Sept. 1, 1964 E. STARON ETAL 3,146,694

STRAPPING METHOD AND APPARATUS

Filed Oct. 27, 1961 2 Sheets-Sheet 1

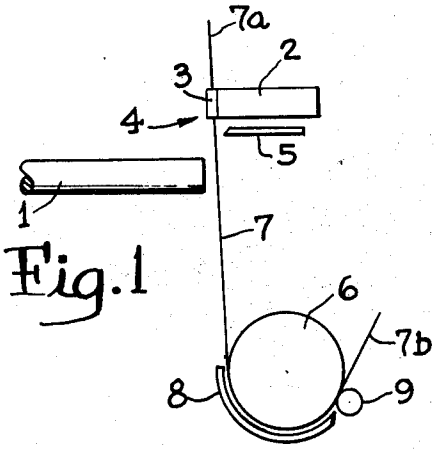


Fig. 1

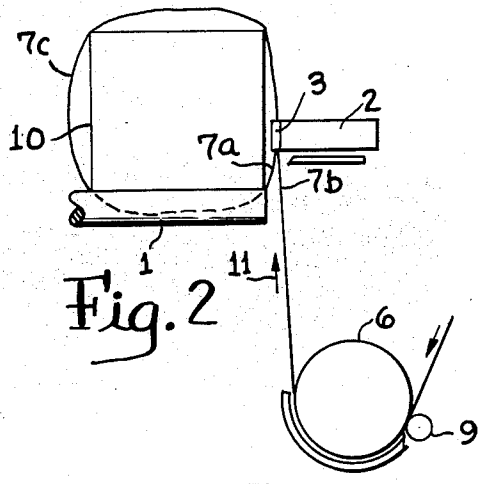


Fig. 2

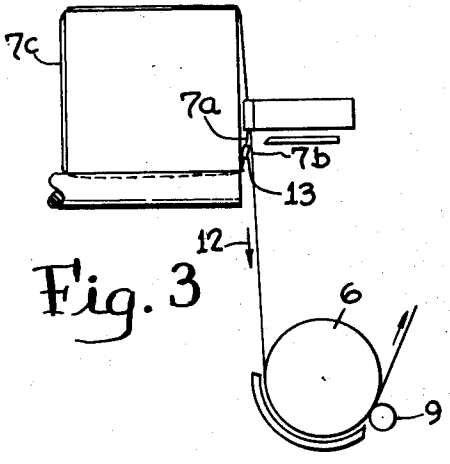


Fig. 3

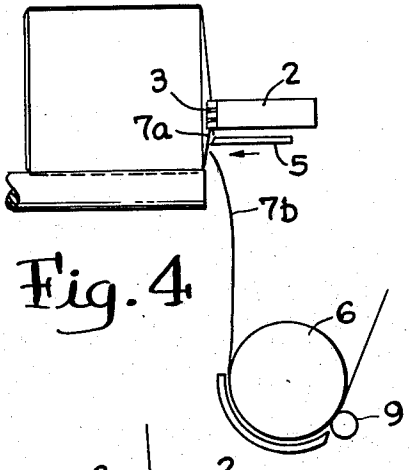


Fig. 4

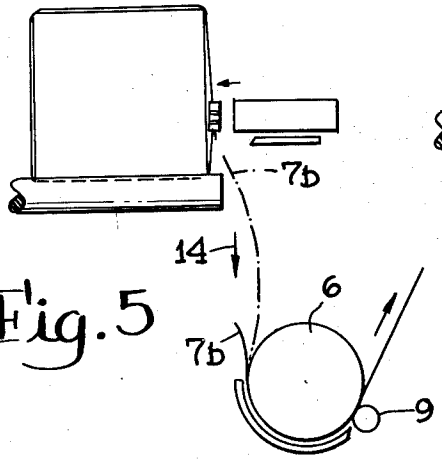


Fig. 5

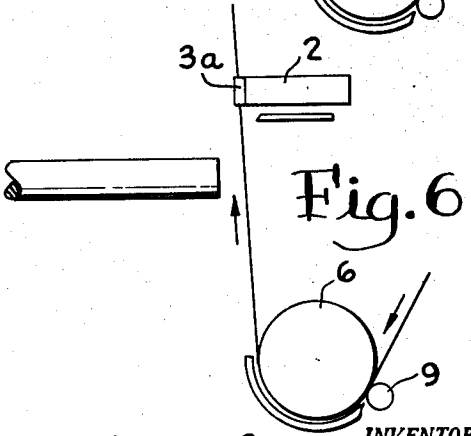


Fig. 6

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STRAPPING METHOD AND APPARATUS

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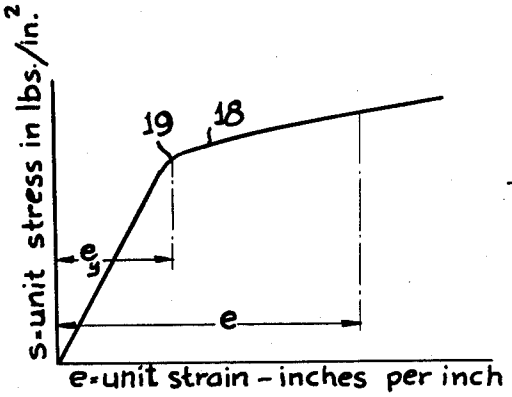


Fig. 7

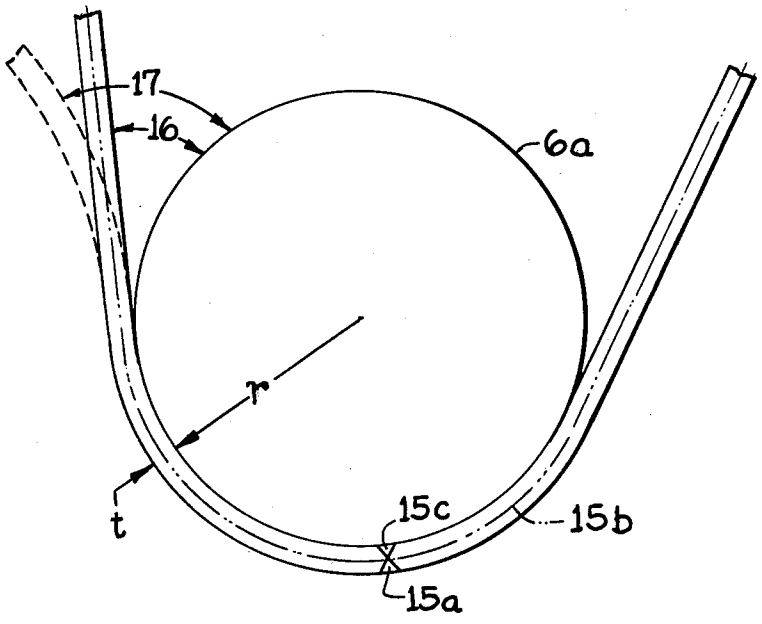


Fig. 8

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STRAPPING METHOD AND APPARATUS

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5 Claims. (Cl. 100—2)

This invention relates to improvements in methods and machines for applying metal binder straps around boxes, packages or other objects.

In machines of a type having means for feeding a length of strap and encircling it into a loop about an object to be strapped, and thereafter gripping the leading end of the strap and reversing the feed means to cause withdrawal of the supply strap end relative to the leading strap end to shrink the loop onto the object, there has been a problem with regard to the strap as it is withdrawn around the package or object being strapped. The problem arises as a result of the strap being curled with a curvature in the direction of the wrap of the strap loop around the object. This curvature results from the wiping action of the strap around a small radius or corner portions of the object. After the object is strapped with the shrunken and tensioned loop with the ends of the loop joined together and the joint loop severed from the supply end of the strap, the then new leading end of the strap is left with this objectionable curvature mentioned. If the curvature is of small enough radius, which it often is, especially as a result of strapping small objects, upon the next subsequent strapping cycle of the machine, the leading strap end with the curvature cannot be fed into the operating portions of the strapping machine. This problem has been quite prevalent and a steady source of difficulty which has not been readily overcome.

It is the principal object of this invention to obviate this difficulty by providing improved mechanism embodied in a strapping machine of the type mentioned whereby any objectionable curvature imparted to the strip as a result of it being withdrawn around the package is removed.

It is another object of the invention to provide improved strap curvature removing means which can be conveniently incorporated in the existing structure of the machine without the addition of extra parts.

It is still another object of the invention to provide a strapping apparatus having a means for removing the objectionable curvature which, although it removes the objectionable curvature, it does not introduce any curvature when the strap is already longitudinally straight. The significance of this is that the means associated with the strap feed of straight strap during the strap feed portion of the strapping cycle in a machine where the strap feed means can be reversed for shinking the loop onto the object being strapped can be adapted for removing the objectionable curvature when the strap feed is reversed during the loop shrinking period. The specific means employed is a roll about which the strap is curved in both the feeding and reverse directions. The roll is calculated to have a radius which does not permanently deform or permanently change longitudinally straight strip presented to it upon feeding, but does remove curvature in the strap which curvature is in a direction opposite to that of the curvature of the roll.

Other objects and advantages of the invention can be better understood by referring to the accompanying drawings, in which

FIGS. 1 to 6 show diagrammatically the principal components of a typical strapping device in which this invention can be embodied and shows the sequential steps in the movement of the parts to execute the method of the invention;

FIG. 7 shows a curve representing the relationship between the elongation of the metal strap and the stresses imposed upon it when operating below and above the elastic limit of the metal strap; and

FIG. 8 shows an enlarged side elevation of the roll shown in FIGS. 1 to 6, around which the metal strap is passed to effect the straightening of the strap.

In a co-pending application for Automatic Box Strapping Machine under Serial Number 640,263, filed February 14, 1957, now Patent No. 3,101,663, in the names of Marchand B. Hall, Edward Staron and Robert E. Hager, a strapping machine is disclosed which is typical of a type in which this invention can be advantageously practiced. It employs an idler feed wheel about which the strap is passed on both the strap feed and strap withdrawal portions of the strapping cycle. FIGS. 1 to 6 of this application diagrammatically disclose some of the principal portions of such a typical apparatus in order to clearly show the relationship of the invention to such a machine and to aid in the understanding of the invention.

In FIG. 1 there is shown a roller conveyor 1 which is intended to support an object to be strapped. Adjacent the forward region of the conveyor is a joint forming mechanism 2 which ordinarily supports a channel shaped seal 3 in a joint forming region 4. Adjacent to the joint forming mechanism 2 is a strap shear 5. Below the level of the conveyor 1 is an idler feed wheel 6 around which is passed the strap 7. A guide 8 directs the strap around the idler wheel and keeps it in contact with it. A rotary feed wheel 9 is positioned adjacent to the idler feed wheel 6 and the strap 7 is adapted to be passed between the two wheels. The supply end 7*b* of the strap 7 is directed from a suitable coil or strap supply (not shown) while the leading end 7*a* of the strap is ordinarily guided by means not shown through the seal 3.

With a typical operating sequence of the apparatus, the parts are all positioned initially as shown in FIG. 1. When it is desired to strap a package or object 10, the object is positioned on the conveyor 1 as shown in FIG. 2 and the rotary feed wheel 9 is rotated in a direction to cause rotation of the idler wheel 6 and feed of the strap in the direction of the arrow 11. The strap is fed through the seal 3 as a guide and either guided mechanically in a guide into a strap loop 7*c* around the object 10 or manually encircled about the object. The leading strap end 7*a* is then guided a second time through the seal 3 to provide overlapping regions between the leading strap end 7*a* and the supply strap end 7*b*. During this strap feed period, the strap is passed around the idler feed wheel and the radius of this wheel is large enough that it will not permanently deform the strap 7 with any curvature if it is longitudinally straight when presented to the wheel 6. In other words, its curvature is not enough to cause plastic deformation of longitudinally straight strap which is bent around it. It should be clearly understood that the term "longitudinally straight" as used throughout this application refers to a condition of the strap whereby, without the application of any external forces, it is longitudinally straight. It should be obvious that a longitudinally straight strip, as intended by this definition, can be curved by applying an external force. Nevertheless, this curved strip which is held curved by the application of the external force is still a longitudinally straight strip within the full intent of the definition. Further, the longitudinal straightness or curvature referred to in this application is that which is in a direction away from the ordinary plane of the strip and not in a direction transversely of the strip. The type of straightness or curvature being referred to is similar to what might be termed "bundle curve," but not necessarily in the same direction. This is a curvature different than

transverse curvature ordinarily referred to as "camber" which is not the type considered in this application.

After the strap loop 7*c* has been applied around the object 10, the strap is withdrawn in the direction of the arrow 12 in FIG. 3 by reverse rotation of the feed wheel 9 while the leading strap end is held in a fixed position by means of a strap gripper 13. This reverse movement of the strap causes the strap loop 7*c* to be shrunk and tightened onto the object 10. Next, as shown in FIG. 4, the joint forming mechanism 2 causes an interlocking joint to be formed between the seal 3 and the overlapping strap ends 7*a* and 7*b*. Immediately thereafter, the shear 5 is moved to shear the supply strap end 7*b* from the connected loop 7*c*. As evident in FIG. 4, the new leading strap end, which is now the supply strap end 7*b*, may be curved as shown with a curvature in the direction of the strap loop about the object. This is a common characteristic of the strap end after it has been withdrawn during the strap loop shrinking period of the cycle due to it having been wrapped around the corners of the object 10. On very large objects, the problem is not so common as a source of difficulty because the resultant curved end may be incorporated in the strap loop, but when the objects are relatively small or of a small radius curvature, in the case of round packages or objects, the problem becomes more serious because the resultant curved strap end is not left in the strap loop on the object. Also, the small radius of the object around which the strap is bent causes a more severe curl or curvature to the strap end.

In order to remove this reverse curvature which is shown in the strap end 7*b* in FIG. 4, the strap is further withdrawn in the direction of the arrow 14 (FIG. 5) by additional reverse rotation of the rotary feed wheel 9. It has been stated that the idler feed wheel 6 is of a radius insufficient to cause any permanent bending of a longitudinally straight strap passed around it. However, it has been found that this same roll can be used to remove reverse longitudinal curvature by withdrawing it around this roll in the manner stated. The apparent reason why the reverse curvature is removed is because the strip portion which is initially longitudinally curved in a direction opposite to the curvature of the roll 6 must be flexed through a greater angle than longitudinally straight strip in order to make the strip conform to the roll curvature. This increased amount of bending causes permanent deformation of the strap which manifests itself by straightening the strap. After the strap is straightened in this manner it is then fed through another seal 3*a* positioned in the joint forming mechanism and, since the strap is longitudinally straight, it feeds through the portions of the machine without providing a snagging problem.

The result of drawing or passing the metal strap endwise around the idler feed wheel 6 is illustrated in FIG. 8 where a portion of the metal strap is shown in conjunction with a side elevation of the roll 6. As the strap passes around the roll 6 the outer portion of the strip is stretched or elongated as indicated by the portion of triangular cross section 15*a* which lies on the outside of a longitudinal neutral zone represented by the dotted line 15*b*. At the same time that the stretching of the outer portion of the metal strap takes place, there is a compression of the portion of the strap which is between the neutral zone 15*b* and the surface 6*a* of the roll 6 as indicated by the area of triangular cross section shown at 15*c*. This action takes place progressively with a resulting longitudinal stretching of all portions of the metal strap which are on the outside of the neutral zone 15*b* and a compression of all portions of the metal strap which are on the inner side of that zone. The radius of the idler feed roll 6 is specifically designed so that if the metal strap is longitudinally straight prior to being passed around the roll 6, upon releasing the strap and letting it assume its natural shape, it will remain longitudinally straight to indicate that no permanent deformation of the strap occurred as a result of it being bent around the roll 6. By having a suitable radius, this condition can be achieved, as stated, and another condition can also be achieved. That condition is one whereby a strap portion having a longitudinal curvature reverse of the curvature of the roll 6 can be permanently deformed by bending it around the roll and thereby return to a longitudinally straight condition. In this manner, it is possible to remove objectionable reverse curvature prior to start of a new strapping cycle. It is apparent from FIG. 8 that a longitudinally straight strap need only be bent through an angle 16 to make it conform to the radius of the roll 6, while a reversely curved strap must be bent through a larger angle 17 to make it conform to the same radius. It is this extra angular movement which causes the strap to be permanently deformed to remove the reverse curvature.

In carrying out the process of the present invention, strip steel having moderate resiliency is preferably employed and good results have been obtained when using comparatively thin metal strap, preferably having a thickness of about 0.023 inch. However, good results can be obtained with metal thicknesses well below and above this thickness.

To effect the condition required for the practice of this invention, the roll 6 should have a radius r such that the bending of the metal strap as it passes around the roll will not set up stresses beyond the elastic limit of the metal when the metal strap is initially longitudinally straight, but will set up stresses beyond the elastic limit of the metal when the strap is reversely curved. If in FIG. 7, the ordinates s by taken to represent the unit stress in pounds per square inch imposed upon the metal strap and the abscissae e be taken to represent the unit strain in inches of elongation per inch of length of the strap, then the curve 18 shows the variation in the unit strain with changes in the stress to which the metal is subjected and the point 19 on the curve represents the elastic limit or yield point of the metal. The values represented by the curve 18 may be determined by test for any given metal. In the case of certain strapping used in machines of a type where this invention can be employed, the value of the unit strain e_y at the yield point 19 is approximately 0.0036 inch per inch, a value determined by experiment. When bending a metal strap around a roll, such as the roll 6, the unit strain e satisfies the equation:

$$e=\frac{t}{2r} \tag{1}$$

in which t represents the thickness of the metal strap in inches and r is the radius of the roll 6 in inches. The derivation of this equation will now be set forth.

Upon reference to FIG. 8, it is apparent, from purely geometrical observation, that

$$e=\frac{2\pi(r+t)-2\pi\left(r+\frac{t}{2}\right)}{2\pi\left(r+\frac{t}{2}\right)} \tag{2}$$

which equation may be reduced to the following form:

$$e=\frac{t}{2r+t} \tag{3}$$

For all practical purposes, where the value of the thickness t of the strip is very small as, for example, on the order of 0.023 inch as employed for metal strapping, Equation 3 may be modified to read:

$$e=\frac{t}{2r} \tag{4}$$

which is the same as Equation 1 above.

From Equation 4 the value of r may be derived as follows:

$$r=\frac{t}{2e} \tag{5}$$

For the purpose of determining the value of r just at the yield point, that is, the radius of the roll **6** which will cause stretching of the metal strip just at the yield point, the value of the yield point strain e_y may be substituted for e in Equation 5 with the following result:

$$(6) \qquad r=\frac{t}{2e_y}$$

For practical purposes Equation 6 may be modified to include a constant C as follows:

$$(7) \qquad r=C\frac{t}{2e_y}$$

C is a constant, determined by experiment, which is greater than the integer 1 and it is included in the equation to insure that the metal strap being bent around the roll **6** will operate below the elastic limit represented by the point **19** on the curve **18**.

If steel strap is used which has a thickness of 0.023 inch and e_y is 0.0036 and C is considered as 1, then r will be 3.2 inches. There is thus determined the radius of the roll **6** which will just reach the point of stretching the outer portion of the metal strap and compress the inner portion as it passes around the roll **6**, with the result that, if the strap is longitudinally straight to begin with, it will emerge from its path around the roll **6** as still longitudinally straight.

It would appear that this radius of 3.2 inches would be the desired one. However, the strap has inherent physical variations in its yield point and in its thickness due to unavoidable manufacturing differences so that the value of C is chosen as somewhat greater than 1 and an acceptable value of C is 1.1 for the thickness and type of material being used. Using such a value of C, the radius r results as 3.5 inches.

By using a radius of 3.5 inches for the roll **6**, if the strap is longitudinally straight when wrapped around this roll **6**, it remains substantially longitudinally straight as it emerges from the roll. However, as the strap portion with a curvature reverse to that of the roll is passed around the roll, it has been found that the reverse curvature is substantially removed.

By removing this reverse curvature at the leading end of the strap at the start of every strapping cycle, the fresh leading end of the strap presented to the strapping mechanisms of the strapping apparatus at the start of each strapping cycle is a straight strap portion which overcomes substantially all of the difficulties previously encountered when the leading strap end was curved.

Although the parts of the apparatus for strapping have been shown diagrammatically, this was done because they can be made in many different ways which are well known in the strapping art and it is not intended to be limited to any specific structure. Further, even though the invention has been shown and described in only one way, it should be clearly understood that it can be modified in many ways without departing from the true scope of the invention as defined by the appended claims.

We claim:

1. The method of removing longitudinal curvature imparted to a metallic strap by it having been wiped around an object being strapped as the strap is shrunk into a tight loop onto the object comprising, confining the strap with the longitudinal curvature to a curved path of opposite curvature, the radius of said opposite curvature being determined by the equation

$$r=\frac{t}{2e_y}$$

in which r is the said radius, t is the thickness of the strip, and e_y is the unit strain of the metal at the yield point.

2. The method of removing longitudinal curvature imparted to a metallic strap by it having been wiped around an object being strapped as the strap is shrunk into a tight loop onto the object comprising, confining the strap with the longitudinal curvature to a curved path of opposite curvature, the radius of said opposite curvature being determined by the equation

$$r=C\frac{t}{2e_y}$$

in which r is the said radius, t is the thickness of the strip, e_y is the unit strain of the metal at the yield point, and C is a constant more than the integer 1.

3. A method of strapping comprising, feeding a length of metallic strap forward from a strap supply into a loop about an object with the leading end of the strap overlapping its supply end, withdrawing the supply end of the strap in a reverse direction to shrink the loop onto the object while holding the leading end of the strap stationary, forming a joint between the overlapping strap ends, shearing the loop from the strap supply, and thereafter withdrawing the leading end of the strap supply through a path of curvature opposite to the direction of the path of curvature around the object, said path of curvature being of such a radius that it causes the strap to be permanently deformed as it passes through the path if the strap leading to the path is curved oppositely to the curvature of the path.

4. The method defined by claim 3 characterized by, the radius of said path of curvature being determined by the equation

$$r=\frac{t}{2e_y}$$

in which r is the said radius, t is the thickness of the strap, and e_y is the unit strain of the metal at the yield point.

5. The method defined by claim 3 characterized by, the radius of said path of curvature being determined by the equation

$$r=C\frac{t}{2e_y}$$

in which r is the said radius, t is the thickness of the strap, e_y is the unit strain of the metal at the yield point, and C is a constant more than the integer 1.

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