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Mori et al.

[11] **3,873,912**

[45] **Mar. 25, 1975**

[54] **METHOD AND APPARATUS FOR FORMING ON A MOVING MAGNETIC MATERIAL A MAGNETIZED MARK OF PRESCRIBED WIDTH REGARDLESS OF VARIATIONS OF SPEED OF MOVING MAGNETIC BODY**

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[30] **Foreign Application Priority Data**

Oct. 16, 1972 Japan 47-103446

[52] **U.S. Cl.** .... **324/34 L**

[51] **Int. Cl.** **G01r 33/12**

[58] **Field of Search** .... 324/34 R, 34 L, 34 H

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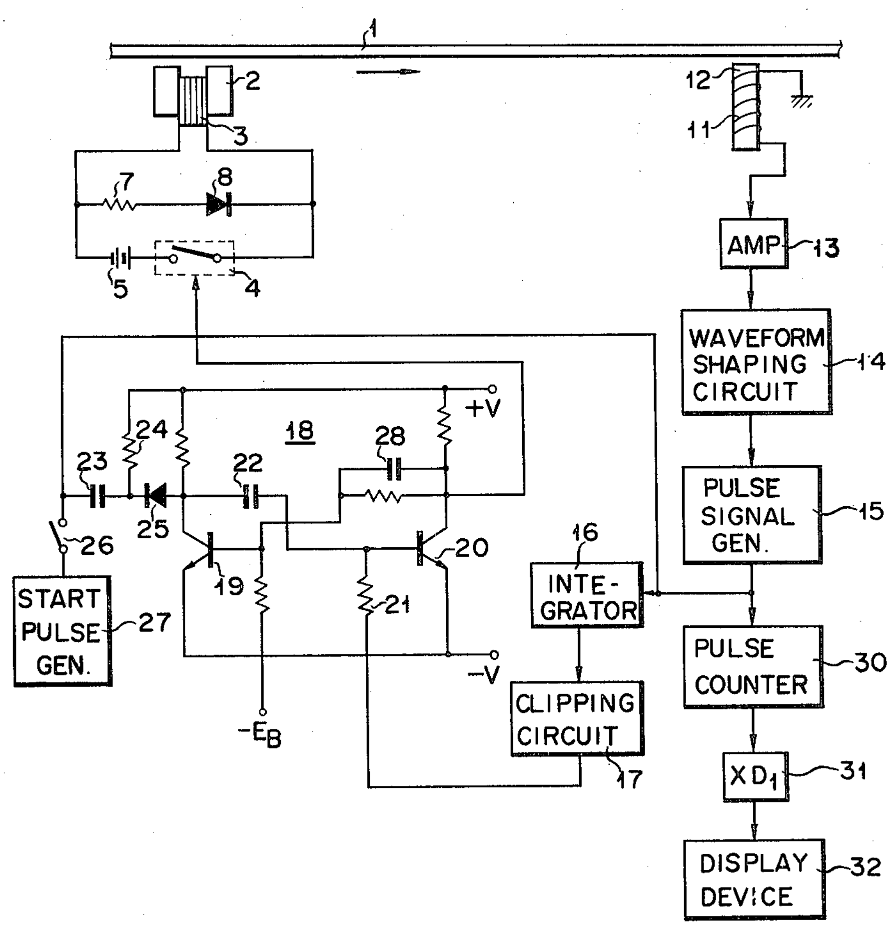
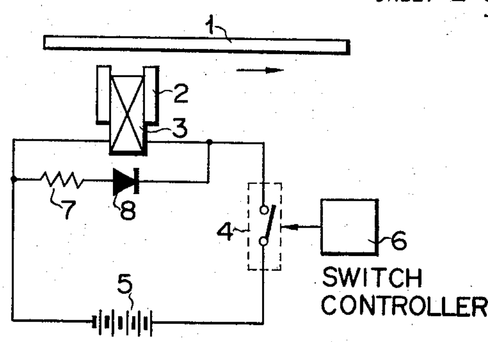
Attorney, Agent, or Firm—Flynn & Frishauf

[57] **ABSTRACT**

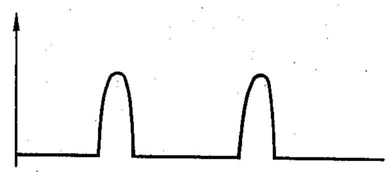
An apparatus for locally magnetizing moving magnetic material which comprises a coil for locally magnetizing the traveling magnetic material and a coil for detecting the magnetic flux of a locally magnetized spot, both coils being linearly arranged aside the magnetic material in its traveling direction; a pulse current generator for supplying the magnetizing coil with pulse current; an extraction device for extracting a signal denoting the speed of the traveling magnetic material out of a detection signal delivered from the magnetized spot-detecting coil; and a control device for controlling by the extracted signal the time width of output pulse current from the pulse current generator so as to cause the locally magnetized spot to have a fixed length extending along the magnetic material regardless of its traveling speed.

7 Claims, 17 Drawing Figures





F I G. 1



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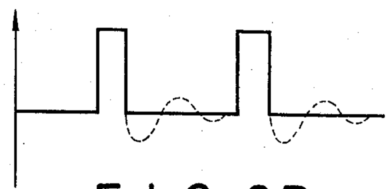
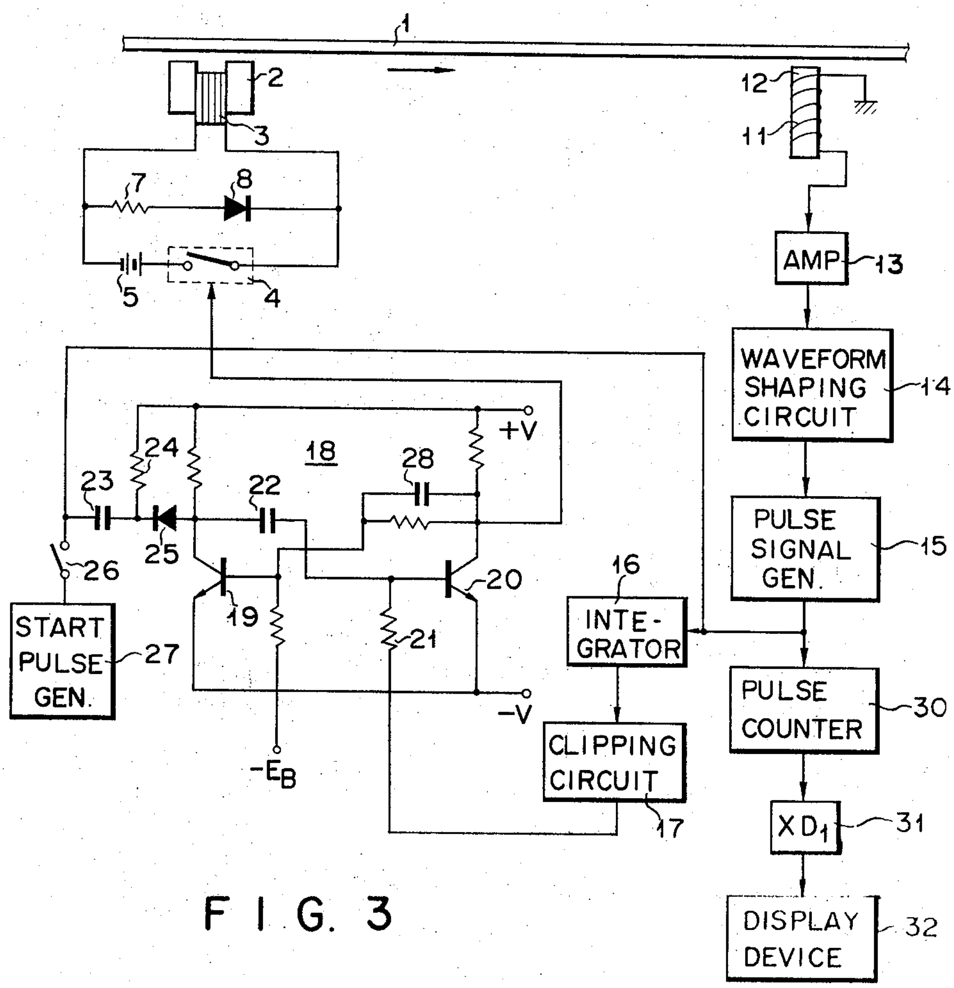


F I G. 2B



F I G. 3

FIG. 4A

FIG. 4B

FIG. 4C

FIG. 4D

FIG. 4E

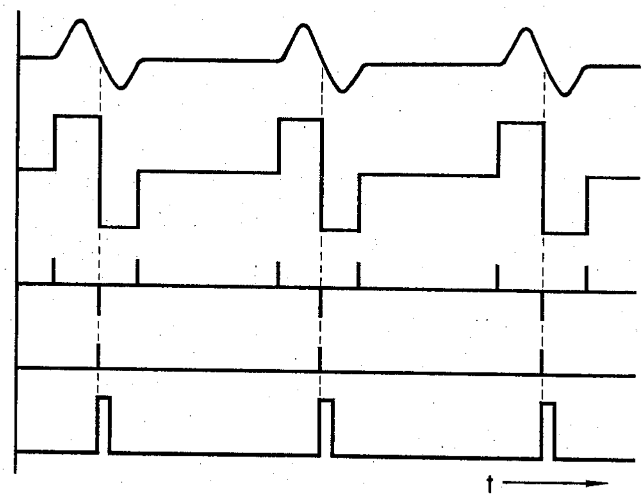


FIG. 5A

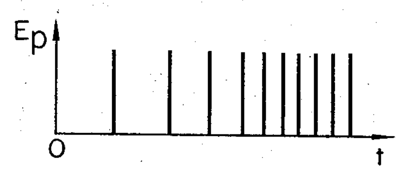


FIG. 5B

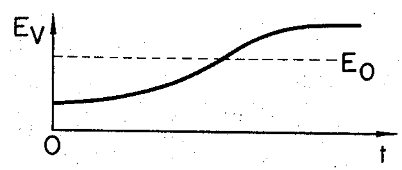


FIG. 5C

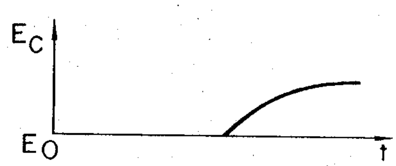


FIG. 6A

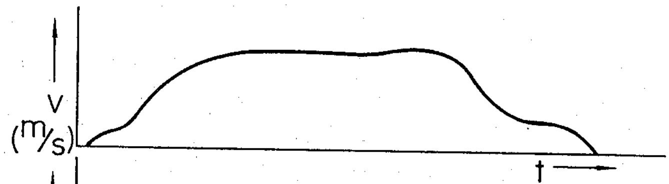


FIG. 6B

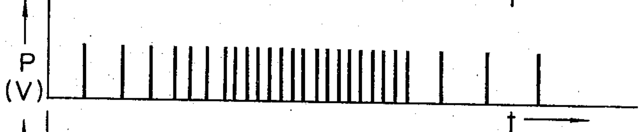


FIG. 6C

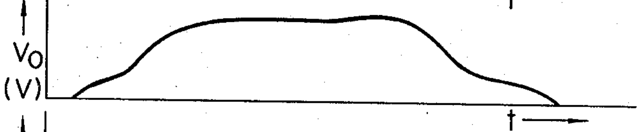
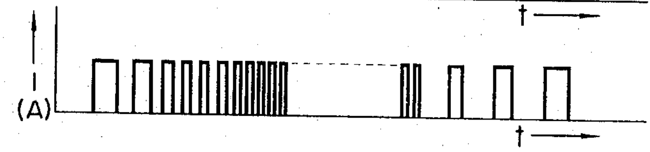


FIG. 6D



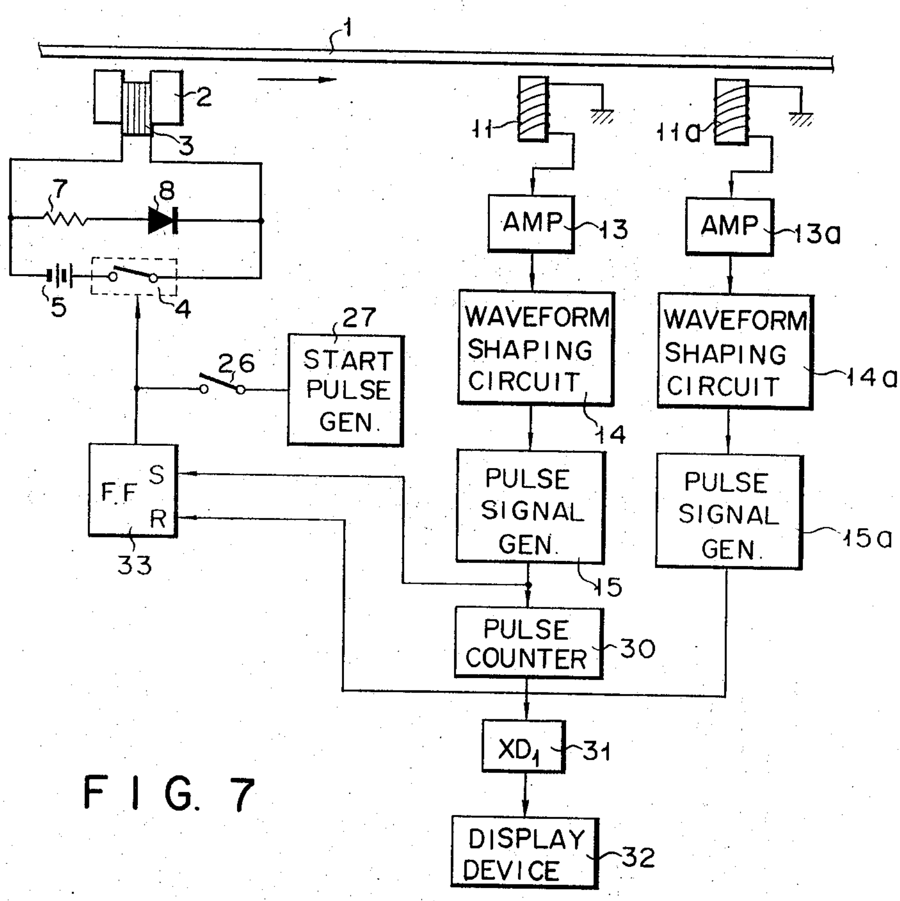


FIG. 7

METHOD AND APPARATUS FOR FORMING ON A MOVING MAGNETIC MATERIAL A MAGNETIZED MARK OF PRESCRIBED WIDTH REGARDLESS OF VARIATIONS OF SPEED OF MOVING MAGNETIC BODY

This invention relates to a method and apparatus for locally magnetizing moving magnetic material at a plurality of equidistant points linearly arranged in the traveling direction of the magnetic material.

The customary practice of, for example, measuring the length of the press-rolled section of steel plating while it is moving on the press roll line has been locally to magnetize the traveling steel plating at a plurality of equidistant points linearly arranged in the running direction of the steel plating, count the number of the locally magnetized spots and convert the counted number of said spots into the length of the press-rolled section of the steel plating.

Among the conventional methods of locally magnetizing moving magnetic material is the one which consists in introducing alternating current through a magnetizing coil positioned close to, for example, traveling steel plating being press-rolled. According to this method, the magnetizing coil is connected to a source of alternating current through the associated switch, and the operation of the switch is turned off when the alternating current falls to a zero level. This process creates a magnetic flux by alternating current of at least more than one cycle. Steel plating is locally magnetized by a magnetic flux thus generated. However, utilization of the locally magnetized spots for measurement of the press-rolled length of steel plating requires the magnetic pole of the magnetized spots and the magnitude of magnetization to be fixed by controlling the phase of the wave form of alternating current associated with the turn off operation of the switch. To this end, a switch controller is used for said phase control associated with the turn off operation of the switch. However, accurate phase control is difficult to attain, giving rise to errors. Moreover, the switch controller is unavoidably of complicated construction, resulting in high cost.

Further, since steel plating is traveling on the press roll line at relatively large varying speeds, the control by the above-mentioned switch controller of the phase of the wave form of alternating current associated with its shutoff should be carried out to the maximum extent of a half cycle in accordance with the varying traveling speeds of the steel plating. Therefore, a switch controller used to this end is necessarily of complicated arrangement, leading to high cost.

Magnetization by alternating current calls for introduction of a large amount of electric energy through the magnetizing coil, presenting the drawbacks that the magnetizing coil has to be formed of a thick wire, and a locally magnetized spot on steel plating unavoidably becomes unduly large to obstruct the accurate measurement of the length of the press-rolled section of the steel plating.

It is accordingly the object of this invention to provide a method for locally magnetizing moving magnetic material and an inexpensive apparatus of simple construction therefor which only requires a power source of relatively small capacity and can locally magnetize traveling magnetic material distinctly at a small spot, thereby attaining high precision measurement of, for example, the press-rolled length of steel plating.

SUMMARY OF THE INVENTION

According to an aspect of this invention, there is provided a method for locally magnetizing a moving magnetic material, which comprises providing a magnetizing coil aside of the traveling magnetic material, and supplying the traveling magnetic material with pulse current having a fixed time width at a prescribed interval.

According to a second aspect of the invention, there is provided a method of locally magnetizing moving magnetic material wherein a coil for locally magnetizing the traveling magnetic material and at least one detector for detecting the locally magnetized spots are linearly arranged at a prescribed interval aside of the magnetic material in its traveling direction; the magnetizing coil is supplied with pulse current having a prescribed cyclic period; a signal denoting the speed of the running magnetic material is extracted out of a detection signal obtained from the locally magnetized spot detector; and the pulse current has its time width controlled by the extracted signal so as to cause the locally magnetized spot to have a fixed length extending along the magnetic material, regardless of its traveling speed.

According to a third aspect of the invention, there is provided an apparatus for locally magnetizing moving magnetic material which comprises a magnetizing coil disposed aside of the traveling steel plating; and a device for supplying the magnetizing coil with pulse current having a fixed time width at a prescribed interval.

According to a fourth aspect of the invention, there is provided an apparatus for locally magnetizing moving magnetic material which comprises a magnetizing coil positioned close to the traveling magnetic material and at least one detector for detecting the locally magnetized spots; a pulse generator for supplying the magnetizing coil with pulse current having a fixed cyclic period; an extraction device for extracting a signal denoting the speed of the running magnetic material out of a detection signal obtained from the locally magnetized spot detector; and a control device for controlling the time width of pulse current by the extracted signal so as to render the length of the locally magnetized spot having a fixed length extending along the magnetic material, regardless of its traveling speed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically shows a method and apparatus for locally magnetizing moving magnetic material according to an embodiment of this invention;

FIGS. 2A and 2B present the wave forms of signals by way of illustrating the operation of the apparatus of FIG. 1;

FIG. 3 is a block circuit diagram of an apparatus according to another embodiment of the invention for locally magnetizing moving magnetic material;

FIGS. 4A, 4B, 4C, 4D and 4E indicate the wave forms of signals appearing at various sections of the circuit arrangement of FIG. 3;

FIGS. 5A, 5B and 5C present the wave forms of signals by way of illustrating the operation of the correction voltage-generating section of FIG. 3;

FIGS. 6A, 6B, 6C and 6D indicate the wave forms of signals by way of illustrating the operation of the apparatus having its circuitry arranged as shown in FIG. 3 for local magnetization of moving magnetic material; and

FIG. 7 is a block circuit diagram of an apparatus according to still another embodiment of the invention for locally magnetizing moving magnetic material.

DETAILED DESCRIPTION OF ILLUSTRATED EMBODIMENTS

Referring to FIG. 1, reference numeral 1 denotes a test object of magnetic material, for example, steel plating traveling at a fixed speed in the direction of the indicated arrow. A U-shaped core 2 disposed close to one side of the steel plating 1 is wound with a magnetizing coil 3. Both ends of the magnetizing coil 3 are connected to a source of direct current 5 having the indicated polarity through a switching device 4. The switching device 4 has its operation controlled by a control signal supplied by a switch controller 6. Where the switching device 4 comprises, for example, a transistor switch, then the switch controller 6 may be formed of an astable multivibrator so as to supply the base of a transistor constituting said transistor switch 4 with a signal for putting it in or out of operation. Parallel connected to both ends of the magnetizing coil 3 is a series circuit consisting of a resistor 7 and a diode 8 having an opposite polarity to the power source 5.

When, in an apparatus for locally magnetizing moving magnetic material arranged as described above, the switch controller 6 is operated to close the switch 4 and immediately after to open it, then pulse current having the wave form of FIG. 2B is supplied to the magnetizing coil 3 from the source of direct current 5. A pulse-shaped magnetic flux produced in the coil 3 by the above-mentioned pulse current causes that portion of the steel plating 1 which is disposed near the core 2 to be self magnetized in the form of a pulse as shown in FIG. 2A. Thus, the steel plating 1 is locally magnetized to an extent corresponding to its quality and thickness, the distance between coil 3 and steel plating 1, and the magnitude of the pulse current passing through the magnetizing coil 3. When the switch 4 is opened by the switch controller 6, then a reverse electromotive force arises at both ends of the magnetizing coil 3 due to its inductance and in consequence transient current indicated in broken lines in FIG. 2B tends to pass across both ends of the magnetizing coil 3. In the magnetizing apparatus of FIG. 1, however, said transient current is suppressed by the resistor 7 and diode 8. Accordingly, good pulse current shown in solid lines in FIG. 2B is supplied to the magnetizing coil 3. Where, therefore, the switch 4 is so controlled by the switch controller 6 as to be operated at an equal interval for a prescribed length of time under the condition in which steel plating 1 is supposed to travel at a fixed speed, then the steel plating 1 is locally magnetized equidistantly in a fixed length.

Actually, however, steel plating 1 used, for example, as a test object runs on the press roll line at large varying speeds, causing the length of locally magnetized spots on said test object to vary with its traveling speed. This event leads to the displacement of the center of locally magnetized spots, giving rise to errors in measuring the press-rolled length of the test object from such locally magnetized spots.

There will now be described the manner in which a magnetic flux is distributed in locally magnetized spots appearing on traveling steel plating 1. With $v(m/\text{sec.})$ taken to denote the speed of the running steel plating 1 and $\tau(\text{sec.})$ taken to represent the time width of the magnetizing pulse current, then the distance $9(m)$ covered by the moving steel plating 1 while current passes through the magnetizing coil 3 may be expressed by the following equation:

$$d = v \cdot \tau \ (m) \tag{1}$$

Namely, when a test object of steel plating 1 running at the speed of $v(m/\text{sec.})$ is locally magnetized with the time width of pulse current set at $\tau(\text{sec.})$, then the test object is supposed to have moved for a distance $d(m)$ expressed by the equation (1) above. Accordingly, the magnetized spot on the moving steel plating 1 has its length along the steel plating 1 increased to an extent of $d(m)$ expressed by the equation (1) above from that attained when the steel plating 1 is magnetized while standing at rest. The increased length Δh of the magnetized spot formed on the moving steel plating 1 may be expressed by the following equation:

$$\Delta h = d = v \cdot \tau (m) \tag{2}$$

Therefore, with $h_1\ (m)$ taken to denote the length of the magnetized spot formed on the steel plating 1 while standing at rest, then the length of the magnetized spot $h_2\ (m)$ provided thereon during transit on the press roll line may be expressed by the following equation:

$$h_2 = h_1 + \Delta h = h_1 + v \cdot \tau \ (m) \tag{3}$$

Further, with $h_0\ (m)$ taken to represent the exact half spot of the length of the magnetized spot, then the exact half length $h_{02}\ (m)$ of the magnetized spot formed on the traveling steel plating 1 may be indicated as follows from the equation (3) above:

$$h_{02} = \frac{h_2}{2} = \frac{h_1 + \Delta h}{2} = \frac{h_1 + v \cdot \tau}{2} (m) \tag{4}$$

Thus, the exact half length $h_{01}\ (m)$ of the magnetized spot provided on the stationary steel plating 1 may be expressed by the following equation:

$$h_{01} = \frac{h_1}{2} (m) \tag{5}$$

It will be noted that the length $h_{01}\ (m)$ formed on the stationary steel plating 1 has a constant defined by the shapes of the magnetizing coil and core, regardless of the period in which power is conducted through the magnetizing coil. Therefore, variations in the length of the magnetized spot on the traveling steel plating 1 may be indicated by an increase Δh of the equation (2) above. Deviations $x\ (m)$ arising in measuring the press-rolled length of the steel plating 1 due to variations in the length of the magnetized spots actually originate with those in detecting the center of each magnetized spot due to changes occurring in the exact half length $h_0\ (m)$ of the magnetized spot. The above deviations may be indicated as follows from the equations (4) and (5) above:

$$x = h_{02} - h_{01} = \frac{\Delta h}{2} = \frac{v \cdot \tau}{2} (m) \tag{6}$$

Therefore, to eliminate any displacement $x\ (m)$ of the center of the magnetized spot caused by changes in the length of the magnetized spot, it would be considered advisable to equalize the exact half length $h_{02}\ (m)$ of the magnetized spot on the traveling steel plating 1 and the exact half length $h_{01}\ (m)$ of the magnetized spot on the stationary steel plating 1. However, the length

h_1 (m) of the magnetized spot on the stationary steel plating 1 is defined by the shapes of the magnetizing coil and core, whereas the length h_2 (m) of the magnetized spot on the traveling steel plating 1 necessarily becomes larger than when the steel plating 1 stands at rest. Consequently, it is impossible to equalize the exact half length h_{02} (m) of the magnetized spot on the traveling steel plating 1 and the exact half length h_{01} (m) of the magnetized spot on the stationary steel plating 1. If, however, the length h_2 (m) of the magnetized spot on the moving steel plating 1 could be fixed and made equal to the length h_1 (m) of the magnetized spot on the stationary steel plating 1, then errors would be eliminated in measuring the press-rolled length of the steel plating 1. Namely, if the length of the magnetized spot on the traveling steel plating 1 was fixed within a prescribed tolerance, and compensation was made for said tolerance, then the error of measuring the press-rolled length of steel plating 1 would be fully eliminated.

There will now be described the method of fixing the length of the magnetized spot on the traveling steel plating 1 within a prescribed tolerance. It will be seen from the equations (2) and (6) that this method can be carried out by rendering the width τ (sec.) of the magnetizing pulse current inversely proportionate to the speed v (m/sec.) of the moving steel plating 1 and fixing an increase Δh (m) in the length of the magnetized spot on the moving steel plating 1.

When the time width τ (sec.) of the magnetizing pulse current is made inversely proportionate to the speed v (m/sec.) of the traveling steel plating 1 and the ratio constant of these two factors is chosen to have a given value k, then an increase Δh (m) in the length of the magnetized spot may be expressed as follows from the equation (2) above:

$$\Delta h = v \cdot \tau = k\ (m) \qquad (7)$$

Therefore, the length h_2 (m) of the magnetized spot on the traveling steel plating 1 and the displacement x (m) of the center of the magnetized spot may be respectively expressed as follows from the equations (3) and (6):

$$\left.\begin{aligned} h_2 &= h_1 + \Delta h = h_1 + k\ (m) \\ x &= \frac{\Delta h}{2} = \frac{k}{2} \end{aligned}\right\} \qquad (8)$$

The above equations show that the displacement of the center of the magnetized spot can be restricted within a prescribed bound by fixing the length of the magnetized spot on the running steel plate 1.

There will now be described by reference to FIG. 3 the embodiment of this invention where a magnetized spot can be formed on traveling steel plating 1 in a fixed length by the aforesaid principle, regardless of the speed of the traveling steel plating 1. The parts of FIG. 3 the same as those of FIG. 1 are denoted by the same numerals. A coil 11 wound about a core 12 to detect the position of magnetized spots is disposed aside of steel plating 1 running in the direction of the indicated arrow at a point spaced for a prescribed distance, for example, one meter from the corresponding magnetizing coil 3. Other magnetic sensitive devices such as SMD, a Hall element and the like can also be used in substitution for the detection coil 11.

A detection signal generated by the detection coil 11 is amplified by an amplifier 13 and conducted to a wave form-shaping circuit 14. An output signal from the amplifier 13 has one sine wave cycle, as shown in FIG. 4A, for each magnetized spot. The wave form-shaping circuit 14 may consist of a known type comprising a rectangular wave-generating circuit including, for example, a Schmidt trigger circuit for producing a rectangular wave signal shown in FIG. 4B; a differentiation circuit for generating an output signal having a wave form illustrated in FIG. 4C by differentiating a rectangular wave signal of FIG. 4B; a clipping circuit for extracting an impulse signal bearing a negative direction out of an output signal from the differentiation circuit; and an inverter. An output impulse signal from the wave form-shaping circuit 14 having a wave from indicated in FIG. 4D is generated at a point substantially corresponding to the center of the sine wave of FIG. 4A, and conducted to a pulse signal generator 15. This pulse signal generator 15 may consist of a monostable mutitivibrator. Thus, the pulse signal generator 15 gives forth a pulse signal having a fixed time width as indicated in FIG. 4E upon receipt of the detection signal of FIG. 4A.

The pulse signal is integrated by an integrator 16, an output signal from which is supplied to a clipping circuit 17. As the result, the voltage whose level lower than prescribed has been clipped is impressed as bias voltage on the base of one transistor 20 included in a monostable multivibrator 18. This monostable multivibrator 18 comprises two transistors 19 and 20 and has the time constant of its oscillation defined by a resistor 21 connected to the base of the transistor 20 and a capaciter 22. An output signal from the monostable multivibrator 18 is supplied to the switching device 4 from the collector of the transistor 20. Part of an output signal from the pulse signal generator 15 is delivered to a differentiation circuit consisting of a capacitor 23 and resistor 24. Only the negative component of an output differentiated pulse from the differentiation circuit is sent to the collector of the transistor 19 through a diode 25. A start pulse generator 27 is connected through a switch 26 to one side of the capacitor 23.

When, in the embodiment arranged as described above, the start pulse generator 27 gives forth a start pulse through the switch 26, then this start pulse is conducted to the differentiation circuit consisting of the capacitor 23 and resistor 24. Of the positive and negative impulses produced in the differentiation circuit upon receipt of the start pulse, the negative one is impressed on the monostable multivibrator 18 through the diode 25, and a switch control pulse is supplied to a switching device 4 from the collector of the transistor 20. As the result, the switching device 4 is operated for a prescribed length of time to introduce pulse current into the magnetizing coil 3, thereby locally magnetizing the steel plating 1 in a prescribed length. The magnetized spot moves together with the steel plating 1 and passes the magnetized spot detector 11. At this time, an electric signal is generated by the coil of said detector 11 in an amount proportionate to the amount of the residual magnetic flux of the magnetized spot and the intersecting speed of coil 11 with the flux. The electric signal thus obtained is subjected, as previously described, to amplification and wave shaping to be converted into a pulse signal. This pulse signal is conducted from the pulse signal generator **18** to the switching device **4.** When the magnetized spot provided on moving steel plating **1** by the preceding start pulse is brought to the magnetized spot detector **11,** then the fresh magnetized spot is formed on said steel plating **1** by the succeeding start pulse. Where the steel plating **1** moves at a fixed speed, and the repetition rate or density of pulses supplied to the integrator **16** per unit of time is fixed, then the voltage impressed on the base of the transistor **20** through the clipping circuit **17** also remains unchanged. Once the start pulse generator **27** generates a start pulse under the above-mentioned condition, then magnetized spots are automatically formed on steel plating **1** equidistantly, provided the steel plating **1** runs at a fixed speed.

Where the distance D_1 (m) between the magnetizing coil **3** and detection coil **11** is multiplied by the number N of output pulses generated by the pulse signal generator **15** for a prescribed lentgh of time, then the press-rolled length l (m) of steel plating **1** passing the detection coil during that time can be measured as follows:

$$l = ND_1\ (m) \qquad (9)$$

In the embodiment of FIG. **3,** a pulse counter **30** counts the number N of pulses generated by the pulse signal generator **15.** The distance between the magnetizing coil **3** and detection coil **11** is multiplied by the counted number of pulses in a calculator **31** to obtain the press-rolled length l (m) of the steel plating **1.** A signal denoting this length l (m) is supplied to a display device **32** for indication.

In fact, however, the length h_2 (m) of the magnetized spot on the traveling steel plating **1** varies with its speed, leading to changes in the exact half length h_{02} (m) of the magnetized spot and the distance D (m) between two adjacent magnetized spots. Therefore, the distance D_1 between the magnetizing coil **3** and magnetized spot-detecting coil **11** presents a slight difference x' (m) from the actually measured distance D_2 (m) between two adjacent magnetized spots on the running steel plating **1.** This difference x' (m) originates with changes in the exact half length h_0 (m) of the magnetized spot, and is equal to the displacement x (m) of the center of the magnetized spot on the traveling steel plating **1** caused by changes in the exact half length h_{02} (m) of said magnetized spot. Therefore, the difference x' (m) between D_1 and D_2 may be expressed as follows:

$$x' = D_2 - D_1 = x = \frac{\Delta h}{2} = \frac{v \cdot \tau}{2} (m) \qquad (10)$$

Thus, an error ratio Z and an error Y occurring in measurement of the press-rolled length of traveling steel plating **1** may be indicated by the equations:

$$\left.\begin{aligned} Z &= \frac{D_2 - D_1}{D_1} = \frac{x'}{D_1} = \frac{x}{D_1} \\ Y &= Nx' = Nx\ (m) \end{aligned}\right\} \qquad (11)$$

In this case, the repetitive period T (sec.) of output pulses from the pulse signal generator **15** may be expressed as follows:

$$T = D_2/v \text{ (sec.)} \qquad (12)$$

When an output pulse signal from the pulse signal generator **15** is supplied to the integrator **16** acting to generate voltage for correcting the time width of magnetizing pulse current, then there is obtained direct current voltage whose level corresponds to the frequency 1/T (Hz) of a pulse signal received.

Where steel plating **1** travels at a speed slowly increasing during a period extending from time 0 to time t, then output pulses generated by the pulse signal generator **15** have the interval gradually reduced as shown in FIG. **5**A. When these pulse signals are integrated by the integrator **16,** then there is obtained such pulse density or voltage E_r of FIG. **5B** as is proportionate to the speed of the running steel plating **1.** of the output voltage E_r from the integrator **16,** a component lower than the voltage E_o previously set in the clipping circuit is clipped to provide output voltage E_r shown in FIG. **5**C. The clipping circuit **17** is intended to eliminate the necessity of controlling the time width of unnecessary pulses when steel plating **1** travels at a slow speed.

When correction voltage obtained through the abovementioned process is impressed on the base of the transistor **20** then the capacitor **22** included in a time constant circuit is charged with voltage varying with the level of said correction voltage. Namely, the faster the speed of running steel plating **1,** the lower the voltage impressed on the capacitor **22.** As the result, an output pulse from the monostable multivibrator **18** has its time width reduced by that extent, rendering the time width τ_o (sec.) of magnetizing pulse current passing through the magnetizing coil **3** inversely proportionate to the speed v (m/sec.) of the running steel plating **1.**

With k taken to denote a ratio constant in defining the above-mentioned inverse proportion, an increase Δh (m) in the length of the magnetized spot may be indicated as k (m) from the equation (7). The length h_2 (m) of the magnetized spot formed on the traveling steel plating **1** and the displacement x (m) of the center of the magnetized spot are fixed at $(h_1 + k)$ and $(k/2)$ respectively from the equation (8). Consequently, an actually measured distance D_2 (m) between two adjacent magnetized spots is also fixed at $(D_1 + k_2)$ as seen from the equation (10). Therefore, with D_1 (m) taken to denote a distance between the magnetizing coil **3** and magnetized spot detecting coil **11,** then the aforesaid distance D_2 (m) between two magnetized spots becomes equal to the distance D_1. Thus the previously mentioned difference x' between the two distances D_1 and D_2 and the error ratio Z and error Y of the equation (11) are eliminated, enabling the press-rolled length l (m) of the traveling steel plating **1** shown by the equation (9) to be accurately measured.

FIGS. **6**A, **6**B, **6**C and **6**D present the wave forms of signals generated at various parts of the embodiment of FIG. **3** to correct the time width of magnetizing pulse current. FIG. **6**A is a graph showing the relationship of operating time and the speed of steel plating **1** traveling, for example, on a press roll line. As apparent from FIG. **6**A, the press roll line speed v (m/sec.) of the steel plating **1** presents variations during the operating time. When the steel plating **1** runs on the press roll line at such varying speeds as illustrated in FIG. **6**A, pulses generated by the pulse signal generator **15** also change in frequency as indicated in FIG. **6**B, and output voltage from the integrator **16** has its level changed as shown in FIG. **6**C. Unless, therefore, the clipping circuit **17** is used, magnetizing current running through the magnetizing coil **3** will have, as shown in FIG. **6**D, a time width inversely proportionate to the speed of the moving steel plating **1**. As seen from the equation (2), the length of the magnetized spot formed on the running steel plating **1** indicates an increase Δh proportionate to its speed v and the time width τ of magnetizing pulse current. To fix said increase Δh, therefore, the locally magnetizing apparatus of this invention renders the time width of magnetizing pulse current inversely proportionate to the press roll line speed of the steel plating **1**.

FIG. **7** shows the circuit arrangement of an apparatus according to another embodiment of this invention for locally magnetizing moving magnetic material. According to this embodiment, two magnetized spot-detecting coils **11** and **11a** are linearly arranged at a prescribed space aside of steel plating **1** in its traveling direction. It is advised that an interval between both detecting coils **11** and **11***a* be so chosen as to be saved from the effect of variations in the speed of the running steel plating **1**, namely, be set at, for example, 10 to 100 mm. Alternating current generated in the detection coil **11***a* is amplified by an amplifier **13***a* and conducted to a wave form-shaping circuit **14***a* constructed in the same manner as the aforementioned wave form-shaping circuit **14**. An impulse signal as shown in FIG. 4D is supplied from the wave form-shaping circuit **14***a* to a pulse signal generator **15***a*. This pulse signal generator **15***a* gives forth a pulse signal as shown in FIG. 4E according to an impulse received. Two output pulses from both pulse signal generators **15** and **15***a* are transmitted to the set terminal of a flip-flop circuit **33** and the reset terminal thereof respectively.

When, under the above-mentioned arrangement, a switch **26** is closed to supply a start pulse from the start pulse generator **27** to the switching device **4**, then said device **4** is rendered conducting by a start pulse for a prescribed length of time. During this operative period, a magnetizing pulse is delivered from the source of direct current **5** to the magnetizing coil **3**. The magnetized spot formed on the traveling steel plating **1** by the magnetizing pulse is brought to a first or forward detection coil **11** together with the moving steel plating. The first detection coil **11** generates a signal according to the magnetized spot. Upon receipt of the detection signal, the pulse signal generator **15** supplies a pulse signal to the set terminal of the flip-flop circuit **33**, which is thus set to give forth an output signal to the switching device **4** for its actuation. When the magnetized spot formed on the steel plating **1** by the start pulse is brought to a second or rear detection coil **11a** upon further movement of the steel plating **1**, then the second detection coil **11***a* produces a detection signal. Upon receipt of this detection signal, the pulse signal generator **15***a* supplies a pulse to the reset terminal R of the flip-flop circuit **33** to reset it, thereby extinguishing an output from the flip-flop circuit **33** and rendering the switching device **4** inoperative. Namely the switching device **4** is actuated only while the flip-flop circuit **33** is set, causing magnetizing pulse current to run through the magnetizing coil **3**. If, therefore, a distance between both detection coils **11** and **11a** is fixed, then the set period of the flip-flop circuit **33** will be shortened in inverse proportion to the speed of the traveling steel plating **1**. Accordingly, the faster the speed of the running steel plating **1**, the shorter the time width of the magnetizing pulse current.

Further, if a distance between both detection coils **11** and **11a** is set at h_1 (m) equal to the length of the magnetized spot provided, for example, on a stationary steel plating, then the magnetizing pulse current will be cut when the steel plating **1** is moved h_1 (m). Therefore, the magnetized spot formed on the traveling steel plating **1** has a fixed length of $2h_1$ (m), regardless of the speed of said plating **1**. Thus the exact half length of the magnetized spot indicated h_1 (m), and a distance D_2 between two adjacent magnetized spots is fixed at $D_1 + h_1$ (m). If, therefore, a distance between the magnetizing coil **3** and magnetized spot-detecting coil **11** is set at $D_1 - h_1$ (m), then a distance D_2 between two adjacent magnetized spots will be equal to D_1. As the result, the displacement x' of the center of the length of the magnetized spot will be fully suppressed. Consequently, the error ratio Z and error Y occurring in measuring the press-rolled length of steel plating **1** will also be eliminated, thereby enabling said measurement to be effected very accurately.

The foregoing description relates to the case where this invention was applied in measuring the press-rolled length of steel plating. The present apparatus which accurately indicates the position of a magnetized spot is also applicable in exactly detecting any desired point on steel plating traveling on the press roll line.

The apparatus which can also measure the speed of traveling steel plating may be used as an accurate speedmeter.

What we claim is:

1. An apparatus for locally magnetizing moving magnetic material comprising:

- a magnetizing coil for forming a magnetized mark on the moving magnetic material;
- at least one detector for detecting the magnetized mark, said magnetizing coil and detector being linearly arranged a fixed distance apart aside the magnetic material in its traveling direction;
- means for supplying the magnetizing coil with pulse current having a fixed repetitive period;
- means for extracting a signal denoting the speed of the traveling magnetic material out of a detection signal delivered from the magnetized mark detector; and
- control means responsive to the extracted signal for controlling the time width of the pulse current so as to render said time width inversely proportional to the speed of the moving magnetic material thereby causing the magnetized mark to have a fixed length regardless of the speed of the material.

2. An apparatus for locally magnetizing moving magnetic material according to claim **1**, wherein the means for supplying pulse current to the magnetizing coil comprises a source of direct current connected to the magnetizing coil; switching means connected between the source of direct current and the magnetizing coil; a switch controller for generating a signal for controlling the operation of the switch; and a series circuit including a resistor and a diode of opposite polarity to the source of direct current, the series circuit being connected in parallel with the magnetizing coil.

3. An apparatus for locally magnetizing moving magnetic material according to claim **1** wherein the magnetized mark detector comprises a core disposed near the magnetic material and a coil wound about the core; the extraction means comprises a wave form shaping circuit for producing one impulse per magnetized mark upon receipt of a detection signal from the detection coil, a pulse signal generator for generating a pulse signal having a prescribed time width upon receipt of an impulse signal from the wave form shaping apparatus and an integrator for generating a voltage having a level proportional to the density of the pulse signals; the pulse current-supplying means comprises a source of direct current connected to the magnetizing coil, a switching device connected between the source of direct current and magnetizing coil, a monostable multivibrator for generating a signal for controlling the operation of the switching device and a series circuit including a resistor and a diode of opposite polarity to the source of direct current, the series circuit being coupled in parallel with the magnetizing coil; and the control means for controlling the time width of pulse current comprises a clipping circuit for supplying an output signal from the integrator to the time constant circuit of the monostable multivibrator.

4. An apparatus for locally magnetizing moving magnetic material according to claim **3** which further comprises a pulse counter for counting the number of pulses delivered from the pulse signal generator; a multiplying circuit coupled to the pulse counter for generating a signal denoting the treated length of the magnetic material by multiplying the counted number of pulses by a prescribed coefficient; and a display device for indicating the treated length of the magnetic material upon receipt of an output signal from the multiplying circuit.

5. An apparatus for locally magnetizing moving magnetic material comprising:

a magnetizing coil for locally magnetizing the moving magnetic material;

a first and a second detector for detecting magnetized marks formed on the moving magnetic material, the coil and both detectors being linearly arranged a fixed distance apart aside the magnetic material in its traveling direction, one detector being further from the coil than the other;

supply means for selectively supplying the magnetizing coil with a direct current pulse in response to a control signal; and

a control circuit for supplying the control signal to said supply means to connect the direct current to the magnetizing coil upon receipt of a detection signal from the first detector and for cutting off the direct current thus supplied upon receipt of a detection signal from the second detector thereby causing the magnetized mark to have a fixed length regardless of the speed of the material.

6. An apparatus for locally magnetizing moving magnetic material according to claim **5** wherein the control circuit comprises a flip-flop circuit which is set by a detection signal from the first detector and reset by a detection signal from the second detector.

7. A method for uniformly marking a moving magnetic body by means of a magnetizing coil which forms a magnetized mark on the magnetic body and by means of at least one detector spaced a fixed distance apart from the magnetizing coil and adapted to detect the magnetized mark, comprising:

converting the output signal of the detector into a control voltage having a voltage level proportional to the speed of the moving magnetic body;

controlling the time width of the output pulse of a monostable multivibrator by the control voltage; and

flowing magnetizing current through the magnetizing coil for a time period which is a function of the controlled time width of the monostable multivibrator output pulse, thereby forming on the magnetic body a magnetized mark of a prescribed length regardless of the speed variation of the moving magnetic body.

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