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WIRE FINISHING MACHINE

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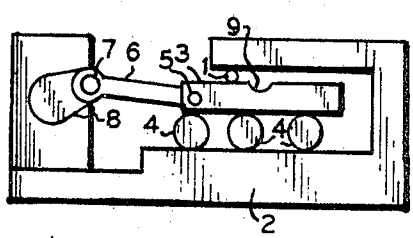

FIG. 1

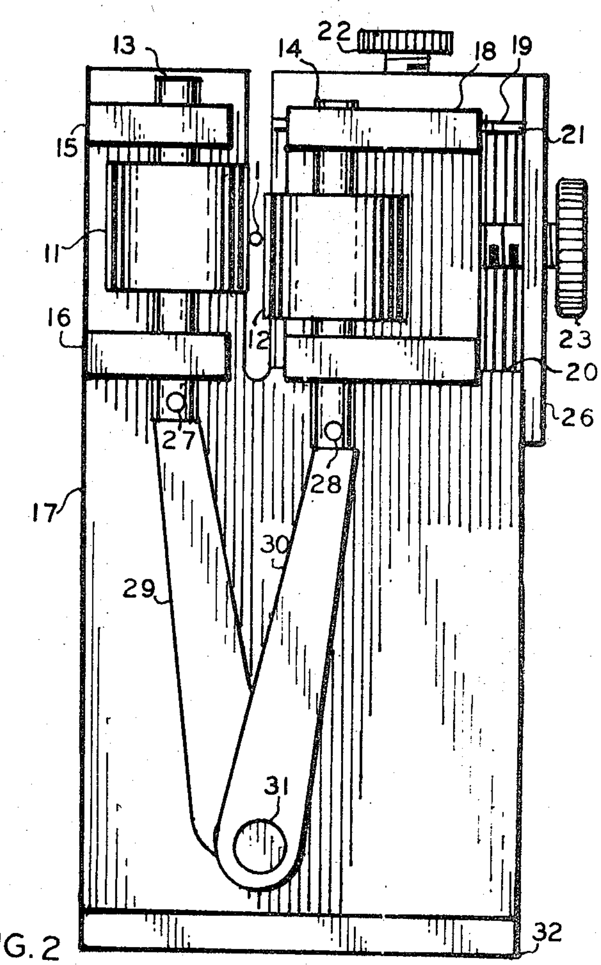

FIG. 2

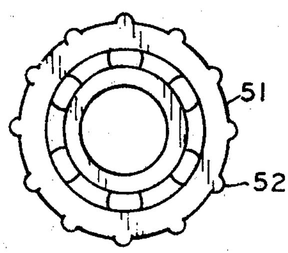

FIG. 4

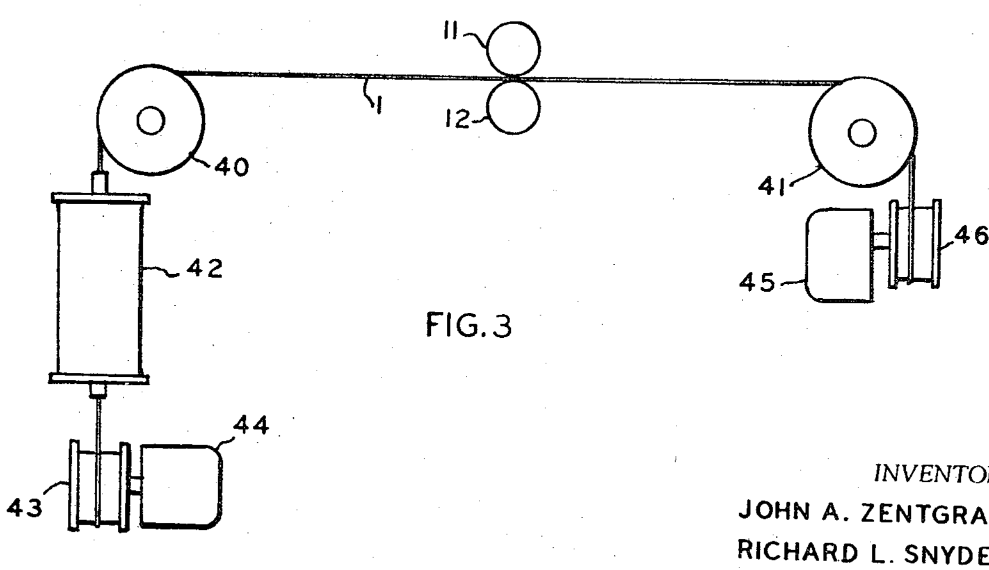

FIG. 3

INVENTORS.

JOHN A. ZENTGRAF &

RICHARD L. SNYDER

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WIRE FINISHING MACHINE

John A. Zentgraf, Daytona Beach, Fla., and Richard L. Snyder, 4625 Van Kleek Drive, New Smyrna Beach, Fla. 32069; said Zentgraf assignor to said Snyder

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ABSTRACT OF THE DISCLOSURE

This machine is capable of rolling the surface of wire so that its finish approaches the quality of optical polishing. It can be used for compacting and finishing heavy layers of metal which have been deposited on wire by electro-plating. Its speed of operation is sufficient for reasonable economy.

This invention is concerned with the production of round wire and, more particularly, with the finish of the surface of the wire.

When wire is produced in the usual way by drawing through dies, its surface is found to have microscopic imperfections in the form of grooves and pits which, for most purposes, are so small that they are of no concern. There are certain applications for wire, however, in which these defects can cause serious problems. In some types of wire, the imperfections can be removed by electrolytic polishing. In others, electrolytic polishing is not effective. Another type of imperfection in the surface of wire is encountered when the wire is electroplated. Thin layers can be easily applied which are smooth and regular enough for most requirements. On the other hand, thick layers of plating have such rough and irregular surfaces that they are of little use. Such surfaces usually have cracks and tend to chip. They cannot be polished electrolytically because the defects are nearly as deep as the layer of plating. There are a number of companies which produce electroplated wires having thin layers, but none who produce it with layers thicker than a very small fraction of the radius of the wire.

One of the applications requiring wire having a very smooth surface is that in which the wire serves as the substrate on which magnetic films, used in computer memories, are supported. These films are between one and ten microinches thick so that imperfections of this magnitude can have considerable influence on the uniformity of the film. In some cases, it is desirable that the films be deposited on a particular metal because of crystalographic considerations. It is generally desirable to relieve the strains of deposition by heating the films and its substrate to the annealing temperature of the film after it has been deposited. To perform this operation successfully, the coefficient of thermal expansion of the substrate must fulfill certain requirements which are not usually available in the selected substrate metal alone. The selected metal may then be plated on a base wire having a compensating coefficient of thermal expansion to the thickness required to achieve the desired overall expansion coefficient. In other cases, a wire may be required to have high conductivity and high strength, particularly at elevated temperatures. For such purposes, molybdenum or tungsten wire, heavily plated with copper or silver, can be used if the outer layer can be made dense enough to effectively utilize the inherent high conductivity of the metal.

Therefore, the primary object of the present invention is to provide a means of improving the surface of round wire.

Another object of the present invention is to provide

a means of improving the metallurgical structure of wire.

Another object of the present invention is to produce a mechanism which can improve the finish of wire at an economically high rate of speed.

Still a further object of the present invention is to provide a means of forming patterns of grooves in the surface of wire.

In accordance with one aspect of the present invention, the new and improved method of smoothing the surface of wire comprises the rolling of a portion of the wire between two surfaces, at least one of which is oscillating in a direction perpendicular to the axis of the wire and moving the wire in a direction parallel to its axis, so that successive regions of the wire are rolled and smoothed.

In accordance with a further aspect of the present invention, the new and improved method of finishing round wire comprises the rolling of the wire between the surfaces of two cylinders whose axes are parallel to one another and perpendicular to that of the wire. One or both of the cylinders have linear oscillating movement parallel to their axes to cause the wire, which is squeezed between them, to roll about its axis. The wire is supported between the rolling cylinders by being tensioned between two pulleys, each of which is positioned at a distance on either side of the rollers. The distance between the supporting pulleys and the rollers is sufficient to prevent the torsional stresses, caused by the wire rolling back and forth, from exceeding the elastic limit. On the other hand, the distance is not great enough to permit torsional waves to develop in the wire. These two conditions are easily fulfilled. The rolling mechanism cannot operate at speeds much above one or two hundred cycles per second. For reasonable wire supporting distances, the natural frequency of torsional vibration in the wire is in the range of thousands of cycles per second. The peak to peak amplitude of the reciprocating rollers is selected to cause the wire to rotate four or five times per stroke, or a total of eight to ten times per cycle. Thus, if the frequency of oscillation of the rollers is ten thousand cycles per minute, the wire will rotate eighty to one hundred thousand revolutions per minute. Any part of the circumference of the wire encounters a rolling surface twice each revolution. This frequency of rolling the wire enables the wire to be passed through the rollers at a high enough speed to make this method of finishing quite economical.

Other objects and many of the advantages of the invention, both as to its organization and as to its method of operation, will be understood in detail from the following description when considered in connection with the accompanying drawings wherein:

FIG. 1 is an elevation of a simple wire rolling mechanism as viewed in the direction of the axis of the wire.

FIG. 2 is an elevation of a wire roller employing cylindrical rolls.

FIG. 3 is a schematic diagram of a wire rolling system.

FIG. 4 is a plan view of a wire roller shaped to form ring shaped grooves at regular intervals along the wire.

Referring now to FIG. 1, there is shown an elevation of a simple rolling machine and an end view of the wire which is being rolled. The wire **1** is pressed between a polished surface on the main frame **2** of the rolling machine and a polished surface of the rolling member **3**. The rolling member is constrained to move in a horizontal path perpendicular to the axis of the wire by the pressure of the wire **1** on the face of the rolling member **3**, which presses the latter against the bearing rollers **4** that support the rolling member by rolling on a polished surface of the member **3** and a polished surface on the main frame **2**. The rolling member **3** is coupled to a connecting rod **6** by the wrist pin **5**. The other end of the connecting rod fits the crank pin **7** of the crank **8**. Rotation of the crank by a motor (not shown) causes the rolling member **3** to move back and forth rolling the wire. Midway in the excursion of the rolling member, the wire rolls into the depression **9** here shown to have exaggerated depth while the wire **1** is in the depression it is free of the grasp of the rolling member **3** and can be moved longitudinally. The reciprocating motion of the rolling member **3** is so rapid that the wire motion, each half strokes, is very small. The intermittent nature of the movement is smoothed out by the elasticity of the wire.

FIG. 2 shows another type of wire rolling mechanism. The wire **1** is rolled between two rollers **11** and **12** which oscillate out of phase with one another on their sliding shafts **13** and **14**. The rollers **11** and **12** can conveniently be formed by the external surface of the outer raceways of high precision double row ball bearings which have been polished to optical smoothness. The inner race of the ball bearing forming the roller **11** is fixed to the shaft **13** which slides in the bearing blocks **15** and **16** that are fastened to the main frame **17**. The shaft **14** to which the inner race of the ball bearing forming the roller **12** is fixed slides in bearing blocks that are part of the carriage **18** which is formed to fit in dovetail ways **19** and **20** cut in the main frame **17**. The ways are fitted with the gib **21** and clamping screw **22**. The position of the carriage **18** and the roller **12** with respect to the roller **11** can be adjusted by means of the thumb screw **23** threaded through the bracket **26** which is fastened to the main frame **17**. The roller shafts **13** and **14** are coupled to connecting rods **29** and **30** by the wrist pins **27** and **28**. The other ends of the connecting rods are fitted to crank pins which are part of the crank shaft **31**. The crank pins are displaced from one another 180° and are at equal distances from the center line of the crank shaft. The crank shaft is driven by an electric motor which is not shown. The main frame **17** is provided with a mounting base **32**.

FIG. 3 is a schematic diagram showing a typical system for polishing wire using the rolling mechanism shown in FIG. 2. The wire **1** is initially wound on the spool **43** which is mounted on the shaft of the motor **44**. This motor is supplied with a low current which causes it to exert a torque in the direction to wind the wire on the spool **43**. The wire **1** is drawn under tension caused by the torque of the motor **44** from the spool **43**. It is passed through a tubular furnace **42** whose temperature and atmosphere are controlled to anneal the wire **1** or its surface if it is plated wire. Beyond this point where the wire emerges from the furnace, it is passed around the grooved idler pulley **40**. It then stretches over a suitable distance to pass between the rolling cylinders **11** and **12**. At a distance equal to that between the idler **40** and the rollers, the wire is passed around a second idler pulley **41** and then to a take-up spool **46** which is driven by a low speed gear motor **45**.

An example of a typical wire finishing system like that shown in FIG. 3 is one constructed to finish a copper plated molybdinum wire. The wire is 0.005 inch in diameter with a molybdinum core diameter of 0.0025 inch. The tension on the wire is between twenty and thirty grams. The annealing furnace temperature is maintained between 1070° and 1080° centigrade. Its atmosphere should be dry hydrogen or inert gas. Dry hydrogen is the preferred atmosphere in this case because it reduces all oxides. The resulting cleanliness at high temperature causes cracks to heal or close by diffusion. At the boundary between the copper and molybdinum, diffusion also occurs causing a copper molybdinum alloy to form which makes a much more intimate and sturdy bond between the two metals than that formed by the plating operation. The pulleys **40** and **41** turn freely and are at least five inches in diameter. The rolling cylinders **11** and **12** are about an inch in diameter. The rollers are the best commercial grade of double row bearing available (Annular Bearing Engineers' Committee Grade 5 or better). The rollers should oscillate along their axes driven by crank throws displaced about 0.030 inch from the center of the crank shaft which may be driven at 5,000 to 10,000 revolutions per minute. With the excursion of 0.030 inch in either direction, a distance of twenty-four inches between the rollers **11** and **12** and the pulleys **40** and **41** is long enough to keep the surface of the wire from exceeding its elastic limit and short enough to avoid torsional resonant effects at this speed. In this case, the wire rotates between 80,000 and 160,000 times per minute. There is considerable tolerance in these distances because the torsional resonance of the wire in these lengths is in the range of 7,500 cycles per second. The take-up spool and its motor are arranged to move the wire at a speed between two and four feet per minute. The space between the rolls **11** and **12** is adjusted to the smallest distance which will cause the wire to roll without slipping. If the wire is very rough at the outset and an optical finish is required, a second annealing furnace and polishing machine may be necessary. The corresponding rollers of the two machines are operated in phase. The second furnace is placed between the two rolling machines and the second pulley moved to maintain the required spacing from the second set of rollers. The wire passing through the second furnace rotates at substantially the same speed as that between the rollers. The finish so produced will be the same as that of the second set of rollers.

FIG. 4 shows a plan view of a roller **51** of the ball bearing type having ridges **52**, parallel to its axis, formed on its surface. Such a roller, used as one of the two finishing rollers, will engrave ring-shaped grooves in the wire.

It should be noted that other patterns such as grooves parallel to the axis or helical grooves can be pressed in the wire by appropriate gravures on the rollers. Indeed, any irregularity in the rollers, even those due to slight polishing marks, will produce a corresponding impression on the wire.

Mechanisms have been described which provide a simple and effective means for finishing wire so that it has either a smooth surface or a surface with a regular pattern pressed therein.

We claim:

1. A device for finishing the surface of a round wire comprised of a wire rolling mechanism, a means of supporting the wire in the mechanism and a means of moving the wire through the mechanism, said rolling mechanism having two members each with a rolling surface which is parallel to that of the other member, said surfaces being pressed on opposite sides of the wire, at least one of said members subject to a reciprocating motion with respect to the other which is parallel to the surfaces and substantially perpendicular to the wire to cause the wire to rotate alternately clockwise and counterclockwise, said supporting means consisting of two members shaped to guide the wire, positioned on either side of the rolling mechanism and so oriented that the wire stretched therebetween passes through the rolling mechanism, said supports positioned a sufficient distance from the rolling mechanism that the wire undergoing torsional oscillations in the mechanism and substantially free of rotation at the supports is prevented from developing strains which substantially exceed the elastic limit of the material of the wire, said means for moving the wire comprised of a pay-out spool mounted on a tensioning mechanism positioned to deliver the wire to one of the supporting members and a take-up spool mounted on a winding mechanism positioned to pull the wire from the second wire support member.

2. A device for embossing a pattern on the surface of a wire comprised of a rolling mechanism, a wire support and means for transporting the wire through the mechanism, said rolling mechanism having two cylindrical rolls free to turn on their axis, at least one of said rolls engraved with a pattern which is the complement of that to be embossed on the wire, said rolls positioned with their axes parallel and perpendicular to the axis of the wire, with regions of their rolling surfaces pressed on opposite sides of the wire, at least one of said rolls provided with a reciprocating motion with respect to the other roll parallel to their axis so that the wire is rolled clockwise and counterclockwise, while pressed against the embossing pattern to impress the pattern on the entire circumference of the wire, said wire support comprised of two wire guides, one on each side of the rolling mechanism and oriented so that the wire stretched therebetween is held in the appropriate position in the rolling mechanism, said wire guides positioned at such distance from the rolls that the torsional strains in the wire due to its rotational oscillation in the rolls are substantially within the elastic limit of the material of which the wire is composed, said wire transport comprised of a spool carrying wire to be embossed mounted on a tensioning

device positioned to deliver the wire to one wire guide and a take-up spool mounted on a winding mechanism positioned to pull the finished wire from the second wire guide, the rolls of said rolling mechanism turning as the wire is pulled between them to cause the embossing pattern to move with the wire so that successive parts of the pattern are pressed into the surface of the wire in its longitudinal direction.

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H. A. KILBY, Jr., Primary Examiner

U.S. Cl. X.R.

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