

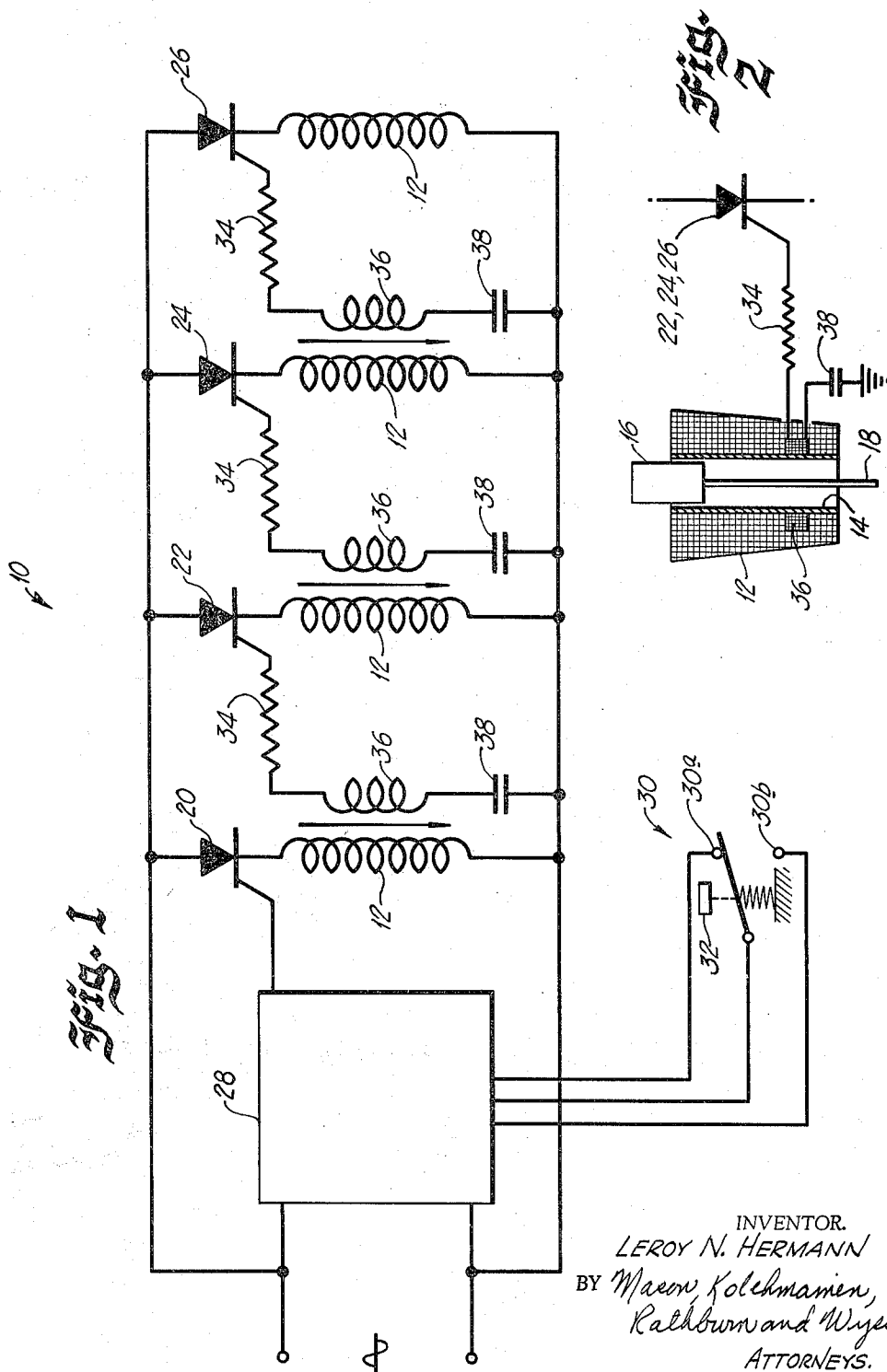
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SYSTEM FOR SUCCESSIVELY ENERGIZING TOOL ACTUATING WINDINGS

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1

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8 Claims. (Cl. 318-122)

This invention relates to a system for selectively operating a fastener driving tool and, more particularly, to a system for operating a plurality of these tools in sequence.

The copending applications of Richard H. Doyle, Serial Nos. 161,651, now Patent No. 3,141,171, and 269,427, now Patent No. 3,172,121, filed December 22, 1961 and April 1, 1963, respectively, disclose portable tools in which a fastener, such as a staple or nail, is driven in a single power stroke by a driving element actuated by an operating winding and a magnetic armature. Although the winding means can be energized by a number of suitable control circuits, it preferably is energized by connecting it directly across an undulating or alternating current potential source for a period not exceeding one cycle of the input potential. The copending applications of Richard H. Doyle et al., Serial Nos. 161,727 and 257,677, filed December 22, 1961 and February 11, 1963, respectively, disclose two such circuits.

In some applications, it is desirable to set or drive a number of fasteners in substantially the same driving operation, as in the fabrication of pallets or furniture. Although this can be done by providing a separate control circuit of the type described in the above-identified applications for each of the tools, this has some disadvantages. In the first place, the cost of the tools with the individual control circuits is much greater than if one control circuit could be used for all of the tools. In addition, the current drain on the power source can become excessive if the control circuits operate to connect a number of the windings across the source during the same cycle, particularly when it is considered that these tools can draw in excess of 100 amperes each.

Accordingly, one object of the present invention is to provide a new and improved system or circuit for controlling the operation of an electrically operated fastener driving tool.

Another object is to provide a system for electrically operating a plurality of fastener driving tools in a desired sequence.

Another object is to provide a circuit for electrically controlling the firing of a plurality of tools.

Another object is to provide an arrangement in which a plurality of electrically operated tools are operated in a synchronized relation by couplings between the operating windings therefor.

A further object is to provide a system for firing electrically operated tools during time spaced cycles of an undulating or alternating current potential by coupling the operating winding of one tool to a control for a subsequent tool.

A further object is to provide a system for synchronizing the operation of electrical tools having an operating winding through which a magnetic armature passes, which system includes an additional coil selectively linked by the armature to provide an output signal.

In accordance with these and many other objects, an embodiment of the invention comprises a circuit for controlling the operation of a plurality of fastener driving or other tools each actuated by an operating winding through which a magnetic armature is movable. The operating winding of one of the tools is connected directly across the potential source in series with a controlled

2

conduction device or gated rectifier. The gate electrode is connected to a control circuit of the type described in the above-identified applications that supplies a firing signal at the beginning of a selected half cycle of an undulating or alternating current potential. This places the rectifier in a conductive condition so that the operating winding of the tool is connected directly across the input power source for one and only one half cycle of the input potential. This moves the armature downwardly through a power stroke to drive the fastener. The control circuit also prevents repeated energization of the winding so that only a single fastener is driven even though the control element or trigger for the control circuit is held actuated for longer.

In applications requiring the concurrent or substantially concurrent operation of a plurality of tools, the operating winding of the tool provided with the independent control circuit also includes an additional inductive means or coil that is selectively coupled by the magnetic armature in this tool during its movement. This coil is connected through a time delay circuit to the gate electrode of a second controlled conduction device, such as a gated silicon rectifier, which is connected in series with the operating winding of a second tool across the potential source. The time delay of the coupling circuit is adjusted so that the gate electrode of the second silicon controlled rectifier receives an enabling signal in a next or other selected cycle following the one in which the first tool was operated. In a similar manner, time delay circuits including an inductive means or coil coupled to the winding of a preceding tool are provided between each tool and the gated rectifier for the operating winding of the next tool to permit the operation of the plurality of tools in sequence following the operation of the first tool provided with the manually actuated control means.

Many other objects and advantages of the present invention will become apparent from considering the following detailed description in conjunction with the drawings, in which;

FIG. 1 is a schematic circuit diagram of a system for controlling the operation of electrically actuated fastener driving tools which embodies the present invention; and

FIG. 2 is a schematic drawing illustrating the coupling between the operating winding for one tool and the control means for another tool.

Referring now more specifically to the drawings, there is illustrated a circuit or arrangement 10 which embodies the present invention and which controls the sequential firing of a plurality of electrically operated tools. The system 10 is illustrated as including four electrically operated tools, such as fastener driving tools of the types described in detail in the above-identified applications. Each of these tools includes an operating winding 12 defining an axial opening 14 in which is slidably mounted a magnetic armature 16 connected at its lower end to a fastener driving element 18. When the winding 12 is energized, the armature 16 moves downwardly so that the fastener driving element 18 engages, drives, or sets a suitable fastener, such as a staple or nail.

To control the selective energization of the windings 12, each of the windings 12 is connected in series with one of a plurality of gated or controlled silicon rectifiers 20, 22, 24, or 26. The rectifiers, when placed in a conductive condition, connect the related operating winding 12 directly across an alternating or undulating potential source. When the fastener driving tools are to be operated, the gated rectifier 20 is placed in conduction under manual control, and the remaining three tools are automatically operated in a timed sequence in response to the operation of the first tool.

More specifically, the gate electrode of the rectifier 20 is connected to a control circuit 28 which is identical to

3

the control circuit shown in either one of the two above-identified applications disclosing control means. The circuit 28 is supplied with energy from the alternating or undulating potential source and includes a switch 30 operable from a position in which a pair of contacts 30a are normally closed to a position in which a pair of contacts 30b are closed. When an actuating means 32 such as a trigger or workpiece engaging means is released to permit the switch 30 to be restored, the control circuit 28 is restored to its normal condition. In response to the operation of the switch 30, the circuit 28 selects the first complete positive-going cycle of the input potential and supplies gate signals to the gate electrode of the rectifier 20 to place this rectifier in a conductive condition during this half cycle. The control circuit 28 disables the rectifier 20 during cycles occurring in the interval after the energization of the winding 12 and before the control switch 30 is restored to its normal or released condition. When the winding 12 is energized, the armature 16 moves downwardly to actuate the driver element 18 to set or drive a fastener. The armature 16 and the connected driver element 18 are restored to a normal position under the control of an armature restoring means, such as a resilient element.

To provide means for automatically controlling the operation of the next tool in response to the operation of the first tool, the operating winding 12 of the first tool is coupled to the control or gate electrode of the rectifier 22 controlling the next tool through a coupling or time delay circuit. This circuit includes a resistance element 34, a winding or inductive means 36, and a capacitor 38 which are connected in series between one side of the potential source and the gate electrode. The winding coil, or inductive means 36, comprises one or a plurality of convolutions disposed within the winding 12 of the preceding tool in the series and preferably disposed in a position spaced from the normal position of the armature 16 and in a position in which it is linked or coupled by the magnetic material of the armature when the tool is operated.

Therefore, when one of the tools is operated by placing, for instance, the first gated rectifier 20 in a conductive condition to energize the first winding 12, this energization of the winding 12 and the resulting movement of the armature 16 to a position linking the coil 36 induces a positive-going potential in the coil 36. This potential is delayed and shaped by the components 34, 36, and 38 to provide a properly shaped positive-going pulse which is applied to the gate electrode of the rectifier 22. When the next positive-going cycle of the alternating current potential occurs, the control circuit 28 prevents conduction through the rectifier 20, and the rectifier 22 is placed in a conductive condition to energize the winding 12 in the second tool. In a similar manner, the operation of the second tool by the energization of the winding 12 induces a potential in the winding 36 of the coupling circuit connected to the next rectifier 24. During the next positive-going cycle, the third tool is operated and provides a gate signal for the fourth rectifier 26 to cause the operation of the fourth tool during the following cycle.

In this manner, the manual actuation of the switch 30 controlling the circuit 28 permits this circuit to control the sequential firing of a plurality of tools without the plurality of control circuits normally required. If desired, the time delay of the coupling circuits including the elements 34, 36, and 38 can be such as to permit several cycles of the input potential to elapse between the operation of successive tools. Further, the magnitude and timing of the control pulses developed by the winding or coil 36 can be adjusted by varying the position of this coil relative to the winding 12 and relative to the operated position of the magnetic armature 16. Even though the timing of the sequential operation of the plurality of fastener driving tools can be adjusted in the manners

4

set forth above, the actual time elapsed between successive firing of the different tools is no more than a small integral number of cycles. If the input potential is supplied by a conventional 60 cycle source, for instance, the elapsed time between the firing times of the different tools, even when these firings are separated by several cycles, is so short that the tool operations can be considered to have happened simultaneously with the actuation of the switch 30. This is true even though the firings are actually distributed in a sequence that reduces the current drain on the potential source.

Although the present invention has been described with regard to a single illustrative embodiment thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A system for controlling the operation of a plurality of fastener driving tools by an undulating potential source comprising a plurality of winding means each adapted to operate one tool, a plurality of controlled conduction devices each adapted to control the energization of one of the winding means by the potential source, a control circuit for selectively controlling one of the controlled conduction devices to energize the related winding means and operate one of the tools, and means coupling each of the winding means to one of the controlled conduction devices so that the operation of the one tool causes the sequential operation of the remaining tools.

2. A system for sequentially operating a plurality of fastener driving tools each adapted to be actuated by a winding means and a magnetic armature, which system comprises a controlled conduction means for controlling the energization of each of said winding means, the energization of each of said winding means moving the armature from a normal position to a displaced position, coupling means coupling each winding means to a subsequent controlled conduction means, said coupling means including inductive means linked by the armature in its displaced position, and means for energizing one of the winding means to cause the sequential energization of the subsequent winding means.

3. A system for controlling the sequential operation of a plurality of fastener driving tools comprising a plurality of winding means for operating the tools, a plurality of controlled conduction devices each having a control electrode and each adapted to control the energization of one of the winding means, a coupling circuit connecting each winding means to the control electrode of a subsequent controlled conduction device, and a control circuit connected to the control electrode of the first controlled conduction device for controlling this device to energize the connected winding means, the energization of the first winding means causing the sequential firing of the remaining controlled conduction devices and the consequent sequential energization of the remaining winding means.

4. A system for controlling the operation of a plurality of fastener driving tools by an undulating potential source comprising winding means for operating each of the tools, a gated rectifier unit for connecting each of the winding means to the potential source, a control circuit connected to the gated rectifier for one of the winding means for placing the connected rectifier in a conductive condition during a selected undulation of the potential source, and means responsive to the conductive condition in the one rectifier and coupling the remaining winding means and gated rectifiers to place the remaining rectifiers in conduction during different undulations of the potential source sequentially following the undulation in which the one rectifier was placed in a conductive condition.

5. A system for sequentially energizing a plurality of

5

winding and magnetic armature assemblies from a source of undulating potential comprising a plurality of controlled conduction devices each adapted to connect the potential source to one of the winding means and each having a control electrode, a delay circuit connected between each winding means and the control electrode of a following controlled conduction device, each delay circuit having a delay on the order of the periodicity of the undulating potential, and means for placing one of the controlled conduction devices in conduction to energize the related winding means and to cause the sequential energization of the other winding means during subsequent cycles of the undulating potential and in synchronism therewith.

6. The system set forth in claim 5 in which each magnetic armature is moved from a normal position to a displaced position by the energization of the related winding means and in which the delay means each include inductive means linked by the armature in its displaced position.

7. A system for controlling the operation of a plurality of fastener driving tools by an undulating potential source,

6

which system comprises a plurality of winding means each adapted to control the operation of one of the tools, a plurality of controlled conduction devices each adapted to control the energization of one of the winding means and each having a control electrode, a control circuit connected to the control electrode of a first one of the controlled conduction devices for controlling the energization of a first one of the winding means, delay means coupling each of the winding means to the control electrode of a subsequent controlled conduction device, said delay means each having a delay on the order of the duration of a cycle of the undulating potential, and means for operating the control circuit so that the winding means are sequentially energized in synchronism with the undulating potential.

8. The system set forth in claim 7 in which the delay means includes means inductively coupled with the selected winding means.

No references cited.

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