Nov. 10, 1959 G. C. DONOVAN 2,912,562

METHOD AND APPARATUS FOR RECONDITIONING CYLINDER LINERS FOR DIESEL ENGINES

Filed April 22, 1957 2 Sheets-Sheet 1

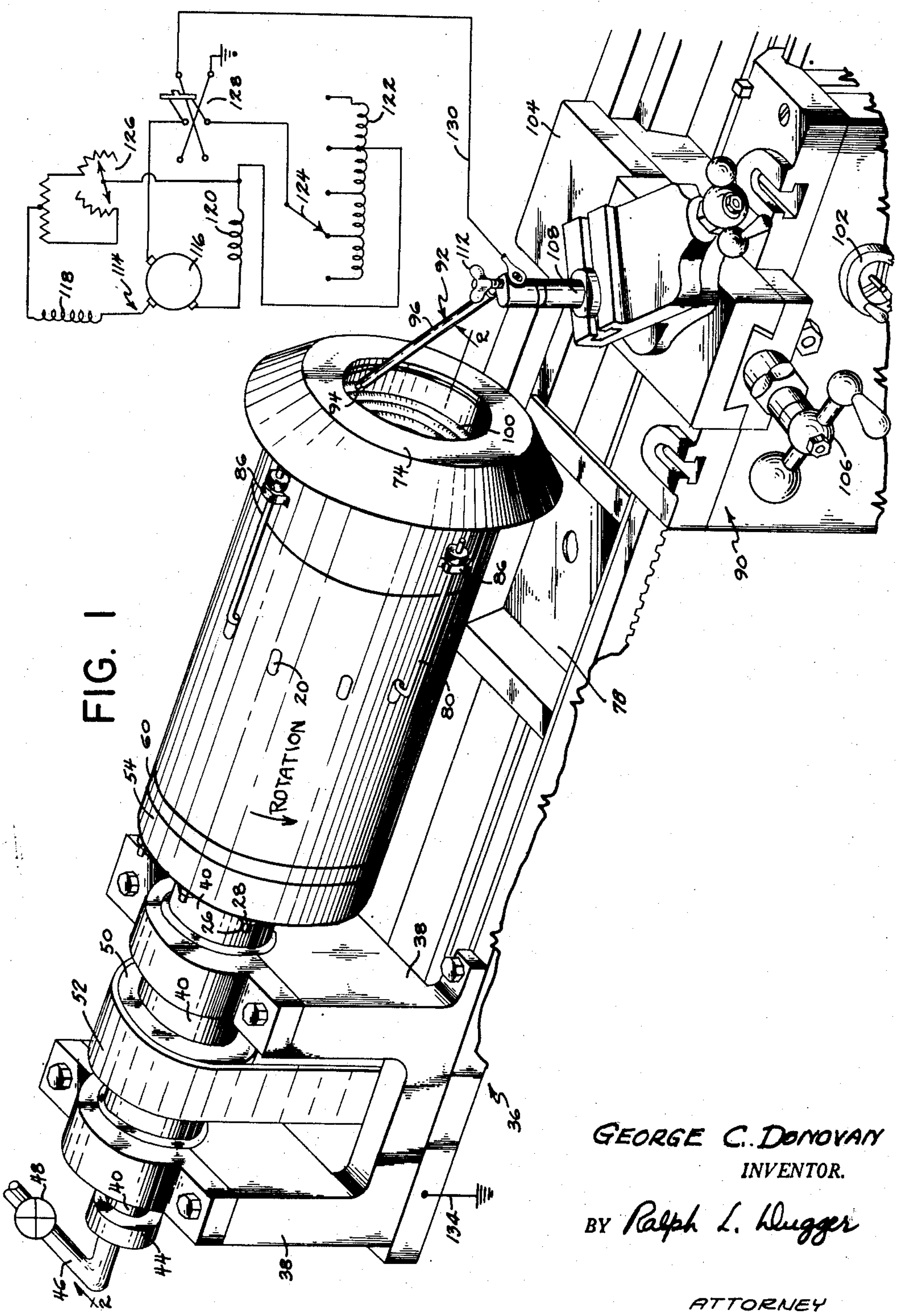

FIG. 1

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Filed April 22, 1957 2 Sheets-Sheet 2

FIG. 2

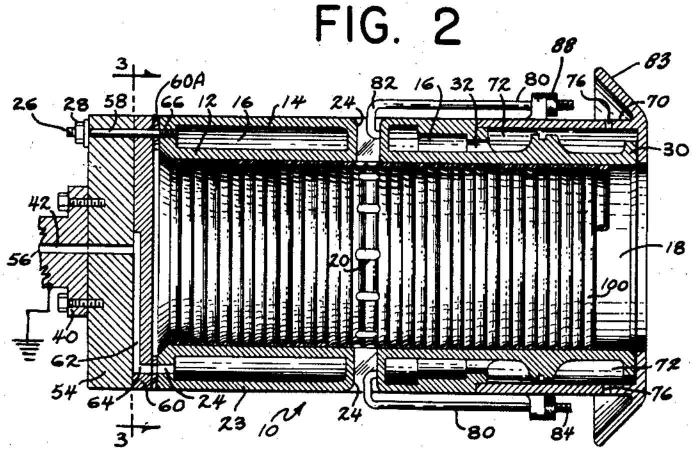


FIG. 3

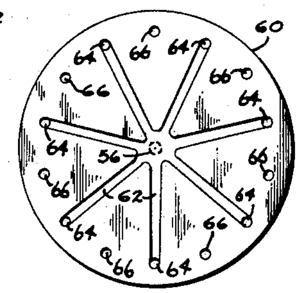
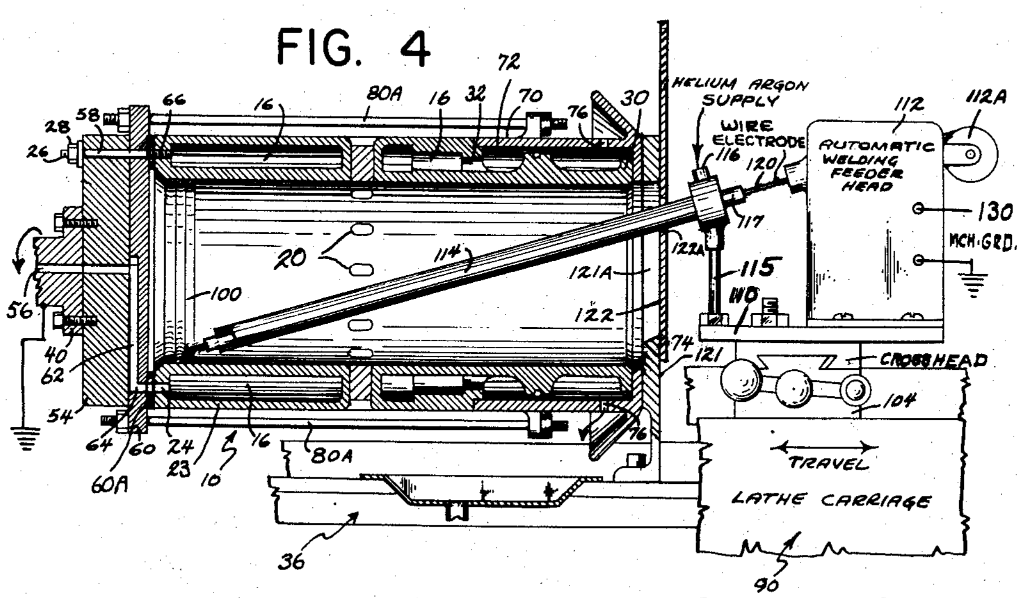


FIG. 4



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METHOD AND APPARATUS FOR RECONDITIONING CYLINDER LINERS FOR DIESEL ENGINES

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20 Claims. (Cl. 219—76)

This invention relates to methods and apparatus for reconditioning the inner surface of cast iron cylinder liners used in engines, particularly diesel engines.

All diesels used in railroad locomotives have liners in the cylinders, and heretofore when a liner became worn and could no longer be rebored it was removed and replaced with a liner of correct dimensions. Owing to the rather intricate design of these cast iron liners, the replacement cost is high. Consequently there is a need for an inexpensive reconditioning procedure.

One object of the instant invention is to provide a simple method and apparatus whereby the inner surface of a worn cylinder liner may be effectively reconditioned at a cost substantially less than the purchase price of a new liner.

Another object of the invention is to resurface the inner wall of a cylinder liner in such a manner that the liner will not become distorted. In this regard it will be appreciated that the reconditioned liner must fit back into the engine block without interference and that the liner's bore when reconditioned must be capable of being machined to accommodate properly the reciprocable piston therein. More specifically, the invention contemplates and it is an object to provide methods and apparatus for depositing of weld metal over the entire inner surface of a cylinder liner by electric arc welding and to use the integral water jacket circumscribing the major portion of the liner structure for supplying cooling water to the liner during the welding period. Since the integral jacket does not extend all the way to one end of the liner structure it is a further object of the invention to provide means for assuring that a flow of water is directed against the reverse side of every portion of the liner wall upon which weld metal is deposited.

Still another object of the invention is to permit the utilization of the threaded studs projecting from one end of standard cylinder liners for mounting the liner during reconditioning. When the liner is actually installed in use these same studs extend upwardly through the cylinder head.

Other and further objects are those inherent in the invention and will be apparent as the description proceeds.

To the accomplishment of the foregoing and related ends, this invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

In the drawing:

Figure 1 is a perspective view of apparatus utilized in the practicing of my reconditioning method;

Figure 2 is a sectional view taken in the direction of line 2—2 of Figure 1;

Figure 3 is a face view of the manifold plate used in distributing cooling water to the liner jacket, the view

being in the direction of line 3—3 of Figure 2; and

Figure 4 is a modified embodiment of my invention showing the cylinder and the members in immediate proximity in section and an automatic setup for welding, part of the latter being shown in schematic.

Referring now in detail to Figures 1 and 2 of the drawing, the construction of a typical cast iron cylinder liner 10 for locomotive diesel engines will first be described. From Figure 2 it will be noted that the liner 10 is of what will be termed generally a double wall structure having an inner wall 12 and an outer jacket 14 forming a chamber 16 therebetween through which the cooling water flows. It is, of course, the inner surface 18 that accommodates one of the diesel's pistons when the liner 10 is installed in an engine block. Intermediate the ends of the liner 10 is a plurality of radially directed exhaust ports 20 to admit scavenging air for compression.

Further describing the conventional liner 10, it will be observed that the left end 23 of the liner as it appears in Figure 2 is provided with a water port 24, actually one of a plurality of such ports leading to the chamber 16. Later on it will be seen that for purposes of illustration seven such ports will be referred to since this is the number in a certain cylinder sleeve. When installed in an engine block these ports 24 serve as discharge ports from the chamber 16, but during a reconditioning operation they will function to admit water to said chamber, all in a manner hereinafter explained. Angularly disposed between each pair of ports 24 is a threaded stud member 26 which is a part of the liner assembly. Special use of these studs 26 will be made for rotatably mounting the liner 10 during its repair. Normally, though, these studs extend upwardly through the cylinder head of the diesel engine. In both situations a nut 28 is affixed to their projecting ends, their opposite ends being threadedly received in tapped apertures formed in the liner structure.

Close inspection of Figure 2 will reveal that the jacket 14 and hence the chamber 16 do not extend completely to the other end 30 of the wall 12. Instead the jacket 14 terminates short of the end 30. A series of ports 32, in practice, function to admit water from a manifold part of the engine, in which the lower end of the liner 10 is positioned. Consequently, while practically the entire length of the inner wall 12 is cooled in actual operation, a problem of cooling this extended wall portion exists as far as reconditioning is concerned. More will be said presently as to how complete cooling is derived during repair.

The foregoing discussion completes the description of a conventional cylinder liner. At this time specific attention is drawn to Figure 1 where the apparatus utilized in carrying out a reconditioning operation of the cylinder liner 10 is pictured. In this figure there is shown a portion of a lathe generally designated 36. A pair of bearing pedestals 38 journal a hollow spindle 40, passage 42 extending completely therethrough as shown in Figure 2. A water swivel 44 is connected to the spindle 40 and coupled to a fixed pipe 46 having a valve 48 therein by which water from a supply is furnished to the spindle while it is rotating. The spindle is rotated by pulley 50 and belt 52 driven by a motor, not shown.

Threaded onto the end of the spindle 40 opposite the swivel 44 is a special face plate 54 having a central water port 56 and a series of bolt holes 58 corresponding in number to the number of studs 26 on the particular cylinder sleeve being reconditioned. In the sleeve here illustrated there are seven studs. Intermediate the face plate 54 and the end 23 of the cylinder liner 10 is a special manifold plate 60 having a plurality of radially arranged grooves 62 leading from a center which is over port 56, thence outwardly to a similar number of water ports 64. The water ports 64 are intended to be aligned with the previously mentioned ports 24 and hence are of the same number, here seven. Between each adjacent pair of water ports 64 is an additional hole 66, to accommodate studs 26. A gasket is provided at 60A and one may be provided between the plates 54 and 60 if needed.

From the preceding description it is believed obvious that cooling water may flow in controlled volume through the valve 48, pipe 46, swivel 44, and spindle 40, then from the spindle through the central aperture 56 of the face plate 54, thence via the radial slots 62 of the manifold plate 60 to the apertures 64 where the water is delivered into the chamber 16.

Since the cooling water utilized during my process exits via the ports 32, to cool the entire inner wall 12 including that section to the right of the ports 32 as shown in Figure 2, the invention contemplates the provision of an adapter sleeve designated 70. The sleeve 70 is substantially the same diameter as the jacket 14, it being intended that it either abut thereagainst as shown in Figure 2 or circumscribe a portion thereof to form an auxiliary chamber 72 in series with the jacket chamber 16. The sleeve 70 is equipped with an integral inturned flange 74 which seats on the end 30 of the liner 10. Neither the sleeve 70 or its annular flange 74 need be of heavy gauge stock and therefore the flange 74 is capable of flexing somewhat, if such proves necessary. A gasket may be used if desired. A series of circumferentially spaced small aperture 76 allow the water to be discharged from the auxiliary chamber 72 into a drain or waste receptacle 78 (Figure 1). An inclined deflector 83 carried by the sleeve 70 aids in the disposition of the water in an out-of-the-way position.

To hold the sleeve 70 on the liner 10, a plurality of stay members 80 are provided. These stays 80 have hook ends 82 and opposite threaded ends 84. The hook ends 82 reach into the ports 20, whereas the ends 84 extend through lugs 86 on the sleeve 70. Nuts 88 on threaded ends 84 permit the stay to be pulled tight and the stays thereby collectively hold the sleeve 70 in its telescoping position with respect to the end of the liner 10.

In the exemplified situation use is made of the lathe carriage 90 for holding and manually feeding a welding electrode 92 having a nickel or nickel-alloy core 94 and a suitable flux coating 96. It is this welding electrode 92 that is to be utilized in depositing a layer of weld metal 100 on the inner surface 18 of the cast iron liner 10. As is conventional with the lathe carriages, the carriage 90 may be manually moved longitudinally of the lathe 36 by means of a lead wheel 102 or if desired an automatic travel may be effected by means of the lead screw (not shown). The carriage 90 supports a cross slide 104 and by reason of a cross feed handle 106 the slide 104 may be manually or automatically advanced transversely of the lathe to compensate for consumption of the welding electrode 96.

A modified tool post 108 is employed for holding the welding electrode 96 inasmuch as it is of stacked construction, there being an insulating washer 110 so as to electrically isolate the upper end thereof. The actual clamping of the electrode 96 to the upper metallic portion of the post 108 is through the agency of a thumb screw, 112, the lower end of the screw contacting the core 94.

The simplest manner of proceeding according to my invention is to carry out the method manually using the setup shown in Figures 1 and 2. In Figure 4 there is illustrated an automatic setup.

In either the manual or automatic setup the welding circuit includes a D.-C. generator 114 having an armature 116, shunt field coils 118, commutating coils 120 and series field coils 122. A current range switch 124 permits selection of the approximate value of welding current to be employed, whereas a current adjusting rheostat 126 permits a finer adjustment within the broader range. A polarity reversing switch 128 is also included in the illustrated circuitry, it being preferable that reverse polarity be used because of the cast iron construction of the liner 10. A conductor 130 leads directly to the upper end of the post 108. The other side of the switch 128 is grounded at 132, the grounding of the lathe 36 at 134 completing the electrical circuit via the welding electrode 92 when the switch 128 is closed and an arc is struck.

Having in mind the construction and arrangement of the principal elements thereof, it is believed that a complete understanding of both the apparatus and method constituting my invention may now be had from a description of the operation. First, the valve 48 is opened to admit cooling water to the chambers 16 and 72. Then the spindle 40 is rotated by energizing the motor (not shown) which drives the belt 52. With the cast iron liner 10 rotating, the welding is started with the welding electrode 92. Before actually striking an arc one should be sure that the current range switch 124 has been placed in a low position and that the rheostat 126 has been adjusted for a relatively low value of welding current. The precise value of welding current will depend upon size of rod 92 and upon the quantity and temperature of cooling water passing through the chambers 16 and 72 together with the specific thickness of the inner wall 12. I prefer to use a small rod, say ⅛" or less and to use the minimum current for holding the arc. Solely as a guide, and not with any thought of limiting the invention, for a ⅛" electrode the current will be in the neighborhood of 55–65 amperes. As hereinbefore indicated the electrode 92 has a nickel or nickel-alloy core.

With the above preliminary arrangements completed the actual surfacing operation can be undertaken. Assuming that the carriage 90 has been initially moved farther to the left than it now appears in Figure 1 and that a relatively long welding electrode 92 is used, an arc is struck at the left end of the liner 10. This is readily accomplished by advancing the slide 104 toward the far side of the lathe and then retracting some. Thereafter the carriage 90 is gradually moved toward the right until the first electrode becomes spent, that is too short to continue. Then a second electrode is substituted and so on until the entire inner surface 18 has been covered with what amounts to a weld deposit in the form of a helical, slightly overlapping bead. Figure 1 shows the liner nearing its completely reconditioned stage as far as the depositing of weld metal is concerned. The arc is interrupted at ports 20, or if desired carbon plugs may be inserted in the ports 20 to carry the arc across.

Upon full completion, the liner 10 may be removed from the face plate 54 and rebored on a different lathe or the same lathe 36 may be used for machining the interior of the inner wall 12 to its original diameter.

While a flux coated welding electrode has been described, it will be appreciated that the electrode may constitute a nickel-iron wire and that an inert gas may be introduced into the interior of the liner through the annular flange to prevent undue oxidation. According to my invention an automatic electrode feeder for wire electrodes, may be mounted on the tool post 108. The electrode wire is then fed automatically. The amount of metal deposited and the overlap of successive beads is determined by varying the rate of feed of the lathe carriage 90. In the case of automatic feed the position of rod 92 illustrates the position of the guide for the wire electrode. Also the flange 74 may be extended so as to nearly close the end of the cylinder to keep in the shielding gas such as helium-argon. Thus overlapping bead is deposited spirally and this may be with a small wire and arc to minimize local heating.

In Figure 4 the setup for holding the cylinder is similar to that shown in Figures 1 and 2 except that plate 60 is made slightly larger so bolts 80A can be run back through it for securing the temporary sleeve 70 in place. Water is run through as previously described. It is noted, with reference to Figures 1, 2 and 4 that the ports **76** are made small in order to insure a little pressure in the jacketing. In this way one can be certain all surfaces being welded will be backed up with water. Also in Figure 4, carbon plugs are fitted into ports **20**, flush with the inside. As the weld bead is being laid, the arc travels across the carbon plug, but the bead metal is not secure on the carbon and is easily cleaned out with the carbon plug, when the job is finished.

In Figure 4, the lathe cross head **104** is used to mount the bracket **110** upon which there is carried an automatic arc welding electrode wire feeder head **112**. The feeder head **112**, per se, is not a part of the invention, and a standard feeder head may be used for feeding the electrode wire automatically according to the arc voltage or at a constant rate. The electrical arc power system is accommodated to the particular feeder head used. The feeder head **112** may include its own, internal supply for a shielding gas (argon-helium etc.) but if not, the gas (where used) is supplied externally via pipe **116** which is supported by post **115** from bracket **110**. Gas is supplied via port **116**. The electrode wire guide sleeve **117** slips loosely through gas tube **114** and the electrode wire **120** slides through tube **117**, being fed automatically from the feeder head **112**, also on bracket **110**.

The two concentric tubes **117** and **114** and the electrode wire **120** slant downwardly into the sleeve **10** being reconditioned. The rotation of spindle **40** of the lathe and the rate of feed of carriage **90** are adjusted in relation to the rate of deposition of weld metal so that the successive turns of the weld bead **100** (which is laid on spirally), will overlap just a little.

The wire electrode **120** can be carried on spool **112A** and the arc welding current conducted through a brush connection to the active end of the electrode wire or may be conducted through the wire on the spool to the extending end being fed to the arc. Control of voltage in the arc circuit to compensate for the wire fed is done as required, to keep the voltage at the arc within desired limits. The cylinder sleeve is, of course, grounded through the lathe as shown diagrammatically in the drawings. A slip ring connection (not shown) may be made to the lathe spindle **40**, if needed, but this is not usually needed because the sleeve bearings of the lathe will usually conduct the relatively low welding current used. Use of graphite grease in the spindle bearings assists conduction.

In order to retain the arc shielding gas within the cylinder sleeve, and reduce wastage as much as possible, I provide two plates **121** and **122**. Plate **121** is mounted stationary on the lathe bed so as to lie flat and vertical against flange **74** of the temporary jacketing sleeve **70** which simply turns with its end in flat contact with the plate **121**. There need be no great pressure, merely a neat fit. The plate **121** has a vertical slot **121A** in it which is wide enough and high enough to accommodate movement of the tube **114** for as the carriage **90** moves along the lathe bed the tube **114** (and **117**) will be withdrawn and hence the elevation at which tube **117** crosses the plate **121** will gradually decrease. In order to close the slot **121A**, I provide the plate **122** which has a hole **122A** in it through which tubes **114**—**117** pass loosely. Plate **122** simply hangs on the tube **117** and slides down the tube until it is in flat contact against plate **121**. Hence as the tubes **114**—**117** are withdrawn the plate **122** gradually slides down the tubes **114**—**117**, always meanwhile resting against plate **121** and hence covers slot **121A**. The arc shielding gas which flows into the liner **10** via tubes **116** and **114** thus fills the interior of the liner **10** and provides an atmosphere of such shielding gas within the liner **10** and much less gas is required as when the arc shielding gas is used under open conditions. There need be only a slight flow of such gas which first flushes the air out of the liner **10** and then itself leaks out between flange **74** and plate **121** and between plates **121** and **122** and around tube **114** where it passes through hole **122A**. The leakage outflow carries away some arc heat, but principal reliance for cooling the liner **10** is placed upon my method of backing up the entire surface which is to be welded by means of water which is kept flowing briskly against the outer surface of the sleeve to keep the entire sleeve cool. Arc heat is accordingly localized at the arc and the heat is drained away as fast as it is evolved by the arc.

As many widely apparently different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments herein.

What I claim is:

1. A method of reconditioning the inner surface of a cast iron cylinder liner having an outer water jacket concentric to its longitudinal axis comprising the steps of mounting said liner to have its longitudinal axis extend through a nearly horizontal plane passing a cooling fluid through the jacket of said liner, rotating said liner about its longitudinal axis while said cooling fluid is passing through said jacket, and simultaneously depositing a layer of weld metal on said inner surface.

2. A method in accordance with claim 1 in which the depositing step is effected by means of electric arc welding.

3. A method in accordance with claim 2 in which said arc welding step is accomplished with an electrode containing nickel.

4. A method in accordance with claim 3 including the additional step of limiting the arc current to a value such that overheating of the cylinder liner is prevented for a given flow of cooling fluid.

5. A method of reconditioning the inner surface of a cast iron cylinder liner having an outer water jacket comprising the steps of passing water through the jacket of said liner, rotating said liner about its longitudinal axis while said cooling water is passing through said jacket, traversing a nickel containing welding electrode from one end of the liner to the other to deposit a helical bead of weld metal on said inner surface and controlling the electric current flowing through said welding electrode so that overheating of the cylinder liner is prevented for a given flow of cooling water.

6. Apparatus for reconditioning the inner surface of a cast iron cylinder liner having an outer water jacket comprising means for rotating said liner about its longitudinal axis and holding said liner to have its longitudinal axis extend in a generally horizontal plane, means for passing a cooling fluid through the jacket of said liner to contact the outer surface of the liner while said liner is being rotated, and means for simultaneously depositing a layer of weld metal on said inner surface.

7. Apparatus for reconditioning the inner surface of a cast iron cylinder liner having an outer water jacket comprising means for rotating said liner about its longitudinal axis, means for passing a cooling fluid through the jacket of said liner while said liner is being rotated, said means for passing a cooling fluid including a face plate having a channel therein whereby the cooling fluid may be conducted from the means for rotating said liner about its longitudinal axis to the outer water jacket, and means for simultaneously depositing a layer of weld metal on said inner surface, the last mentioned means including a holder for a welding electrode.

8. Apparatus in accordance with claim 7 in which said last mentioned means includes a carriage mounted for longitudinal and transverse movement relative to said rotating means, said carriage supporting said holder.

9. Apparatus in accordance with claim 7 including means for adjusting the value of the electric current flowing through said electrode and means for adjusting the flow of cooling fluid through said jacket.

10. Apparatus for reconditioning the inner surface of a cast iron cylinder liner having an outer water jacket

extending from one end thereof toward its opposite end but terminating at a locus spaced from said opposite end, a face plate having a central aperture and a plurality of angularly spaced apertures disposed radially outward from said central aperture, means for rotating said face plate, conduit means for supplying cooling water through said central aperture, means for attaching said cylinder liner relative to said face plate for rotation in unison therewith, manifold means for distributing the cooling water supplied via said central aperture to one end of said jacket, a water adapter sleeve having an inturned flange at one end engageable with said opposite end of said cylinder liner, the other end of said adapter sleeve being engageable with a portion of said cylinder liner adjacent the nearer end of said jacket, and welding electrode holding means movable longitudinally and transversely of said face plate for traversing said electrode within the cylinder liner to deposit a layer of weld metal on the inner surface thereof.

11. Apparatus in accordance with claim 10 in which said adapter sleeve is formed with a plurality of radially directed apertures adjacent its inturned flange for the discharge of said cooling water.

12. Apparatus in accordance with claim 11 in which said cylinder liner is provided with a plurality of scavenging ports directed inwardly through the jacket intermedially the ends thereof, said adapter sleeve having a plurality of radially projecting lugs thereon, and a plurality of stay members having offset portions at one end engageable in said ports and having their other ends adapted to engage said lugs to thereby retain said adapter sleeve on said cylinder liner.

13. Method of reconditioning a cast iron cylinder liner for an internal combustion engine which comprises mounting said cylinder sleeve for rotation about its longitudinal axis, forming a water jacket around said sleeve to have a longitudinal length approximately equal to the length of the sleeve and passing a flow of water continuously through said jacket for cooling the outer surface of the sleeve continuously during reconditioning, depositing a continuous spiral of weld metal in a bead in which successive turns of the spiral overlap at least slightly while said sleeve is continuously cooled by a flow of water passing through said jacket.

14. The method of claim 13 further characterized by closing both sleeve ends sufficiently to retain an atmosphere of non-oxidizing arc-stabilizing gas in the interior of said sleeve, and introducing a wire of arc electrode metal through the said closure into closely spaced relationship to the interior surface of said sleeve for forming an arc for depositing the said metal on the interior surface of said sleeve while introducing said gas thereinto.

15. The method of claim 14 further characterized in that the gas is introduced into the sleeve through the same end of the liner as the wire, the outflow of gas from said sleeve is restrained, and a continuous flow of such gas into the sleeve maintained while metal from said wire is spirally deposited in an overlapping spiral on the interior of said sleeve.

16. An apparatus for reconditioning cast iron cylinder sleeves of internal combustion engines which comprises means for mounting said sleeve for rotation about the axis of said sleeve, water jacket means around the exterior of said sleeve, a fluid inlet into and a fluid outlet from said water jacket means and water supply means for conducting a flow of water continuously through said sleeve but out of contact with the interior surface of said sleeve, means for closing the ends of said sleeve sufficiently to restrain the outflow of gas from the interior of said sleeve, means for introducing a flow of non-oxidizing arc-stabilizing gas into the interior of said sleeve, means for introducing a continuous welding wire electrode into said sleeve and into proximity with the ends thereof, and for moving said electrode longitudinally of the sleeve as the sleeve is rotated, means for introducing a flow of electric current through said electrode and through said arc and said sleeve for maintaining an arc between the electrode and the sleeve as the sleeve is rotated, means for moving the electrode longitudinally of the sleeve for depositing a spiral bead of weld metal on the interior thereof as the sleeve is rotated the successive turns of said spiral overlapping at least slightly for building a continuous layer of weld metal on the interior of said sleeve.

17. Apparatus for lining a cylinder made of ferrous material having a water jacket about the surface of said cylinder opposite the one to be lined, means for rotating said cylinder, means to conduct water through the aforementioned means to the water jacket without obstructing the surface that is to be lined, means for making a positive connection between the cylinder and the rotating means and electric arc welding means for depositing a lining on the cylinder while it is rotated.

18. The apparatus of claim 17 further characterized in that there is provided means for retaining an atmosphere of non-oxidizing arc-stabilizing gas in the presence of the surface of the cylinder being lined, said means being mounted outside of the cylinder in spaced relation thereto.

19. A method of reconditioning the inner surface of a cast iron cylinder liner having an outer concentric water jacket of a substantially shorter length than the length of the jacket to be lined comprising the steps of extending the effective length of the water jacket to be substantially equal to the length of the liner to be reconditioned, passing a cooling fluid through the water jacket in contact with the outer surface of the length of the liner to be reconditioned, rotating said liner about its longitudinal axis while said cooling fluid is passing through said jacket, and simultaneously depositing a layer of weld metal on said inner surface.

20. Apparatus for reconditioning the inner surface of a cast iron cylinder liner having a concentric outer water jacket of a longitudinal length substantially shorter than the longitudinal length of the liner to be reconditioned comprising means for extending the effective length of the water jacket to be substantially equal to the longitudinal length of the liner to be reconditioned, means for rotating said liner about its longitudinal axis, means for passing a cooling fluid through the jacket of said liner while said liner is being rotated, and means for simultaneously depositing a layer of weld metal on said inner surface.

References Cited in the file of this patent

UNITED STATES PATENTS

1,886,503	Shockey	Nov. 8, 1932
1,898,060	Noble	Feb. 21, 1933
1,924,876	Morgan	Aug. 29, 1933
2,187,786	Jacobus	Jan. 23, 1940
2,496,188	Wiese	Jan. 31, 1950
2,654,014	Schaefer	Sept. 29, 1953
2,729,578	Hedlund et al.	Jan. 3, 1956