Dec. 26, 1950 W. B. CARLSON 2,535,782

APPARATUS FOR EXPANDING TUBES IN TUBE SEATS

Filed Aug. 19, 1948 2 Sheets-Sheet 1

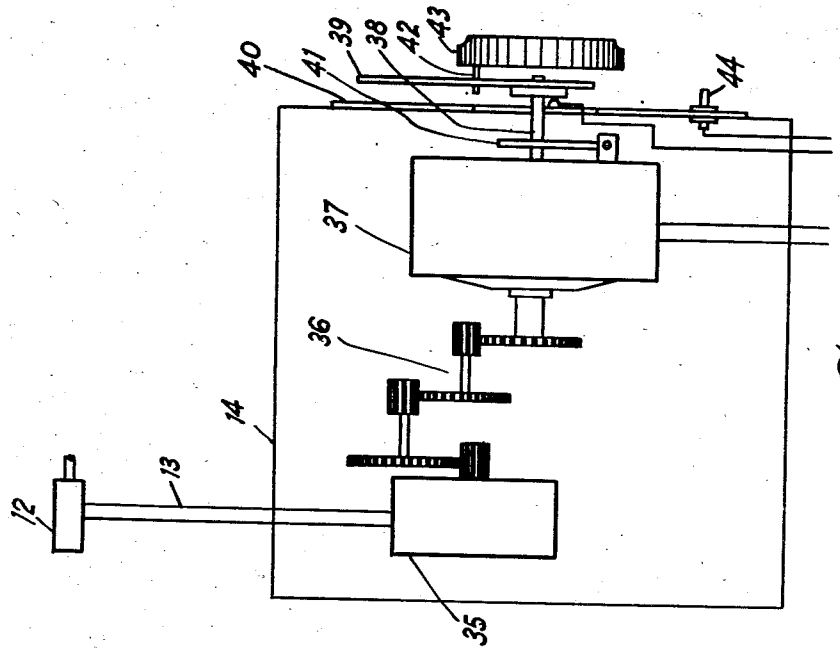


Fig. 2

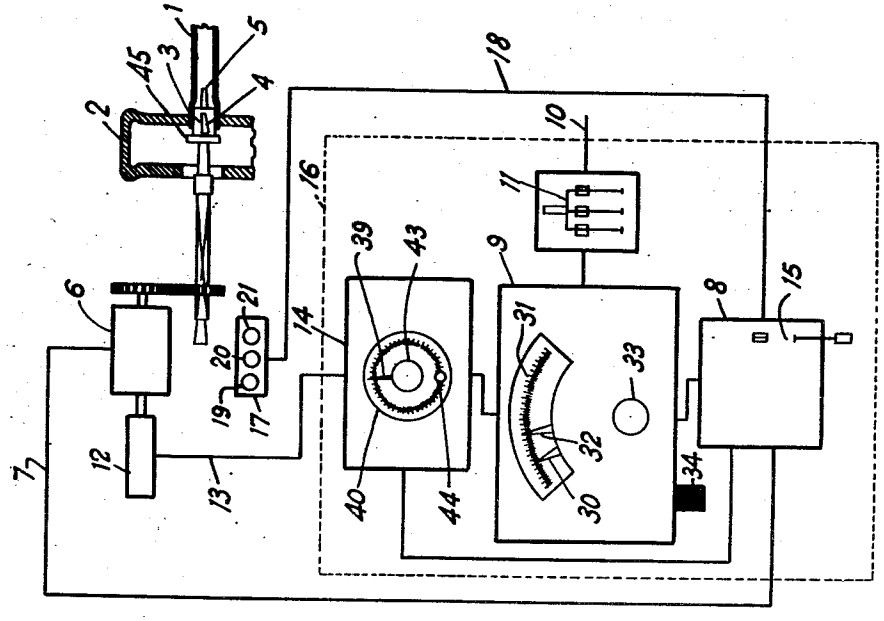


Fig. 1

INVENTOR
Walter B. Carlson
BY
ATTORNEY

Dec. 26, 1950 W. B. CARLSON 2,535,782

APPARATUS FOR EXPANDING TUBES IN TUBE SEATS

Filed Aug. 19, 1948 2 Sheets-Sheet 2

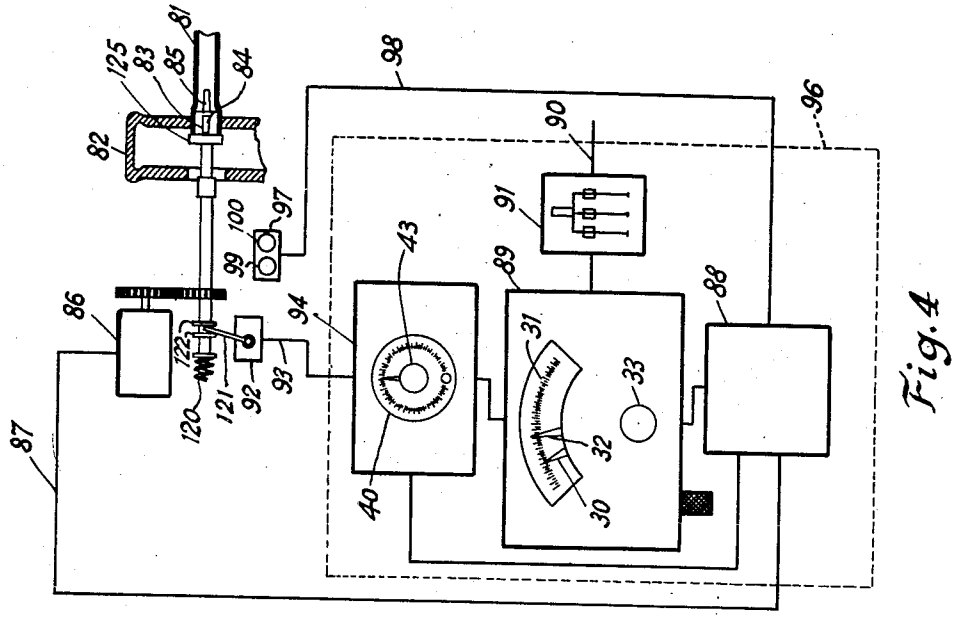


Fig. 4

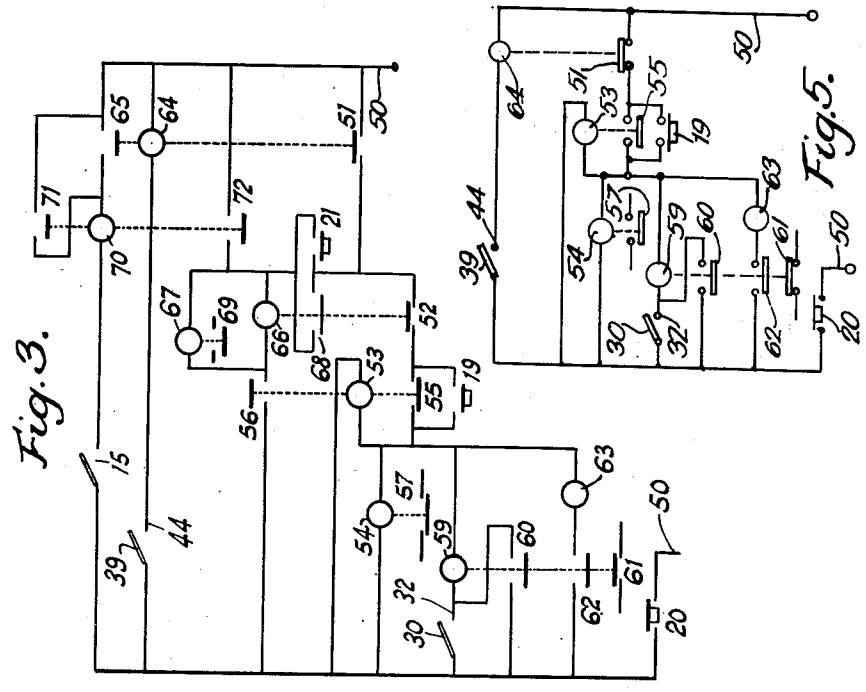


Fig. 3.

Fig. 5.

INVENTOR
Walter B. Carlson
BY
W. Holbrook
ATTORNEY

Patented Dec. 26, 1950

2,535,782

UNITED STATES PATENT OFFICE

2,535,782

APPARATUS FOR EXPANDING TUBES IN TUBE SEATS

Walter B. Carlson, London, England, assignor to The Babcock & Wilcox Company, Rockleigh, N. J., a corporation of New Jersey

Application August 19, 1948, Serial No. 45,088
In Great Britain August 28, 1947

11 Claims. (Cl. 153—82)

1

This invention relates to a method of and apparatus for expanding tubes in tube seats by means of roller expanders. Usually determination of the degree of expansion considered proper for a joint has depended upon observation of the joint or a part thereof, such as observation of the degree of longitudinal tube extrusion or the degree of yielding of the tube seat. In practice such methods tend to lead to inconsistencies and considerable time is taken to make the observations.

An object of the invention is to enable joints between tubes and tube seats to be formed with a substantial degree of uniformity. Another object is to expedite the formation of such joints.

The present invention comprises the method of expanding a tube in a tube seat which includes applying a roller tube expander to the expansion of the tube with the expander mandrel rotated by means of a power device, detecting an increase in the power required occurring when the tube is expanded to nip the seat in the resistance to rotation of the mandrel, and thereafter completing the expanding operation by operating the expander so that the mandrel moves axially relatively to the body or the expander through a predetermined or substantially predetermined distance.

The invention also includes tube expanding apparatus comprising a power device adapted to drive a roller tube expander, means for measuring mandrel movement axially relatively to the body of the expander, and means adapted to be actuated as a result of an increase in the power required occurring when a tube is expanded to nip a seat in the resistance to rotation of the mandrel and thereby automatically to bring into operation means to measure subsequent mandrel movement, the means for measuring mandrel movement being so arranged that when a predetermined extent of mandrel movement has been completed the expanding operation is stopped.

In the case of propulsive roller tube expanders, there are sufficiently constant relations between the rate at which the mandrel moves axially relatively to the body of the expander, the rate of rotation of the body of the expander, and the rate of rotation of the mandrel, and such movement of the mandrel may be measured by counting the turns made by the mandrel.

The invention also involves the method of expanding a tube in a tube seat which includes the application of a propulsive roller tube expander to the expansion of the tube with the expander mandrel rotated by means of a power device, de-

2

tecting an increase in the power required occurring when the tube is expanded to nip the seat in the resistance to rotation of the mandrel, and thereafter completing the expanding operation by rotating the mandrel through a predetermined or substantially predetermined number of turns.

The invention also involves tube expanding apparatus including a power device adapted to drive a propulsive roller tube expander, a mandrel revolution counter arranged to be driven by the power device, and means adapted to be actuated as a result of an increase in the power required occurring when the tube is expanded to nip the seat in the resistance to rotation of the mandrel and thereby automatically to bring into operation means to count subsequent revolutions, the revolution counter being arranged to stop rotation of the mandrel when a predetermined number of such subsequent revolutions has been counted.

The invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Fig. 1 illustrates a layout of equipment for use in automatically expanding a tube end in a header by means of a propulsive roller tube expander;

Fig. 2 illustrates to a larger scale elements of a mandrel revolution counter included in the equipment illustrated in Fig. 1;

Fig. 3 illustrates an arrangement of relays and control circuits for the operation of the equipment illustrated in Fig. 1;

Fig. 4 illustrates a modified layout of equipment for use in automatically expanding a tube end in a header by means of a roller tube expander in which the rollers have no lead angle; and

Fig. 5 illustrates an arrangement of relays and control conduits for the operation of the equipment illustrated in Fig. 4.

Referring to Figs. 1 to 3, and particularly to Fig. 1 of the drawings, equipment for automatically expanding the end of a tube 1 in a header 2 comprises a propulsive roller tube expander of known form with a cage 3 carrying inclined expanding rollers 4, which during expansion are forced against the inner wall of the tube end by a tapered mandrel 5 which is inserted axially within the cage and to effect expansion is rotated in a direction such that the cage tends to advance into the tube. A fixed cape 45 on the cage limits axial movement of the cage by abutting against the tube end surface. For driving the mandrel, a suitable three-phase electric driving motor 6 is provided. Power for the driving

motor is supplied by cable 7 from a switch unit 8.

The switch unit 8 is supplied with power for the driving motor from a power-measuring and control device 9 to which power is led from a supply cable 10 via a switch 11.

Upon the shaft of the driving motor is arranged a small single phase electric generator 12 connected by cable 13 to a mandrel revolution control unit 14. The mandrel revolution control unit is electrically connected to the switch unit 8, and is electrically connected also with the power-measuring and control device 9.

The power measuring and control device 9 and the mandrel revolution control unit 14 are provided with adjusting means to be described, and with the switch unit 8, on which is mounted a reversing-control switch 15 to be described, and the switch 11, are mounted within a cubicle 16 which is located in some convenient position and provided with a door having a lock. Control of the operation of the driving motor can be exercised by means of a mobile control panel 17 connected with the switch unit 8 within the cubicle by cable 18, and having a normally open "start" push button switch 19, a normally closed "stop" push button switch 20, and a normally open "reverse" push button switch 21.

The power measuring and control device 9 includes a watt-meter having an indicator needle 30 movable over a scale 31 and arranged to complete an electric circuit should it touch a contact 32, the position of which may be adjusted by means of an adjustment 33. The watt-meter needle is damped in a known manner by a metal disc arranged to rotate between the poles of a magnet and the amount of damping is adjustable by displacing the magnet axially of the disc by means of the knob 34.

Referring to Figs. 1 and 2, the mandrel revolution control unit 14 includes a small self-starting electric motor 35 of a kind adapted to rotate in synchronism with the generator 12 to which it is connected by the cable 13, generator 12 and motor 35 forming a self synchronous system. The rotation of the motor is transmitted through a reduction gear train 36 to one plate of a magnetic clutch 37, the other plate of which is connected to a spindle 38 carrying a pointer 39 which moves in front of a dial 40 upon which mandrel revolutions are indicated. The spindle 38 is biased by a hair spring 41 so that when the clutch is disengaged the pointer moves until it reaches an abutment 42 on an adjusting knob 43. A fixed contact 44 is provided and by making contact with contact 44, the pointer is arranged to close an electric circuit.

For expanding the end of the tube 1 in the header 2 with the equipment illustrated, the damping of the watt-meter needle is suitably adjusted by means of the knob 34, the position of the contact 32 is suitably adjusted by the adjustment 33, the adjusting knob 43 is turned until the pointer 39 indicates a suitable number of mandrel turns, if desired the reversing control switch 15 is closed, and the power is applied by operation of the switch 11. The expanding operation is now controlled by operation of the mobile control panel 17. When the "start" push button switch 19 is closed a circuit is completed, between suitably energized conductors 50 (Fig. 3), through a normally closed relay contact 51, another normally closed relay contact 52, the "start" push button switch 19, relay coils 53 and 54 arranged in parallel, and push button switch 20. The relay coil 53 when thus energized closes a normally open relay contact 55 in parallel with the "start" switch, enabling the "start" switch to be released without breaking the circuit, and opens a normally closed relay contact 56. The relay coil 54 when energized is arranged to connect the driving motor 6 to the power supply for driving the mandrel in the forward direction, this action is schematically indicated in Fig. 3 by the closing of the normally open relay contact 57.

The driving of the mandrel requires electric power which is indicated by a movement of the watt-meter indicator needle 30 but such movement is insufficient to bring the needle into contact with the contact 32 before the tube has been expanded to nip the tube seat. After the tube has been expanded to nip the tube seat, the power taken by the motor in continuing the expansion rises above a predetermined value at which the watt-meter needle, after a delay depending upon the damping thereof, comes into contact with the contact 32. The damping is adapted so that in the event of the power rising for a short while to the predetermined value for any reason, e. g. possibly scale in the tube, and before the tube is expanded to nip the tube seat the possibility of the watt-meter needle moving sufficiently to contact 32 prematurely is avoided or reduced.

Contact between the watt-meter needle 30 and the contact 32 energizes a relay coil 59, in parallel with the relay coils 53 and 54, and thereby effects closure of a normally open relay contact 60 so connected as to enable the watt-meter needle to return to a zero position without breaking the circuit through the relay coil 59; disconnection (as represented by the opening of the relay contact 61) of the watt-meter from circuit; and closure of a relay contact 62 which energizes coils (represented by 63) of the magnetic clutch 37 which thereupon engages.

With the magnetic clutch in the engaged position the synchronous motor 35 drives the spindle 38 so that the pointer 39 moves away from the abutment 42 and over the dial 40 towards the contact 44. After a predetermined number of mandrel turns, depending upon the position to which the abutment 42 was adjusted, the pointer 39 contacts the contact 44, closing an electric circuit which is arranged to energize a relay coil 64. Energization of the relay coil 64 is arranged to open the aforementioned normally closed relay contact 51, whereby de-energization takes place of the relay coil 53, resulting in opening of the relay contact 55 and closing of the relay contact 56, of the relay coil 54, resulting in the cutting-off of power for forward drive of the mandrel, of the relay coil 59, and of the relay 63, resulting in disengagement of the magnetic clutch 37 allowing the pointer 39 to move back under the influence of the hair spring 41 to de-energize the relay coil 64 and to contact the abutment 42. The energization of the relay 64 also closes a relay contact 65 in a circuit controlled by the reversing-control switch 15.

Should the reversing-control switch 15 have been placed in the open position, the relay 64 after de-energization recloses the switch 51 without having initiated automatically any fresh operation. In order to drive the mandrel in the reverse direction, the "reverse" push button switch 21 may be closed, as a result of which a circuit is closed through the relay contact 51, the switch 21, two relay coils 66 and 67 in parallel, relay contact 56 and the push button switch 20. Energization of the relay coil 66 opens the

normally closed relay contact 52 and closes a normally open relay contact 68 which is arranged in parallel with the switch 21 and allows the switch 21 to be opened without de-energizing the relay coils 66 and 67. Energization of the relay coil 67 is arranged to connect electric power to the driving motor 6 for driving the mandrel in the reverse direction; this action of the relay coil 67 may be schematically indicated by the closing of the normally open relay contact 69. When desired, after the expander is free in the tube, the motor is stopped by operating the "stop" push button switch 20, whereupon the relay coils 66 and 67 will be de-energized, the power to the motor will be cut off, and the relay contacts 68 and 52 will return to their normal positions. The control circuits and relays are then in their original conditions.

Should on the other hand the reversing-control switch 15 be in the closed position when the relay coil 64 is energized by the contact of the pointer 39 with the contact 44 at the end of the predetermined number of mandrel turns after the nipping of the tube seat, a circuit will be completed through the relay contact 65, a relay coil 70, the reversing control switch 15 and the push button switch 20. The energization of the relay coil 70 is arranged to close a normally open switch 71 in parallel with the relay contact 65, enabling relay contact 65 to be opened, when the relay coil 64 becomes de-energized, without breaking the circuit through the relay coil 70. Energization of the relay coil 70 also closes a normally open relay contact 72 through which current may flow to energize the relay coil 67, thereby causing the application of power to the driving motor for reverse drive of the mandrel, and to energize the relay coil 66. The motor is stopped when desired after the expander is free in the tube by operation of the "stop" push button switch 20, whereby the relay coils 66, 67, and 70 are de-energized.

Operation of the "stop" push button switch 20 at any time during the forward or reverse movement of the mandrel will always stop the motor. Operation of the "reverse" push button switch 21 during the mandrel forward drive will have no effect because the relay contact 56 remains open to prevent the energization of the relay coils 66 and 67. Operation of the "start" push button switch 19 during the reverse movement of the mandrel will have no effect because the relay contact 52 remains open to prevent the energization of the relay coils 53 and 54.

Usually a number of similar tubes have to be expanded in respective similar tube seats and the values to which the various adjusting means in the cubicle are set are appropriate for the expansion of all the said tubes. Thus, after the expansion of one of the said tubes, and with the expander free in the tube, the mandrel and cage may be withdrawn by hand from the header axially of the tube and the motor moved, e. g. by traversal along a supporting bench, until the mandrel is in line with the axis of another similar tube seat within which lies or is brought to lie a tube end to be expanded therein. The cage is suitably inserted in the tube end and the mandrel advanced axially by hand until the rollers bear suitably firmly both against the inner surface of the tube and the mandrel, and the "start" push button is operated to initiate the automatic expansion of the said tube with the same setting of the adjusting means as previously.

The expanding operation is expeditiously performed since the necessity of observing the progress of the expanding operation at the joint is obviated.

The various adjustments enable the apparatus to be used in the expansion of widely diverse sizes of tube in various designs of expanded tube joints. The desired uniformity of expansion is obtained notwithstanding inconsistencies of a practical order in the tube or tube seat dimensions or in the characteristics of the materials of the tube or tube seat or in the voltage of the power supply. The cessation of the expanding operation is brought about by the completion of a predetermined number of mandrel turns after the tube nips the seat and not by measurement of a predetermined maximum power input to the driving motor, which might result in frequently under- or over-expanding tubes. Moreover, inconsistencies due to faulty control are reduced or eliminated since normally the expanding operation once started is continued under automatic control until the completion of the operation.

Referring to Fig. 4 of the drawings, equipment for automatically expanding the end of a tube 81 in a header 82 comprises a roller tube expander of a kind in which the rollers 84 are arranged in the cage 83 without a lead angle and are forced radially outwardly by a tapered mandrel 85 which is inserted axially into the cage and, to effect expansion, is rotated by an electric driving motor 86 at the same time as it is subjected to an axial thrust, imposed by any suitable means represented by the compression spring 120, directed inwardly of the tube. A fixed cape 125 on the cage limits axial movement of the cage by abutting against the tube end surface. Power for the driving motor is supplied by cable 87 from a switch unit 88, which is supplied with power for the driving motor from a power measuring and control device 89, which is similar to the power measuring and control device 9 described with reference to Figs. 1 to 3, and to which power is led from a supply cable 90 via a switch 91.

The mandrel driving motor 86 is mounted in a fixed position relatively to the header 82 for the expansion of a tube end while the mandrel 85 is mounted so as to be movable on its own axis to be able to advance into the tube under the influence of the said imposed thrust. Axial movement of the mandrel 85 into the tube is arranged to drive a small electric generator 92 connected by cable 93 to a mandrel travel control unit 94 which is similar to the mandrel revolution control unit 14 described with reference to Figs. 1 to 3 except that mandrel travel distances instead of mandrel revolutions are marked upon its dial. The mandrel travel control unit is electrically connected to the switch unit 88, and is electrically connected also to the power measuring and control device 89. The electric generator 92 is provided with gearing so as to be actuable at suitable rates of rotation by an arm 121 an end of which is arranged to project between two collars 122 fixed at a suitable position on the mandrel driving shaft.

The power measuring and control device and the mandrel travel control unit, which are provided with adjusting means of the corresponding members 9 and 14 described with reference to Figs. 1 to 3, are, together with the switch unit 88 and the switch 91, mounted within a cubicle 96 which is located in some convenient position and provided with a door having a lock. Control

of the operation of the driving motor can be exercised by a mobile control panel 99 connected with the switch unit 88 within the cubicle by cable 98, and having a normally open "start" push button switch 99 and a normally closed "stop" push button switch 100.

For the automatic expansion of a tube, an arrangement, shown in Fig. 5, of relay coils and control circuits is provided which is similar to the arrangement described with reference to Fig. 3, but circuits, concerned with reverse operation, including the relay coils 66, 67, and 70, relay contacts 56, 65, 68, 71, and 72, push button switch 21, and reversing control switch 15, are omitted, while the circuits of the relay coils 53, 54, 59, and 63 are not interruptible by a relay contact 52. In order to carry out an expanding operation, the expander cage and rollers and the mandrel are inserted in the tube end, the adjustments in the power measuring and control device and the mandrel travel control unit are suitably set, the power is applied by closing the switch 91, and the "start" push button switch 19 is operated. Closure of switch 19 picks up relays 53 and 54. Relay 53 completes its holding circuit around switch 19 by closure of contact 55. Relay 54 connects driving motor 86 to the power supply by closing contact 57. The mandrel is then rotated by the driving motor and, as the tube end is enlarged, moves inwardly of the tube and actuates the small electric generator. When the tube is expanded to nip the seat, the power taken by driving motor 86 rises and the needle 30 of the power measuring and control device is thus moved to engage the pre-set needle 32. Engagement of these two needle contacts picks up relay 59 which closes its own holding circuit through contacts 60. Relay 59 also opens contacts 61 disconnecting the watt-meter from the circuit and closes contact 62 to energize the coils (represented by 63) of the magnetic clutch to engage the latter.

The synchronous motor energized from generator 92 thereby is connected to drive spindle 38 so that pointer 39 moves away from abutment 42 and over dial 40 toward contact 44. When the predetermined axial travel of the mandrel after the movement when the tube nips the seat has been carried out, pointer 39 engages contact 44 to energize relay 64. This opens the normally closed relay contact 51, breaking the holding circuits of relay coils 53 and 54. Tripping of relay 54 breaks the motor circuit. Relay 59 is also deenergized which breaks the circuits for clutch coil 63 to disengage the magnetic clutch. Pointer 39 moves back under the hair spring 41, breaking the circuit for relay 64, and again contacts abutment 42. The mandrel operation is thus automatically interrupted after a pre-set axial travel.

The operation may be stopped at any previous moment by operating the "stop" push button switch 100.

The drive of the electric generator includes a pawl and ratchet wheel arrangement (not shown) so that the arm 121 may be moved by the collars 122 without rotating the moving parts of the generator 92 when the mandrel is withdrawn from the tube by any suitable means after the expanding operation.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form of my invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. Tube expanding apparatus comprising a power device adapted to drive a roller tube expander; means measuring mandrel movement axially relative to the body of the expander and adapted to control energization of said power device; and power measuring means associated with said power device and including means operable, responsive to an increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said mandrel movement measuring means to control energization of said power device; said mandrel movement measuring means being arranged to deenergize said device after a predetermined mandrel movement under the control of said mandrel movement measuring means.

2. Tube expanding apparatus comprising a power device adapted to drive a roller tube expander; means measuring mandrel movement axially relative to the body of the expander and adapted to control energization of said power device; and power measuring means associated with said power device and including means operable, responsive to a sustained predetermined increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said mandrel movement measuring means to control energization of said power device; said mandrel movement measuring means being arranged to deenergize said device after a predetermined mandrel movement under the control of said mandrel movement measuring means.

3. Tube expanding apparatus comprising a power device adapted to drive a roller tube expander; means measuring mandrel movement axially relative to the body of the expander and adapted to control energization of said power device; power measuring means associated with said power device and including means operable, responsive to an increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said mandrel movement measuring means to control energization of said power device; said mandrel movement measuring means being arranged to deenergize said device after a predetermined mandrel movement under the control of said mandrel movement measuring means; and a time delay means associated with said power measuring means whereby the latter is effective to activate said mandrel movement measuring means only upon a sustained predetermined increase in power requirements of said device.

4. Tube expanding apparatus comprising an electric motor adapted to drive a roller tube expander; means measuring mandrel movement axially relative to the body of the expander and adapted to control energization of said motor; a wattmeter associated with said power device; and means controlled by said wattmeter and operable, responsive to an increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said mandrel movement measuring means to control energization of said power device; said mandrel movement measuring means being arranged to deenergize said device after a predetermined mandrel movement under the control of said mandrel movement measuring means.

5. Tube expanding apparatus comprising a

power device adapted to drive a roller tube expander; means measuring mandrel movement axially relative to the body of the expander and adapted to control energization of said power device; and power measuring means associated with said power device and including means operable, responsive to an increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said mandrel movement measuring means to control energization of said power device; said mandrel movement measuring means being arranged to deenergize said device after a predetermined mandrel movement under the control of said mandrel movement measuring means; said mandrel movement measuring means being driven by a synchronous motor energized from an alternating current generator driven in dependence upon mandrel movement.

6. Tube expanding apparatus comprising a power device adapted to drive a roller tube expander; means measuring mandrel movement axially relative to the body of the expander and adapted to control energization of said power device; power measuring means associated with said power device and including means operable, responsive to an increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said mandrel movement measuring means to control energization of said power device; said mandrel movement measuring means being arranged to deenergize said device after a predetermined mandrel movement under the control of said mandrel movement measuring means; said mandrel movement measuring means being driven by a synchronous motor energized from an alternating current generator driven in dependence upon mandrel movement; and means operable automatically, responsive to completion of a mandrel movement, to reset said mandrel movement measuring means.

7. Tube expanding apparatus comprising a power device adapted to drive a propulsive roller tube expander; a mandrel revolution counter driven by said power devise and adapted to control energization of said power device; and power measuring means associated with said power device including means operable, responsive to a sustained increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said revolution counter to control energization of said power device; said revolution counter being arranged to deenergize said device after a predetermined number of mandrel revolutions under the control of said counter.

8. Tube expanding apparatus comprising a power device adapted to drive a propulsive roller tube expander; a mandrel revolution counter driven by said power device and adapted to control energization of said power device; power measuring means associated with said power device including means operable, responsive to a sustained increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said revolution counter to control energization of said power device; said revolution counter being arranged to deenergize said device after a predetermined number of mandrel revolutions under the control of said counter; and a time delay means associated with said power measuring means whereby the latter is effective to activate said revolution counter only upon a sustained predetermined increase in power requirements of said device.

9. Tube expanding apparatus comprising an electric motor adapted to drive a propulsive roller tube expander; a mandrel revolution counter driven by said motor and adapted to control energization of said motor; a wattmeter associated with said power device; and means controlled by said wattmeter and operable, responsive to a sustained increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said revolution counter to control energization of said power device—said revolution counter being arranged to deenergize said device after a predetermined number of mandrel revolutions under the control of said counter.

10. Tube expanding apparatus comprising a power device adapted to drive a propulsive roller tube expander; a mandrel revolution counter driven by said power device and adapted to control energization of said power device; power measuring means associated with said power device including means operable, responsive to a sustained increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said revolution counter to control energization of said power device; said revolution counter being arranged to deenergize said device after a predetermined number of mandrel revolutions under the control of said counter; and means controlled by said counter to reverse rotation of said mandrel after completion of such predetermined number of revolutions.

11. Tube expanding apparatus comprising a power device adapted to drive a propulsive roller tube expander; a mandrel revolution counter driven by said power device and adapted to control energization of said power device; power measuring means associated with said power device including means operable, responsive to a sustained increase in power requirements of said device occurring when the tube has been expanded to nip the seat, to activate said revolution counter to control energization of said power device; said revolution counter being arranged to deenergize said device after a predetermined number of mandrel revolutions under the control of said counter; remote control means for said power device; and a synchronized follow up system including a receiver connected to said counter, a transmitter actuated responsive to mandrel rotation, and synchronized transmission means interconnecting said transmitter and receiver.

WALTER B. CARLSON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,410,646	Gallon	Mar. 21, 1922
1,514,712	Maupin	Nov. 11,1924
1,615,502	Bourn	Jan. 25, 1927
1,739,980	Meunier	Dec. 17, 1929
1,826,482	Rummel	Oct. 6, 1931
2,041,915	Fisher	May 26, 1936
2,324,030	Schellin	July 13, 1943
2,355,852	Fisher	Aug. 15, 1944
2,389,098	Welch	Nov. 13, 1945
2,448,512	Brackett	Sept. 7, 1948