Oct. 6, 1970 K. B. GARNER ET AL 3,531,963

BENDING APPARATUS

Filed Dec. 4, 1967 2 Sheets-Sheet 1

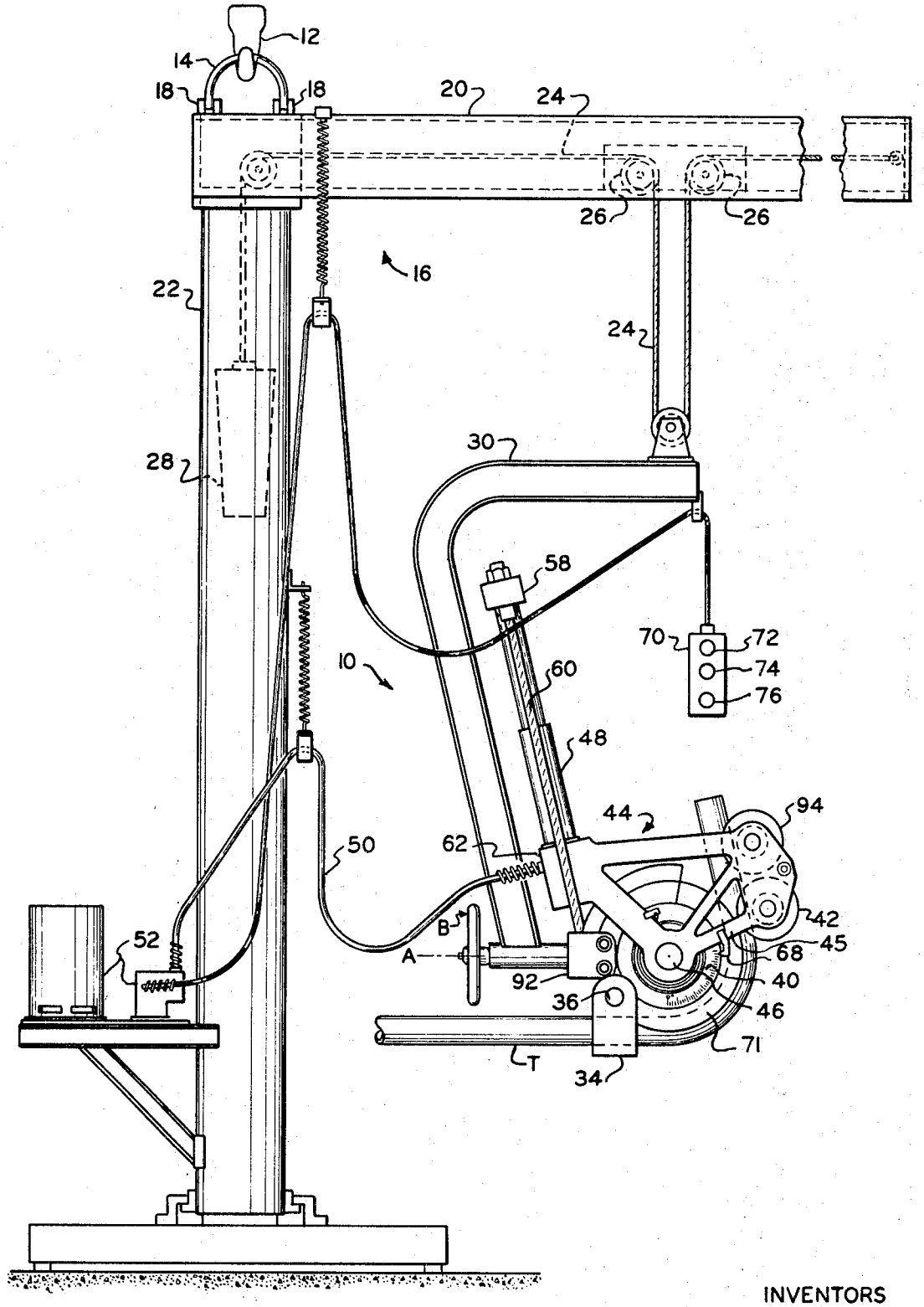


FIG. 1

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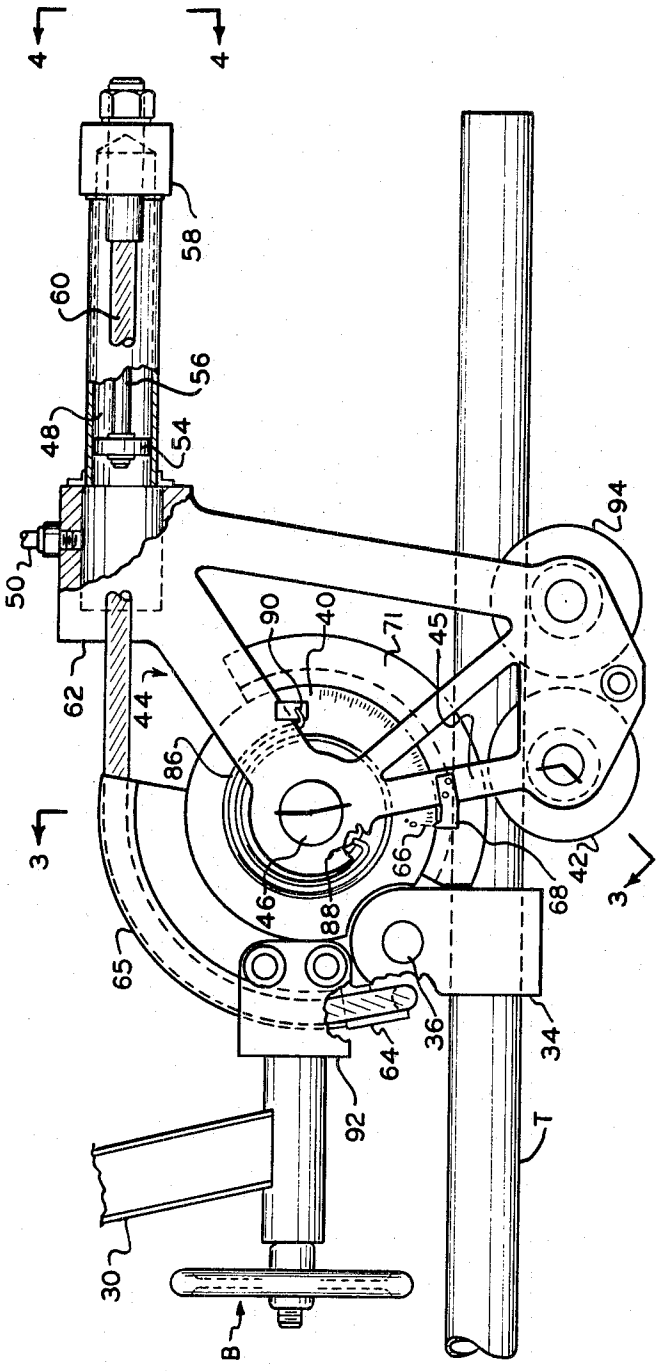


FIG. 2

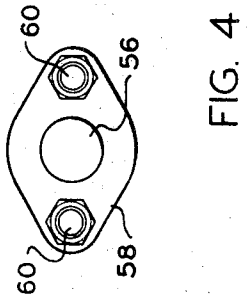


FIG. 4

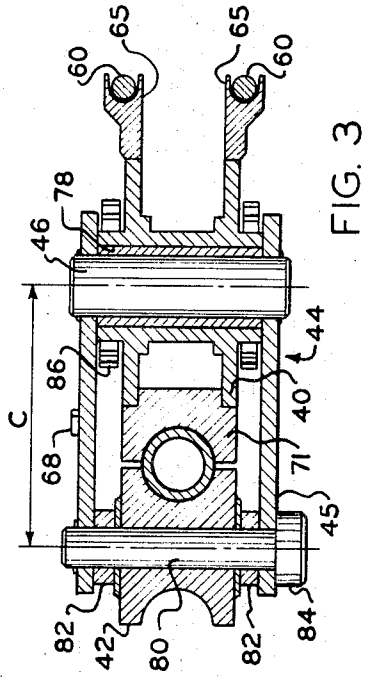


FIG. 3

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United States Patent Office 3,531,963 Patented Oct. 6, 1970

3,531,963

BENDING APPARATUS

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Filed Dec. 4, 1967, Ser. No. 687,858
Int. Cl. B21c 51/00
U.S. Cl. 72—31 5 Claims

ABSTRACT OF THE DISCLOSURE

A portable tube bending apparatus mounted for readily conveyable movement on a support, the apparatus accomplishing the bending of a tube by the interaction of a grooved bending roller with a grooved quadrant die. The grooved bending roller is mounted on a linkage assembly which, in turn, is mounted for rotation about the grooved quadrant die. An hydraulic jack and cable means is specifically controllable to actuate the bending apparatus to bend a tube to a particular desired angle, the apparatus itself being used as a protractor for measuring the bend angle. The grooved bending roller is located on the linkage assembly in such a manner so that it will provide the sole clamping force necessary to hold a tube in the bending apparatus while providing sufficient bending leverage to bend the tube without distortion.

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to the art of tube bending and more particularly to a portable tube bending apparatus.

In many areas of manufacture, it is necessary to take standard tubing lengths and bend them to arrive at a desired configuration. The conventional means of bending tubing where accuracy of bend radius, accuracy of bend angle, and control of roundness on small radius bends are required involve the use of large, stationary, relatively expensive machines. The tubing is brought to a machine, the entire tube being in a state of motion during the bending process. In the machines of the prior art, hydraulic cylinders and mechanical leverage means have been used in an attempt to gain the necessary forces required to bend tubes of large wall thickness. Such devices, however, must be large in nature and, therefore, it is not practical to make them portable. Although there are in the field some portable tube bending devices, it has been found that these portable benders do not have sufficient strength to accomplish bending of large tubes with appreciable wall thickness such as found in many areas of boiler design, for example.

Therefore, in view of the existing need for a powerful, yet portable tube bender, we have derived a simple, relatively inexpensive apparatus which has the power to bend large, thick walled tubes while easily being taken to the work. The work itself can remain stationary while the bending apparatus, which is suspended from a portable manipulator, provides the bending process motion. In our bending device, we use a grooved quadrant die mounted on a support means and a linkage rotating relatively thereabout, the linkage being rotated by hydraulic jack and cable means. On the linkage means there is mounted for interaction with the grooved quadrant die a grooved roller which serves, as a result of its novel local location, as clamping means for the tube and also bending means therefor. To accomplish this dual function, the roller means is mounted on the linkage to significant distance greater than the distance of a coincident radius of the grooved quadrant die to the point of tangency between

a tube to be bent and the quadrant die plus the radius of the roller means. In this manner, when the roller contacts the tube to be bent in the device, it will be at some point to the right (or left) of the point of tangency of the tube to the grooved quadrant die. The roller, therefore, will serve to clamp the tube (necessary to maintain roundness) and at the same time will have a significant bending moment arm rather than deriving its moment arm from a crushing of the tube as is the case with the present tube bending devices.

The grooved quadrant die support means has an angle measuring scale attached thereto; and the linkage means has a corresponding angle indicating pointer. When the hydraulic jack and cable means are actuated to perform the bending function by rotating the linkage means about the grooved quadrant die, the pointer on the linkage means will traverse the scale on the support means and the exact angle of bend may be determined at any time. By a unique control for the hydraulic jack and cable means, the jack may be actuated to bend the tube to an approximate angle to which it is desired to bend the tube. Pressure in the jack may then be released to the extent that strain in the tube will be relaxed and an exact reading of the amount of bend of the tube may be determined. If the angle of bend has not been fully accomplished, the jack may then be reactuated to complete the desired degree of bending. When the desired angle is accomplished, total pressure may then be relieved from the jack so that the tube may be easily removed from the bending device.

Another unique feature of our invention is the use of a wire cable means in cooperation with the hydraulic jack to actuate the bending apparatus. The cable means is attached at both ends to the ram of the hydraulic jack and entrained at its mid-portion over a transverse sheave mounted on the grooved quadrant die support means while being guided by guide sheaves also located on the support means. This arrangement results in an automatically balanced application of force reaction on the linkage means to which the hydraulic jack cylinder is attached. While the cable unwraps from the guide sheaves, it is kept co-axial with the jack and its line of pull is always tangential to an imaginary circle about the axis of the grooved quadrant die support means so that the torque is equal at every angle. This organization of elements develops the maximum bending force output for a given unit of space.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an overall perspective of the portable bender of this invention showing a tube bent to greater than 90°;

FIG. 2 is a detailed plan view of the particular bending apparatus with portions broken away for clarity;

FIG. 3 is a sectional view along line 3—3 of FIG. 2; and

FIG. 4 is a sectional view along line 4—4 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings wherein like reference characters are used to designate like elements, FIG. 1 shows the tube bending apparatus of our invention, generally designated **10**. Crane hook **12** carries a crane eye **14** which is used in turn to carry the portable boom means **16**. The crane eye **14** is attached by supports **18** to an overhead suspension boom **20** of the portable boom means **16**. The overhead suspension boom **20** is supported by an upright boom support **22**. Cable **24** entrained on pulleys **26** mounted on a trolley carries the tube bending support member **30**. The cable **24** is fixed at one end to the suspension boom **20** and at the other to a counterweight **28** which serves to balance the weight of the tube bending

apparatus **10** and thus enable it to be readily positioned by the operator.

A yoke means **34** to constrain a tube T to be bent is mounted by means of a pin **36** to a grooved quadrant die support means **40**. A main pin **46** extends through support means **40** at the central axis thereof. A grooved bending roller **42** is mounted on linkage assembly **44** which is supported on main pin **46**. Attached to the linkage assembly **44** at jack mounting portion **62** is the cylinder of an hydraulic jack **48**. A flexible hydraulic hose **50** is attached at one end to any hydraulic pump **52** and at the other end to hydraulic jack **48**.

As best seen in FIG. 2, the hydraulic jack **48** has therein an hydraulic piston **54** and ram **56**, the ram **56** terminating at ram head **58**. Attached to the ram head **58** on either side thereof (see FIG. 4) is a wire cable **60**. The wire cable **60** passes through jack mounting means **62** and is guided by guide sheaves **65** on support means **40** while being entrained at its mid-portion about transverse sheave **64** also mounted on the support means. Guide sheaves **65** keep the wire cable **60** coaxial with hydraulic jack **48**.

On the support means **40**, adjacent linkage assembly **44**, is located an angle indicating scale **66**. An angle indicating pointer **68** is attached to the linkage assembly **44** in such a manner so as to indicate a reading on the angle indicating scale **66**, for determining the angle of tube bend. A control means **70** is attached to hydraulic pump **52** in order to control the operation of hydraulic jack **48**. The control means in cooperation with the angle indicating means (**66**, **68**) is operated by the novel method explained hereinbelow to bend a tube to an exact bend angle as desired.

Referring now to FIG. 3, it can be seen that grooved quadrant die support means **40** carries a grooved quadrant die **71** at an outer portion thereof while at its central axis there is located a bearing **78**. Main pin **46** is supported by the bearing **78**. The linkage assembly **44** is mounted for relative rotational movement with main pin **46** about support means **40**. The linkage carries a roller shaft **80** to support the grooved bending roller **42**. The roller shaft **80** is located on the linkage assembly **44** a distance C from the axis of the support means **40**. Distance C is determined as follows. The linkage assembly **44** contains a portion **45** located on the extension of a line coincident with a radius to the point of tangency which a tube to be bent will make with the grooved quadrant die **71**, the extension being of a length greater than the radius of the grooved roller **42**. The roller shaft **80** is mounted at the end of this extended portion **45** and the grooved roller **42** is in turn mounted thereon in close enough relationship to the grooved quadrant die **71** so that the clamping action therebetween necessary to maintain roundness of the tube being bent is effected, yet far enough away to develop the necessary bending leverage.

Bearings **82** and roller shaft cap **84** transversely locate the grooved bending roller **42** relative to the stationary grooved quadrant die **71**. It is noted that the grooved bending roller **42** and grooved quadrant die **71** are readily replaceable with similar members of varying size to accommodate bending of different size tubes.

Spiral return spring **86** is fastened at one end **88** to support means **40** and at the other end **90** to linkage assembly **44**. The purpose of spiral return spring **86** is to return linkage assembly **44** to its original position after a tube is bent as explained hereinbelow. The grooved quadrant die support means **40** is connected to the tube bending apparatus support **30** by means of a suspension yoke and swivel **92**. By loosening clamping nut B of the suspension yoke and swivel **92**, the grooved quadrant die support means **40** may be adjusted about the axis A to bend a tube at any angle.

With the invention thus described, the operation is as follows. By means of a suitable overhead crane, the portable boom **16** may be taken to the location of the desired

tube to be bent. By benefit of the counterweight **28**, the operator may easily provide final adjustment of the tube bending apparatus **10** by hand. By loosening clamping nut B, the suspension yoke and swivel **92** can be rotated about axis A thus rotating the tube bending apparatus **10** so as to enable a tube to be bent in any desired direction. Yoke **34** is removed after first lifting out pin **36**. The bending machine is then placed over the tube T during which time the tube T is loosely constrained between the grooved quadrant die **71** and grooved bending roller **42**. The yoke **34** and pin **36** are then replaced. Button **72** of the control means **70** is then actuated causing hydraulic fluid to be pumped to hydraulic jack **48** through flexible hose **50**. As the fluid enters the hydraulic jack **48**, the piston **54** moves the ram **56** (and ram head **58**) to cause tension on the wire cable **60**. Simultaneously, a reactive compressive force is exerted on the jack mounting means **62**. Because the length of cable **60** is fixed, the reactive force causes mounting means **62**, and thus the linkage assembly **44**, to rotate counterclockwise about the axis of main pin **46**. The wire cable **60** unwraps from the guide sheaves **65** on support means **40** so that it is kept coaxial with the jack **48** to provide equal torque at every angle as noted above. As is well known, large forces can be developed with the use of hydraulic jacks and wire cables. Generally speaking, more force per unit size of arrangement can be developed in this manner than with other mechanical organizations of similar size. The use of a wire cable, thus, performs a two-fold function. It enables the tube bending apparatus **10** to produce a maximum power output per unit size while creating a balanced torque at every bending angle. By the use of cables, therefore, we are able to keep the device small and thus portable yet develop a sufficient force to bend large, thick-walled tubes.

The bending roller **42** is carried counterclockwise about the main pin **46** with the linkage assembly **44** and interacts with grooved quadrant die **71** causing the tube T to be bent on a radius corresponding to that of the grooved die **71**. By locating the roller **42** in the manner as explained above, we are able to maintain the shape of the tube to be bent while at the same time accomplishing a clamping action upon the tube T between the roller **42** and the grooved quadrant die **71**. Such clamping action, as noted above, is needed to control the roundness of the tube being bent. Such action is provided on conventional prior art bending machines by means in addition to the bending means; no such additional means is here required.

The angle indicating pointer **68** is observed during bending; and when the desired angle of bend is reached as determined on the angle indicating scale **66**, the button **72** is released. The hydraulic pressure will cease to build up thus stopping the bending action, but the hydraulic pressure will not be released. The second button **74** will then be pushed causing sufficient pressure to be released allowing the tube to "spring back" a few degrees to a position wherein the strain in the tube is released. The pressure remaining in the jack **48** will keep the roller **42** firmly against the tube T. The actual angle of bend may then be read; and if insufficient, the button **72** can be pushed again to complete the bend to the desired angle. In the above manner the bending apparatus itself is used as a protractor enabling the angle of bend to be accurately measured while the tube remains in position for corrective bending.

Once the desired angle of bend is obtained, a button **76** is then pushed releasing all hydraulic pressure. Spiral return spring **86**, connected between support **40** and linkage assembly **44** and put in tension as a result of relative movement therebetween, causes the linkage to return to its initial position (as shown in FIG. 2) upon the release of hydraulic pressure. Yoke **34** may then be removed by pulling pin **36** and the tube is then free to be easily removed. The bending machine may then be moved on to the next tube to be bent.

As shown in FIGS. 1 and 2, an additional roller **94** may be provided if so desired. The purpose of the additional roller **94** is to give a greater leverage arm for bending extremely large, thick-walled tubes over that obtained by roller **42**. This additional roller, however has been found necessary only in limited circumstances.

Thus it can be seen that we have derived a portable bending device with several novel features. By the use of hydraulic jack and cable means and their unique arrangement, we are able to generate sufficient power to control the shape of small radius bends on large, thick-walled tubes while retaining the apparatus of a sufficiently small size to enable it to be made portable. By the particular location of the grooved bending roller, we are able to clamp the tube, thereby eliminating the need for additional clamping structure, while at the same time developing a sufficient bending moment arm to prevent crushing of the tube during bending. We also provide a unique measuring system and bending method which permits simple, accurate determination of the bend angle by means of the bending apparatus itself while the tube remains therein and is still in position for corrective bending.

While we have illustrated and described a preferred embodiment of our invention, it is to be understood that such is merely illustrative and not restrictive and that variations and modifications may be made therein without departing from the spirit and scope of the invention. We therefore do not wish to be limited to the precise details set forth but desire to avail ourselves of such changes as fall within the purview of our invention.

We claim:

1. A portable tube bending apparatus comprising: a portable boom means; a tube bending means; pivotal connecting means for connecting said tube bending means to said portable boom means for universal movement with respect thereto; an angle indicating means mounted on said tube bending means; an hydraulic jack and cable actuating means operatively connected to said tube bending means; control means for said actuating means whereby said tube bending means may be actuated to bend a tube to a desired angle as indicated by said angle indicating means, said control means then releasing said actuating means only to the extent that strain in said tube will be released, and said control means completely releasing said actuating means upon reaching the desired degree of tube bend.

2. A portable tube bending apparatus as claimed in claim **1** wherein said tube bending means comprises a main mounting pin, a relatively stationary grooved quadrant means carrying said main mounting pin, a linkage assembly, a bending member mounted on said linkage assembly, said linkage assembly being mounted on said main mounting pin whereby it may be rotated about the axis of said pin by said actuating means.

3. Apparatus as recited in claim **2** wherein said hydraulic jack and cable actuating means comprises an hydraulic ram and cylinder and a wire cable, said cylinder portion being fixed to said linkage assembly, a fixed means mounted on said stationary quadrant means, said wire cable being attached between said hydraulic ram and said fixed means.

4. Apparatus as recited in claim **3** wherein said fixed means includes a sheave, said wire cable being fixed at both ends to said hydraulic ram and having its mid-portion entrained about said sheave.

5. Apparatus as recited in claim **2** wherein said bending member is a grooved roller, and said linkage assembly includes a portion located on the extension of a line coincident with a radius to the point of tangency which a tube would make with said grooved quadrant means, said extension being of a length greater than the radius of said grooved roller, said grooved roller being mounted on the outer end of said extension.

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U.S. Cl. X.R.

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