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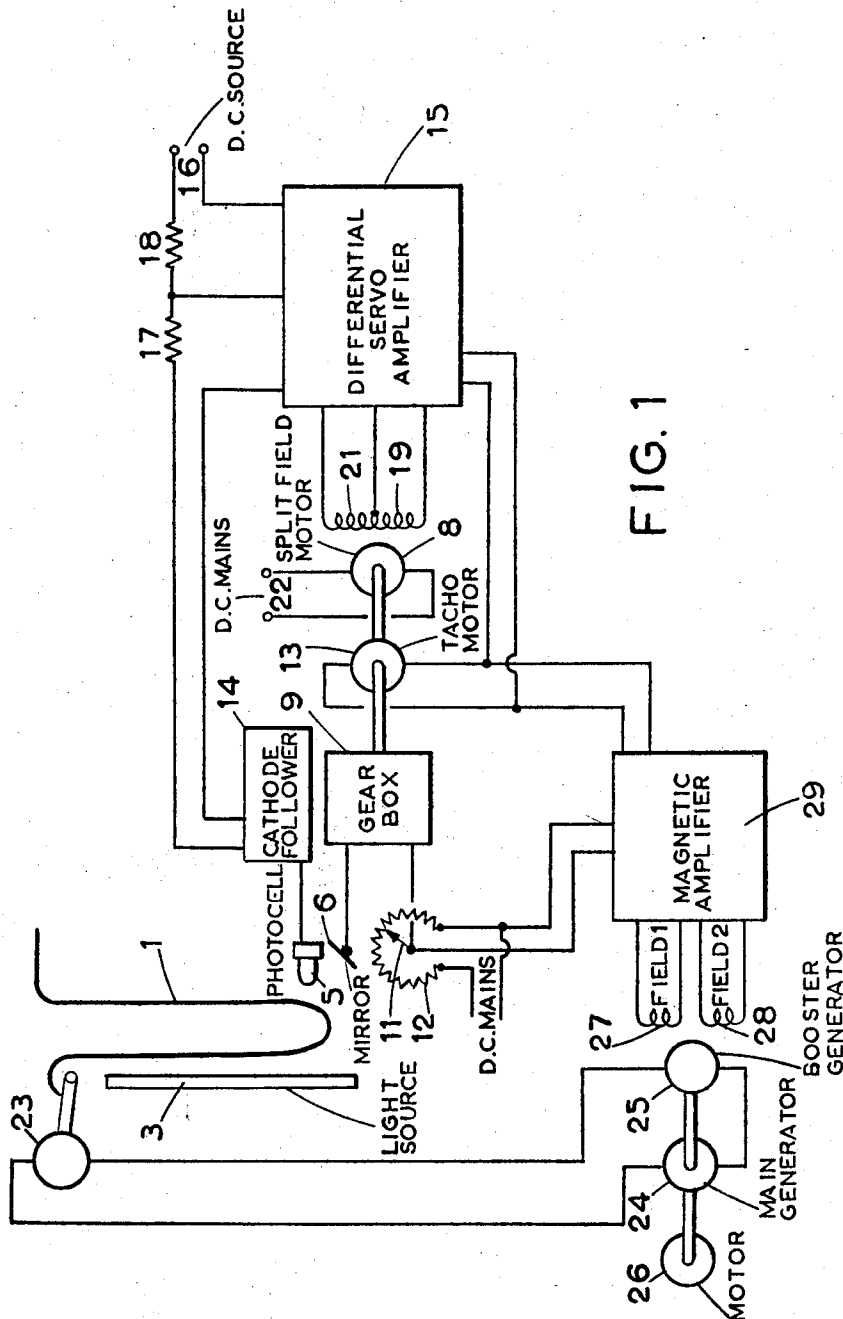
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MECHANISM FOR THE CONTROL OF STRIP MATERIALS

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3 Sheets-Sheet 1



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FIG. 2

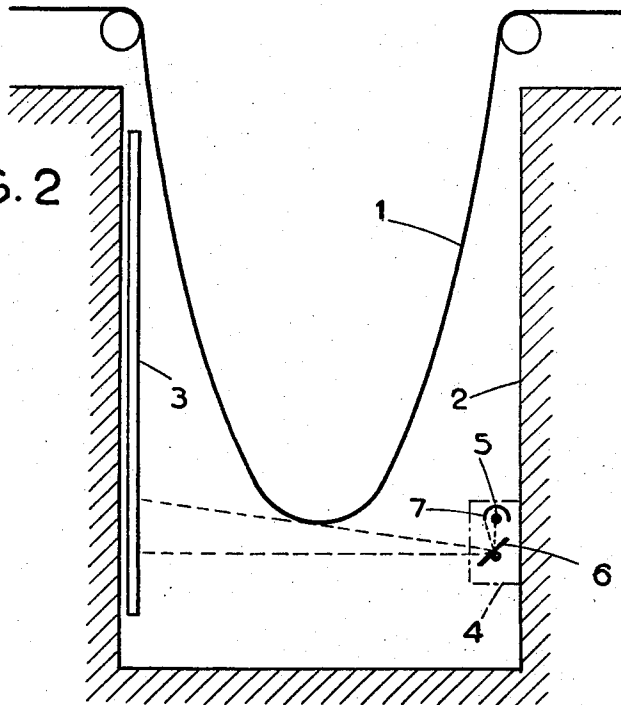
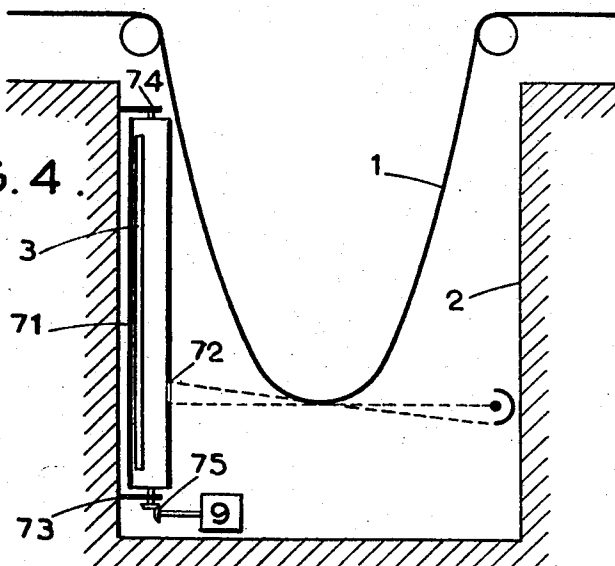


FIG. 4



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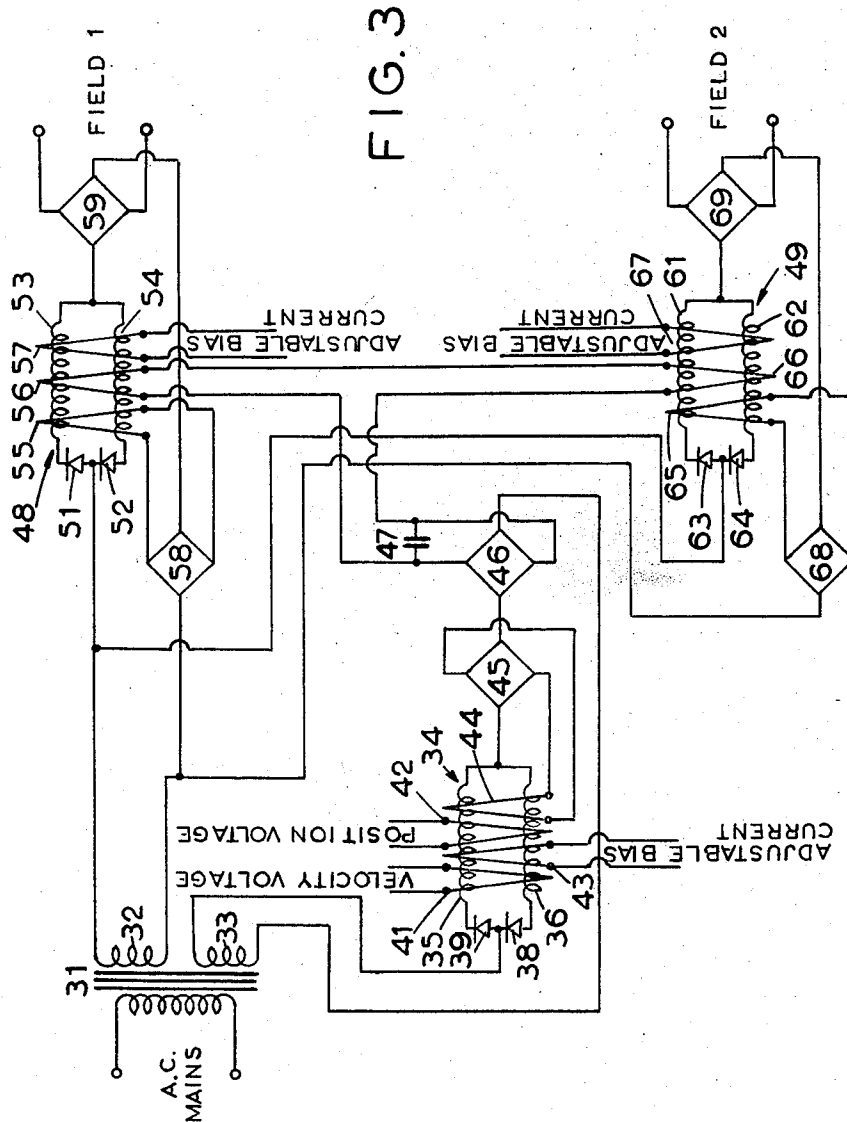
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MECHANISM FOR THE CONTROL OF STRIP MATERIALS

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3 Sheets-Sheet 3



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MECHANISM FOR THE CONTROL OF STRIP MATERIALS

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Claims priority, application Great Britain
January 10, 1956

9 Claims. (Cl. 271-2.2)

This invention relates to mechanism for the control of movement of strip material, being of the kind where the moving strip is allowed to form a downward loop under gravity between two rollers or the like and the position of the bottom of the loop is sensed by photo electric means which control the speed of feeding either to or from the loop such that the loop is maintained a constant size irrespective of whether the speed of movement of the strip varies. An example of the above kind of mechanism is the apparatus for feeding sheet steel strip into a side trimming machine and a shearing machine for shearing the strip into lengths. The shearing machine is manually controlled to deliver the lengths of strip as required and the control mechanism of the kind referred to is used to control the speed of rotation of the reel or other source of strip and the side trimmer in accordance with the manually controlled speed of the shearing machine. For this purpose two loops are provided, one between the source and the side trimming machine and another between the side trimming machine and the shearing machine. The photo electric means on each loop controls the speed of the strip into the loop.

It is found that where the photo electric means senses the position only of the bottom of the loop that the inertia of the strip and rollers and the like associated with the feed are such that it is easily possible for the loop either to straighten out or to become excessively big with the result that damage might occur to the apparatus or the strip.

The object of the present invention is to provide a more accurate control of strip movement in mechanism of the kind referred to than has hitherto been the case.

In accordance with the present invention in a mechanism of the kind referred to, the photo electric means is sensitive to the speed of movement of the bottom of the loop as well as to the actual position and control is exerted accordingly on the speed control means of the strip. By this means a control is effected which is dependent on the rate of change of position of the bottom of the loop as well as on the actual variation in position from the predetermined position so that the control may exert a suitably large force to overcome inertia if the speed of movement of the bottom of the loop is large. It is further within the scope of the invention to arrange that the photo electric means are sensitive to acceleration or change in acceleration of the bottom of the loop.

In order that the invention may be clearly understood two embodiments thereof will be described as applied to the loop control of mechanism for feeding sheet steel strip with reference to the accompanying drawings, in which:

Figure 1 is a schematic drawing of the whole of one embodiment of the invention;

Figure 2 is a detailed view showing the arrangement of the loop, light and photocell;

Figure 3 is a circuit diagram of the magnetic amplifier referred to in Figure 1; and

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Figure 4 is a schematic diagram of a further embodiment of the invention.

Referring to Figures 1, 2 and 3, the steel strip in the form of a loop is indicated at 1 and is located in a light tight pit 2. On one side of the loop in the pit an elongated light source 3 is located, whilst on the opposite side of the pit there is a box 4 enclosing a photocell 5 and a rotating mirror 6. A shield 7 around the photocell prevents direct illumination from the light source impinging on the photocell and limiting the light to that which is reflected from the mirror 6. Mirror 6 is rotated by a split field motor 8 through the medium of a gear box 9. A further drive from the gear box rotates the movable contact 11 of a potentiometer 12 which is connected across a fixed D.C. source. The drive from the split field motor 8 operates a tachogenerator 13 which generates a D.C. voltage proportional to motor speed.

The photocell output is initially amplified in a preamplifier 14 of the cathode follower type and the output passes to differential servo amplifier 15. The output before being fed into the amplifier 15 is balanced against the voltage from a D.C. source 16 through the medium of two resistors 17 and 18. The output of the tachogenerator 13 is also fed into the differential servo amplifier. It is thought unnecessary to describe the amplifier 15 in further detail, since it comprises merely two separate thermionic valve D.C. amplifiers, one fed by the output from tachogenerator 13 and the other fed by the difference voltage from the cathode follower 14 and D.C. source 16. The output of the two amplifiers included in amplifier 15 are fed to the two halves 19 and 21 of the field of split field motor 8. These two outputs are arranged in opposition so that the magnetisation of the field of motor 8 represents an amplified version of the difference of the two inputs to amplifier 15. The rotor of the motor 8 is fed from a D.C. source 22 of constant value so that rotation of the motor is dependent upon the direction of magnetisation of the field.

With the apparatus so far described it is possible to sense the position of the loop 1, the operation being that if an excess of light falls on photocell 5, the split field 19 and 21 is energised through amplifier 15 to cause motor 8 to rotate, driving mirror 6 in such a direction that the amount of light passing the bottom of the loop and being reflected from the mirror to the photocell is reduced. The output from tachogenerator 13 provides a velocity signal, the feed back preventing any tendency for the system to oscillate, whilst at the same time allowing the mirror 6 to follow accurately and reasonably quickly the bottom of loop 1.

Movement of the strip forming the loop is controlled by a D.C. electric motor 23 which obtains its supply of current from two generators in series, one being a main generator 24 and the other a booster generator 25. These two generators are driven from an electric or other motor 26 rotating at a substantially constant speed. The booster generator 25 includes two field windings 27 and 28 which are energized from a magnetic amplifier 29. The magnetic amplifier 29 is controlled by the voltage selected by moving contact 11 of potentiometer 12 and the output voltage of tachogenerator 13. The magnetic amplifier 29 is shown in more detail in Figure 3. Power is supplied from the A.C. mains source which energizes the primary winding of a transformer 31 having two secondaries 32 and 33. The secondary 33 supplies power for a transducer 34 which is arranged in the well known manner to have a pair of main windings 35 and 36 fed with alternating current through rectifiers 38 and 39, together with two control windings 41 and 42, an adjustable bias winding 43 and a feed back winding 44. The feed back winding is energized by the output of a full wave rectifier 45 in series with the alternating current passing through

the windings 35 and 36. The output from the tachogenerator 13 is fed to the control winding 41 and forms the velocity voltage signal into the amplifier 29. The control winding 42 is fed with the voltage from the potentiometer 12 which forms the position voltage signal. The output from transducer 34 is obtained from a full wave rectifier 46 also in series with A.C. supply to the transducer windings 35 and 36. The output from the rectifier 46 is smoothed by condenser 47 and is fed to two further transducers 48 and 49. Both of transducers 48 and 49 are fed from the secondary 32. Transducer 48 includes a pair of half wave rectifiers 51 and 52 carrying the alternating current to a pair of windings 53 and 54. Around these windings are located a feed back winding 55, a control winding 56 and an adjustable bias winding 57. The feed back winding 55 is fed from the output by a full wave rectifier 58 in series with A.C. supply to windings 53 and 54, whilst the transducer output is obtained from the full wave rectifier 59. This output is fed to the field 27. The transducer 49 comprises a pair of windings 61 and 62 which are fed from the A.C. supply through two half wave rectifiers 63 and 64. Around these windings 61 and 62 are located the feed back winding 65, the control winding 66 and the adjustable bias winding 67. The feed back winding is fed from the output of a full wave rectifier 68 in series with the A.C. supply to the windings 61 and 62. The output from the transducer 49 is obtained from the full wave rectifier 69 in series with the A.C. input, the output of this rectifier being connected to field 28. The control windings 56 and 66 of transducers 48 and 49 are connected in series and fed with the output from transducer 34 which appears as the D.C. output of full wave rectifier 46.

The whole magnetic amplifier operates in effect as a push-pull amplifier, the D.C. supply to one field increasing as the supply to the other field decreases and vice versa. Control is effected jointly by the control windings 41 and 42.

In operation, whilst the loop is moving the mirror 6, as previously explained, continuously seeks an equilibrium position to allow a certain amount of light to impinge on photocell 5. Signals of the position and angular velocity are fed to the control windings 42 and 41 respectively. If, for example, the strip drive motor 23 is supplying strip too quickly into the loop and the loop is extending downwardly into the pit at an excessive speed and is approaching the bottom of the pit, the mirror 6 will move angularly at an equivalent velocity to the movement of the bottom of the loop, whilst the angular position of the mirror indicating approach of the loop to the bottom of the pit will be indicated by the position signal to control winding 42. The position voltage signal will then be very small and the velocity signal large and will be such that the fields 27 and 28 are energized to produce a voltage on the booster generator which opposes the voltage of the main generator and reduces voltage supply to the motor 23 to a minimum to reduce its velocity and halt downward movement of the loop. If on the other hand strip is being taken from the loop more quickly than it can be supplied by motor 23, the loop bottom will rise and approach the top of the pit. The position signal voltage given to the amplifier will then increase, whilst since the loop is moving upwardly the output of the tachogenerator will be reversed in polarity from that effective in the last example. The effect of the magnetic amplifiers is then to entirely reverse the energization of the fields from that in the last example and the output from booster generator 25 will now be such as to add to the output from generator 24 to cause motor 23 to rotate as quickly as possible in order to cause the bottom of the loop to move downwardly into the pit. The whole apparatus will give automatic adjustment of the speed of the motor 23 in accordance with the speed at which the strip metal is taken from the loop. The equilibrium position is arranged to be substantially central of the depth

of the pit but, of course, some variation will occur by reason of the speed of strip movement and the necessity to cause corresponding energization of the booster field. Where the motor 23 acts to unwind a reel of strip, whose diameter gets smaller as the strip is used, the control is found to be extremely effective.

Referring now to Figure 4 of the drawings, the loop 1 and pit 2 are substantially as previously described. The difference is in the location of the photocell and the means for sensing the bottom of the loop. A light strip 3 is employed as in the previous example, but the strip is enclosed in an opaque cylinder 71 having a helical slot 72 extending around it for approximately 360° extending the length of the cylinder. The cylinder is mounted in bearings 73 and 74 and is rotatable by means of a bevel gear drive 75. The bevel gear drive is rotated by a gear box 9 substantially as set out in the previous embodiment. All further controls of operation are as set out in the previous embodiment, and movement and position of the bottom of the loop are sensed by rotation of the cylinder 71 to the position which allows light to pass from the slot over the bottom of the loop to the photocell. It will be seen that in the normal position of equilibrium the slot will move to a position where a small amount of light only passes the loop bottom to the photocell and in any position of the loop where the full amount of light from the slot facing the opposite wall of the pit can impinge on the photocell will result in movement of the cylinder so that the effective portion of the slot is lifted.

Many other arrangements of the invention are possible, in particular variations are possible in the sensing by the photocell of the bottom of the loop and in the electrical control mechanism which controls the speed of movement of strip into the loop. It will be seen that by using a signal of velocity of the loop bottom in conjunction with a signal of position it is possible for the control to anticipate dangerous positions of the loop where it might contact the bottom of the pit or alternately move entirely out of the pit.

We claim:

1. A strip material movement control apparatus comprising strip delivery means, strip receiving means, a variable speed driving motor for the strip delivery means to maintain a downward loop under gravity between the delivery and receiving means, a photo-electric means to generate signals in accordance with the position and the vertical velocity of the bottom of the loop and a control for the variable speed motor energised by said signals to adjust motor speed to cause the bottom of the loop to move to a predetermined vertical position and to tend to reduce vertical velocity of the bottom of the loop away from the predetermined position, said photo-electric means comprising a photo-electric cell, a light source, a servo controlled light directing means to adjust flow of light from the source to the photo cell over the bottom of the loop, a servo control energised by light falling on the photo cell to adjust the light passing over the bottom of the loop and falling on the photo cell to a predetermined amount and position and velocity signal generators operated by the servo controlled light directing means.

2. A strip material movement control apparatus as claimed in claim 1, wherein a light source is disposed on one side of the loop and the photo cell on the other, the servo controlled light directing means comprising a pivotally mounted mirror and a servo motor to rotate the same.

3. A strip material movement control apparatus as claimed in claim 1, wherein the light source is elongated in the vertical direction and is disposed on one side of the loop, and the photo cell is disposed on the other side, the servo controlled light directing means comprising a slotted member and a servo motor to move the member so that the slot position is variable to vary the light falling on the photo cell.

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4. A strip material movement control apparatus as claimed in claim 3, wherein the slotted member comprises a rotatably mounted cylinder surrounding the light source and having a helical slot which during rotation selects different parts of the source to direct light on to the photo cell.

5. A strip material movement control apparatus comprising a strip delivery means, strip receiving means, a variable speed electric motor driving the strip delivery means to maintain a downward loop under gravity between the delivery and receiving means, a light source, a photo electric cell, a servo controlled light directing means to control flow of light from the source over the bottom of the loop to the photo cell, a servo control responsive to the signal generated in the photo cell to adjust the position of the light directing means so that the bottom of the loop reduces the light falling on the photo cell to a predetermined amount, a position signal generator driven by the light directing means to generate a signal dependent on position of the latter, a velocity signal generator driven by the light directing means to generate a signal in accordance with the speed of the latter, and a speed control for the electric motor to tend to cause the bottom of the loop to move to a position where the position signal generator will give a predetermined signal which itself would cause no further movement of the loop and to tend to reduce the velocity of the bottom of the loop as indicated by the velocity signal away from the said position.

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6. A strip material movement control apparatus as claimed in claim 5, wherein the speed control of the variable speed electric motor is operable in response to the sum of the position and velocity signals.

7. A strip material movement control apparatus as claimed in claim 6, wherein the position signal generator comprises a potentiometer whose sliding contact is connected for movement with the servo controlled light directing means to select a voltage signal and the velocity signal generator comprises a tachometer driven by servo controlled light directing means to generate a voltage signal proportional to speed of the latter.

8. A strip material movement control apparatus as claimed in claim 7, including a magnetic amplifier to control the electric motor speed and wherein the two voltage signals are fed to individual control windings on the amplifier.

9. A strip material movement control apparatus as claimed in claim 8, including a constantly driven generator whose output feeds the variable speed motor and field windings for the generator energised by the output of the magnetic amplifier.

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