

April 2, 1940.

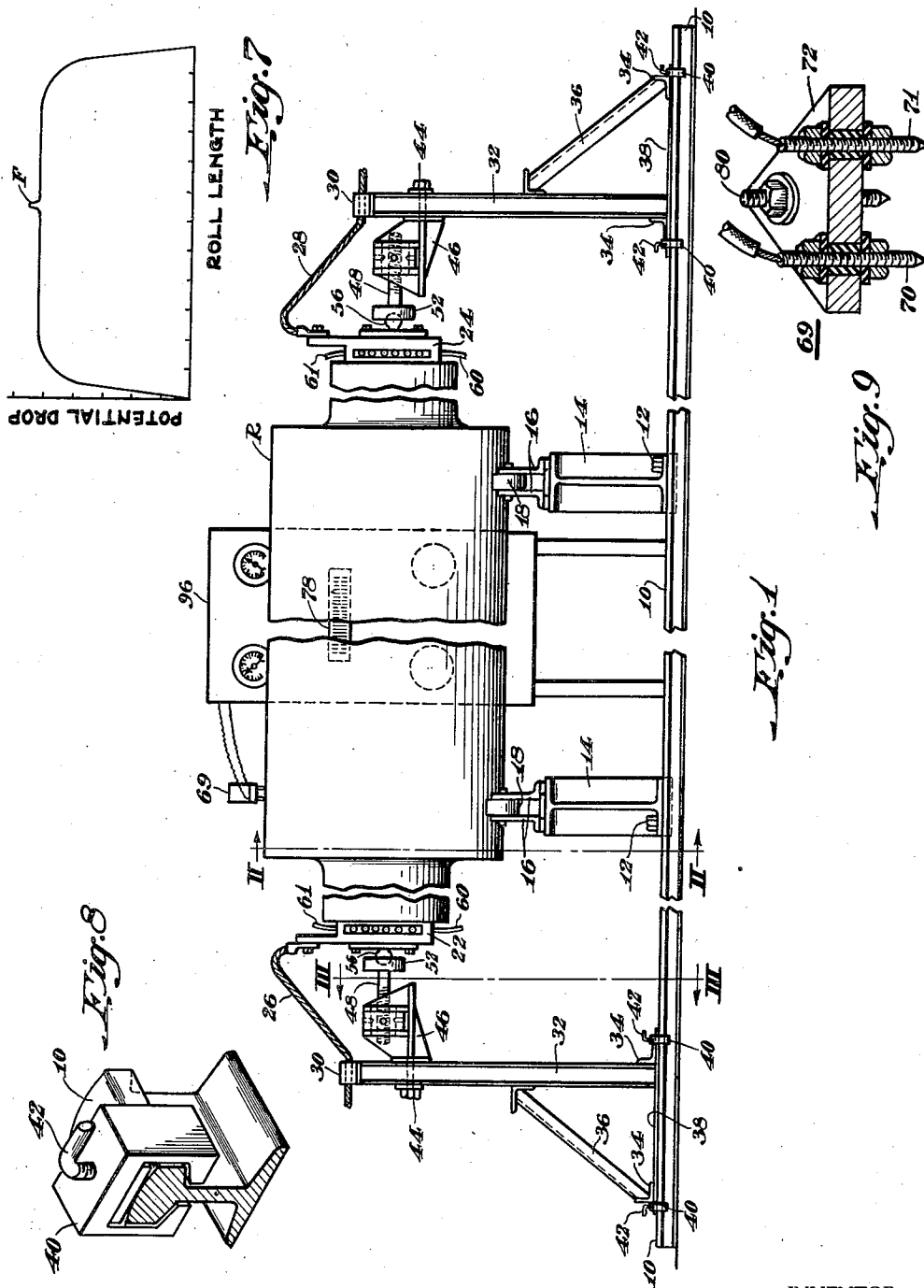
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2,195,504

APPARATUS FOR TESTING ROLLS

Filed March 4, 1937

4 Sheets-Sheet 1



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APPARATUS FOR TESTING ROLLS

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4 Sheets-Sheet 2

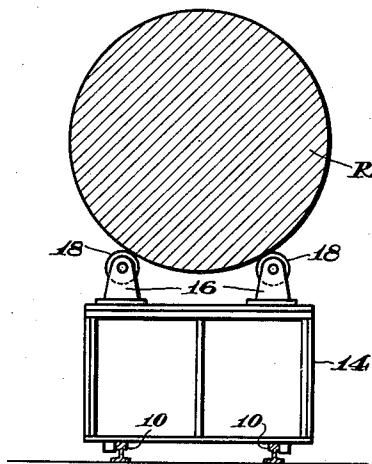


Fig. 2

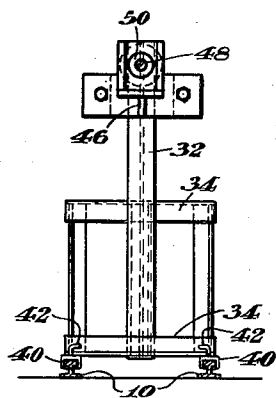


Fig. 3

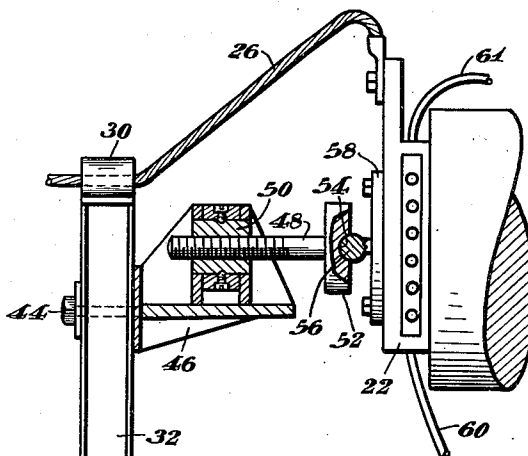


Fig. 4

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4 Sheets-Sheet 3

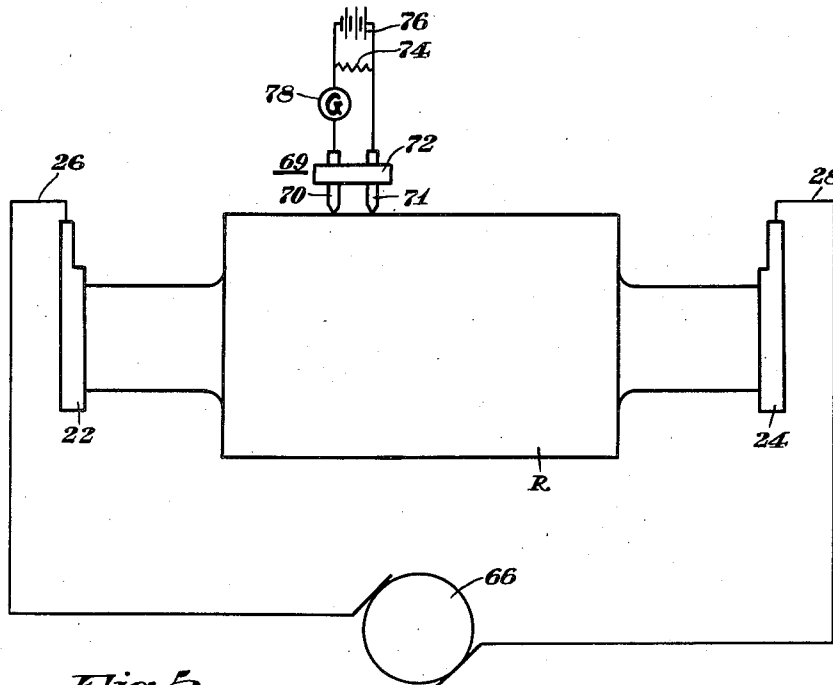


Fig. 5

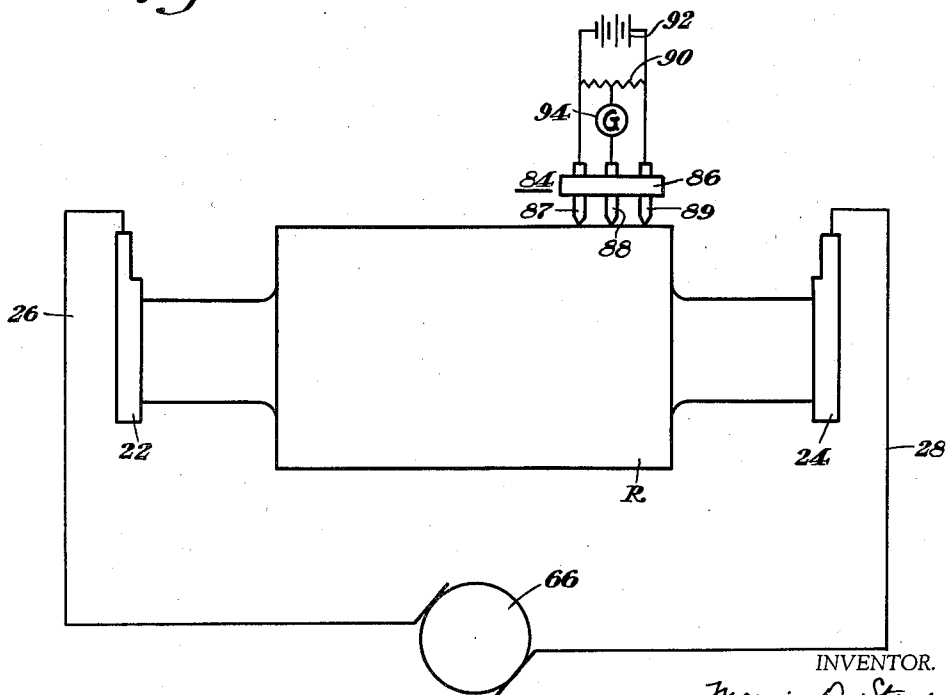


Fig. 6

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4 Sheets-Sheet 4

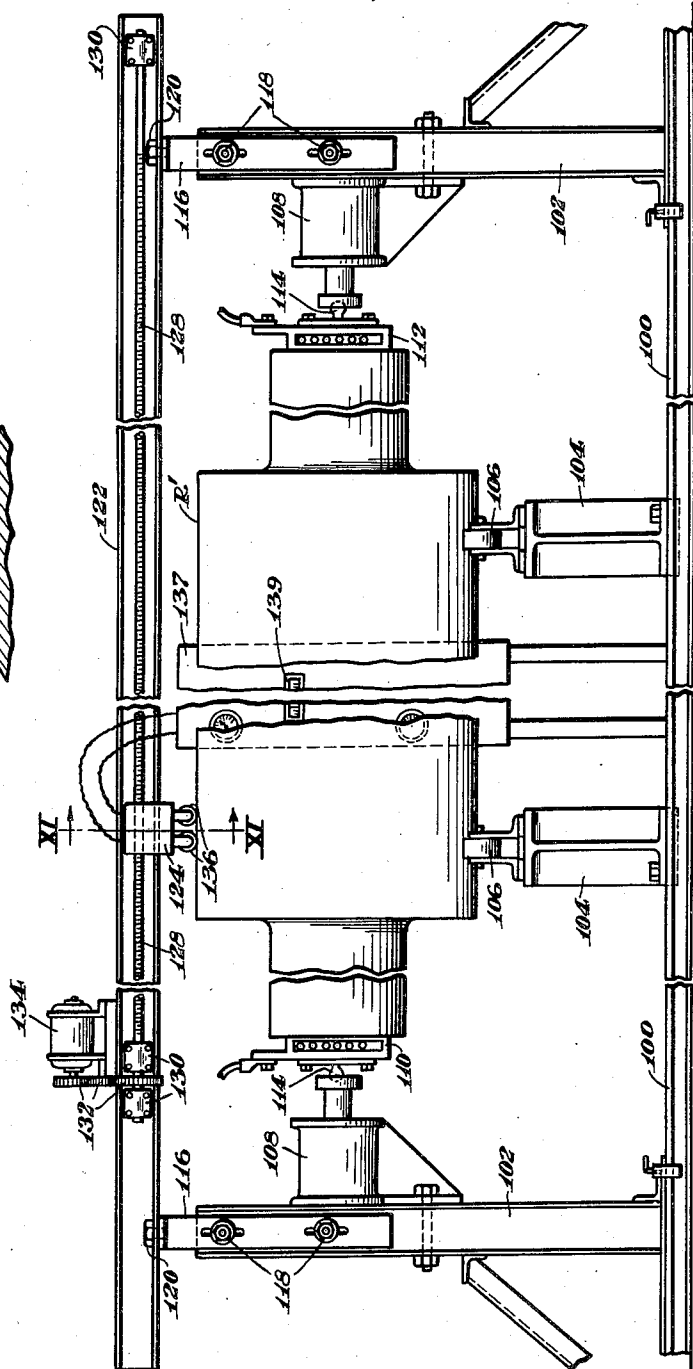
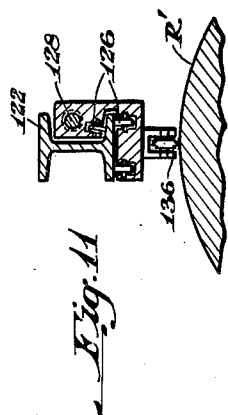


Fig. 10

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UNITED STATES PATENT OFFICE

2,195,504

APPARATUS FOR TESTING ROLLS

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7 Claims. (Cl. 175—183)

This invention relates to methods and apparatus for making large metal rolls, such as employed for rolling metal, and more particularly relates to methods and apparatus for testing rolls of the indicated character to determine if internal faults or flaws are present therein, such as may constitute a potential source of roll breakage.

Substantially all metal rolls of large size such as used in rolling metal are made by casting the rolls, rough turning or machining, heat treating the roll and thereafter completing the machining and finally grinding the roll surface. This method is a relatively expensive one when rolls of from 20 to 60 or more inches in diameter and from about 4 to about 20 or more feet in over-all length are made. In the first place, it is extremely difficult to cast a large body of metal, as for example iron, steel or alloys thereof, into a roll of the same or varying diameter without having internal casting faults therein. Further, the machining and heat-treating operations often tend to accentuate the casting faults or to introduce other flaws in the roll which are not visible from the surface of the roll.

Rolls of the type described have long proven to be a constant source of trouble in metal rolling mills, due to the inability of the manufacturer of the roll to guarantee the roll against failure and because failure of the roll in service is highly undesirable since it interrupts plant production schedules, may injure operators, damage machine parts or spoil metal being handled by the roll. The seriousness of the problem of the satisfactory provision of sound long-wearing rolls is well evidenced by the fact that it is not uncommon for large apparently sound rolls to actually break or crack apart during shipment due to faults therein aggravated by the relatively minor shocks and loads imparted thereto in handling. However, by known methods of inspection it has been found substantially impossible to locate internal faults in a roll which are not visible on the outside of the roll.

Prior to my invention railroad rails have been tested for internal flaws by an electric method which is claimed to provide very excellent results. In so far as I am aware, however, there has been no suggestion of testing large diameter cast metal bodies such as rolls for internal flaws by some electrical method. Apparently the difference in diameter, shape, use and method of manufacture has prevented the testing of cast metal rolls for internal flaws.

It is the general object of my invention to avoid and overcome the foregoing and other difficulties

attending the manufacture and testing of cast metal rolls of large diameter by the provision of novel methods and apparatus for readily and accurately manufacturing and testing cast metal rolls.

Another object of my invention is to provide an improved method of manufacturing cast metal rolls wherein after certain basic steps in the method have been performed the roll is tested for flaws so that if they are discovered the roll can be scrapped without expending further time and labor thereon.

Another object of my invention is the provision of substantially automatic apparatus for testing rolls to determine the presence therein of internal flaws so that the roll manufacturer can substantially guarantee the rolls manufactured.

Another and more particular object of my invention is the provision of means and methods for determining the internal character of a cast metal roll of large diameter and considerable length, which means and methods avoid, overcome and eliminate existing testing errors.

The foregoing and other objects of my invention are achieved by that method of manufacturing large cast metal rolls which includes the steps of casting the roll, rough turning the roll and thereafter testing for internal flaws therein by applying direct electrical current longitudinally of the roll, measuring the potential drop at a plurality of points spaced longitudinally of the roll so as to ascertain that the potential drop is uniform and that the roll is free of casting flaws, and completing the manufacture of the roll if free of flaws by heat treating the roll and, with or without an intermediate testing step as just described, completing the machining of the roll and thereafter finally testing the roll for internal flaws as described.

Suitable apparatus for achieving the testing method described, which apparatus is constructed in accordance with the principles of my invention, includes a frame with means on the frame to receive and mount a cast metal roll of large diameter and relatively long length for rotary movement about its axis. Incorporated with the frame are means for supplying steady direct electric current of relatively low potential and high amperage, and adjustable means for connecting the electric current to the roll for a longitudinal movement therethrough. The electric connecting means may be cooled by suitable mechanism and completing the combination is means for measuring the potential drop at longitudinally spaced points along the roll.

In the accompanying drawings, Fig. 1 is a side elevation, partly broken away, illustrating apparatus incorporating the principles of my invention and shown supporting a roll in testing position; Fig. 2 is a vertical transverse cross-sectional view taken on line II—II of Fig. 1 and illustrating the roll support; Fig. 3 is a transverse vertical cross-sectional view taken on line III—III of Fig. 1 and showing details of the means for clamping the electrical connections to the roll tested; Fig. 4 is a longitudinal vertical sectional view of the electrical connection to the roll and the means for clamping the connection in place; Fig. 5 is a schematic wiring diagram of the electrical circuit employed in the apparatus; Fig. 6 is a view similar to Fig. 5 but of a modified type of testing circuit; Fig. 7 is a representation of a typical graph obtained by plotting potential drop against roll length during the testing operation; Fig. 8 is a perspective view of the means for adjustably securing the supports for the electric connector clamps to the bed of the apparatus; Fig. 9 is a perspective view, partly in section, of the potential drop pick-up or roll-contacting member of the testing apparatus; Fig. 10 is a side elevation similar to Fig. 1 but of another embodiment of my invention; and Fig. 11 is a transverse vertical cross-sectional view taken on line XI—XI of Fig. 10.

For a better understanding of my invention reference should be had to the apparatus of Figs. 1 to 4 and Figs. 8 and 9 which illustrate one actual embodiment of the principles of my invention. In the referred-to figures of the drawings, the numerals 10 indicate generally a frame or base—usually formed of a pair of railroad rails positioned in spaced parallel relation upon a suitable floor or foundation. Adjustably positioned longitudinally of the rails, as by means of clamps 12, are a pair of pedestals 14 each carrying at their upper ends a pair of brackets 16 rotatably supporting rollers 18. The rollers 18 provide a trough-like support for a roll R to be tested and permit rotary movement of the roll about its longitudinal axis, as will be evident.

During the testing operation, direct electric current of relatively low potential and high amperage is passed longitudinally through the roll and this is preferably accomplished by clamping contact plates 22 and 24 to the ends of the bearing or wabblers portions of the roll. Contact plates 22 and 24 are connected to electric cables 26 and 28 which extend to the source of electric current, which has not been shown in Fig. 1. The electric cables 26 and 28 may be and generally are more than one in number and the several cables are ordinarily held together and away from the remaining parts of the apparatus by insulating clamps 30. In order to clamp the connector plates 22 and 24 tightly against the ends of the roll, I provide adjustable take-up mechanisms at each end of the frame 10, each mechanism including an upright 32, such as an I-beam having transverse supports 34, generally angle irons, welded or otherwise fastened thereto with necessary diagonal strengthening braces 36. Flat, relatively narrow plates 38 are welded longitudinally between the members 34 so that the plates overlie the rails of the frame 10 and receive C-shaped clamps 40, best shown in Fig. 8, which clamps include locking screws 42 whereby each upright 32 can be locked to the frame 10 in any desired position longitudinally thereof.

Adjustably mounted vertically of each upright 32, as by locking means 44, is a bracket 46 which, as will be best seen in Fig. 4, carries a screw 48

for adjustable movement toward and from the roll R. This is accomplished in the embodiment of my invention illustrated by receiving the screw 48 in an internal threaded bushing 50 carried for rotary but non-axial movement in the bracket 46. The end of the screw 48 is formed with a flange 52 having a socket 54 which receives a ball 56 carried by a plate 58 bolted to the adjacent contact plate. The ball and socket connection 54 and 56 allows the contact plate to exactly adjust itself to the end of the roll R when the bushing 50 is turned relative to the screw 48 to move the screw toward the roll and tighten the contact plate firmly into electric engagement with the end of the roll.

The contact plates 22 and 24 may be and preferably are cooled during the testing operation by suitable fluid means circulated in the hollow interior of the plates as by way of conduits 60 and 61. In this connection, it will be appreciated that the relatively high amperage flow through the roll results in a considerable heating of the electrical leads and it has been found advantageous to maintain the contact plates 22 and 24 at substantially the same temperature as the roll body.

In Fig. 5 I have illustrated one type of electric circuit employed in the testing apparatus just described. The electrical leads 26 and 28 connected to contact plates 22 and 24, respectively, extend to a source of steady, low-potential, high-amperage, direct electrical current, the source of the electric current being indicated in the figure by the numeral 66. Preferably I employ a homopolar generator as a source of the desired electric current.

The potential drop in the roll is measured by suitable mechanism including a pick-up 69 having two electric contacts 70 and 71 carried by a suitably insulated plate 72 and connected in shunt with a suitable resistance coil 74 in turn shunted by battery 76. A galvanometer 78, preferably of the D'Arsonval type, but of source of any highly sensitive and if desired recording character, is connected in series with one of the leads between the contacts 70 and 71 and the coil 74. In actual operation the pick-up 69 may take the form illustrated in Fig. 9 wherein the contacts 70 and 71 are sharp-pointed pins carried in insulated relation and between about $\frac{1}{2}$ and about 2 inches apart by the plate 72 which in turn supports a third pin 80 so as to form a stool. The pick-up 69 is adapted to be placed with the contacts 70 and 71 positioned along a longitudinal of the roll so that the potential drop longitudinally of the roll and at any desired plurality of points will be indicated upon the galvanometer, as hereinafter more fully described.

When my apparatus is constructed as illustrated in Fig. 6, the two-contact pick-up 69 shown in Fig. 5 is replaced with a three-contact pick-up identified generally by the numeral 84. This indicator includes a supporting plate 86 carrying three pointed contacts 87, 88 and 89 in longitudinal alignment with each other and connected in shunt to a resistance coil 90 and a battery 92. A galvanometer 94 of any of the types above described is connected in series between the middle contact 88 and the center of the coil 90 so as to indicate any variations in the average potential drop longitudinally of the roll. Since in Fig. 6 the remaining parts of the schematic wiring diagram are similar to those shown in Fig. 5, they have been indicated by the same reference numerals.

Referring again to Fig. 1, the potential drop pick-up 69 has been illustrated as positioned on top of the roll R and electrically connected to an instrument panel 96 containing the galvanometer 78 and suitable other instruments to indicate and control the character of the electric current supplied to the roll.

The embodiment of my invention illustrated in Figs. 10 and 11 is generally similar to that heretofore described but more particularly is of an automatic or semi-automatic type adapted for greater production. Specifically, the apparatus includes a base 100 formed of rails or other suitable means which adjustably receive uprights 102. The base 100 likewise carries pedestals 104 each in turn journaling rollers 106 which provide a cradle rotatably receiving a roll R' for movement about its axis. The uprights 102 carry fluid pressure or like means 108 for quickly clamping contact plates 110 and 112 against the ends of the roll R' through ball and socket joints 114.

Each upright 102 carries a vertical adjustable extension 116 fastened thereto by suitable bolt and slot connections 118, which extensions are adjustably secured as by clamping means 120 to a readily removable overhead I-beam 122. The I-beam 122, as best shown in Fig. 11, carries a traveling head 124 for movement longitudinally of the I-beam. Wheels or rollers 126 carried by the head 124 may be provided to reduce the friction between the I-beam and head. A longitudinally extending screw 128 journaled at its ends in suitable bearings 130 carried by the I-beam provides for controlled movement of the head 124 along the I-beam. This is accomplished by suitably threading a bushing or aperture in the head 124 so as to cooperate with the threaded rod 128. The end of the rod 128 is connected by gearing 132 with an electric motor 134 carried by the I-beam 122.

A pick-up device of either the two- or three-contact type is secured to the bottom of the head 124 so that in the travel of the head along the roll suitable electric contact therewith will be made. The contact means may comprise brushes but I preferably employ sharp-rimmed contact wheels 136 suitably journaled to the bottom of the head 124 and insulated from each other as will be understood. The electrical connections of this embodiment of my invention are exactly the same as shown in Figs. 5 or 6 dependent upon whether a two-contact or three-contact pick-up is preferred. However, with this form of my invention a recording type galvanometer is employed. A control panel for the apparatus is indicated generally at 137 and includes the recording galvanometer 139 and any other necessary or desirable instruments.

In the operation of the apparatus of Figs. 1 to 9 a roll to be tested is positioned upon the cradle provided by the rollers 18 and the uprights 32 are brought in and clamped near the ends of the roll. The brackets 46 are adjusted to align the screws 48 with the ends of the roll and relative movement of the screws 48 and bushings 50 tightly clamps the contact plates 22 and 24 against the ends of the roll. A longitudinal strip of the roll on its upper periphery is carefully cleaned as by first grinding, thereafter cleaning with emery cloth and finally alcohol so as to provide the best possible surface for perfect electrical contact. Now the pick-up 69 is placed substantially at the end of the roll with the contacts 70 and 71 thereof spaced longitudinally of each other and rested

with a predetermined pressure on the cleaned roll surface.

Low-potential, high-amperage, direct current as for example about 10,000 amperes at a pressure of about two volts is supplied through the roll from the source 66 and with large diameter rolls several minutes are allowed to pass so that the roll is completely saturated with current and the flow is not confined to only the outer portions thereof. Once the flow of current has become steady the drop in potential of the current between the contacts 70 and 71 is read upon the galvanometer 78 or if the galvanometer is of the recording type, is recorded thereby. Now before the contacts 70 and 71 are moved to a point stepped longitudinally of the roll, I reverse the flow of electric current through the roll and take the potential drop in the electric current. I have found that any errors as created by thermo-electrics (due to the difference in the temperature of the contacts 70 and 71 and the roll R) and any difference due to electrolytics (difference in the metal of the contacts 70 and 71 and the roll R) and substantially all other parasitic losses are balanced out by passing the electric current first through the roll in one way and then through the roll in the other direction. Readings are taken on the galvanometer in both cases and averaged, with a single average reading then being recorded or taken for each position of the pick-up 69 longitudinally of the roll.

The pick-up 69 is then moved one step longitudinally of the roll and the operation is repeated. The stepped longitudinal movement of the indicator is such that the actual distance of the step is substantially the same as the distance between the contacts 70 and 71. In other words, the contact 70 is set down in the new stepped position so that it engages substantially the same part of the roll as engaged originally by the contact 71. In this manner by moving the pick-up 69 step by step longitudinally of the roll and taking an average reading of the potential drop along the entire length of the roll, it is possible to determine if there are any internal flaws or faults in the roll because these will cause the roll to have a smaller cross section at such points with the result that the potential drop radially of such points will be greater than average and can be readily determined when of reasonable size by the use of a sensitive galvanometer as herein described.

After the potential drop has been measured along the first selected longitudinal of the roll, the screws 48 are backed off and the roll R is turned through any desired arc such as 90° so as to present a new longitudinal along which the potential drop is measured, as above described. In this manner any desired number of indications are taken longitudinally and circumferentially of the roll to determine the potential drop longitudinally thereof. The results for one longitudinal of a selected roll have been graphically plotted as shown in Fig. 7 wherein the abscissa is the roll length in feet and the ordinate is the potential drop in millivolts. From this graph it will be recognized that the potential drop is uniform for the length of the roll except at the shoulder portion and at one point marked "F" where it has gone above the average. This point in the curve indicates an internal fault in the roll tested approximately 6½ feet from the left shoulder portion thereof, such as may result in failure of the roll in use.

If instead of the wiring diagram illustrated in Fig. 5, the diagram illustrated in Fig. 6 is em-

ployed, the operation is substantially the same as that just described except that the pick-up 84 is employed and is stepped longitudinally of the roll substantially the distance between two adjacent contacts 87 and 88 or 88 and 89. Ordinarily there is a balanced shunting of the electric current through the resistance coil 90, and as long as the resistance of the roll between the contacts 87, 88 and 89 is uniform the galvanometer 94 will indicate no flow of electric current. However, when a flaw in the roll is positioned between the contacts 88 and 89 the shunting circuit becomes unbalanced and the galvanometer 94 will indicate proportionately. The stepped forward movement of the pick-up 84 will thereafter bring the flaw between the contact 88 and the contact 87 to cause an unbalancing of the shunting circuit in the opposite direction, at which time the galvanometer 94 will indicate proportionately but in the opposite direction.

The embodiment of my invention illustrated in Figs. 10 and 11 is in general operated quite similarly to the method described above. First with the I-beam 122 removed the roll R' is lowered onto the cradle formed by the rollers 106 and the uprights 102 are moved to and clamped at a point adjacent the ends of the roll R'. The fluid pressure means 108 are then vertically positioned so that when actuated the contact plates 110 and 112 are forced into tight electrical contact with the ends of the roll. The I-beam 122 is now moved into place above the roll and is secured to the extensions 116 which are vertically adjusted so that the contact wheels 136 are in firm electrical engagement with the surface of the roll.

Unlike the step-by-step movement of the pickups 69 and 84 of the modification of Figs. 1 to 9 in the operation of the apparatus of Figs. 10 and 11, the head 124 is advanced continuously along a given longitudinal of the roll R' by means of the motor 134 with the contact wheels 136 progressively picking up the potential drop. The potential drop along the roll is in this form of my invention recorded by the galvanometer and mechanism associated therewith so that a permanent record is provided. Carrying out the method described above I may pass electric current through the roll R' from left to right while the head 124 is moving from left to right along the roll. Thereafter the current to the roll can be passed from right to left and the head 124 likewise moved from right to left on the same longitudinal of the roll.

Once a given longitudinal has been tested for potential drop the fluid pressure means 108 are adjusted so as to release the pressure on the contact plates 110 and 112 and the roll is then turned, as for example through 90° to provide a new longitudinal on the roll to be tested for potential drop. The contact plates 110 and 112 are then reclamped and the new longitudinal of the roll is tested for potential drop as above described, and in a similar manner several longitudinals spaced circumferentially of the roll are tested in turn for potential drop. Ordinarily four are so tested. Wherever the tests show that the potential drop is greater than average or where the galvanometer in the wiring diagram of Fig. 6 is unbalanced, the roll tested contains an internal flaw radially of the high potential drop.

In the actual manufacture of cast rolls I have found that my improved apparatus and methods for locating internal faults in cast metal rolls not only allows the roll manufacturer to substan-

tially guarantee to the customer the roll sold, but also enables the manufacturer to save considerable cost and labor in roll manufacture. More particularly, I contemplate first casting the roll in the usual manner, thereafter rough turning or machining the roll and then testing the roll for internal faults, as heretofore described. If it is found that the roll contains dangerous internal flaws it is scrapped immediately without further expensive operations being performed thereon. If the roll is found to be sound after casting and rough turning it is heat treated and machined and is then again tested, as above described, to determine if any flaws have developed in the heat-treating or machining operations. If the roll is still satisfactory it is given the final grinding operation and is then finally tested before shipment to the buyer. I may eliminate one or more of the testing operations in the method just indicated, as for example after heat treating the roll can be machined and ground with a final testing operation then being performed.

From the foregoing it will be recognized that I have provided methods and apparatus for locating internal flaws or faults in cast metal rolls of large diameter and considerable length. The methods adapt themselves to commercial roll manufacture and involve little labor and time to complete while saving many expensive heat-treating and machining operations which might be performed on any given roll heretofore which actually had internal faults therein such as would cause premature failure of the roll. Perhaps the most outstanding feature of my invention is that by its use rolls employed for rolling metal can be known to be sound and reliable, and expensive and dangerous breakdowns in metal rolling mills can be substantially eliminated.

While in accordance with the patent statutes several embodiments of my invention have been illustrated and described in detail, it will be appreciated that my invention is not limited thereto or thereby but is defined in the appended claims.

I claim:

1. The combination in apparatus for locating internal flaws in metal rolls which comprises a frame, means on the frame to receive and mount a metal roll of large diameter and relatively long length for rotary movement about its axis, means for supplying steady direct electric current of relatively low potential and high amperage, adjustable means for connecting the electric current to the roll for flow lengthwise of the roll, and means for progressively measuring the potential drop at longitudinally spaced points along the roll, said last-named means including a longitudinally extending member adjustably positioned above the roll, a head slidably carried by the member, contacts engageable with the roll and carried by the head, a recording galvanometer and a shunt connected to the contacts, and mechanism for moving the head along the member.

2. Apparatus for testing cast metal rolls of large diameter and considerable length for inclusions, cracks, or other sources of weakness which comprises a frame, means adjustably mounted on the frame at a plurality of points for receiving a roll for rotary movement about its axis, contact-carrying means adjustably mounted on the frame adjacent the ends of the roll, contacts carried by the last-named means and adjustable to and from electrical engagement with the ends of the rolls, a beam supported by the means carrying the contacts so as to be

positioned parallel with the axis of the roll and spaced just vertically above the roll, a carriage slidably mounted on the beam, means for moving the carriage along the beam, contacts adapted to engage with longitudinally spaced points of the roll and supported by the carriage, means for supplying relatively low-potential high-amperage current to the contacts engaging with the ends of the roll, and means associated with the contacts on the movable carriage for measuring the potential drop along a longitudinal of the roll.

3. Apparatus for testing cast metal rolls of large diameter and considerable length for inclusions, cracks, or other sources of weakness which comprises a frame, means adjustably mounted on the frame at a plurality of points for receiving a roll for rotary movement about its axis, means adjustably mounted on the frame adjacent the ends of the roll, contacts carried by the last-named means and adjustable to and from the electrical engagement with the ends of the rolls, a beam supported by the means carrying the contacts so as to be positioned parallel with the axis of the roll and spaced vertically above the roll, a carriage slidably mounted on the beam, means for moving the carriage along the beam, contacts adapted to engage with longitudinally spaced points of the roll and supported by the carriage, means for supplying relatively low-potential high-amperage current to the contacts engaging with the ends of the roll, and means associated with the contacts on the movable carriage for measuring the potential drop along a longitudinal of the roll.

4. Apparatus for testing for internal flaws in large rolls, for example, those used in metal rolling mills, which includes a frame, a pair of means adjustably mounted on the frame at spaced points and each including a pair of cradle-forming rollers adapted to engage with the enlarged body portion of the roll and rotatably supporting the roll for rotation about its axis, contact supporting means adjustably mounted adjacent the ends of the frame, a contact adapted to be clamped against each end of the roll, means for cooling each contact, and adjustable means comprising a pneumatic motor positioned between each con-

tact and its associated contact supporting means for clamping the contact in firm electrical engagement with the end of the roll.

5. Apparatus for testing for internal flaws in large rolls, for example, those used in metal rolling mills, which includes a frame, a pair of means adjustably mounted on the frame at spaced points and each including a pair of cradle-forming rollers adapted to engage with the enlarged body portion of the roll and rotatably supporting the roll for rotation about its axis, contact supporting means mounted adjacent the ends of the frame, a contact adapted to be clamped against each end of the roll, means for cooling each contact, and adjustable means positioned between each contact and its associated contact supporting means for clamping the contact in firm electrical engagement with the end of the roll.

6. Apparatus for testing for internal flaws in large rolls, for example, those used in metal rolling mills, which includes a frame, means mounted on the frame and including cradle-forming rollers adapted to engage with the enlarged body portion of the roll and rotatably supporting the roll for rotation about its axis, contact supporting means mounted adjacent the ends of the frame, a contact adapted to be clamped against each end of the roll, means for cooling each contact, and adjustable means positioned between each contact and its associated contact supporting means for clamping the contact in firm electrical engagement with the end of the roll.

7. Apparatus for testing for internal flaws in large rolls, for example, those used in metal rolling mills, which includes a frame, means mounted on the frame and including cradle-forming rollers adapted to engage with the enlarged body portion of the roll and rotatably supporting the roll for rotation about its axis, contact supporting means mounted adjacent the ends of the frame, a contact adapted to be clamped against each end of the roll, and adjustable means positioned between each contact and its associated contact supporting means for clamping the contact in firm electrical engagement with the end of the roll.

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