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METHOD OF WORKING METAL

Filed June 13, 1928

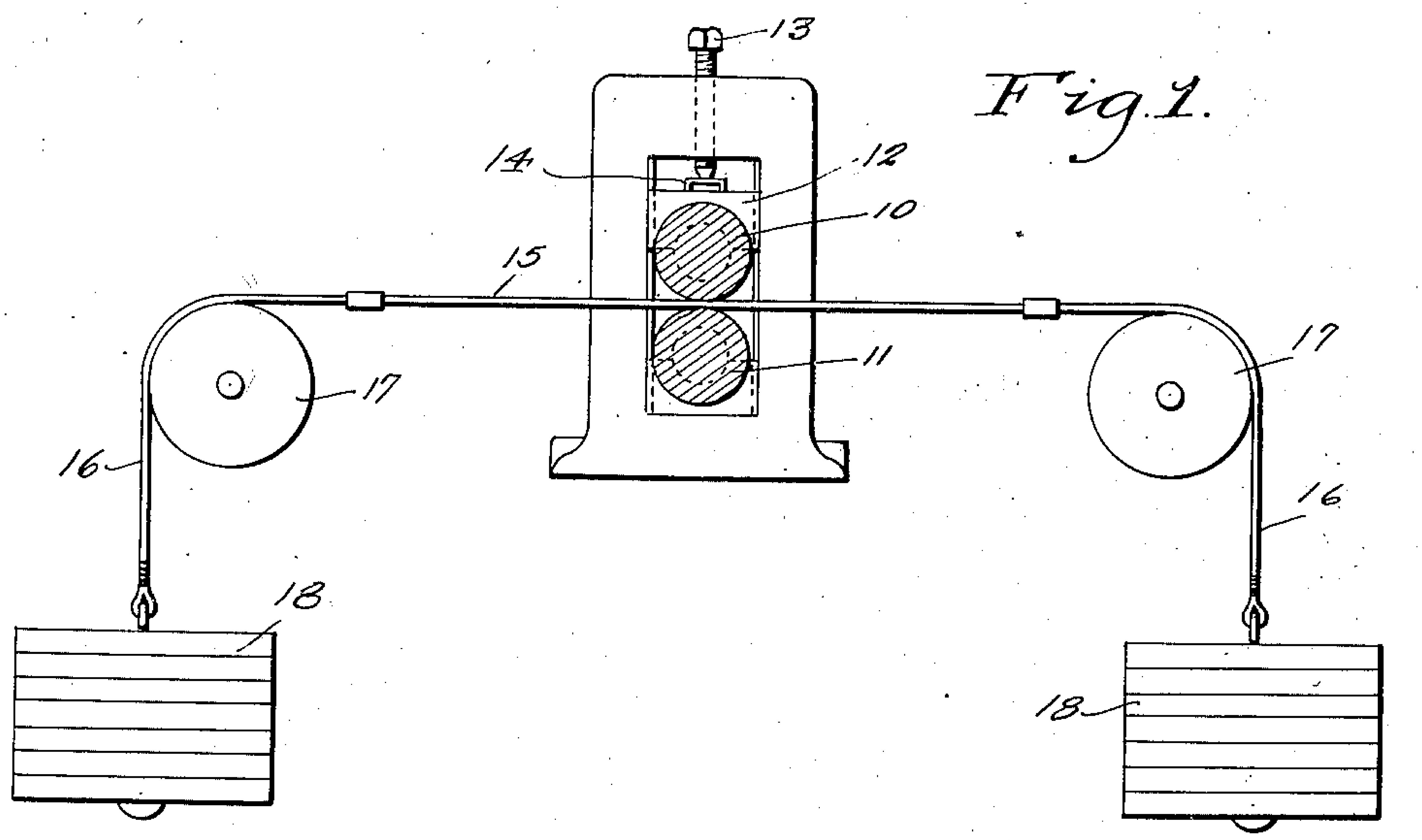

Fig.1.

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METHOD OF WORKING METAL

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The present invention relates to the art of metal working, being especially applicable to the rolling of strip steel or flat wire of iron or steel or their alloys, and the forming of sheets and other strips by the use of rolls or forming dies. It consists essentially in working metal by compression while such metal is under a considerable tension transversely of the compressive forces. It further consists of the use of compressive forces considerably less than those used in present practice.

One object of the present invention is to enable a greater elongation in at least one dimension to be had without further heat treatment of the metals being worked and without danger of injury to or failure of such metals.

A further object of this invention is to make possible the use of rolls made of harder, and therefore usually more brittle, material than in present practice, by which a superior finish may be given to the material being worked.

Another object is to reduce the necessary pressure on the rolls or revolving dies by which the surface of such rolls or dies is preserved and wear and tear on the bearings is reduced.

Another object of the invention is the reduction of distortion in strip or flat wire being rolled, such as "ruffled edges", which are due to roll bending or overheating of the rolls near the roll necks.

Further objects of the present invention are the production of superior products at a less cost than heretofore, the superior polishing produced on the finished product and such other objects as will appear from the disclosure and claims.

In order to enable others to more clearly understand the invention I have illustrated one embodiment thereof in the accompanying drawing which shows certain means by which my invention may be practiced. I do not, however, intend to limit my invention to the specific means shown, as many other means may be used by those skilled in the art in the practice of my invention.

Figure 1 is a cross section of a rolling mill in which my invention may be practiced.

To enable others skilled in the art to practice this invention I will give a detailed account of the several essential parts of the apparatus illustrated.

In the rolling mill in Figure 1, 10 and 11 are the usual rolls, which may, however, be of smaller cross sectional area and of greater hardness in practicing my invention than is the usual practice. Roll 10 is pressed toward roll 11 by a bearing 12 which is compressed by screw 13 which bears upon a breaking block 14 resting upon the bearing 12. 15 is a bar or strip of metal being worked between the rolls. It is fastened at either end to tension devices which may, as illustrated, comprise flexible members 16 running over pulleys or sheaves 17 and vertically sustaining weights 18 from their depending ends.

In the practice of the invention as illustrated in Figure 1 the weights 18 are sufficient to put a tensile stress upon the bar or strip 15 being worked, approaching or in some cases even exceeding its elastic limit.

The block 14, in some cases, is designed to break if the compression screw 13 is transmitting a compressive force through the bearing 12 and rolls 10 and 11 upon the work 15 exceeding 90 per cent of the elastic limit of such work. The work may be advanced between the rolls by positively driving the rolls or by allowing the rolls to idle and placing a greater tensile stress upon one side of the rolls than the other.

In the former practice it has been customary to place compressive force upon material being worked which approached or exceeded the elastic limit of the material at the point of contact under the conditions at which it was worked. This was deemed necessary in order to obtain the lengthening of such strip desired. The metal was made to flow by the force of such compression. It has been the practice in certain mills to place a small tensile stress upon the work to prevent kinking and to assist in a slight lengthening effect of the rolling. In the present invention, however, the reverse relation of forces holds. The tensile stress placed upon the work approaches or even exceeds the elastic limit of the work, while the compressive forces, contrary to all precedent, are less than 90 per cent of the elastic limit of the work at the conditions while working and may be far less than that value, approaching zero as a limit. I have found it possible to obtain an elongation of the work without injury thereto far exceeding that possible when the compressive force approaches or exceeds the elastic limit of the metal, which is the present practice. I have found it possible to obtain such elongation when the compressive force was a very small fraction of the elastic limit of such work. In practice I prefer to have such compressive force from 10 to 50 per cent of the elastic limit of the work and to have the tensile force approach or even exceed the elastic limit of the work.

In order to clearly understand the radical departure of the present invention from the usual practice it is only necessary to consider mathematically the relation of forces concerned in the rolling of strips. If the original thickness of a strip is T_1 and the thickness after passing between rolls is T_2 then T_1-T_2 is the total reduction of the pass and $\frac{1}{2}(T_1-T_2)$ is the amount of reduction on either the upper or lower half of the work. Then if the arc "a" of contact of one roll with the work is small compared to the diameter D of the roll then neglecting negligible errors

$$=\frac{\frac{1}{2}(T_1-T_2)}{a}=\frac{a}{D}$$

Therefore

$$a=\tfrac{1}{2}\sqrt{2D(T_1-T_2}$$

Let B be the breadth of the work then the area of contact A of work and roll is

$$\tfrac{1}{2}B\sqrt{2D(T_1-T_2)}$$

If E is the elastic limit of a standard test specimen in compression then according to the former knowledge of those skilled in the art the necessary total roll pressure must approach or exceed

$$\tfrac{1}{2}EB\sqrt{2D(T_1-T_2)}$$

before the rolling is effective.

I have found, however, that by the use of a tension upon the work, approaching or exceeding the elastic limit of the work, the necessary roll pressures may be reduced to from 90 per cent of the above almost to zero. I prefer to use 15 per cent to 50 per cent of what has been considered the lower limit of effective pressures.

In the diagram it will be noted that the weights are adjustable. A suitable number of them may be removed after each pass so as to suit the tension to the strength of the strip. In some cases, it is more desirable to have a stronger pull on the strip on one side of the mill than on the strip on the other side. It is especially desirable to have a strong pull on the strip leaving the mill when making heavy reductions, to prevent slippage of the strip and injury to the rolls. In some cases, the weights on the entering side may be all removed and thus the tension be reduced to zero or else regulated to just enough to hold the strip in position. If, however, the tension in the strip on the leaving side of the mill be held up to the neighborhood of the elastic limit, the method still falls within the scope of my claims, since there is a zone in the strip between the last points of contact with the rolls, in which the strip is in tension up to the neighborhood of the elastic limit and at the same time is under a very low compression. The back tension in this case is caused by large reductions in which the shoulder of the strip as it is being reduced in the mill, presses against the rolls so as to cause a very appreciable horizontal force component.

It is to be understood that this rolling may be done at any temperature and is not specifically limited to iron-containing metals. It has a wide application in the making of highly polished watch springs, sheet metal, iron and steel alloy strips, razor blades, etc. In practice oil may or may not, as desired, be placed upon the rolls, but if used will be of peculiar advantage, due to the fact that the compressive force is so small that the oil will lower the frictional resistances and it will be possible to maintain a high polish upon the rolls and the strip or sheet worked. The rolls may be constructed of material which may be much harder than is possible at present, as the smaller pressures obviate the danger of breaking the more brittle hard rolls; or on the other extreme, the rolls may be of material softer than the strip being worked, as the pressures used are considerably under the elastic limits of the materials worked. This latter is of very peculiar importance in the rolling of strips and sheets of a very hard material.

I do not wish to be limited to the form illustrated and to the method described except as defined by the appended claims.

I claim:

1. In a method of rolling metal, the steps consisting in drawing it between rolls and applied to the trailing end thereof a tension approaching the elastic limit, said rolls being driven solely by the tension in the strip.

2. In a method of working metal, the steps including drawing an elongated piece between rolls driven solely by the tension in the piece, applying a tension approaching the elastic limit in the piece as it leaves the rolls, and subjecting the portion of the piece entering the rolls to a high back tension.

3. In a method of working metal strip, the

steps including pulling a strip between rolls driven by a tension in the strip, applying a forward tension to the strip leaving the rolls approaching the elastic limit, subjecting the rolls to a pressure less than the elastic limit, and subjecting the strip entering the rolls to a restraining tension.

4. In a method of working metal, the steps including drawing a strip between rolls driven solely by the tension in the strip, and applying tensions approaching the elastic limit to the strip entering the rolls and the strip leaving the rolls.

5. In a method of working metal strip, the steps including drawing the strip between rolls driven solely by the tension in the strip, applying tensions approaching the elastic limit to the strip, and exerting a comparatively low pressure on the rolls.

6. In a method of rolling metal strip, the steps including pulling the strip between rolls driven solely by the tension in the strip, continuously advancing the strip while maintaining the trailing end thereof under a tensile force approaching the elastic limit to reduce the compressive force exerted by the rolls.

7. In a method of working metal, the steps including drawing the strip between rolls driven by the tension in the strip, applying a tensile force in the neighborhood of the elastic limit to the strip, and applying a compressive force at right angles to the tensile force intermediate the ends of the strip, said compressive force being materially below the elastic limit.

8. In the art of rolling metal, the steps including pulling a strip between rolls driven solely by the tension of the strip, subjecting the strip longitudinally to tension in the neighborhood of the elastic limit, and laterally to a slight compression only.

9. In a method of rolling ferrous metal strip, the steps including drawing it between rolls driven solely by the tension of the strip, tensioning the strip substantially to the elastic limit, and lightly compressing it between the rolls.

10. In a method of cold rolling ferrous strip, the steps including drawing it between rolls driven solely by the tension in the strip and applying a high restraining tension to the trailing end of the strip.

In testimony whereof I affix my signature.

WILLIAM C. McBAIN.