast blocks or metal strips in maximum feasible reduction stages into such a thickness, generally 6 to 8 mm, as to make them suitable for being coiled. In particular this applies in association with continuously operating strip casting plants which produce cast strip of more than 12 mm thickness.

It is common to arrange powerful two- or four-high rolling mills following strip casting machines of this character to form the cast strip down to the thickness which is required as a preliminary. Whereas in the case of relatively narrow strips or soft materials, such as high grade aluminum, this requirement can be met with one single roll stand (Schweizer Aluminium Rundschau No. 3/1964), in the case of strips with a width which may for example exceed 500 mm, and in cases where harder materials or strips have to be dealt with and which have to be cast in relatively thick gauge for technical reasons, a plurality of successive roll stands is necessary (The Engineer, Dec. 25, 1964, Page 1,065). Plants of this nature are extremely expensive to install and also to maintain. Moreover their erection demands a large floor-space and expensive foundations. The economy of these installations for the purpose stated is greatly impaired by the fact that only a small portion of the actual operating capacity of these roll stands can be utilised because of the very small strip speed imposed by the casting machines.

In order to avoid these defects, it has been proposed to use so-called planetary rolling mills (Light Metals and Industry, January 1965, Page 60) or swing roll stands (The Engineer, Nov. 22, 1963, Page 842). These arrangements have the advantages over the method indicated above of achieving a very high reduction ratio in one pass, wherefore the entire deformation required can be performed in one single machine even with harder materials. It has been found in practice, however, that these apparatus are only suitable for comparatively small widths of strip because of the deflection of the operating rollers on account of their relatively small diameter. Further arrangements for the working of strips and bars even with utilisation of the heat available from the casting operation are described in the "Handbuch des Stranggiessens" by Dr. Hermann on pages 446 to 453.

It is an object of the present invention to devise an apparatus which is able to cope in the single stage with thickness reductions hitherto only possible with devices as mentioned above. The apparatus here proposed for this purpose is however much simpler as a result of which its installation and operating costs are considerably smaller, and it also has substantially more favourable economical features in relation to known plants of this character. Moreover, strips of any width can be handled, so that the range of utilisation of the apparatus is correspondingly greater.

The apparatus according to the invention comprises two driven feed rollers, the weight of which is about 80 to 120 kp per centimetre strip width, and a rolling assembly, and it is characterised by the fact that this assembly comprises a driven rotary roller system on both sides of the strip to be worked, each such system comprising a mainshaft rotatable in bearing blocks at the

two ends which are adjustable relatively to one another, and at least two rollers rotatably mounted on this mainshaft parallel to the latter and rotatable from a special drive through the agency of friction clutches, the width of these rollers being greater than that of the strip which is to be worked, the rollers being all uniformly distributed around the mainshaft and at the same radial distance from the latter, and the mass of the rollers being selected so that the centrifugal force produced by the rotation thereof around the main axis of the roller system concerned is approximately equal to one half the maximum rolling force which is produced, the mainshafts and roller systems being synchronously driven in relatively opposite directions and so coupled together that, by virtue of the rotary motion of the two systems, rollers of these systems meet the strip in pairs, one from each system, simultaneously at the same angle and from the two sides of the strip, as the latter is being moved by the feed rollers between the two systems, the cooperating rollers then engage the strip between them and form it under an appropriate pressure until the minimum distance between the rollers is achieved, and all these pairs of rollers making such rolling engagement at each rotation of the roller systems and forming the forwardly moving strip successively to the required thickness.

A preferred embodiment of the apparatus according to the invention is illustrated in the drawing, in which:

FIG. 1 is a side view of the actual rolling assembly of the apparatus,

FIG. 2 is an end view, partly in section of the rolling assembly of FIG. 1, and

FIG. 3 illustrates the drive means for the rolling assembly.

Two feed rollers 1 and 2, driven at uniform speed, are provided in the illustrated apparatus for advancing the strip B which is to be worked, and which for example arrives from a continuously operating casting machine. Gripper rollers 1 and 2 advance the strip in the direction of arrow P_1 towards the rolling mill (FIGS. 1 and 2) adjoining a casting machine. As is well known in the art, vibrations set up during the rolling procedure are desirably not transmitted back into the casting machine. For this reason it is necessary for the feed rollers 1 and 2 to be dimensioned so that they are of a sufficient mass for the incident vibrations to be practically completely absorbed. The feed rollers must therefore have a mass of approximately 80 to 120 kg per centimetre strip width depending on the resistance to deformation prevailing in the area of the strip which is to be deformed and on the reduction ratio. The roller driving gear is infinitely adjustable to enable the speed of the strip to be accurately set to the prevailing conditions.

The strip is deformed between two rotating roller systems of the rolling assembly which are synchronously driven in opposite directions and are disposed symmetrically in relation to the strip to be worked (FIGS. 1 and 2). In principle these systems are constituted as follows:

The actual working rollers 5, 6, which are somewhat wider than the strip of maximum width to be worked, are arranged on main shafts 3, 4 so as to be disposed parallel to these latter. The rollers 5, 6 are of like form and are distributed uniformly around the main shafts with their centres at a distance R from the axes of the latter, being rotatable in special bearings 42 mounted on these mainshafts. Aside from these bearings there is no contact between the rolls and the mainshafts.

FIG. 1 shows that the two roller systems each comprise four rollers **5** and **6** respectively. It will be understood that in principle there may be two or three rollers only in each system, or more than four rollers.

The distance D separating the axes of the two main shafts **3** and **4** from one another is so chosen that during the rotation of the two systems the rollers **5** and **6** approach to within a distance *a* between one another corresponding to the required thickness of the reduced strip. The driving means for the two rolling systems can be coupled in such a way as to meet the requirements that a pair of rollers, one from each of the two systems, meet the strip simultaneously and at the same angles and thence roll the strip down between them and deform it at an appropriate pressure until the minimum distance between the rollers is reached. As the systems turn the rollers subsequently part and meet together again against the strip after one rotation of the systems.

During the travel of the strip from left to right each roller pair of the roller systems comes into rolling engagement, whereby successive elements in the body of the strip are reduced to the required thickness.

The main shafts **3** and **4** are mounted in bearing blocks **17, 18** which are adjustable relatively to one another to enable the thickness of the deformed strip to be set to the required amount *a*.

The roller systems are rotated by their drive means in the direction of arrow P_2 before the strip to be worked is introduced into the rolling mill at the start of the operation. At the same time the rollers **5** and **6** are set into rotation in the direction of arrow P_3 by a special driving means to avoid undesirable stresses arising from an excessive angular acceleration at the commencement of a rolling operation.

The rate of rotation of the rollers is infinitely variable and is adjusted so that the component of the velocity on the surface of the rollers in the direction of the strip, resulting from the rotation of the individual rollers and the whole roller system, corresponds to the speed of advance of the strip B.

Since during their rolling on the strip, the rolls undergo a variation in angular speed, due to the stretching of the strip by its deformation, it is necessary to incorporate in the drive of each individual roller a yielding element in the form of a resilient or slipping clutch to cater for the slight variation of the angular speed of the roller pair concerned during the engagement of the rollers, independently of the speed of the remaining rollers of the set.

As a consequence of the rotation of the roller systems about the axes of the mainshafts **3** and **4** there is a substantial centrifugal force acting on rollers **5** and **6** which are arranged eccentrically at a spacing R from the axes of the mainshafts. This centrifugal force acts against the rolling pressure during the rolling and this is an advantage which is here exploited. It caters for a very notable reduction in the strain on the bearings of the roller spindles and in the rollers themselves and thereby reduces the deflection thereof during the actual rolling engagement. The choice of speed of rotation of the roller systems and the eccentricity R of the rollers and ultimately the masses thereof, are adapted to the prevailing conditions.

This situation is of particular attribute to machines for the treatment of wide strips. The most favourable force conditions arise when the centrifugal force is about one half the maximum anticipated rolling pressure. The following data is given to exemplify the order of dimensions which meet these optimum conditions of force relationships of the rollers in practical instances:

Rate of rotation of the roller system $n = 200$ to 800 per minute.

Number of rollers per roller system $Z = 2$ to 8

Eccentricity of the rollers $R = 200$ to 600 mm

Diameter of the rollers $d = 200$ to 800 mm

A further advantage of the apparatus here proposed, in relation to planetary rolling mills, lies in the fact that the flywheel effect of the individual roller systems is very high because they represent large rotating masses, so that a uniform and smooth running of the machine is ensured despite the intermittent action.

The rate of travel of the strip determines the required number of rolling engagements per unit time, and this is represented by the product of the rate of rotation and the number of rollers per roller system. Optimum deformation conditions are fulfilled when the mean advance of the deformed strip per roller engagement is about 0.5 to two times the thickness thereof.

With a rate of rotation of the roller systems of about 500 rotations per minute and with a four roller arrangement, a mean strip speed of 8 to 32 metres per minute, which corresponds to the output of a continuously operating strip casting machine, is given for a final strip thickness of 7 mm.

Since the rolling process takes place intermittently a longitudinal oscillation, superimposed on the mean speed, is applied to the worked strip by the roller engagement. This oscillation can be completely compensated and the uniform speed of travel of the strip restored by the use of a socalled strip loop.

To facilitate reading of the drawing, the feet of the machine, except for those at the two sides, are not illustrated in FIG. **2**. As can be seen from FIG. 1 the feed rollers **1** and **2** are driven by way of intermediate shafts **7** and **8** which have keyed thereon pinions **9** and **10** which engage with toothed rings **11** and **12** screwed to rollers **1** and **2**.

Rollers **1** and **2** are rotatably mounted on fixed shafts **1***a* and **2***a* which are mounted in robust plummer blocks **14** and **15** which are displaceable on the machine frame **13**.

Two double acting hydraulic cylinders **16** are provided at the two ends of the rollers to produce the gripping force thereof and these are so dimensioned as to be capable of clamping the strip sufficiently powerfully to avoid any slip during the rolling in the ensuing working process. The forces required for this purpose can actually slightly reduce the strip thickness between the rollers under certain conditions. The cylinders are also used to vary the distance between the rollers for the introduction or removal of the strip.

The two roller systems which actually perform the reduction or deforming of the strip each comprise, as is apparent from FIGS. **1** and **2**, a mainshaft **3** or **4**, respectively, the bearing bodies **42** which are rigidly connected thereto, the rollers **5** or **6** respectively which are eccentrically mounted at a distance R from the axis of the mainshaft concerned, and the driving means described below. The mainshafts **3** and **4** are rotatably mounted at the two sides of the machine frame **13** in bearing blocks **17** and **18** which are displaceable in slideways.

The two roller systems are rotated by a main motor 19 through a reduction gear and pinion stand 20 and cardan shafts 21 and 22. Rollers 5 and 6 are rotated by separate drive means, these merely serving to accelerate the rollers while the machine is being started to compensate for frictional forces in the bearings. The rollers can be driven from one end or, as shown by FIG. 2, for symmetrical reasons from both ends. In the present instance use is made of an oil hydraulic system and it will be observed that there is a hydraulic pump 23 driven by the main motor and given an infinitely variable rate of feed and two hydraulic motors 24 and 25, connected in parallel, fed from pump 23. The roller drive means are interconnected through two gearings 25 and 27 through a shaft 28, to ensure a uniform rate of rotation of the rollers of the two roller systems even during idle running. The drive is imparted from gearings 26 and 27 through cardan shafts 29 and 30 to intermediate shafts 33 and 34 rotating in bearings 31 and 32, and thence through toothed belts 35 and 36 to toothed collars 37 on mainshafts 3 and 4. Thence the drive is imparted to the toothed pinions 38 on the roller spindles which engage the toothed collars 37.

Whilst in the embodiment illustrated in the drawings, the strip B passes through the apparatus in the horizontal direction, it will be appreciated that the apparatus can be devised for an inclined or reversing direction of travel, and indeed any desired direction of travel upwards or downwards can be catered for.

The method of driving the rollers illustrated and described merely represents one of various possibilities. It is for example possible to conduct this drive without the use of belts and using only appropriate toothed gearing.

To allow for variation of the angular speed of individual rollers which are in rolling engagement during performance of the machine, and without straining the drive, friction clutches with an appropriately selected torque (not shown for the sake of simplicity) may be associated with the toothed pinions 38. The thickness a of the rolled strip, given specific dimensions of the roller systems, is determined by the axial spacing D of the mainshafts.

The rate of deformation of the strip can be varied within desired limits by adjustment of the length of the threaded spindles 40. This enables a uniform thickness of strip to be achieved at both sides of the latter.

The bearing blocks 17 and 18 are urged by hydraulic cylinders 39, arranged at the two sides thereof and numbering four in all, against the threaded spindles 40 which are arranged between the bearing blocks and are of adjustable effective length. The closing pressure exerted by the cylinders must be larger than the rolling pressure exerted between the roller pair which are cooperating during the rolling procedure. This closing pressure can be checked by known limiting means to ensure against overstraining of the rolling systems.

The adjustment of the bearing blocks, that is to say the regulation of the distance between them, can be performed by other means such as are used in the rolling mill art.

The main bearings 41 of the rolling systems and the roller bearings 42 can be lubricated by pressure oil through oil ducts 44 in the main bearings. Thence the used oil passes through the run-out connections 46 into an oil storage plant (not shown) comprising a cooler filter and tank. The major part of the oil is introduced into the bearings 42 by ducts present in the main shafts and bearings. Used lubiricating oil emerging laterally from these is collected in the shell 46 and thence passed in each case through a connection 47 and conduits (not shown) likewise to the oil storage plant. Lubrication of the toothed wheels of the roller driving means and of bearings, for which purpose roller bearings are used, is performed by the oil mist which prevails in the cavity concerned.

Appropriate shaft seals and collars are used to prevent undesirable escape of oil.

To prevent adhesion of the rolls to the strip B which is operated on, a rolling oil-emulsion is continuously sprayed on to the rolling surfaces through nozzles 49 at the two sides of the strip.

The plant illustrated in FIGS. 1 and 2 is intended for the treatment of continuously cast aluminium strips of about $A = 60$ mm thickness to $a = 7$ mm at a strip speed of $v_o = 0.8$ to 3.2 m/minute or $v_1 =$ ca. 7 to 28 m/minute. In order to maintain the feed conditions set out above a rate of rotation of $n = 500$ /minutes is used and in each case four rolls per roller system. This gives $z =$ 4 times 500 = 2000 roller engagements per minute.

The eccentricity of the rollers amounts to R = 300 mm and the diameter of the same $d = 310$ mm.

The totalmass of a roller, including roller spindle, clutch and driving pinions, amounts to M = 625 kg.

Under the conditions indicated and in the treatment of a strip of an aluminium alloy with 1 % Mn and 1 % Mg, having a width of 750 mm and at a temperature of 350° to 400° C, a rolling force of about 100,000 kp is developed.

The centrifugal force K of a roller which develops during the rotation of a roller system thus amounts to:

$K = M \cdot R \cdot \omega^2 = 625 \cdot 0.3 \cdot 52.36^2 = 51.404 \cdot 10^4$ N = 52,400 kp

If the rollers are not in engagement, the load on their bearings is equal to the centrifugal force, and thus during engagement the load amounts to:

$K' = 100{,}000 - 52{,}400 = 47{,}600$ kp or

$K'/2 = 23{,}800$ kp per bearing.

The reduction in load on the bearings which results from the centrifugal force of the rollers also has the additional benefit of less bending strain on the rollers.

What I claim is:

1. An apparatus for rolling metal strip, having two driven feed rollers, the weight of which is about 80 to 120 kp per centimetre strip width, and a rolling assembly, said rolling assembly comprising a driven rotary roller system on both sides of the strip to be worked, each such system comprising a mainshaft, bearing blocks at the two ends of said mainshaft which bearing blocks are adjustable relatively to one another and in which said mainshaft is rotatably supported, at least two rollers rotatably mounted on said mainshaft parallel to the latter and a special drive for rotating these rollers through the agency of friction clutches, the width of these rollers being greater than that of the strip which is to be worked, the rollers being all uniformly distributed around the mainshaft and at the same radial distance from the latter, and the mass of the rollers being selected so that the centrifugal force produced by the rotation thereof around the main axis of the roller system concerned is approximately equal to one half the maximum rolling force which is produced; and means being provided for synchronously driving said mainshafts and roller systems in relatively opposite di-

rections, said mainshafts and roller systems being so coupled together that, by virtue of the rotary motion of the two systems, rollers of these systems meet the strip in pairs, one from each system, simultaneously at the same angle and from the two sides of the strip, as the latter is being moved by said feed rollers between the two systems, the cooperating rollers then engaging the strip between them and forming it under an appropriate pressure until the minimum distance between the rollers is achieved, and all these pairs of rollers making such rolling engagement at each rotation of the roller systems and forming the forwardly moving strip successively to the required thickness.

* * * * *