Nov. 24, 1964 D. C. KALBFELL 3,158,805

METHOD AND APPARATUS FOR MAGNETICALLY MARKING SHEET STEEL BY DEPOSITION OF METAL IONS

Filed June 2, 1958 3 Sheets-Sheet 1

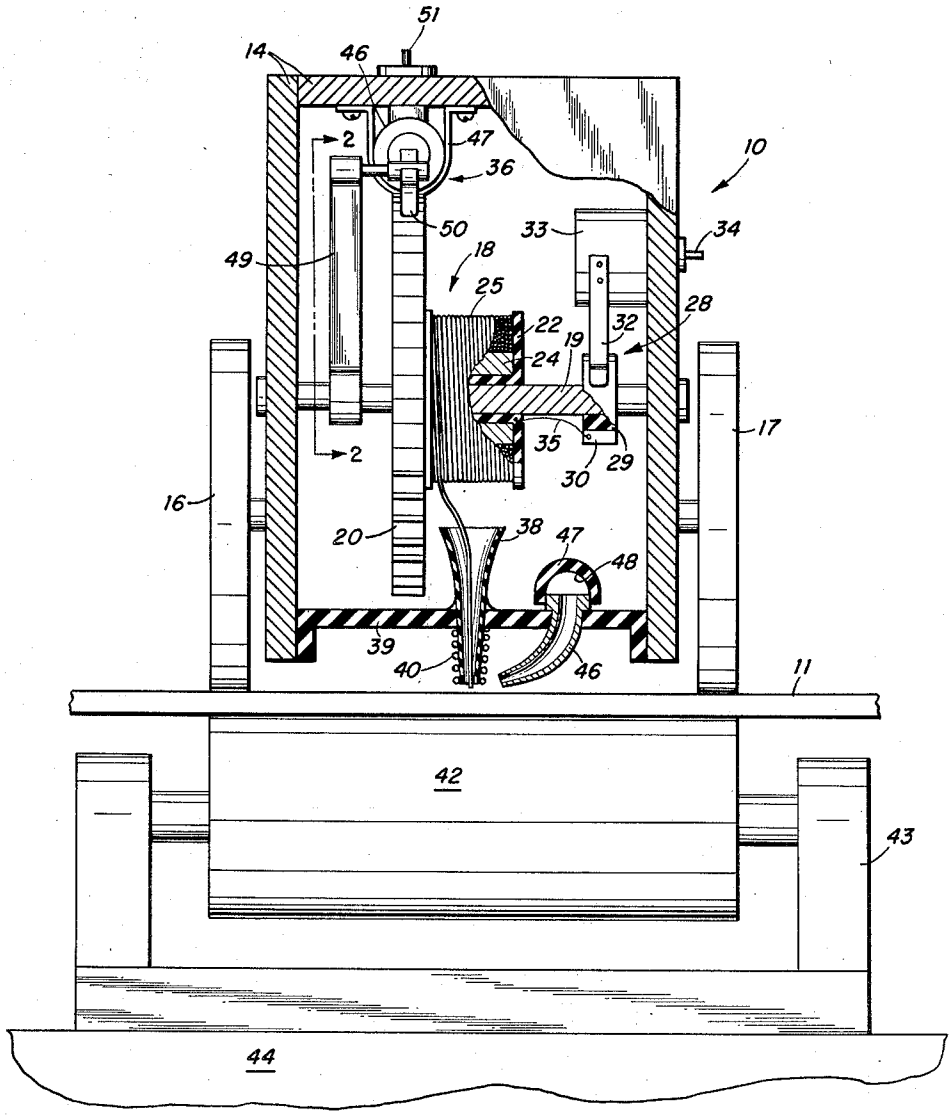


Fig. 1

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METHOD AND APPARATUS FOR MAGNETICALLY MARKING SHEET STEEL BY DEPOSITION OF METAL IONS
Filed June 2, 1958 3 Sheets-Sheet 2

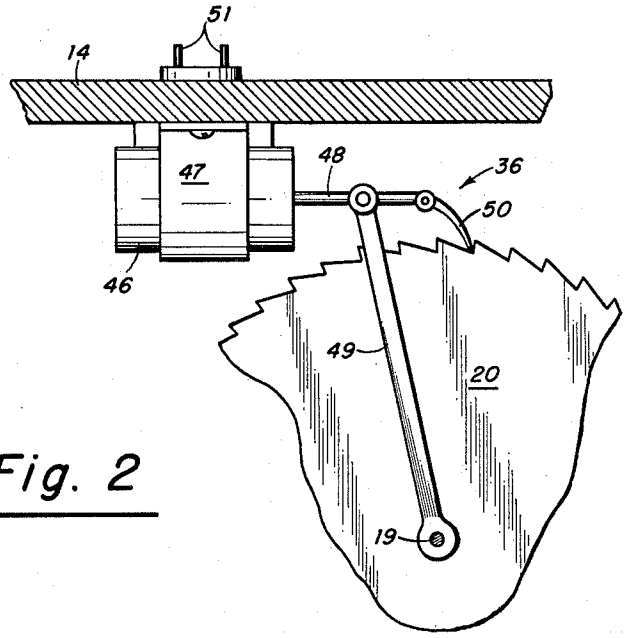


Fig. 2

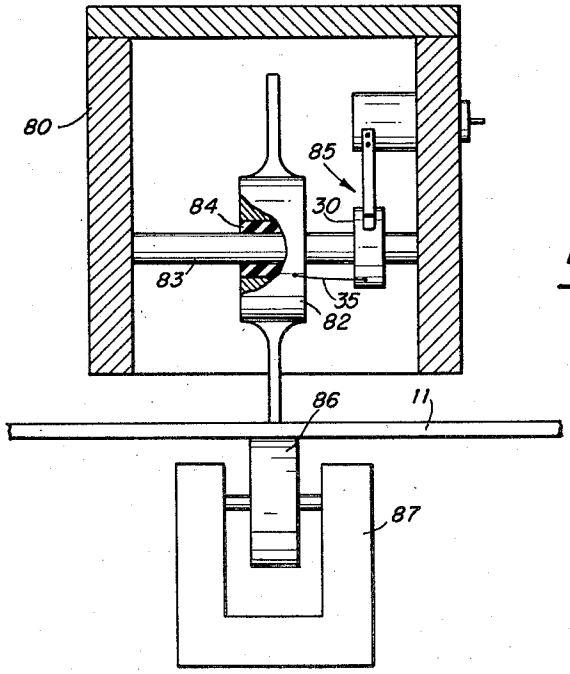


Fig. 4

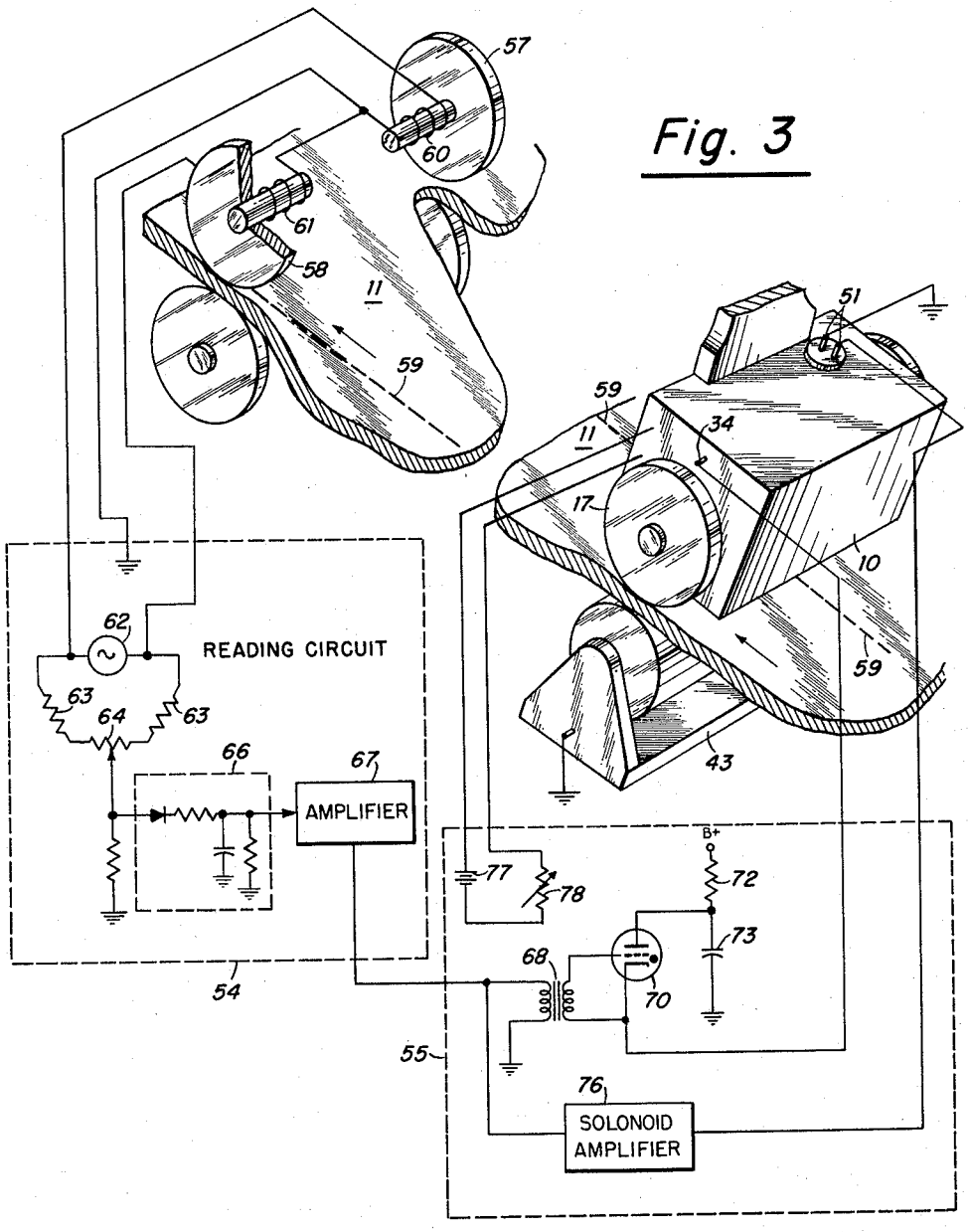
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Filed June 2, 1958 3 Sheets-Sheet 3

Fig. 3



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3,158,805

METHOD AND APPARATUS FOR MAGNETICALLY MARKING SHEET STEEL BY DEPOSITION OF METAL IONS

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Filed June 2, 1958, Ser. No. 739,101
10 Claims. (Cl. 324—34)

The present invention relates to a sheet steel marking system, and more particularly, to a system for altering the permeability of sheet steel at predetermined spots for marking purposes.

A system for magnetically recording toroidally shaped areas on soft sheet steel for marking purposes is disclosed in a copending application entitled "Magnetic Marking System" of David C. Kalbfell, Serial Number 739,110 and filed June 2, 1958, now Patent No. 3,019,385. As pointed out in that disclosure, previous sheet steel magnetic marking systems have generally failed because non-toroidal magnetic patterns are easily erased by normal demagnetizing forces, and vibration. The toroidally shaped areas as recorded in accordance with the invention in the above noted disclosure contained closed flux lines which eliminated the normally occuring demagnetizing forces and hence resisted erasure; but still might be erased by very severe vibration or mechanical strain.

The present invention is based on a completely different manner of marking sheet steel and offers totally stable and permanent magnetic characteristics of the marked points. Thus, in instances where the operation of the prior disclosed system may be marginal, due to extremely low remanence point characteristics of the steel or an unusually heavy vibration environment, the present system may be employed with the assurance that the marking will be permanent in nature.

This is accomplished by producing an alloy of high permeability or large remanence at the marked spots. In one embodiment, the end of a conductive wire is placed in close proximity to the sheet steel and a very high potential positive pulse is applied to the wire when adjacent to the points along the steel which are to be marked. The ensuing arc causes positive metal ions from the wire to be deposited on the steel surface. Now, by initially forming the wire out of a metal, a typical example being nickel, or a combination of metals, which are normally employed to raise the permeability of average ferrous materials, the spot of ion deposition will exhibit greatly increased permeability or retentivity depending upon the amount of alloying material transferred to the sheet steel.

In the other embodiment, a wheel, having a disc-like outer edge and formed of a permeability increasing material similar to the wire noted in the first mentioned embodiment, is adapted to roll along the steel surface. Upon application of a current pulse between the wheel and sheet steel, the wheel point of contact becomes heated, the mobility of its molecules increased, and some wheel material is transferred to the steel surface.

The spots or areas thus marked by either recording embodiment may be recognized by a permeability sensing or reading arrangement in which a pair of similar iron wheel, shaft and coil assemblies respectively pass over marked and unmarked surface areas. By connecting the pair of windings in a wheatstone bridge arrangement, energized by an A.-C. source and initially balancing it for the condition when both wheels pass over unmarked areas, wherever a marked spot is encountered by the one wheel arrangement, the inductance of its associated winding will be appreciably increased owing to the much higher permeability of the spot material. The increased inductance will unbalance the bridge causing an output signal to be produced.

Either marking mechanism, coupled with the permeability reader, can be arranged to mark predetermined lengths along a moving piece of sheet steel, as described in the referred to application for patent, by coupling read signals to the record circuit. If the alloyed spot is toroidally magnetized, then a remanence reader as in the referred to copending application, could be used, but the permeability reader described in accordance with the present invention would generally be preferred.

It is, accordingly, the principal object of the present invention to provide apparatus for marking a moving sheet of steel by modifying its permeability at predetermined spots and then sensing the changed permeability.

Another object of the present invention is to provide a mechanism for altering the permeability of moving magnetizable material at selected spots for marking purposes.

Still another object of the present invention is to provide apparatus for depositing a small amount of high permeability material on a moving sheet of steel for marking purposes.

A further object of the present invention is to provide apparatus for detecting spots on a sheet of moving magnetizable material having different permeability values than the surrounding material surface.

Another object of the present invention is to provide sensing apparatus for detecting small regions of high permeability on the surface of a moving sheet of steel having a generally low permeability value.

Still another object of the present invention is to provide apparatus for changing the permeability of moving sheet steel at selected spots by depositing minute amounts of material having a different permeability value from the sheet steel and sensing the changed permeability of the spots for reading purposes.

Other objects and features of the present invention will become apparent to those skilled in the art as the following disclosure is set forth in which a detailed description is given of a preferred embodiment of the invention as illustrated in the accompanying drawings in which:

FIGURE 1 is a view, partly in cross section, of a marking mechanism according to the present invention;

FIGURE 2 is a side view, partly in cross section, taken along section lines 2—2 of FIGURE 1, of the wire dispensing actuating mechanism;

FIGURE 3 is a circuit diagram of the recording and reading circuitry of the present invention shown in conjunction with the recording and reading mechanisms shown schematically; and

FIGURE 4 is a front view, partially broken away and partially in cross section, showing another embodiment of a marking mechanism according to the present invention.

In FIGURE 1 is shown one embodiment of a recording mechanism according to the present invention. An ion marking gun **10**, partly in cross-section, is generally indicated adjacent a moving piece of sheet steel **11**. Gun **10** includes a frame structure, indicated generally at **14**, which includes left, right, top, forward, and rear panels or sides. A pair of wheels **16** and **17**, are respectively connected by appropriate shafts to the left and right panels of frame **14** and are adapted for making rolling contact with moving sheet **11**. A wire dispensing assembly is generally indicated at **18**. It includes a shaft **19** rotatably mounted between right and left sides of frame **14**. A ratchet wheel **20** is attached to shaft **19** as is a bobbin **22** constructed of an electrical insulating material, such as vinyl plastic. An inner plug **24** of a conducting material, such as copper, is inserted around the center portion of bobbin **22**. Finally, ion supply wire **25** is wrapped around plug **24** in conductive contact therewith.

A brush assembly is generally indicated at **28** and includes a pair of concentric rings **29** and **30**, of non-conductive and conductive material, respectively, on shaft

19. A mounting block 33, of insulating material, is attached to the right side of frame 14 and holds a brush 32, preferably making a spring biased, conductive contact with conductive ring 30. Ring 30 is connected by a lead 35 to plug 24, and a terminal 34, projecting out of the right panel of frame 14, is connected to brush 32. A solenoid stepping drive arrangement, indicated at 36, is shown in detail in FIGURE 2, and reference is made to the description given in connection therewith for this feature of the ion gun.

An ion wire guide 38, of a general funnel shaped configuration, and constructed of an insulating material such as Mycalex, is mounted to a guide mounting support 39 at its lower end, support 39, in turn, being mounted to opposite sides of frame 14. Finally, a focusing coil 40 is wrapped spirally around the lower end of guide 38. Its end point, through which the end of wire 25 protrudes, is preferably in direct line between the contacts made by wheels 16 and 17 with sheet 11.

A curved nozzle 46 is mounted in an appropriate opening in mounting support 39 and is connected through a conduit 47, shown in cross-section, through an opening 48 in the rear panel to a source of gas, not shown, such as hydrogen, employed, as later described, for annealing purposes. The end of the nozzle is suitably curved so that the gas emitted therefrom will envelop the space surrounding the end of wire 25 and adjacent sheet 11 surface.

A roller or drum 42, of conductive material such as copper or brass, is supported by a U-shaped mounting bracket 43 for rolling contact with sheet 11. It is positioned directly beneath the points of contact of wheels 16 and 17 for the purpose of providing a firm support for the entire ion gun against the sheet steel and also, as will be described later, offering a conductive return path for the current flow through the end of ion wire 25.

Before describing the ion gun operation, its structure will be completed by a description of FIGURE 2 in which is shown a side view, taken along section lines 2—2 of FIGURE 1, of the solenoid ratchet-drive mechanism portion of the wire dispensing assembly 18. In particular, a solenoid 46 is held to the upper panel of frame 14 by a U-shaped bracket 47. The plunger 48, of solenoid 46, is pivotally connected to one end of a guide arm 49, the other end of arm 49 being pivotally connected to shaft 19. A pivoted, spring-biased ratchet arm 50 is attached to the outer end of plunger 48 and is adapted for making contact with the ratchet teeth in wheel 20.

The detailed description of the marking and measuring operation preferred by the entire system, according to the present invention, is presented in conjunction with FIGURE 3. However, at this point, for the purpose of describing the operation of the ion gun assembly of FIGURES 1 and 2, it may be stated that the record circuitry associated with ion gun 10 will provide a pulse of high positive potential between terminal 34 and ground. The resulting current flow will pass serially through brush 32, ring 30, conductor 35, plug 24, ion supply wire 25 to ground which is constituted by sheet 11, roller 42, etc.

In particular, the potential existing between the tip of wire 25 and sheet 11, is assumed sufficient to arc over, and the resultant heat generated at the wire tip, in association with the electric field of the arc, will cause metal ions, formed of the wire 25 material, to leave the wire tip and be accelerated toward the relative negative potential of the grounded sheet 11. Since coil 40 is, as shown in FIGURE 3, continuously energized by a D.-C. current, its resulting magnetic field will act to guide or focus the metal ions along its axis. These focused and accelerated ions will be deposited, in a small area or dot since the recording pulse will be of short time duration. Also, by maintaining the ion gun assembly at a constant distance from the edge of sheet 11, all deposited spots will lie along a predetermined line and hence be capable of being read by a reading assembly maintained at the same edge distance. As will be given in more detail later, the gas emitted from the end of nozzle 46 helps to anneal the metal deposition for increasing still further the permeability of the area thus marked.

In the ion depositing process just described, the material of wire 25 adjacent sheet 11 will be removed to form the deposit on sheet 11. Hence, after each recording operation, it is necessary to advance the wire from the spool in order to bring up more wire material for the next depositing operation. This is accomplished by the solenoid drive mechanism arrangement. In the record circuitry, the pulse serving to actuate the high potential pulse for performing the deposition process is likewise applied to a solenoid drive amplifier, connected to solenoid 46. Owing to the inertia of the solenoid plunger and guide arms, the deposition process will be completed prior to the solenoid actuation.

Upon receipt of this amplified current pulse, plunger 48 will be moved forward and pivot point 50 will step wheel 20 one ratchet division before retraction of the solenoid plunger. The rotation of the ratchet wheel, in turn, will act to unwind a small incremental length of wire 25 which will be guided through guide mechanism 38 such that its end will again be in close proximity to sheet 11. It will be seen that in this arrangement, a basic self-regulating feature is present in that if wire 25 is pushed too far, the ensuing arc produced by the next marking process will burn a greater than normal amount off onto the surface of sheet 11. On the other hand, if the movement should be too little, then owing to the greater distance between its end and sheet 11, a smaller amount will be burned off.

A secondary effect of the marking operation by the described ion deposition process will be that the current flow from the tip end of wire 25 to sheet 11 will act not only to deposit the wire metal ions but will also tend, by reason of the circular magnetic flux pattern set up around the current path flow to leave a residual magnetized pattern, also of toroidal shape, surrounding the edges of the deposited spot. In this respect then, the operation of the device of the present invention resembles the operation of the device of the previously referred to application for patent.

In general, the ion supply wire may be formed of any metal capable of modifying or changing the particular permeability value that sheet steel 11 might have. This broad property is permissible since the reading apparatus, to be described later in FIGURE 3, will sense permeability differences in sheet 11, regardless of whether the permeability value of the steel at the marked points is effectively raised or lowered in value. As a practical matter, however, since the usual variety of sheet steel has extremely low initial permeability values, wire 25 may be composed of a metal such as nickel, generally employed as an alloying agent in forming high permeability magnetic materials. Or, it may consist of a combination of metals which together have a markedly high permeability value. An example of this latter, might be the so-called moly-permalloy combination in which nickel, molybdenum and iron are properly mixed. Thus the deposited material may cause the permeability to be increased primarily by an alloying action with the soft steel, as by nickel, or may raise the permeability of the marked alloying area primarily by its own high intrinsic permeability, as with moly-permalloy. An an example of the former, a deposition of sufficient nickel to average about 40% by volume in the alloyed area would raise the permeability of the soft steel from several hundred to about 4000 at that spot, while an alloyed area comprising 80% nickel would have a final permeability of over 20,000. Either figure, as will readily be appreciated, greatly exceeds the actual permeability increase required for ready detection.

This increase of permeability will be enhanced considerably by subjecting the ion deposition area to a gaseous atmosphere, of a suitable type to be described, as delivered

by nozzle 46. In particular, without this atmosphere, the intense heat produced by the arcing process may cause the surface of the steel around and including the deposition to be oxidized with a consequent permeability reduction of a considerable amount over that obtainable without oxidation. Any inert gas, such as nitrogen, neon, argon, etc., maintained under suitable pressure, and ejected from the nozzle in sufficient quantities to completely envelop the arcing region, will help to prevent oxidation by merely excluding atmospheric oxygen from the vicinity. A reducing gas, such as hydrogen, serves better since it will not only act to prevent external oxidation but, as will be appreciated by those skilled in the annealing art, assists to anneal the deposited area and still further elevate its final permeability value.

In FIGURE 3 is shown a read station, a record station, and associated circuitry according to the present invention. Ion marking gun 10 is schematically shown in conjunction with a a pair of read wheels 57 and 58 having coils 60 and 61 on their respective shafts. Read wheel 58 is positioned relative to the edge of sheet 11 to roll along a path 59 along which lie the marked spots deposited by gun 10. One end of coil 60 is connected to one end of coil 61 and the resulting common junction is connected to ground. The other ends of coils 60 and 61 are connected across the two output terminals of an A.C. signal source, indicated generally at 62. A matched pair of resistors 63, a balancing potentiometer 64 and coils 60 and 61 form a wheatstone bridge. The output of the bridge appears at the moveable arm of potentiometer 64 which is coupled through a rectifying filter circuit 66 to the input of an amplifier 67.

The output of amplifier 67, constituting the output signal of read circuit 54, is connected, within record circuit 55, through a transformer 68 to the grid of a current switching device, such as thyratron 70. The cathode of thyratron 70 is connected to terminal 34, the high potential input terminal of ion gun 10, while the plate of thyratron 70 is connected through a resistor 72 to a source of very high potential, indicated at B+. A capacitor 73 is connected between the plate of thyratron 70 to ground. As is also indicated, roller 42, base 43, and sheet 11 are at ground potential to complete the thyratron discharge circuit. Also shown as part of the record circuit is a solenoid amplifier 76 connected between the output terminal of amplifier 67 in the read circuit and the pin connection 51, representing the solenoid input terminal. The other pin connection of solenoid 36 is connected to ground, as indicated. Finally, a source of potential, such as battery 77, is serially connected with a variable resistor 78 to the focusing coil 40, not shown in this figure, within the ion gun unit.

In considering the operation of the read circuit, assume that read wheels 57 and 58 are passing over areas of sheet 11 having identical permeability, i.e., no mark deposition is passing under wheel 58. Under this condition, the inductances of coils 60 and 61, primarily a function of the permeability presented by their respective iron shafts, wheels and sheet 11 contact areas, are nearly identical. Potentiometer 64 is then adjusted to balance out any slight differences between the coils, to produce a bridge output of zero voltage. On the other hand, when a deposited mark is encountered by wheel 58, its higher permeability will cause the inductance of coil 61 to be increased, unbalancing the bridge. Under this condition, an A.-C. signal is produced at the output terminal of the bridge, taken at the movable arm of potentiometer 64. This signal, in turn, will be rectified by the rectifier 66 and appear as a signal at the input of amplifier 67. The polarity of this output signal will be established by the direction of connection of the diode, or rectifying element, within rectifier circuit 66, which will be of positive polarity.

Amplifier 67, may be of a two stage variety and will produce a positive output pulse for each incoming positive signal from rectifier 54. Transformer 68, used for potential isolating purposes, will couple each amplified positive pulse to the grid of thyratron 70. Prior to the appearance of this input pulse, capacitor 73 will have charged up to the potential of the B+ source through resistor 72. Upon thyratron 70 being triggered, the charge on capacitor 73 will be discharged through the ion gun conductive path, formed of terminal 34, the brush arrangement, wire 25, to the grounded sheet steel 11. In the manner explained earlier, this high potential discharge will produce an arc from the end of wire 25 to sheet 11 with an ensuing ion transfer and deposit taking place.

This same pulse applied to transformer 68 is also coupled to solenoid amplifier 76 which acts to amplify the output signal of amplifier 67 and activate solenoid 46 to advance the ion source wire in the wire dispensing assembly. Battery 77 and variable resistance 78 serve to supply focusing current to the focusing coil in order that the ion flow will be focused to produce a spot on sheet 11.

It is, of course, evident that the recording operation could be actuated independently from an external pulse source rather than from the reading mechanism.

In FIGURE 4 is shown another form of marking mechanism, shown in schematic fashion, according to the present invention. A wheel 82 is attached through a shaft 83 to a frame 80. The outer portion of wheel 82 is tapered to form a thin disc at its periphery, and this disc portion makes rolling contact with the sheet steel 11. The inner or hub portion 84 of the wheel is formed of a material having electrical insulation properties, such as Bakelite, to provide an electrical isolation between the outer wheel section and shaft 83. This outer portion may be composed of one or a combination of the metals as described previously for wire 25 of FIGURE 1, and having the property of modifying the permeability of magnetic materials, such as sheet 11, when mixed with the surface or deposited thereon.

A brush arrangement is indicated at 85 and is similar to the brush arrangement 28 of FIGURE 1. By this brush assembly, a current pulse can be passed through wheel 82 to sheet 11. Directly opposite the point of contact between disc 82 and sheet 11 is a rotatable wheel 86, preferably formed of a metal having high thermal conduction properties, such as copper. It is contained within a yoke 87, by a suitable shaft arrangement.

This FIGURE 4 marking mechanism may be operated with the electronic record circuit 55 in FIGURE 3 as described for use with the ion gun arrangement of FIGURES 1 and 2. The particular circuit parameters, may, however, be modified for use with the FIGURE 4 mechanism to produce a high current pulse, of relatively low potential, in contrast with the high potential pulse needed to start the arc in the previous embodiment. This can be achieved by making the B+ potential of a considerably lower magnitude and increasing the capacity of condenser 73.

The current pulse, in FIGURE 4, will be applied through the brush arrangement at 85, conductor 35 to wheel 82, the rim of wheel 82 through sheet 11 to the grounded copper wheel 86. This heavy current flow will produce a heating effect at the area of contact between the rim of wheel 82 and sheet 11, the heating, in turn, greatly increasing the molecule mobility of the wheel 82 material, with the result that a sufficient number of them will be transferred to the sheet 11 surface to thereby constitute a mark. This transfer action will, of course, be enhanced by the natural wiping action present between the wheel rim and the steel surface as the steel movement imparts a rotation to the wheel at the contact area. The electric current flow is also of a direction to carry metallic ions from the wheel to the sheet.

This area of deposited material will, as in the former example, possess a higher permeability, owing to the selection of the disc 82 material, than will the surround-

ing areas of sheet 11. Hence, the reading arrangement, as illustrated in FIGURE 3, may be employed to sense these marked areas.

It will be appreciated, of course, by those skilled in the art, that the foregoing disclosure relates only to detailed preferred embodiments of the invention, and that numerous modifications or alterations may be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. In combination with a piece of magnetizable metallic material having a relatively low permeability value: an elongated magnetizable means having a relatively high permeability value, one end of said elongated magnetizable means being positioned in close proximity to said piece of magnetizable material; ionizing means coupled to said elongated magnetizable means for ionizing said one end to discharge ions therefrom and accelerate the ions toward said piece of magnetizable material; and magnetic focusing means setting up a magnetic field aligned with said elongated means and positioned between said one end and said piece of magnetizable material for focusing the discharged ions onto said magnetizable material for alloying therewith to form a deposit area thereon having a relatively high permeability value.

2. A device for marking the surface of a piece of magnetizable material having a first initial permeability value, said device comprising: magnetizable wire means having an end positioned in close proximity to said piece of magnetizable material, said wire means having a second initial permeability value; electrical pulse generating means operable when actuated for passing a pulse and producing an arc between said end and said piece of magnetizable material whereby the end of said wire means is discharged as ions; focusing means including means setting up a magnetic field aligned with said wire means for directing the discharged ions onto the surface of said piece of magnetizable material to form a deposited area having a permeability value differing from said first initial permeability value; wire dispensing means associated with said wire means and operable when actuated to move the end of said wire means toward said piece of magnetizable material a distance substantially corresponding to the amount removed by said ion discharge; and means for actuating said electrical means and said wire dispensing means.

3. The device according to claim 2, including, in addition, means for excluding oxygen from the region of said arc for preventing oxidation of said deposited area.

4. The device according to claim 3 wherein the last-named means directs a reducing gas which envelops said arcing region during the annealing of said deposited area.

5. In combination: first and second magnetizable metallic means having first and second permeability values, respectively; means for alloying a portion of said first magnetizable means with said second magnetizable means at a predetermined surface part whereby said predetermined part has a permeability value differing from said first permeability value of the remaining surface part; and permeability difference detecting means respectively associated with said remaining surface part of the first magnetizable means and said predetermined part thereof for detecting said predetermined part.

6. In combination: first and second magnetizable metallic means having first and second permeability values, respectively; means for ionizing a portion of said first magnetizable means to discharge ions therefrom and accelerate the same toward said second magnetizable means; means for focusing the discharged ions onto a predetermined portion of the surface of said second magnetizable means for alloying therewith to form a deposit area thereon having a permeability value differing from said second value of the remaining surface portion of the second magnetizable means; and permeability difference detecting means respectively associated with said remaining surface portion of the second magnetizable means and said predetermined portion thereof for detecting said predetermined portion.

7. Apparatus for marking spaced lengths along the surface of a moving sheet of steel, said steel normally having a first initial permeability value, said apparatus comprising: ferromagnetic means of a second permeability value; actuable means responsive when actuated for depositing a portion of said ferromagnetic means on said sheet of steel in a small area for alloying therewith, said small area having a permeability value differing from said first value; first means in magnetic coupling engagement with the surface of said sheet of steel at a distance equal to said spaced length from said actuable means and positioned to intercept said small area; second means in magnetic coupling engagement with the surface of said sheet of steel and positioned to miss said small area; first and second inductive means magnetically coupled to said first and second means whereby the inductance values of said first and second inductive means are related to the permeability of the surface of said sheet of steel engaged by said first and second means, respectively; and differential inductance detecting means coupled to said first and second inductive means and responsive to said small area passing said first means for actuating said actuable means whereby a series of small areas of differing permeability values are formed at said spaced lengths along the surface of said sheet of steel.

8. Apparatus for marking spaced lengths along the surface of a moving sheet of steel, said steel normally having a first permeability value and including an initially marked area of a different permeability value, said apparatus comprising: ferromagnetic means of a second permeability value and having an end in close proximity to the surface of said steel; actuable ionizing means coupled between said ferromagnetic means and said sheet of steel for ionizing said end; focusing means for focusing the ionized portion of said end onto the surface of said steel sheet to form a deposited marked area, said deposited area having a permeability value differing from said first value; first means in magnetic coupling engagement with the surface of said sheet of steel at a distance equal to said spaced length from said end and positioned to intercept both said initially and said deposited marked areas on the surface of said sheet of steel; second means in magnetic coupling engagement with the surface of said sheet of steel and positioned to miss said initially and said deposited marked areas; first and second inductive means magnetically coupled to said first and second means, respectively, whereby the inductance values of said first and second inductive means are related to the permeability of the surface of said sheet of steel engaged by said first and second means, respectively; and differential inductance detecting means coupled to said first and second inductive means and responsive to the passage of said initially and said deposited marked areas for actuating said selectively actuable ionizing means whereby a series of deposited portions are placed on the surface of said sheet of steel to constitute marks at said spaced lengths.

9. The method of marking and detecting information on a moving sheet of steel comprising the steps of marking said sheet by depositing positive metal ions in spots on the surface thereof from a point in proximity to said surface and disposed along a predetermined path of travel of the sheet, and detecting said spots at another point in said path of travel of the sheet by magnetically sensing the difference in permeability of said spots and surface areas of said sheet respectively disposed laterally of said spots relative to said path of travel of the sheet.

10. The method of marking and detecting information on a moving sheet of steel comprising the steps of marking said sheet by depositing magnetizable metal in spots on the surface of the sheet from a first point in proximity to said surface and disposed along a predetermined path of travel of the sheet, detecting said spots at a second point in said path of travel of the sheet by magnetically sens-

ing the difference in permeability of said spots and surface areas of said sheet respectively disposed laterally of said spots relative to said path of travel of the sheet, and initiating said depositing of metal from said first point when a spot is detected at said second point.

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