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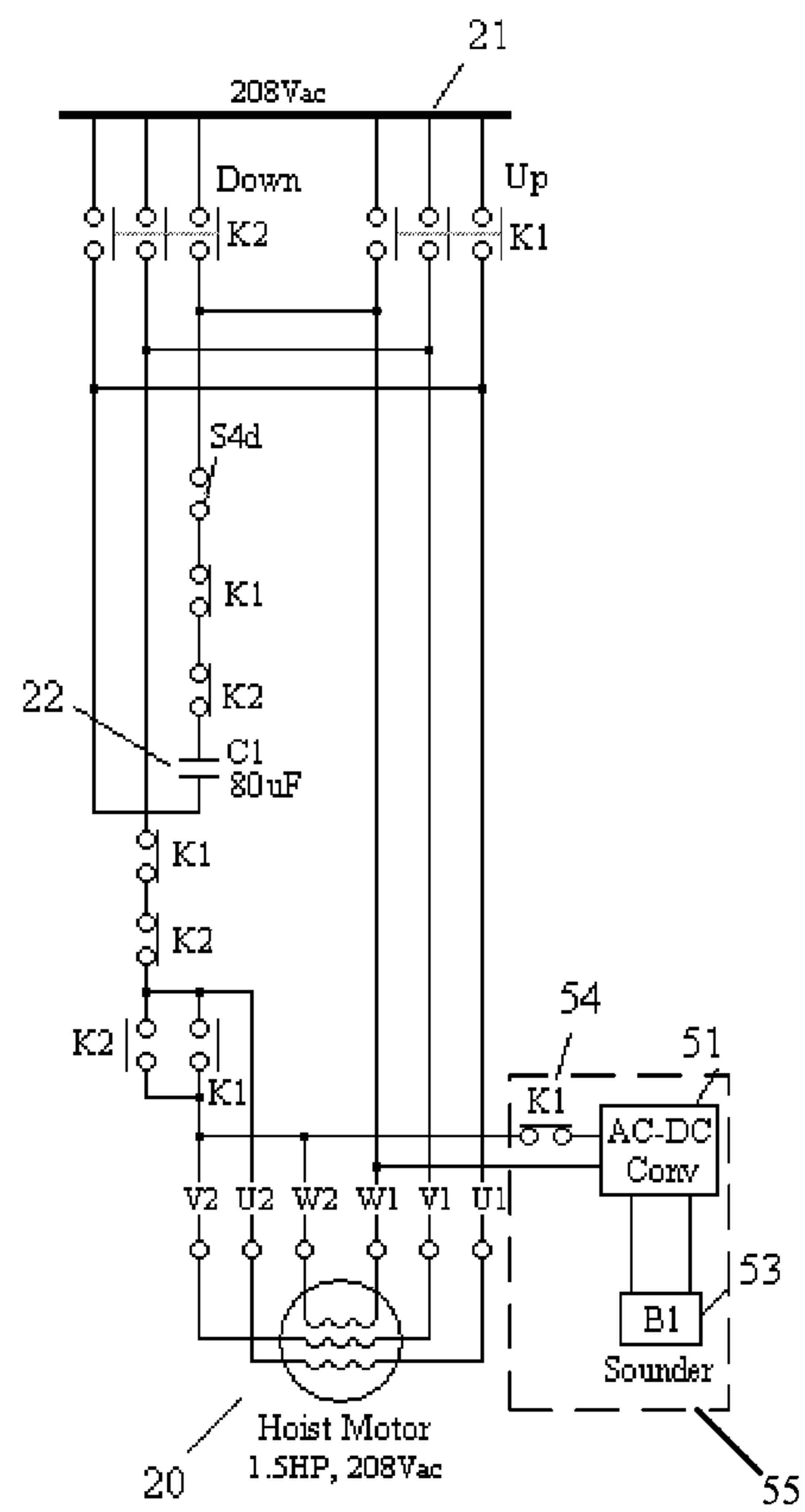


(57) **Abrégé/Abstract:**
An elevator within a tower, such as a wind tower, includes a traction or drum type hoist powered by an electric motor where the hoist provides the mechanism to cause the vertical ascent or descent of the elevator. The descent of the elevator is used to drive the electric motor, which is arranged to act as a generator and provide regenerative braking as well as power to drive an alarm device or devices.

ABSTRACT

An elevator within a tower, such as a wind tower, includes a traction or drum type hoist powered by an electric motor where the hoist provides the mechanism to cause the vertical ascent or descent of the elevator. The descent of the elevator is used to drive the electric motor, which is arranged to act as a generator and provide regenerative braking as well as power to drive an alarm device or devices.

TOWER ELEVATOR ALARM SYSTEM

BACKGROUND

[0001] Many methods of providing alarms responsive to human senses are known such as audible, visual, and tactile.

[0002] As a safety measure it may be required to alert persons in a tower, for example a tower used for production of energy from wind, of the motion of an internal access elevator where a hazard may result. This is particularly important where such an elevator is not necessarily provided with a protective hoistway to prevent body parts from invading the volume corresponding to the path of the elevator throughout its range of motion, such as would be the case of elevators for public use. Such tower elevators are commonly used to transport technicians and their tools from the lower platform to the nacelle at the top of the tower, and to the intervening spaces. Additionally, such an elevator may be required to descend while unpowered, for example during a power failure. Where a power supply is not available, standard powered alarms such as a strobe light, may or may not be powered such as during a power failure.

[0003] The elevator as disclosed herein differs from an elevator used to transport the general public within a building in that it is typically but not necessarily a simpler construction and may be guided with cables tensioned between the top and base of the tower rather than using rails attached to the tower structure. Additionally, the hoist is typically mounted within the car rather than at the top of the structure.

SUMMARY

[0004] In one embodiment, there is provided a tower. The tower includes an elevator cabin, an electric motor coupled to the elevator cabin, a sheave coupled to the electric motor, and a power source electrically coupled to the electric motor when operational so that power from the power source is selectively applied to the electric motor to cause the sheave to rotate relative to a suspension cable fixed to a structure of the tower, the sheave rotation operable to raise or lower the elevator cabin within the tower. The tower further includes an alarm device electrically coupled to the electric motor such that the electric motor is operable to power the alarm device during descent of the elevator cabin without the need for power from the power source. Current generated by rotation of rotor or stator winding in the electric motor is used to provide electromotive braking of the elevator cabin.

[0005] The tower may be a wind turbine tower.

[0006] The electric motor may include a component of a hoist.

[0007] The tower may include an AC to DC converter electrically coupled between the electric motor and the alarm device to control voltage applied to the alarm device.

[0008] The alarm device may include a sound generating device.

[0009] The alarm device may include a light generating device.

[0010] The tower may include a manual brake that causes the elevator cabin to stop when applied and to descend when released.

[0011] In accordance with another embodiment, there is provided an apparatus for providing power to an alarm device without the need for an extrinsic power supply. The apparatus includes a traction hoist mechanism comprising an electric generator coupled to a sheave such that rotation of the sheave causes an electrical output from the electric generator, and an elevator cabin adapted to couple to a suspension cable such that movement of the elevator cabin in a first direction causes rotation of the sheave. The apparatus further includes an alarm device in electrical communication with the electric generator, the alarm device capable of generating an alarm responsive to the electrical output from the electric generator. Current generated by rotation of rotor or stator winding in the electric generator is used to provide electromotive braking of the elevator cabin.

[0012] The hoist may include a fraction hoist.

[0013] The first direction of the elevator cabin may be a vertical descent.

[0014] The alarm device may include a sound generating device.

[0015] The alarm device may include a light generating device.

[0016] The apparatus may include a digital device coupled between the electric generator and the alarm device to selectively operate the alarm device.

[0017] In another embodiment, there is provided a method for powering an alarm device. The method involves releasing an elevator cabin to cause the elevator cabin to descend in a tower, causing the elevator cabin to rotate a sheave that is frictionally coupled to a suspension cable, and causing the sheave to rotate a motor such that the motor generates electrical power as a result of the rotation, the electrical power providing power to an alarm device. The method further involves causing current generated by rotation of rotor or stator winding in the motor to provide electromotive braking of the elevator cabin.

[0018] The method may involve coupling the elevator cabin to the suspension cable wherein the suspension cable is fixed to a structure of a vertical tower.

[0019] The motor may be a component of a hoist.

[0020] The hoist may be either a traction hoist or a drum hoist.

[0021] The alarm device may generate a sound when power is applied to it.

[0022] The motor may generate an alternating current and the current may be converted to a direct current before applying the power to the alarm device.

[0023] The step of releasing the elevator cabin may involve releasing a manual brake.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The foregoing summary, as well as the following detailed description of preferred embodiments, is better understood when read in conjunction with the appended drawings. For the purposes of illustration, there are shown in the drawings exemplary embodiments; however, the present disclosure is not limited to the specific methods and instrumentalities disclosed. In the drawings:

[0025] Fig **1** shows a diagrammatic representation of an example wind tower elevator according to the embodiment;

[0026] Fig **1**a shows a diagrammatic representation of rotation of a sheave.

[0027] Fig **2** shows a partial schematic embodiment of the electrical system of an example wind tower elevator according to the embodiment;

[0028] Fig **3** shows a partial schematic embodiment of the unpowered electrical system of an example wind tower elevator according to the embodiment;

[0029] Fig **4** shows typical waveforms characteristic of regenerative voltage according to the embodiment;

[0030] Fig **5** shows a schematic of an embodiment of a power converter according to the embodiment.

DETAILED DESCRIPTION

[0031] Certain specific details are set forth in the following description and figures to provide a thorough understanding of various embodiments of the disclosure. Certain well-known details often associated with tower elevators are not set forth in the following disclosure to avoid unnecessarily obscuring the various embodiments of the disclosure. Further, those of ordinary skill in the relevant art will understand that they can practice other embodiments of the disclosure without one or more of the details described below. Finally, while various methods are described with reference to steps and sequences in the following disclosure, the description as such is for providing a clear implementation of embodiments of the disclosure, and the steps and sequences of steps should not be taken as required to practice this disclosure.

0[0032] **Fig 1** diagrammatically shows a typical elevator **1** installation in a wind tower. The elevator **1** has a traction hoist mechanism **5** coupled directly to the elevator cabin **7**. The hoist mechanism **5** has an electric motor **20** that is coupled to and rotationally drives a sheave **3** via a reduction gearbox (not shown). Although the traction hoist is used herein to demonstrate aspects of the embodiment, a drum type hoist could also be used but is not further described herein.

[0033] A power source (not shown) from an external supply, for example from an outlet on a building, is selectively coupled to the electric motor. Selective application of the power source to electric motor **20** causes rotation of the sheave **3** in a clockwise or counter clockwise direction (see Fig. **1**A). Elevator cabin **7** is coupled to a stationary suspension wire **4** by wrapping around sheave **3** with preferably, but not necessarily, a single turn. Suspension wire **4** is fixed to a stationary structural member **6**. As such, when electric motor **20** rotates sheave **3**, the rotation of sheave **3** causes elevator car **7** to effectively climb up or down suspension wire **4**, depending on the direction of rotation. When electric motor **20** is unpowered, a primary brake (not shown) is engaged to prevent rotation of the electric motor **20** thereby preventing motion of elevator cabin **7**.

[0034] When the primary brake is manually released and elevator **1** is unpowered, the weight of elevator cabin **7** is sufficient to back-drive electric motor **20** through the reduction gearbox. As a result, electric motor **20** is caused to rotate, driven by friction between suspension wire **4** and sheave **3**. In that case, electric motor **20** acts as a generator and outputs power.

[0035] **Fig 1A** shows the direction of rotation of sheave **3** relative to suspension wire **4** as elevator cabin **7** descends. Of course, suspension wire **4** is drawn tightly around sheave **3** by the weight of elevator cabin **7** fastened to fixed suspension structure **6**.

[0036] In various applications, elevator cabin **7** may travel vertically in an unenclosed space (a hoistway). Because the space through which the elevator travels may be at least partially unenclosed, persons at various levels in the path of the elevator cabin's hoistway could enter into the space through which elevator cabin **7** may pass. As a result, such persons are at risk of serious injury. For example, if an elevator is descending, unwitting personnel could enter elevator cabin **7** descent space and be struck by the elevator. Consequently, to enhance the safety of those in the vicinity of elevator cabin's **7** hoistway path, an alarm system is provided to give advance warning of the approach of elevator cabin **7**. This is particularly true when power is lost to the elevator **1**. The loss of power could result in the concomitant loss of adequate lighting thereby increasing the safety risk. In the event that power is lost to the elevator **1**, elevator cabin **7** may still descend through it's hoistway. In that case, power is still provided by use of the electric motor **20** to generate sufficient power to power an alarm system.

[0037] **Fig 2** shows a partial schematic of electrical controls **21** for electric motor **20** power management. Several of the electric contacts (K**1** and K**2**) are shown in the unpowered state and are not further considered herein, but act to create an electrical connection status between the various windings of electric motor **20** and other elements in the schematic to enable regenerative braking.

[0038] An alarm system **55** is driven by the generated voltage from the electric motor **20** and is illustrated as comprising an AC-DC converter **51** connected via contact **54** to terminals W1 and W2 of electric motor **20**. Contact **54** is optional and acts to enable alarm **53** during unpowered motion and disable alarm system **55** during powered motion should this be desired. For example, it may be the case that alarm system **55** is operation during every descent of elevator car **7**. Alarm device **53** is connected by way of an AC-DC converter **51**. While a DC supplied sounder **53** is shown as the alarm device, other types of alarm device may also be used such as an AC operated device, a light, or an actuator for other alternatives, including but not necessarily connection to a SCADA or wireless system or recording device. For convenience of description, a low voltage DC piezoelectric sounder may be incorporated herein as an alarm device.

[0039] Of course a battery may also be provided to supply power when required; however any extrinsic supply needs additional support such as a battery charger or exercise of a replacement or replenishment function, with resulting extra costs and maintenance requirements. By using the intrinsic properties of the elevator **1** and electric motor **20**, a significant advantage of permanent availability without collateral equipment may be provided, resulting in lower cost and improved availability and reliability.

[0040] **Fig 3** is a diagram showing the current path for regenerative braking and power generation derived from Fig **2**. It will be seen that for a three phase motor as is typically but not necessarily used in an elevator, that each of the motor windings **23**, **24**, **25** is placed in series by the connections afforded by the various contacts in Fig **2**. Further, a capacitor **22** is included in the series connection with motor windings **23**, **24**, **25**, capacitor **22** being responsible for a phase shift between voltage and current in windings **23**, **24**, **25** and motor rotor (not shown) such as to cause a lagging magnetic field resisting rotation drive of electric motor **20** and thereby providing regenerative braking action as is well known.

[0041] If the primary brake (not shown) is released manually, then as elevator **1** descends unpowered and friction between suspension wire **4** and sheave **3** causes electric motor **20** to rotate via the gearbox. As such, electric motor **20** will act as an electric generator resulting in electric power at the motor terminals, e.g., W**1** and W**2**, while providing braking action, i.e. slowing the descent of the elevator car **7**.

[0042] **Fig 4** is an oscillographic recording **30** of the generated voltage resulting from acceleration from rest of an elevator when the elevator is set into unpowered descent, measured across terminals W**1** and W**2** of said motor. Of course other terminals may equally be specified as the source of voltage such as W**1**, U**1** or W**2**, V**1**, or any other combination. As depicted, the generated voltage and frequency varies widely in a range to nominally **350** Volts peak depending on the descent speed of said elevator. Typically, an elevator as described herein for a wind tower in the US will descend at a maximum speed between **35** feet per minute and **60** feet per minute. From recording **30** the generated voltage at steady descent speed is nominally **280**V peak.

[0043] According to an aspect of this embodiment, the voltage output from electric motor **20** is, in turn, used to power alarm system **55**. The motion of descent elevator car **1**, cause the generation of electrical energy that is available to drive alarm system **55**. As the generated voltage increases to high levels, the voltage supplied to alarm system is maintained by the AC-DC converter at an appropriate level, for example **10** V, according to the operating needs of the alarm system. A specific alarm sounder **53** may be specified to have a specified sound power output at a specified voltage. Preferably the sound level remains with a range of +/- **5**dB relative to the chosen level such as **75**dB.

[0044] As should be understood from said oscillographic recording **30**, a lower speed of descent results in said regenerative voltage being lower. Consequently, it may be advantageous for the alarm system **55** to correspondingly operate at a lower voltage to ensure that the least descent movement results in an alarm being generated. It may also be advantageous to use a means of deriving the voltage to power alarm system **55** that minimizes cost and complexity. The method herein disclosed may uses a low power piezoelectric sounder which require a nominal supply of **10**V at **7**mA to provide a sound level of nominal **75**dB, and will also be relatively insensitive to voltage variation. In general, a light indicator will likely require more power to operate than a sounder but may also be used in place of or in addition to a sounder in some applications. A light source such as LED would be a low voltage choice.

[0045] **Fig 5** is a circuit schematic of one embodiment of an AC-DC converter **51** capable of providing a nominally constant power source to drive alarm sounder **53** with nominally constant energy. Other embodiments are also possible to provide power to an alarm sounder or other alarm device including means not requiring conversion to DC, however this embodiment is described as representative.

[0046] Diodes D**1**, D**2**, D**3**, and D**4** comprise a full wave rectifier supplying a pulsating DC voltage to MOSFET Q**1**. Equally, a half wave rectifier could be employed, however improved efficacy results with a full wave rectifier. The gate of Q**1** is connected to the DC supply via a high value resistor R**1** (e.g., **1**M) and to transistor Q**2** via a further low value resistor R**3** (e.g., **1**k). When the voltage on the gate of Q**1** is sufficiently higher than the voltage at its drain, Q**1** conducts and charges capacitor C**2** causing the voltage to increase. At the same time said alarm sounder A**1** **53** receives voltage (power) and operates to generate an alarm sound.

[0047] As voltage on C**2** increases to a point above the conduction point of zener diode D**5**, for example **10**V, Q**2** is turned on via resistor R**4** (e.g., **1**k). High value resistor R**5** (e.g., **100**k) is provided for stability. When Q**2** turns on, the voltage at the gate of Q**1** is reduced below the point where Q1 conducts, and capacitor C2 receives no further charge. At this point C2 begins to discharge through alarm sounder A1 **53** and thus provides continuity of power for alarm sounder **53** until the next charging cycle.

[0048] By correct choice of components as above, the nominal voltage at the drain of Q1 is approximated by the turn on voltage of zener D5, is largely independent of the source voltage, for example at terminals W1, W2, and also above a low limit value, for example 15V peak, and is proof against overload or damage from the high voltages generated by the motor.

[0049] A three-phase motor is described herein; however, other types of generating devices could similarly be used including a separate extrinsic generator attached to or separate from the hoist motor. Also a DC or single phase induction motor could also act as an intrinsic generator and is included by implication as demonstrating the same ability to provide a voltage supply to operate an alarm device as disclosed.

[0050] As a further consideration, while the alarm device **53** is powered by voltage at the terminals of the electric motor, it is similarly feasible to use the electric current flowing through the electric motor. By use of a current transformer as is well known, power to drive an alarm device may also be provided.

[0051] The foregoing description has set forth various embodiments of the apparatus and methods via the use of diagrams and examples. While the present disclosure has been described in connection with the various embodiments of the various figures, it is to be understood that other similar embodiments may be used or modifications and additions may be made to the described embodiment for performing the same function of the present disclosure without deviating there from. Furthermore, it should be emphasized that aspects of the embodiments described herein may have a variety of applications. For example, while aspects of the embodiments described relate to elevators used for vertical transportation, they may also apply to elevators and other mechanisms used for inclined conveyance, for example a cable car disposed on a hillside.

EMBODIMENTS IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A tower, comprising:

an elevator cabin;

an electric motor coupled to the elevator cabin;

a sheave coupled to the electric motor;

a power source electrically coupled to said electric motor when operational so that power from the power source is selectively applied to the electric motor to cause the sheave to rotate relative to a suspension cable fixed to a structure of the tower, the sheave rotation operable to raise or lower the elevator cabin within the tower; and

an alarm device electrically coupled to said electric motor such that said electric motor is operable to power the alarm device during descent of said elevator cabin without the need for power from said power source;

wherein current generated by rotation of rotor or stator winding in said electric motor is used to provide electromotive braking of the elevator cabin.

2. The tower of claim **1** wherein the tower is a wind turbine tower.

3. The tower as recited in claim **1**, wherein the electric motor comprises a component of a hoist.

4. The tower as recited in claim **1**, further comprising an AC to DC converter electrically coupled between the electric motor and the alarm device to control voltage applied to the alarm device.

5. The tower as recited in claim **1** wherein the alarm device comprises a sound generating device.

6. The tower as recited in claim **1** wherein the alarm device comprises a light generating device.

7. The tower as recited in claim **1** comprising a manual brake that causes the elevator cabin to stop when applied and to descend when released.

8. An apparatus for providing power to an alarm device without the need for an extrinsic power supply, comprising:

a traction hoist mechanism comprising an electric generator coupled to a sheave such that rotation of said sheave causes an electrical output from said electric generator;

an elevator cabin adapted to couple to a suspension cable such that movement of said elevator cabin in a first direction causes rotation of said sheave; and,

an alarm device in electrical communication with said electric generator, said alarm device capable of generating an alarm responsive to said electrical output from said electric generator;

wherein current generated by rotation of rotor or stator winding in said electric generator is used to provide electromotive braking of the elevator cabin.

9. The apparatus as recited in claim **8** wherein the hoist comprises a fraction hoist.

10. The apparatus as recited in claim **8** wherein the first direction of the elevator cabin is a vertical descent.

11. The apparatus as recited in claim **8** wherein the alarm device comprises a sound generating device.

12. The apparatus as recited in claim **8** wherein the alarm device comprises a light generating device.

13. The apparatus as recited in claim **8** comprising a digital device coupled between the electric generator and the alarm device to selectively operate the alarm device.

14. A method for powering an alarm device, comprising:

releasing an elevator cabin to cause the elevator cabin to descend in a tower;

causing the elevator cabin to rotate a sheave that is frictionally coupled to a suspension cable; and

causing the sheave to rotate a motor such that the motor generates electrical power as a result of the rotation, the electrical power providing power to an alarm device;

causing current generated by rotation of rotor or stator winding in said motor to provide electromotive braking of the elevator cabin.

15. The method for powering an alarm device as recited in claim **14**, further comprising: coupling the elevator cabin to the suspension cable wherein the suspension cable is fixed to a structure of a vertical tower.

16. The method for powering an alarm device as recited in claim **14** wherein the motor is a component of a hoist.

17. The method as recited in claim **16** wherein the hoist is either a traction hoist or a drum hoist.

18. The method as recited in claim **14** wherein the alarm device generates a sound when power is applied to it.

19. The method as recited in claim **14**, wherein the motor generates an alternating current and wherein the current is converted to a direct current before applying the power to the alarm device.

20. The method as recited in claim **14** wherein the step of releasing the elevator cabin comprises releasing a manual brake.

Fig. 1

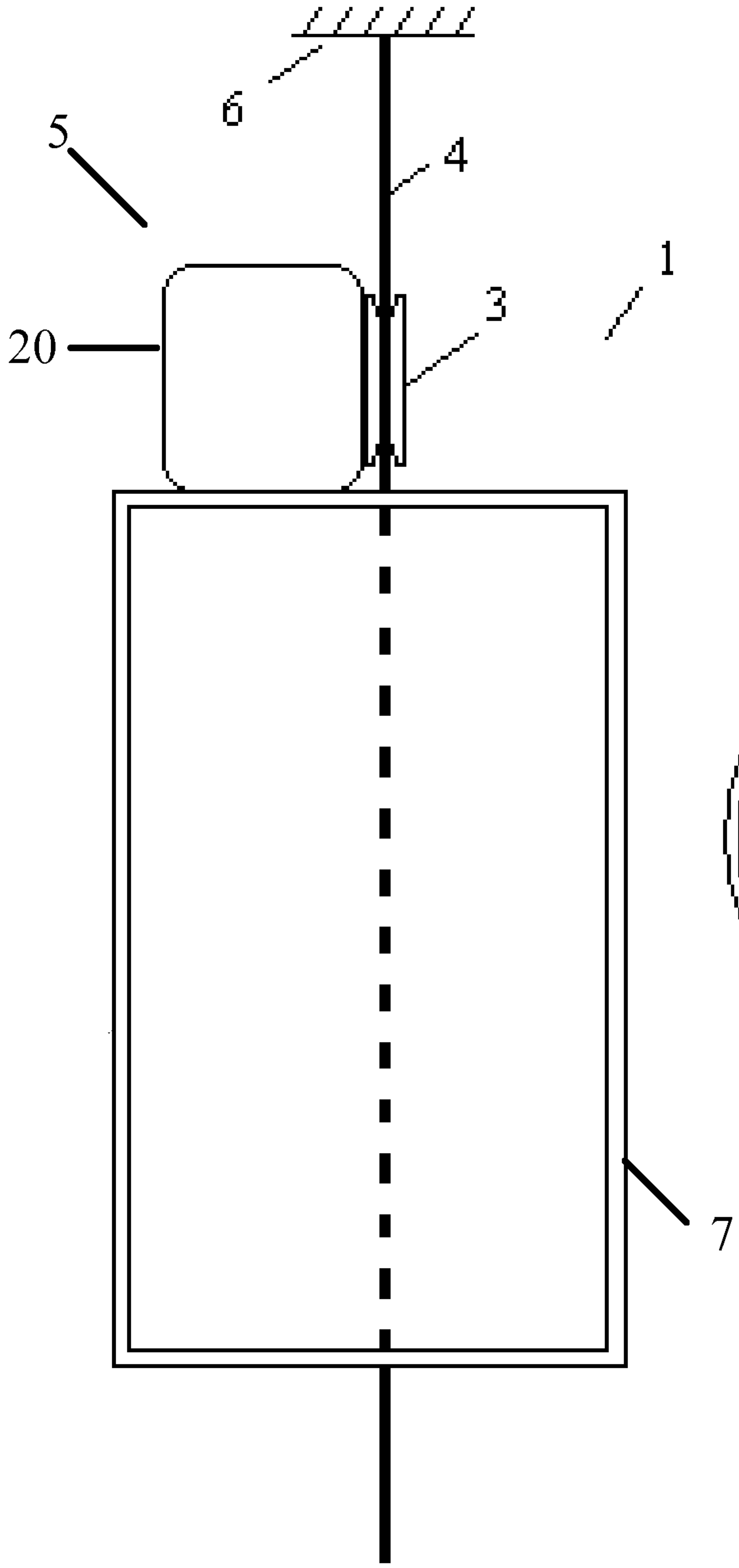
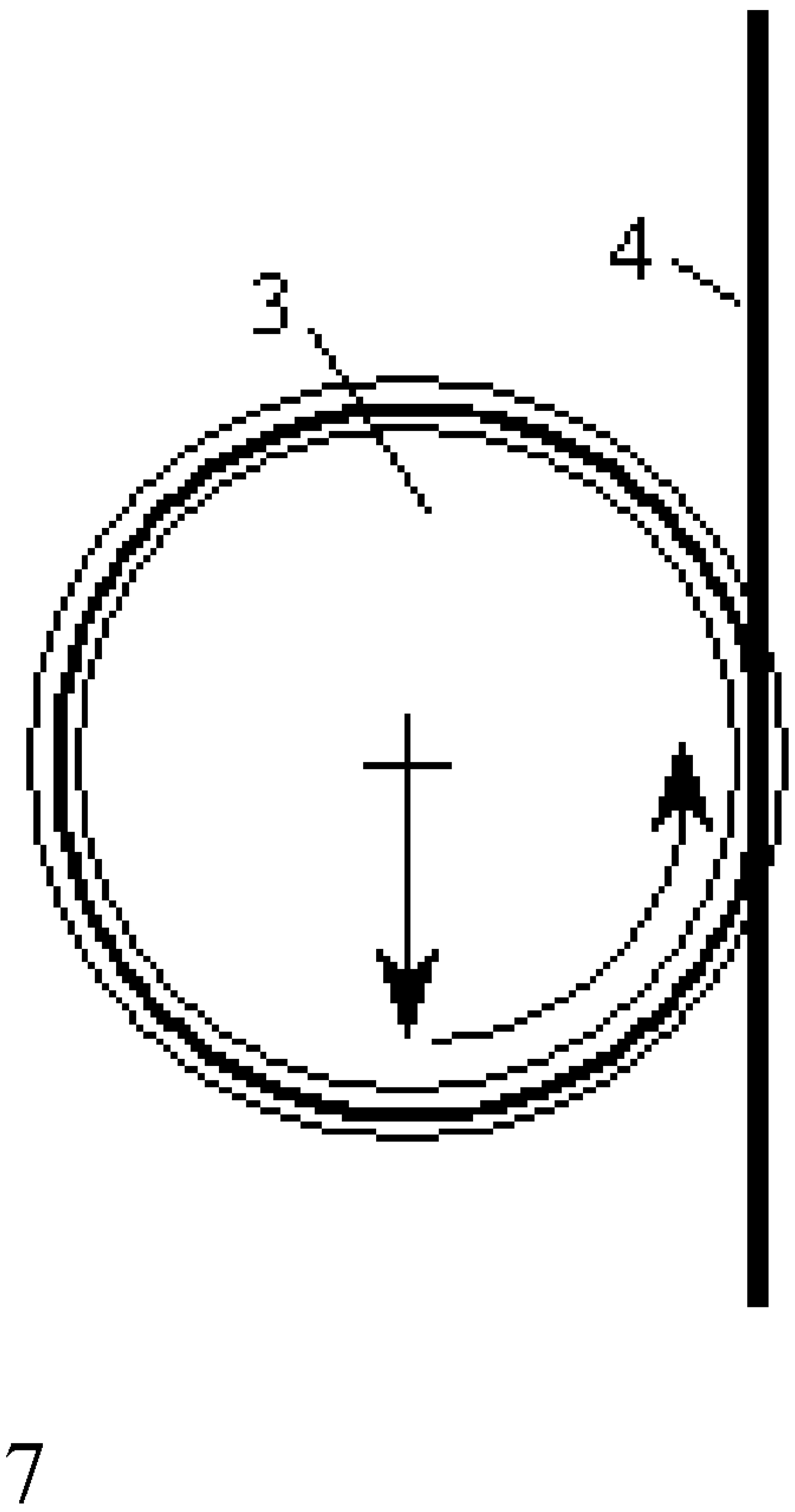
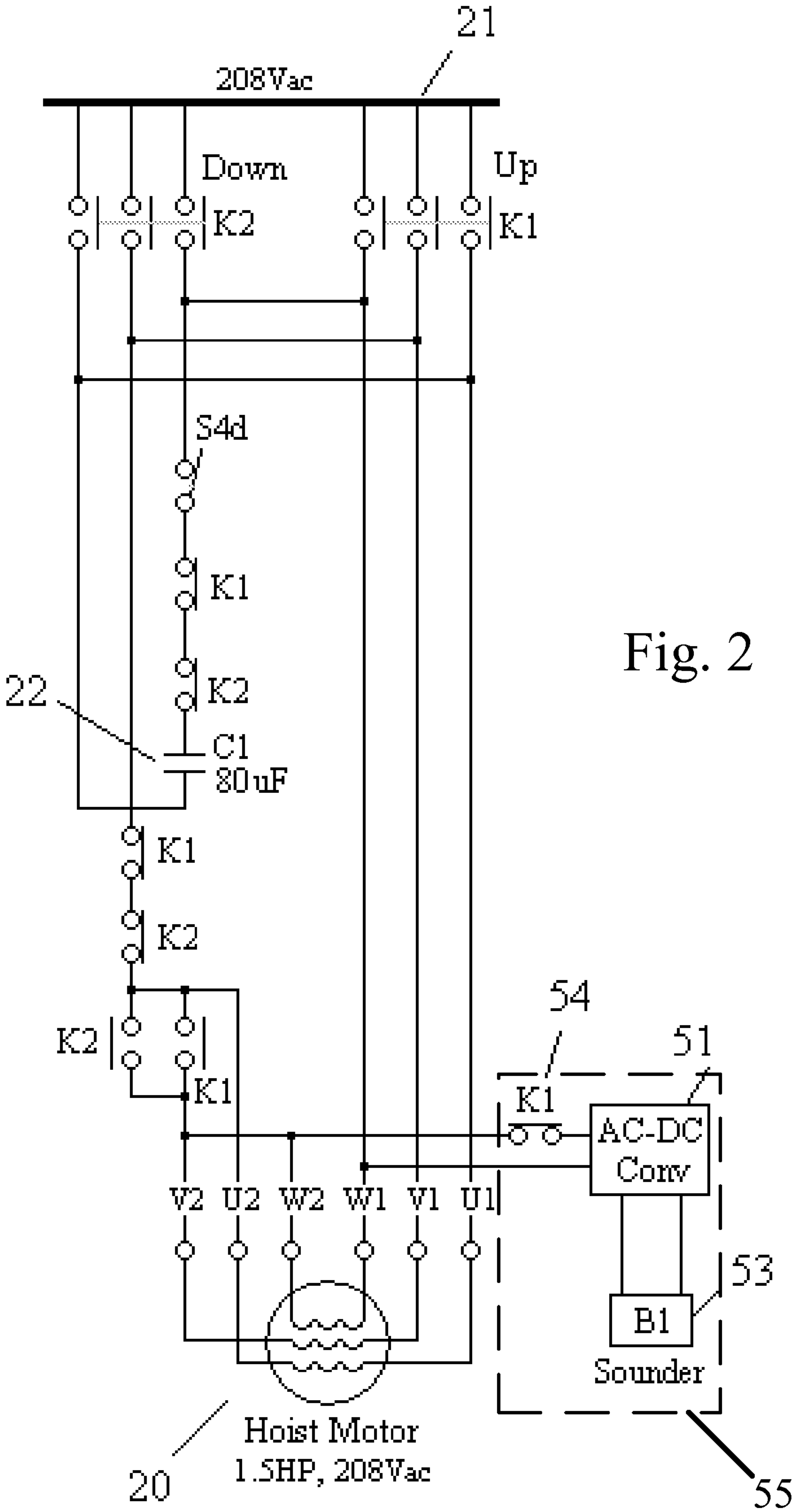


Fig. 1A

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K1
AC-DC
Conv
V2
U2
W2
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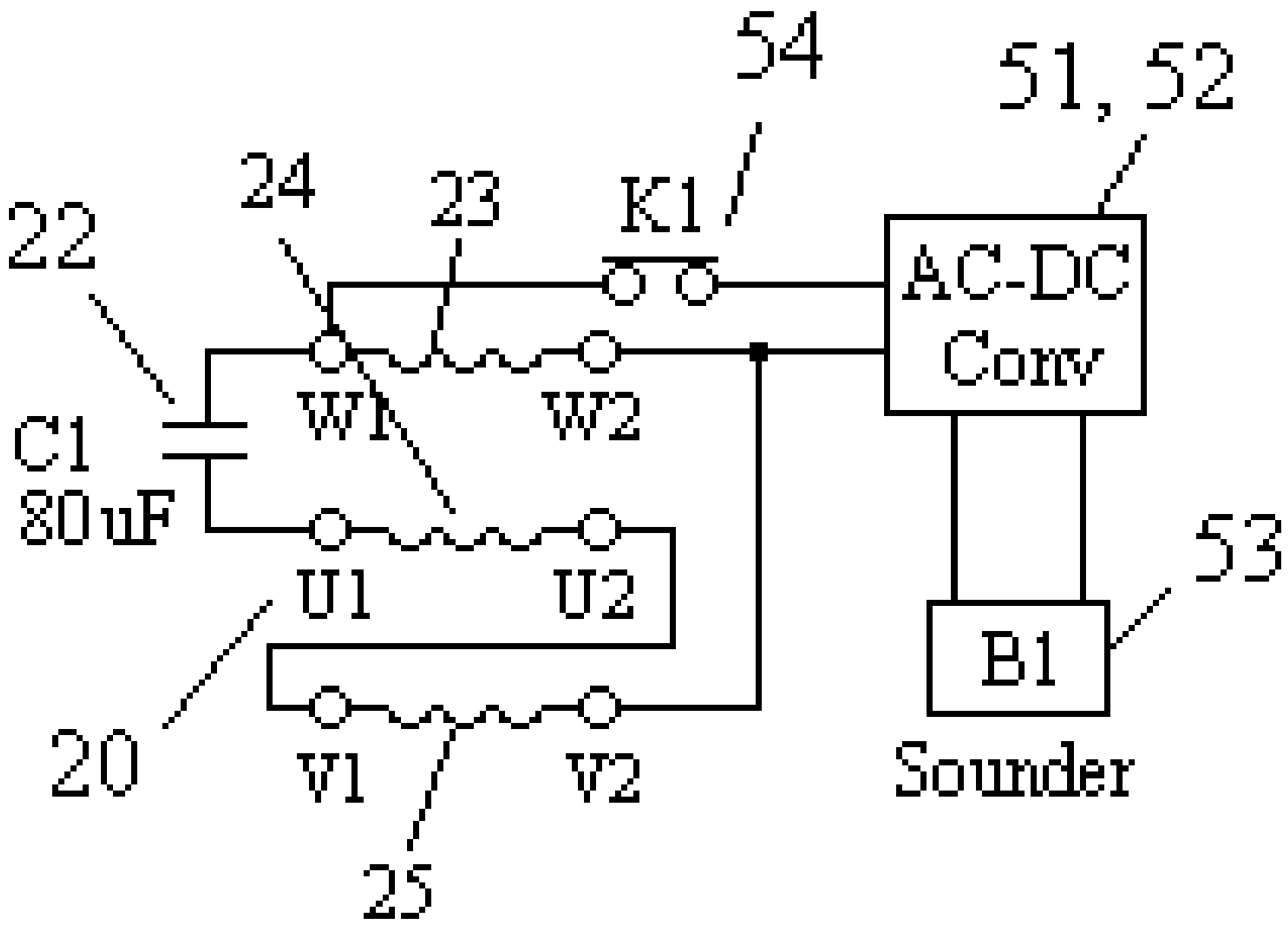
53
B1
Sounder
Hoist Motor
1.5HP, 208Vac
20
55

Fig. 2

Fig. 3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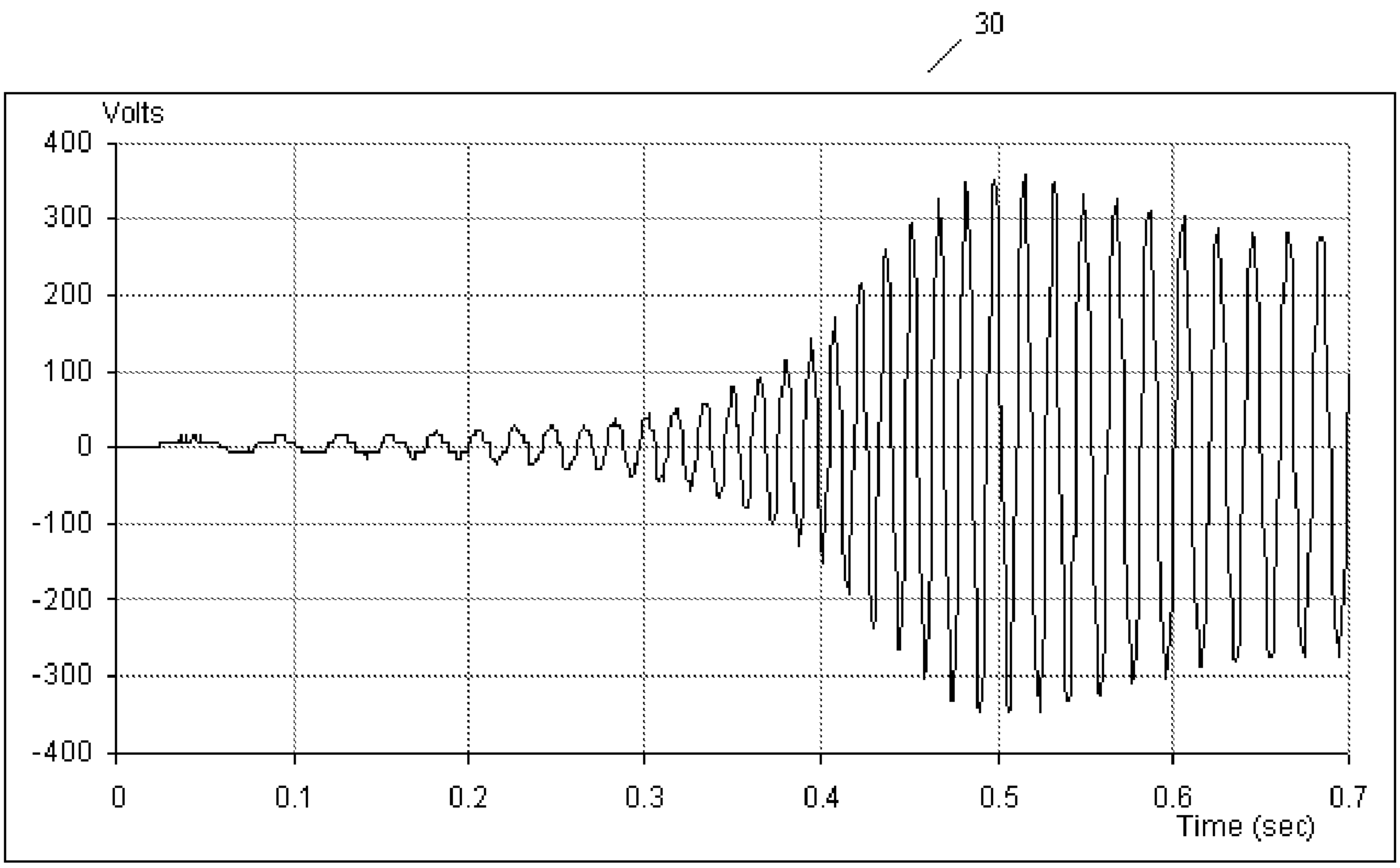
25

Fig. 4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Time (sec)

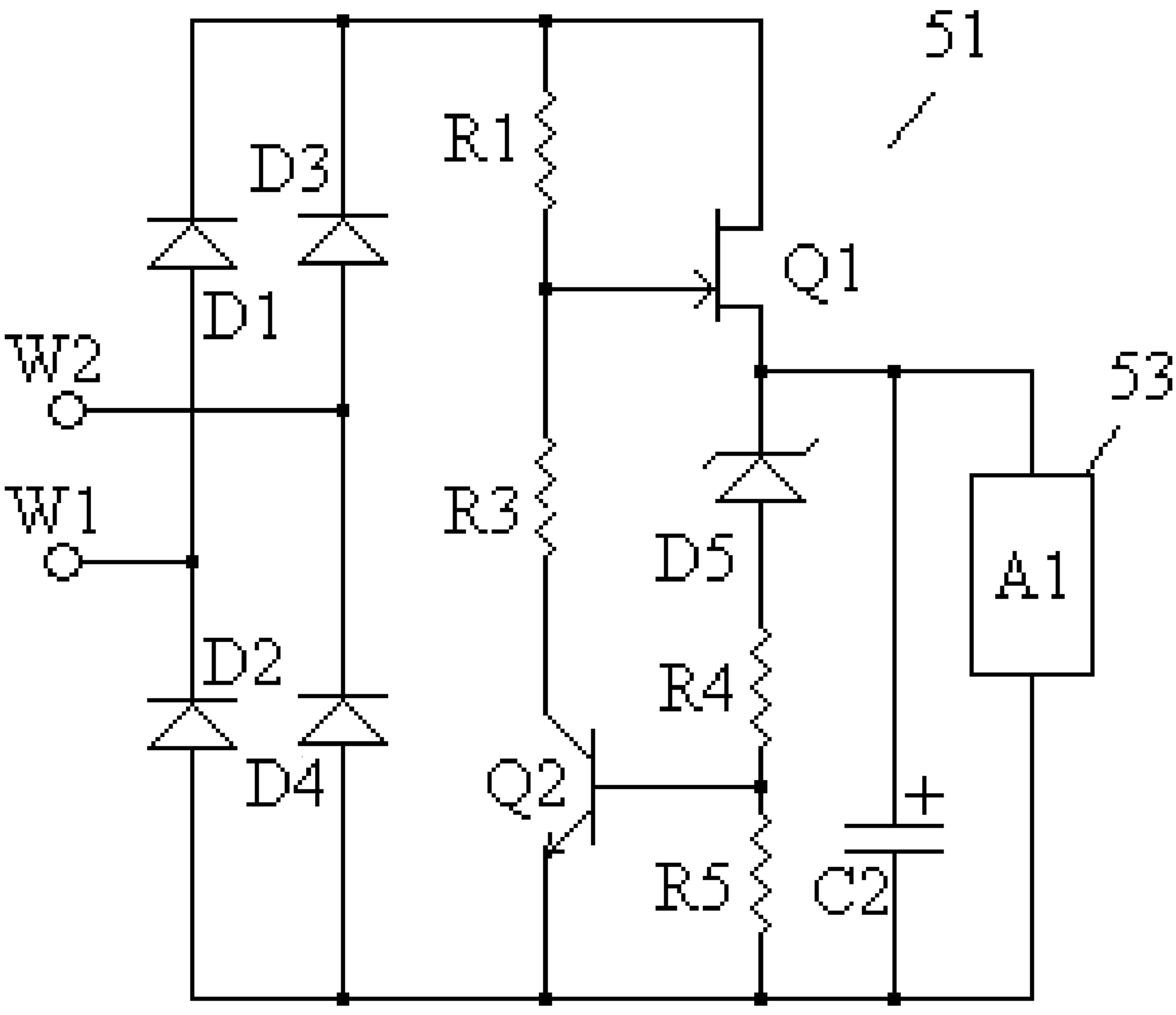
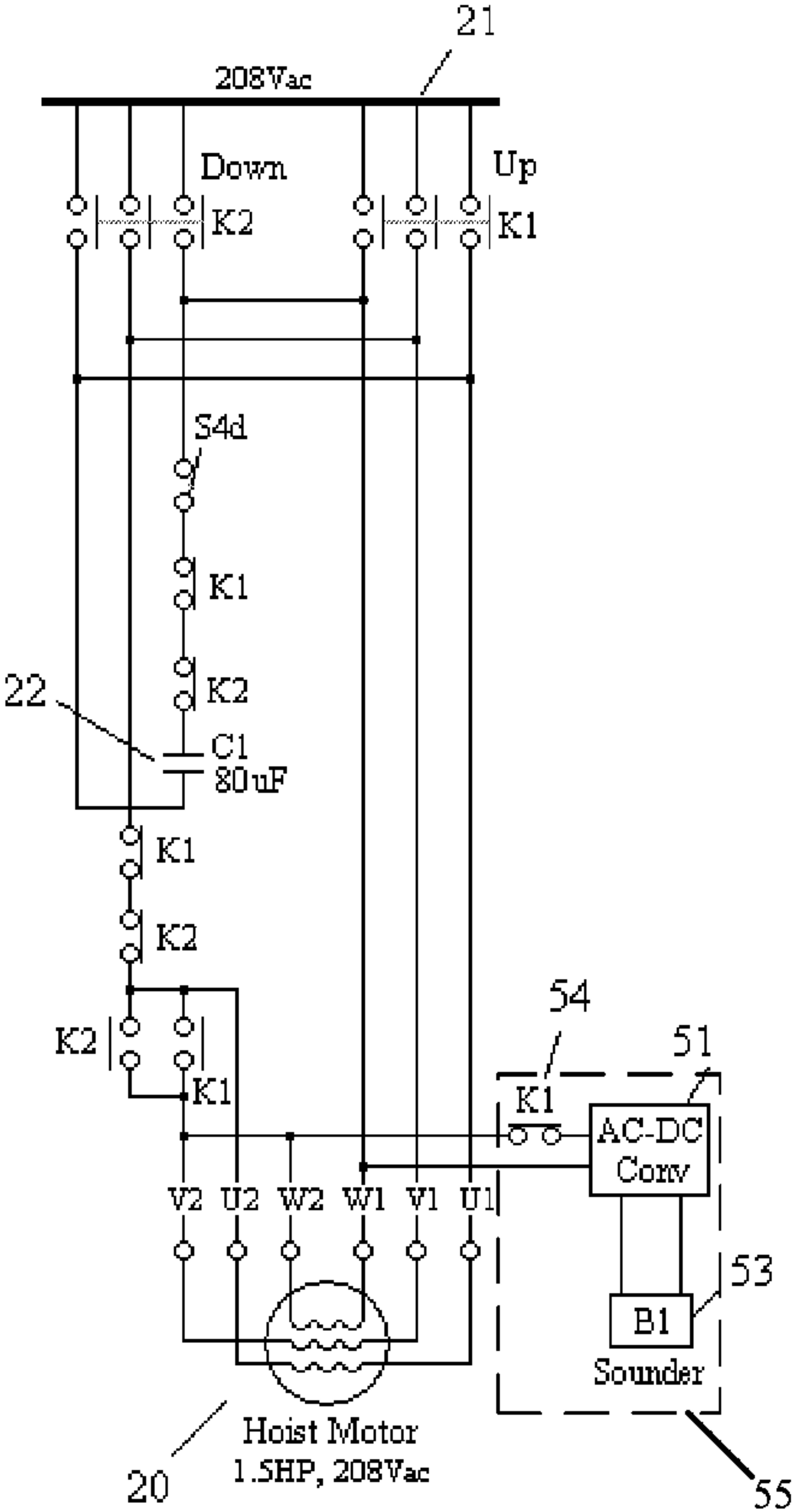


Fig. 5



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Hoist Motor
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55