The present invention relates to improvements in thin wall conduit benders. More specifically, the invention finds particularly useful application in pipe benders for electric conduit where precise angularity of bends is desired.

Pipe benders in use as well as those which have been proposed are numerous. They normally comprise an arcuate casting with a bending groove, a pipe gripping abutment, and a handle which fits into a socket formed integrally with the arcuate casting.

In operation the conventional benders produce an angularity of bend which is measured by the eye of the user. Sometimes a protractor scale may be used in association with a floor engaging stop. In other cases a protractor may be mounted on the arcuate body proportioned to the arcuate portion of the body.

Existing pipe benders also fail to provide for the elasticity of the pipe or conduit, which induces an inherent error in the bends. In addition, the existing benders fail to permit accurate bending with reference to the tool alone, but normally rely on a flat surface for their functioning.

With the foregoing in mind, it is the general object of the present invention to provide a pipe bender which will bend thin wall conduit accurately to a predetermined angle. A related object is to furnish a pipe bender which will bend thin wall conduit with equal effectiveness whether the bending is done on the floor or with the bender in a reversed position.

Another object of the invention is to furnish a pipe bender which avoids flattening or crimping of the bends in thin wall conduit.

Still another object of the invention is to provide a pipe bender which enables the user to exert greater effective manual pressure throughout the course of the bending operation.

Further objects and advantages of the invention will become apparent as the following description of an illustrative embodiment proceeds, taken with the accompanying descriptive drawings in which:

Figure 1 is a side elevational view of a pipe bender illustrative of the present invention, showing the open or tube-entering side.

Fig. 2 is a longitudinal vertical sectional view of the pipe bender showing a straight length of tube positioned thereon preparatory to bending.

Fig. 3 is a longitudinal vertical sectional view of the pipe bender showing a bent tube positioned thereon, preparatory to forming a reverse bend.

Fig. 4 is a sectional view taken on line 4—4 of Fig. 2.

Fig. 5 is a side elevational view showing the side opposite that of Fig. 1, illustrating the allowance protractor.

Fig. 6 is a top plan view of the tool.

Fig. 7 is a sectional view taken on line 7—7 of Fig. 6, showing a tube positioned on the tool after the forming of a 90° bend.

Fig. 8 is a sectional view taken on line 8—8 of Fig. 7 and showing a tube entering the groove of the stop member.

Fig. 9 is a perspective view on a larger scale of the stop member.

Fig. 10 is a bottom view, also on a larger scale, of the stop member.

Fig. 11 is a partial elevational view of a modified form of the pipe bender.

Fig. 12 is a sectional view taken on line 12—12 of Fig. 11.

Fig. 13 is a top plan view of the modified portion of the pipe bender shown in Fig. 11.

Fig. 14 is a side elevational view of a straight tube marked for bending.

Fig. 15 is a side elevational view of the tube of Fig. 14 after bending.

In broad outline, the invention contemplates a pipe bender having an arcuate conduit receiving channel, and an adjustable stop selectively positioned along the channel, according to the predetermined bend as read from the unique allowance protractor. The allowance protractor is calibrated to compensate for the elasticity of the conduit prior to being bent to an extent where it passes its elastic limit. Provision is made in the arcuate channel to allow for initial elasticity in the bend, as well as to confine the walls of the conduit to prevent elliptical deformation. The sliding stop not only is integrated with the allowance protractor, but also is provided with a novel self-locking split base to insure further accuracy. The details of these components and a full appreciation of their functional advantages will be more fully appreciated as the details of the construction of an illustrative bender proceed.

The bender body

Referring now to Fig. 1, it will be seen the body of the bender is a casting 10. In the preferred form of the invention, this body is of arcuate form and extends substantially through 140°. PROJECTING RADIALLY FROM THE BODY IS A HOLLOW CYLINDRICAL PORTION 11, HAVING INTERNAL THREADS 12 TO RECEIVE A THREADED PIPE HANDLE OR LEVER 13.

TWO INTEGRALLY FORMED UPSTANDING SIDE WALLS 14, 15 DEFINE BETWEEN THEM A LONGITUlDlAL ARCULATE GROOVE 16 IN WHICH THE TUBES ARE BENT. ONE OF THE SIDE WALLS 14 TERMINATES IN A RADIAL LINE OR EDGE 17. THE OTHER SIDE WALL 15 EXTENDS FORWARDLY TO SUPPORT ABUTMENT 18 EXTENDING LATERALLY AND TERMINATING IN AN UPSTANDING LIP 19 WHICH LIES IN THE SAME PLANE AS SIDE WALL 14. ABUTMENT 18 IS LATERALLY U-SHAPED, CORRESPONDING GENERALLY TO THE SHAPE OF GROOVE 16.


STARTING AT THE END OF THE SHORT STRAIGHT PORTION 20, GROOVE 16 IS LONGITUdINAL ARCULATE. HOWEVER, IT SHOULD BE UNDERSTOOD THAT FOR THE SHORT DISTANCE 20, 21 THE GROOVE 16 IS LONGITUdINAL STRAIGHT, AND TANGENT TO THEARCULATE PORTION. THE SHORT STRAIGHT PORTION FROM 20 TO 21 IS SUBSTANTIALLY EQUIVALENT IN LENGTH TO 3° OF ARC.
The pipe grip

The pipe grip 18 has two base sections, an outer section 24 and inner section 22 which converge at a modest ridge 23. The inner portion of the grip base is longitudinal with the pipe, parallel to the initial flat portion 20, 21 of the arcuate groove 16, and offset from the groove by a distance substantially equal to the diameter of the tube.

As best seen in Fig. 2, when a straight tube 25 is positioned on the tool, one side of the tube impinges on the inner section 22 of the abutment, while the opposite side of the tube impinges on portion 20–21 of groove 16. Referring now to Fig. 3, it will be seen that when a bent tube 26 is positioned on the tool preparatory to forming a closely adjoining reverse bend, a portion of the first bend impinges on the abutment forward portion 24. It is therefore apparent that the two abutment portions 22, 24 perform separate and distinct functions.

In order to establish the curvature of forward abutment portion 24, an arc 23–a is drawn from junction point 23 between the front and rear portions of the abutment, first to the bottom of the tube. A second arc 21–a is drawn from the lead edge of the bending groove 21, with a radius equal to that of groove 16 plus the diameter of the tube. From the intersection of the arcs 21–a and 23–a, a third arc is drawn with a radius equal to that of groove 16, and this third arc defines front portion 24 of the abutment. Longitudinally the front and rear portions of the abutment 22, 24 are equal to seven tenths of the tube's diameter, which has been found adequate to prevent indentation or flattening.

Referring to Fig. 1, the pipe grip 18 is defined by the lip portion 19, and edge 17 of side wall 14. The distance from the edge 17 to the lip 19 is made substantially one eighth of an inch larger than the tube diameter. While this dimension permits the easy entrance of the tube, it should be apparent that it is also a practical minimum. One of the advantages of the pipe bender is that it confines all bending rearwardly from the initial fulcrum 20, needed to prevent the flexing or so-called break-down of the tube in the open gate portion 17, 19, where no side wall support is available. In conventional benders, flattening of the tube frequently originates in the portion lying in the open gate of the tool. By limiting this distance to the minimum as described, the portion of the tube in the gate is too short to flex or bend, and all bending occurs rearwardly from the initial fulcrum 20.

The pipe groove

In order to produce smooth round bends free from wrinkles and flattening, the lateral dimensions of groove 16 are critical. In conventional benders of this type, the width of groove 16 has always been made slightly in excess of the tube diameter. Such construction permits the tube to expand laterally under bending stress. Upon removal from the tool, the tube expands farther to equilibrium, which is invariably in excess of the original diameter. Therefore, it is always difficult and often impossible to reinsert a tube so bent into the groove for forming in the open gate of the tool. By limiting this dimension to the minimum as described, the portion of the tube in the gate is too short to flex or bend, and all bending occurs rearwardly from the initial fulcrum 20.

The leverage advantage

Another advantage of the invention is to provide the user with means to exert greater foot pressure while forming a bend on the floor. The difficulty of keeping the tube in contact with the floor, which has been acknowledged in the patent literature, but no effective means has been previously devised to hold the tube down. This is largely due to an incomplete understanding of the function of the bender body 18. While conventional benders have provided a foot-rest 29, the handle 13 has always been regarded as the exclusive means for rocking the body. Further, since bends greater than 90° are not commonly employed in electrical conduit installations, the body of previous benders has been limited substantially to 90°. As already explained, and as shown clearly in the drawings, the body of the improved bender extends through an arc of 140°. The leverage obtainable by means of foot pressure exerted on the foot-rest or heel 29 of any bender of this type may be measured as the chord of an arc, drawn from the fulcrum of a bend to the heel. At the outset, a bend with a bend limited to 90° may be said to have the leverage of a 90° chord. When the bend has been formed to 45°, the leverage is reduced to that of a 45° chord. Obviously, when the bend approaches 90°, there no longer is a chord, and all leverage is lost. As a consequence, the workman must attempt to hold the tube down by sheer strength for an additional 45°. Upon the completion of a 90° bend the improved bender affords foot leverage of substantially 50°. In order to appreciate the magnitude of the force available by means
of foot pressure, it may be worthy of note that, with the improved bender a half-inch tube may be bent by rocking the body 10 exclusively by foot pressure on heel 29, using the handle 13 only to maintain the bender upright. A proportionate part of the force required to rock the body, of course similarly applicable when bending larger tubes.

The extension of the body 10 to 140° is adequate to hold the smaller sizes of tubes in contact with the floor close to the fulcrum. However, in the bending of larger sizes greater difficulty is experienced. To overcome this, an ample form of the tool has been devised to still further increase the applicable foot leverage. As shown in Figs. 11 and 13, an integral lug 30 is formed near the heel 29. Through a hole in the lug 30 a rotatable pin 31 is passed to pivotally support a forked lever 32. The pin 31 may be held in place by any convenient means, as by coiled pins not shown. At the opposite end of the lever is a hole through which is inserted a rod 33, about one foot in length. The rod is positioned so that substantially equal portions project laterally from lever 32. The rod 33 may be locked in lever 32 by any convenient means, as for example by a wing-screw 34 passing through threaded engagement with lever 32 into contact with rod 33.

In normal operation the lever 32 will be in the position shown in dotted lines. In this position, by pressing his foot against the laterally extending rod 33, a workman can exert foot pressure with the advantage of a 90° lever, as previously described. After the bend has been formed to approximately 45°, the lever 32 may be tilted or pivoted to the position shown in full lines. In this position, even at the completion of a 90° bend, the equivalent of 90° of leverage will still be afforded. The lever 32 is arcuate shaped, so that in one position it will rest in contact along the inner periphery of body 10, and in the extended position it will abut the corresponding arcuate shaped portion 35 of heel 29. When the tool is used in the reversed position, that is, resting on the far end of the handle 36, lever 32 may be held in place by any convenient means as by a spring 37.

As previously described, the rod 33 extends equally from both sides of the lever 32. This enables two workmen to co-operate in the bending of larger tubes, since each is enabled to stand on one side of the tool and exert foot pressure by means of the rod 33. In this manner, tube which have heretofore required the use of hydraulic benders or other expensive devices may be bent more quickly by a simple hand tool.

As the bender is rocked on the floor, the handle 36 moves through a wide arc. Since the position of the handle greatly affects the ability of the workman to apply force, a further advantage of the bender is to provide simple means for varying the position of the handle. To accomplish this, socket 11 is provided with a boss 38 to which is attached a spring 39, by means for a screw 40 which passes through a hole in the spring. Near the opposite end of the spring a shoulder stud 41 is passed through a hole in the spring, the stud having a threaded portion by means of which a nut 42 holds the spring against the shoulder 43 of the stud. A reduced portion 44 of the stud passes loosely through a hole in the socket 11, and extends beyond into register with a hole 45 drilled through the wall of pipe handle 36. A second hole 46 is drilled through the handle substantially diametrically opposite the first hole.

As clearly shown in Fig. 11, handle 36 has an integral bend relatively close to socket 11. This bend is preferably formed to an angle of substantially 20°. It will be understood that when stud 41 is engaged in hole 45 of the handle, the latter will be in the position indicated by dotted lines, and moreover that the bend in the handle will lie in the same plane as the bender body 10. After a tube has been bent approximately 45°, stud 41 may be pulled out of engagement with hole 45 by pressing against 75 the upturned portion of the spring at 47. This may be conveniently accomplished by the workman's shoe. As soon as stud 41 is disengaged from the hole 45, the handle 36 may be turned or rotated in socket 11, whereupon spring 39 will assume the position shown in full lines. The positioning of the handle as described will maintain it throughout the forming of a 90° bend in a position in which the workman can more advantageously apply force thereto to rock the body 10. Combined with the additional foot leverage previously described, the adjustment of the handle enables two workmen to cooperate to bend larger tubes than was heretofore possible by means of simple hand tools of this type.

**The pipe stop**

Figs. 9 and 10 show the unique stop member of the bender, generally designated by the reference numeral 50. A longitudinally straight groove 59 is formed in the central portion of the stop. Laterally, this groove is dimensioned similarly to groove 16. Opposite the groove 59 the central portion 51 is longitudinally arcuate and laterally convex, being dimensioned to fit slidably in groove 16 of body 10, as best seen in Fig. 8. It will be understood that groove 59 will be tangent to the portion 54, and consequently will also be tangent to groove 16 regardless of where stop 50 may be positioned in groove 16. Projecting laterally from the central portion 51 are shoulder portions 52. These extend at right angles to support integrally formed pointed members 53. The pointers are dimensioned to overlap side walls 14 and 15 of body 10, and the outer edges 54 are arcuate dimensioned to conform to the extreme outer periphery of side walls 14, 15. The pointers terminate in radiial edges 55.

Integrally formed on one of the pointers is a boss 56 threaded for engagement with a thumb-screw 57, by means of which stop 50 may be locked in any selected position in groove 16. To aid the thumb-screw in maintaining the stop in position, the central portion 51 of the stop is longitudinally split by a fine saw-cut, as clearly shown. As best seen in Fig. 8, when a tube 58 is bent or forced into groove 59, which like groove 16 is dimensioned a few thousandths of an inch less than the tube diameter, the tube will spread the stop into frictional contact with groove 16, while the tube is frictionally engaged by groove 59. The stop therefor is not moved or displaced by the applied bending force.

As best seen in Fig. 2 the heel 29 terminates and partially encloses groove 16. The internal portion 69 of the heel serves as an abutment for the remainder portion 61 of stop 50. It will be understood that ordinarily the stop will be located in this position of abutment, and that thereby the stop is located in the proper position for forming a 90° bend without noting the position of the pointer edges 55.

**The allowance protractor**

Fig. 5 shows three scales. The outermost, 71, is a conventional protractor indexed from zero to 90°. The middle scale 72 is a novel protractor hereinafter identified as an allowance protractor. The allowance protractor comprises an arc of 94½° divided into 90 equal portions each equal to one degree plus three minutes of arc. The third scale 73 consists of a series of graduations laid out along the same arc forming part of the allowance protractor 72. The graduations of scale 73 are selected cosecants corresponding to the angles indicated on the allowance protractor 72. The purpose of the three scales will presently be explained.

The angle to which any tube will bend to reach its elastic limit may be determined experimentally. In the case of one-half inch thin-wall electrical tube, for example, this angle is found to be 24° when bent in the tool illustrated and described. Consequently, in conjunction with allowance protractor 72, the pointers 53...
are so dimensioned that when edge 55 registers zero, groove 59 is tangent to a point 2° advanced in groove 16. This relationship of the bend is illustrated in Fig. 2. The inner edge of the tube 25 on the straight portion 20—21 of groove 16 has been previously described. It may be seen that the tube makes an angle of 2° with groove 59, as indicated in 25b. If the tube is bent to bottom in groove 59 and then released, it will merely spring back to its original position; only permanent bending results. However, if stop 50 is advanced so that pointer edge 55 moves from zero to register 1° on allowance protractor 72, and the tube is again bent to bottom in groove 59, a permanent bend of 1° will result.

In addition to the initial angle of 2° required to reach the elastic limit of the tube, it has been determined experimentally that there is an additional spring, directly proportional to the angle of a bend. Again using one-half inch tube as an example, this additional or secondary spring is found to be substantially 1° for each 30° of bend, or 45° for a 90° bend. This is equal to 3 minutes of arc per degree of bend. As already explained, the pointers 53 are dimensioned to allow for the initial 2° of spring. Allowance protractor 72 provides an index of the necessary overbending required to form any angle of bend, from zero to 90°. By dividing a 94½° arc into 90 equal portions of one degree each, the necessary overbending allowance of 3 minutes is made for each degree of bend. By setting pointer edge 55 in register with any angle on allowance protractor 72 and bending a tube until it bottoms in groove 59, a bend of the desired angle will result. The forming of a 90° bend is illustrated in Fig. 7. Stop 50 is at the extremity position, abutting the portion 60 of heel 79 and thereby locating pointer edge 55 in register with the 90° mark of allowance protractor 72. When the tube is bent to bottom in groove 59, as shown in dotted lines, the bend measures 94½°. Upon release of bending pressure, the tube will spring back to the position indicated in full lines, or 90°.

The conventional protractor

This also explains the purpose of the conventional protractor 71. While the allowance protractor is used to position the stop 50, and accurately predetermine the angle of the bend, it cannot be used to indicate with equal accuracy the terminal point of the bend. Since it is at times advantageous to mark the terminus of a bend as a reference point for additional measurements, this is readily accomplished by drawing a pencil mark on the exposed portion of the tube, in register with a graduated scale of the conventional protractor 71, corresponding numerically with the graduation of the allowance protractor 72 to which the pointer edge 55 was set. Since the angle has been accurately pre-determined, it only remains necessary to mark the terminus with reference to the conventional protractor 71, and this is most conveniently done before the tube is removed from the tool.

Although the allowance protractor 72 is herein described with reference to a single type of tool, and intended tube, it should be apparent that those skilled in the art may readily devise similar protractors for use in conjunction with any bending machine in which the relative rotary motion between an accurately grooved forming die, and a tube bent into substantial conformity with such die, where a machine is used to form large numbers of bends on a single type of blank, or tube, but where the angles of such bends are varied, an allowance protractor proportioned to the spring qualities of such tube will permit accurate setting of stop members without trial and error. With respect to the stop member 50 of the bender, it should be apparent that the stop is equally effective when the tube is bent along the face of the handle. The latter is the position employed when making reverse bends or offsets, the tube in such cases being worked against the tool. In either position of use, the stop acts as a direct tangential abutment for the tube. This feature is important, for while the first bend of an offset could be made on the floor, the second bend cannot, since obviously the first bend would have to project below the surface of the floor in order to position the tube for the second bend.

In exposed electrical conduit installations, 90° bends predominate. This is because the conduits follow the rectangular outlines of buildings, and are not run diagonally across walls or ceilings. Hence, single bends of less than 90° have little application. However, offsets or reverse bends embodying two equal bends of lesser angles are frequently required. Workmen often must produce such offsets on the job site, without tools involving layout that might be appropriate for factory or mass production methods. There is no occasion for mass production in conduit installations, and offset bends are devised individually for a particular location. This has previously been accomplished entirely by trial and error methods, and a further objective of this invention is to provide simple and reliable means for producing offset bends.

The offset scale

The forming of two bends of equal angular measurement may readily be accomplished by the use of the stop member 50, and a minute stop 56. From this mark a series of angles in conjunction with which the distance between bends may be established as a simple rectilinear measure

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ment, and the complete procedure of producing offsets changed from guess work to a simple and dependable method. As the largest radius for which such tools of the present invention may be dimensioned is approximately ten inches, it will be understood that the accuracy of measurements as described will be commensurate with the type of work involved.

The scales thus far described are shown only on one side wall, 15, as seen in Fig. 5. It should be apparent that the same scales may be duplicated on the opposite side wall 14, shown in Fig. 1. As stop member 50 has two pointers, the necessary co-operation between the pointer, and any scales on side wall 14, is provided. It therefore lies within the scope of the invention to duplicate on side wall 14 the scales shown on side wall 15. Moreover, in the same manner that offset scale 73 is derived from the allowance protractor 72, scales of other functions of angles, as for example a scale of spaced values of the natural sine, or a scale of spaced values of the natural versed sine, may also be shown as part of an allowance protractor, it being provided that any and all such additional scales have the same reference zero, and that they be concentric. Such additional scales have a limited application in the measurement of certain pipe bends, and inasmuch as they can be added to the tool without substantially increasing its cost, they are advantageous.

Although a particular embodiment of the invention has been shown and described in full here, there is no intention of thereby limit the invention to the details of such embodiment. On the contrary, the intention is to cover all modifications, alternative embodiments, usages and equivalents of the binder for hollow conduits as fall within the spirit and scope of the invention, specification and appended claims.

I claim as my invention:

1. In a pipe binder having an arcuate body defining a pipe groove at its periphery and having a pipe grip at one end of the groove, an angular scale along the arcuate periphery of the body, and a slidable stop proportioned for a nest fit within the groove, the stop being characterized by means for removably securing it within the groove and a pointer portion which coacts with the angular scale indicia to measure the angle of bend to be made.

2. In a pipe binder of the character defined in claim 1 above, the slidable stop being characterized by a central slot thereby permitting the body to expand when the pipe engages the stop thereby spreading the stop within the pipe groove further locking the stop against displacement.

3. In a pipe binder of the character defined in claim 1, a handle bent at 20°, and socket means on the binder body to reversibly receive the handle.

4. A pipe binder of the character defined in claim 1 having an arcuate portion of 140°, and a foot pressure application point at the end of the arcuate portion thereby insuring bending leverage throughout the course of a 90° bend.

5. In a pipe binder of the character defined in claim 1, a U-shaped bending groove defined by spaced walls, the inner faces of the walls being proportioned to define a groove having a semi-circular cross section with a diameter slightly less than the tube intended for bending, the walls extending tangentially upward from the semi-circular section to a height thereat of 0.7 of the diameter is buried within the groove when fully engaged.

6. In a pipe binder having an arcuate body portion with a peripheral pipe engaging groove, a tangential tube engaging fulcrum at the beginning of the bending surface equalling the tangential projection of an arc equivalent to the angular deflection of the pipe required to exceed the elastic limit of the pipe when bent at the arcuate radius of the pipe engaging groove.

7. In a pipe binder having an arcuate body portion and a stop with angular measurement means nested within a peripheral bending groove, an allowance protractor for cooperation with the stop measurement means, the protractor bearing angular indicia compensating for the angularity of the elastic limit of the pipe for bending so that after over-bending to the apparent angle on the allowance protractor the measured bend of the pipe will be the same as the apparent bend on the allowance protractor.

8. In a pipe binder of the character defined in claim 7, an offset scale coordinated with the allowance protractor to read the natural cosecant of the associated allowance protractor angle.

9. In a pipe binder having an arcuate body, with a stop at one end of the arcuate portion and a pipe grip at the other end of the arcuate portion, an auxiliary foot operated pedal, comprising, in combination, swivel means adjacent the stop end of the arcuate body portion, a link coupled at one end to the swivel means, a transverse foot rest removably secured to the end of the link remote from the swivel coupling, and yieldable means on the pipe binder body securing the link in the inoperative position.

10. In a pipe binder having an arcuate body defining a pipe groove at its periphery and having a pipe grip at one end of the groove, an angular scale along the arcuate periphery of the body, and a slidable stop proportioned for a nest fit within the groove, the stop being characterized by means for removably securing it within the groove and a pointer portion which coacts with the angular scale indicia to measure the angle of bend to be made, said pipe groove having an initial tangentially straight surface to prevent flattening of a tube during bending.

11. In a pipe binder having an arcuate body defining a pipe groove at its periphery and having a pipe grip at one end of the groove, an angular scale along the arcuate periphery of the body, and a slidable stop proportioned for a nest fit within the groove, the stop being characterized by means for removably securing it within the groove and a pointer portion which coacts with the angular scale indicia to measure the angle of bend to be made, said pipe grip having an inner tangentially straight portion for accommodating a length of straight pipe and the outer portion inclined outwardly from the inner portion to accommodate the bend portion of a pipe when producing a reverse bend.

12. In a pipe binder having an arcuate body defining a pipe groove at its periphery and having a pipe grip at one end of the groove, an angular scale along the arcuate periphery of the body, and a slidable stop proportioned for a nest fit within the groove, the stop being characterized by means for removably securing it within the groove and a pointer portion which coacts with the angular scale indicia to measure the angle of bend to be made, the other end of said groove being a stop rest positioned to provide a 90° pipe bend when said stop is secured against the rest.

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