

- [54] DUAL VOLTAGE SPEED CONTROL FOR
FORCED AIR HEAT EXCHANGER

3,332,621	7/1967	Tanner.....	236/49 X
3,585,471	6/1971	Ecclesia.....	318/225 A

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[57] ABSTRACT

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[52] U.S. Cl..... 165/39, 318/305

[51] Int. Cl. F28f 27/00

[58] **Field of Search** 236/49, 76; 165/39;
318/225 A, 305, 500

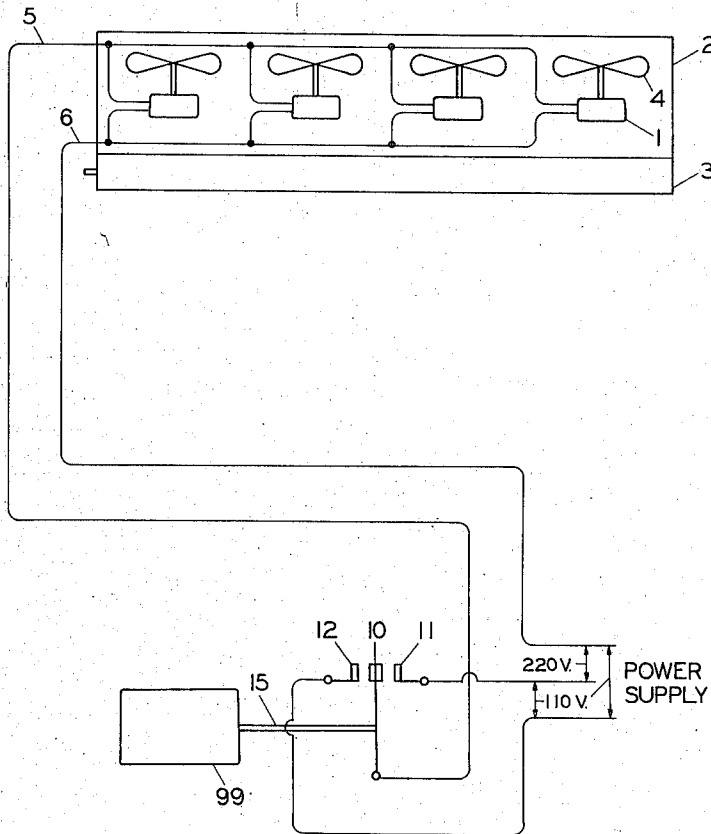
[56] References Cited

UNITED STATES PATENTS

1,361,546	12/1920	Politowski.....	318/305
2,519,490	5/1943	Clark.....	318/225 A X
2,632,876	3/1953	Willits.....	318/225 A
2,650,337	8/1953	Raver.....	318/305
2,663,000	12/1953	Keith.....	318/225 A X
2,855,553	10/1958	Morgan.....	318/500 X

A forced circulation air cooled refrigerant condensers and their controls and power supply which allow the condensers to operate at normal high fan speed during summer or high ambient conditions when maximum condensing capacity is required and which have provisions for the operation of the condenser fans at roughly half speed when the ambient is less than maximum, when maximum condensing capacity is not required. This change in fan speed is achieved without the use of a "two speed motor" by the expedient of connecting a lower than normal voltage power supply to the condenser motor leads or alternately by reconnecting dual-voltage motors operating at the lower name plate voltage for the higher name plate voltage.

20 Claims, 4 Drawing Figures



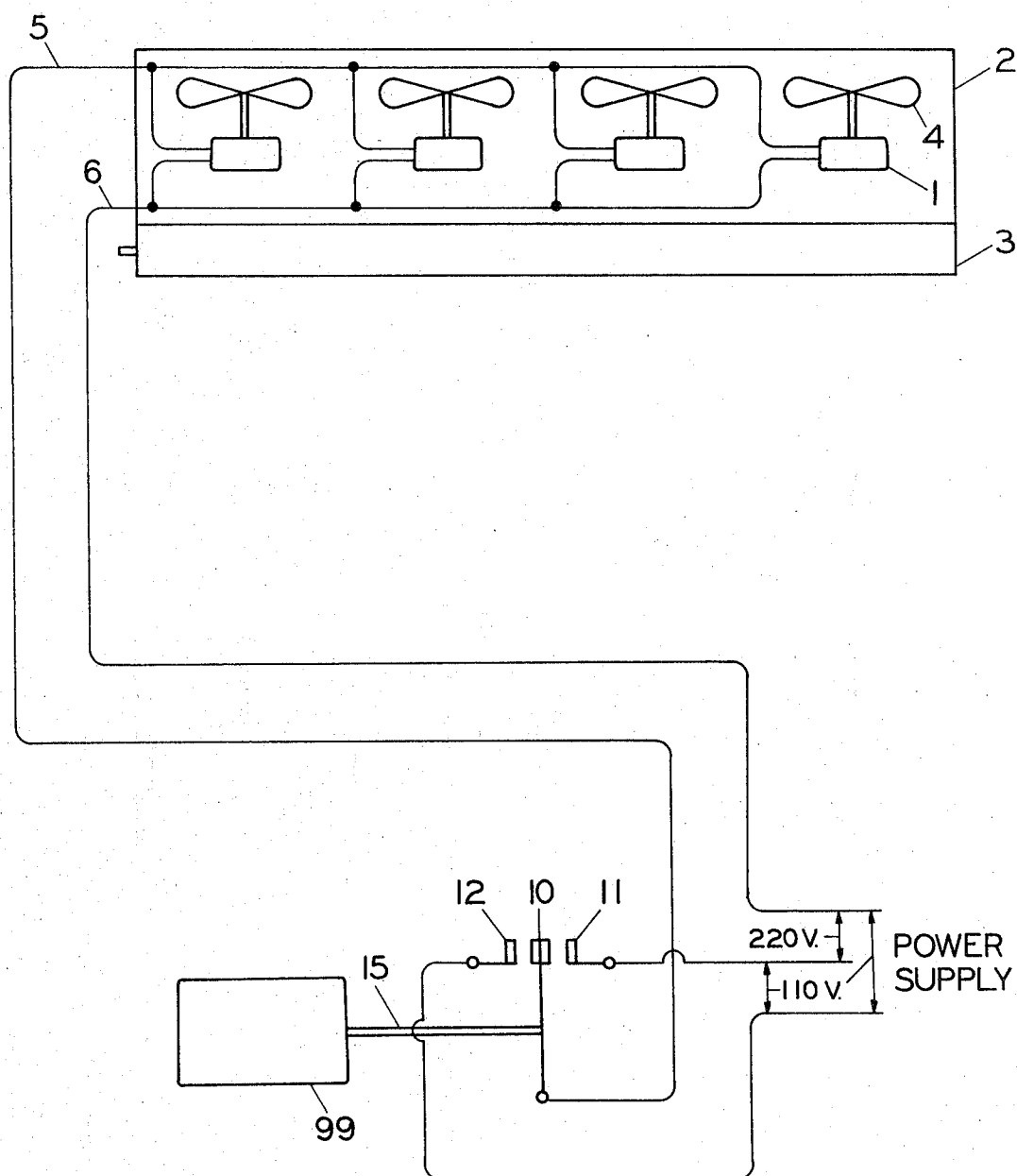


FIG. 1

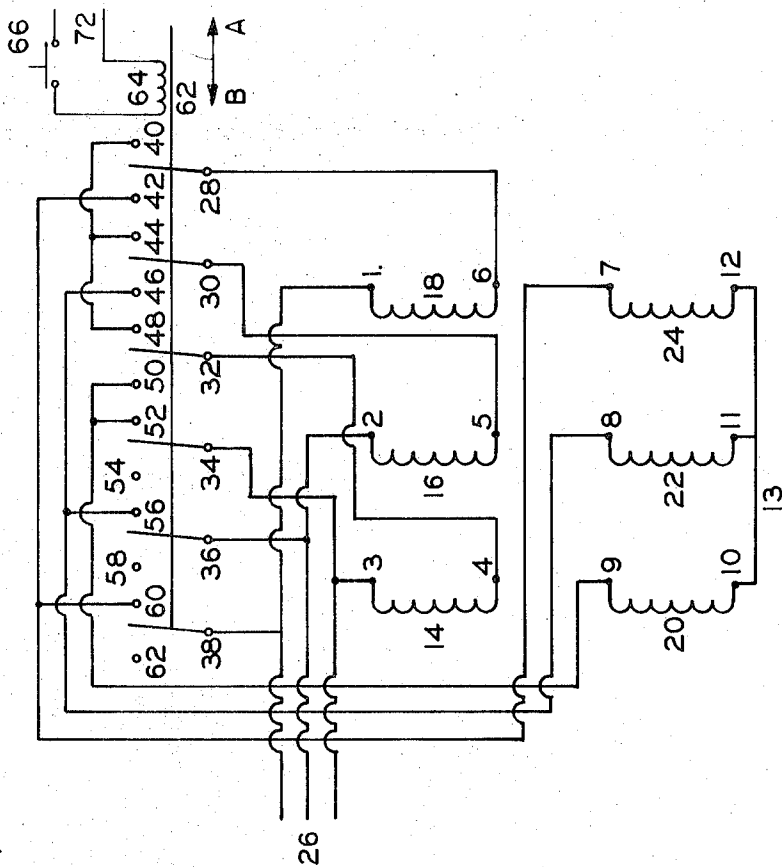


FIG. 4.

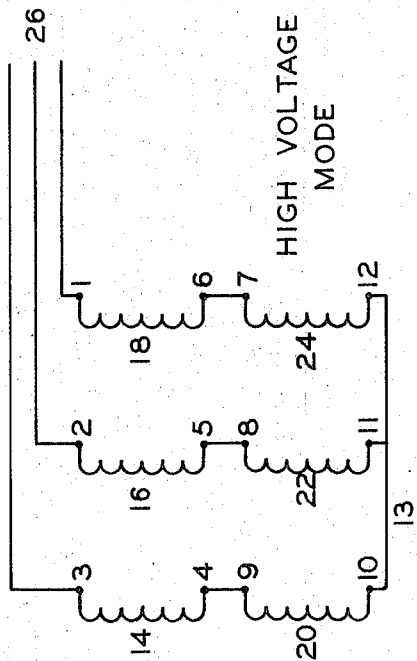


FIG. 2.

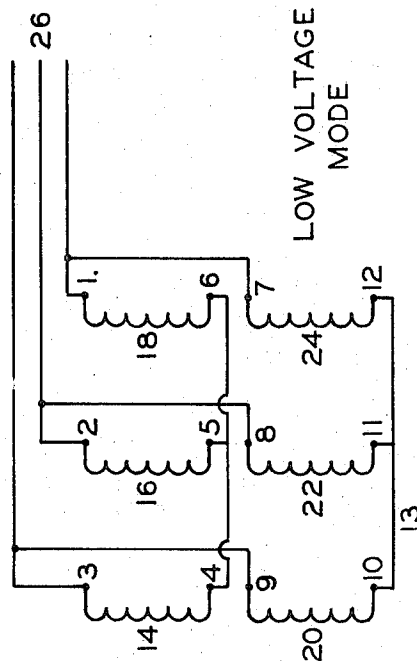


FIG. 3.

DUAL VOLTAGE SPEED CONTROL FOR FORCED AIR HEAT EXCHANGER

BACKGROUND

1. Field

Refrigeration systems, in the course of their cooling the desired area or product, must reject the heat absorbed at the cold element (plus the work put in by the compressor motor to move the heat) at a hot element. The cold element is called an evaporator, the hot element is called a condenser.

Refrigeration systems were initially designed with their condensing elements of the type that employed water for carrying away the heat. As refrigeration systems grew in size and as the cost of water supply distribution and waste increased, refrigeration systems designers began to use air instead of water to cool the condensing element. Air has the virtue of being clean, non-corrosive and available for only the cost of blowing it through the condensing element. In addition, the use of air for this purpose, until recently, created no environmental pollution since the condensing element affected the air chemically in no way and added no dissolved or suspended particles to the air used.

Recently, however, it has been discovered that forced air circulation refrigerant condensers are responsible for a type of environmental pollution which in inhabited areas must be controlled. The pollution generated by these forced air circulation condensers is noise.

The sound power generated by fans is sharply related to the fan speed by the law $\text{dB change} = 50 \log_{10}(\text{Speed}_2/\text{Speed}_1)$.

This formula indicates that reduction of a given fan speed by a factor of two would result in a reduction in emitted sound power of 15dB. This is by contrast with the situation where two fans are operating and one is shut off reducing the emitted sound power by a factor of two which causes a reduction of emitted sound of only 3dB.

These relationships and facts about the sound produced by fans are well known (see *Handbook of Noise Control*, Harris, Edition 1957, chapter 25, page 10 ff.

2. Prior Art

The concept of controlling fan speed to control noise also is well known. To this time, two major means for controlling fan speed on air cooled condensers have been employed. The first required the use of specially designed and wound two speed fan motors. The second requires a motor whose speed is affected by the input voltage, along with a reactor, a resistor or other device, well known to those who are well versed in the electric and electronic sciences, inserted in series with the power supply circuit to the motor which serves to reduce the input voltage or reduce the energy content of the input alternating electricity by sharply shifting the phase between the voltage and the current.

Motors correctly designed for operation at reduced voltages will then slow down and the fans which they drive will emit less noise in accord with the previously stated formula.

For small motor horse powers it is relatively economical to secure dual speed wound motors or even to supply reactors or resistors for the purpose of reducing the effective voltage applied to the motor.

Large air cooled condensers, which by virtue of their size, are most prone to contribute large quantities of noise to the atmosphere, use large motors to drive their fans. Specially wound large motors specifically designed for two speed operation are very costly compared to the single speed version. In addition, the speed reduction achieved by most two speed motors is in the range of 1,150 to 850 RPM, a reduction of 25 percent, which would produce a change in emitted sound power of 6.2dB, a barely detectable change. Reactors for large motors are costly because they must handle large currents. For example, one commercially available air cooled condenser uses five $\frac{3}{4}$ horse power fan motors, each drawing 6 amperes at 220 volts. A reactor capable of carrying 30 amperes continuously would have to be used for speed control. Such a device itself would be nonstandard and very costly compared to the cost of the motors. A voltage dropping resistor would have to have the ability of dissipating, without overheating, over $3\frac{1}{2}$ kilowatts of energy.

SUMMARY OF THE INVENTION

Since the alternating current motors used on most air cooled condensers, where the motors directly drive the fans (direct-drive type), are of the permanent split capacitor or shaded pole construction with a relatively high slip characteristic, these can generally be employed for fan service at half voltage without overheating. This is because the fan law, which predicts that only one-eighth the driving horse power will be required at half speed compared to full speed, is in accord with the motor law which states that at half voltage only one-eighth power will be available. Using time, light, temperature or sound as a control parameter, the invention suggests connecting alternating current fan motors normally operating at full voltage and full speed to a lower voltage.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 illustrates the control system for connecting the higher or lower voltage power source to the motor or motors of an air cooled condenser.

FIG. 2 shows a dual voltage motor connected for high voltage mode.

FIG. 3 shows a dual voltage motor connected for low voltage mode.

FIG. 4 shows the control arrangement for alternately connecting a dual voltage motor to either high or low voltage mode for achieving full or half speed.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a horizontal elevation in cut-away of an air cooled condenser employing four fan motors 1 each driving its own fan blade 4 mounted in a fan section 2 cooling a condenser coil 3. The four fan motors are connected in parallel and their input power supply wires are 5 and 6. The input power supply is a 220 volt/110 volt, single phase, three wire network which is widely used throughout the continental United States. The switching from high voltage to low voltage for the purpose of operating the fans at full or half speed is carried out automatically by control 99 which is a thermostat whose temperature sensing element is connected to push rod 15 in such a way that an increase in temperature moves the push rod 15 to the right, causing push rod 15 to press moving contact 10 into electrical con-

nection with stationary contact 11 establishing the 220 volt power supply across condenser power input wires 5 and 6. On a reduction in temperature the thermostat causes push rod 15 to move to the left and draw the moving contact 10 into electrical connection with stationary contact 12. Additionally, control 99 could be a photocell, a timer or a sound detector. Where control 99 is a photocell, it would be constructed in a way to move push rod 15 to the right or the left in accord with the amount of light reaching the photocell.

Where control 99 is a timer, it would cause push rod 15 to move to the right or the left in accord with the preset timer adjustment.

Where control 99 is a sound detector, it would act to move push rod 15 to the right or to the left in accord with the sound intensity reaching the sound detector, all in accord with control principles which are well known in the related industries. In each case, the movement of control rod 15 to the right or the left would be sufficient for contact 10 to engage either right-hand contact 11 for high voltage-high speed operation, or left-hand contact 12 for low voltage-low speed operation.

The same change in motor speed can be accomplished on three phase motors by reducing the input voltage to half. Unfortunately, where 220 volt, three phase networks are available there are no 110 volt networks available. Where 440 volt, three phase networks are available, 220 volt, three phase networks are infrequently available.

However, three phase motors are most frequently wound for dual voltage application so that 220/440 volt, three phase motors are essentially standard in the industry. Such a motor operating on 220 volts can be effectively induced to operate at half name plate voltage by continuing to supply 220 volt power to it, but by reconnecting the wires provided at the motor junction box for 440 volt operation. The application then of 220 volt power input to the 440 volt internal motor connection will result in half voltage operation while the application of the 220 volt network to the motor reconnected for 220 volts will result in full voltage operation.

It is an important feature of this invention that the control means for producing half voltage are standard and well known in the industry for the single phase arrangement. Only a thermostat is needed where the speed change is to be in response to temperature, or a timer where a speed change is to occur at certain times. A single pole-double-throw switch is required for the single phase arrangement. A six pole-double-throw or three double pole-double-throw relay must be employed, actuated either by a thermostat, a timer or other mode-determining-element such as a photoelectric cell sensing the degree of darkness for the three phase case.

FIG. 2 shows the six individual windings of a three phase dual voltage motor. The windings are in related pairs, numbered 14 and 20, 16 and 22, 18 and 24. Each winding has two leads or terminals, winding 14, terminals 3 and 4, winding 20, terminals 5 and 10, winding 16, terminals 2 and 5, winding 22, terminals 8 and 11, winding 18, terminals 1 and 6, winding 24, terminals 7 and 12.

For high voltage, each of the paired windings are connected in series. In most cases, connections 10, 11 and 12 are internally connected by the factory, as by

wire 13, since change from high to low voltage mode does not require reconnection of these terminals.

The connection for high voltage modes shown in FIG. 2 provides a three phase power supply 26 connected to terminal 3 of winding 14, terminal 2 of winding 16, and terminal 1 of winding 18. The pairs of windings are connected in series by connecting together their mating terminals 4 and 9, 5 and 8, and 6 and 7. FIG. 3 shows the motor of FIG. 2 with its windings connected in low voltage mode. Again terminals 10, 11 and 12 are connected together by wire 13. However, instead of the coil pairs 14 and 20, 16 and 22, and 18 and 24 being connected in series, in this case they are connected in parallel. This is achieved by wiring together terminals 4, 5, and 6 by connection wire 26. Then both terminals 3 of winding 14 and 9 of winding 20 are connected to one of the phases of three phase power supply 26. Terminal 8 of winding 22 and terminal 2 of winding 16 are both connected to the second phase connection of power supply 26. Finally, terminal 7 of winding 24 and terminal 1 of winding 18 are connected to the third remaining phase connection of three phase power supply 26.

If power supply 26 is selected to provide full power when the windings are connected to it in the low voltage mode of FIG. 3, then it will produce only one-eighth power when the same motor is connected to the same power source but when its windings are connected as in FIG. 2, in the high voltage mode.

FIG. 4 illustrates a six pole-double-throw relay for achieving change over from high voltage mode to low voltage mode in such a motor automatically under the control of a time, light, temperature or sound sensing device which might control the switch 66, energizing relay coil 64, which would cause platen 62 to move either into the A position, when the coil is energized, or B position when it is deenergized.

Platen 62 is an insulating connection which causes simultaneous motion of all the relay clappers, 28, 30, 32, 34, 36 and 38.

The same power supply, 26, as used in FIG. 2 and FIG. 3, is employed in FIG. 4. When coil 64 is energized, moving platen 62 into the A position, clapper 28 mates with contact 40, clapper 30 mates with contact 44 and clapper 32 mates with contact 48. These contacts are bridged together by wire 64 which serves to tie together terminals 4, 5 and 6 in a manner exactly analogous to that performed by wire 26 in FIG. 3. Clappers 34, 36 and 38 are connected to three phase power supply 26 which also connects directly to terminal 3 of coil 14, terminal 2 of coil 16 and terminal 1 of coil 18.

When platen 62 is in the energized or A position, clapper 34 mates with contact 52 supplying power to terminal 9 of coil 20. Note that the same phase is directly connected to terminal 3 of coil 14. Clapper 36 mates with contact 56 supplying power to terminal 8 of coil 22. Note that this phase also supplies power directly to terminal 2 of its mating coil 16. Clapper 38 mates with contact 60 supplying power to terminal 7 of coil 24. Note that this same phase supplies power to terminal 1 of its mating coil 18. Therefore, when relay coil 64 moves platen 62 into the A position, the coils and terminals of the motor are connected to three phase power supply 26 in the low voltage mode and in this mode, the motor develops full power and operates at full speed.

When contact 66 is broken causing coil 64 to be energized, platen 62 moves by spring, not shown, or by gravity to position B. The clapper 28 mates with contact 42, clapper 30 mates with contact 46, clapper 32 mates with contact 50. These contacts serve in each case to connect together terminals 6 of coil 18 and 7 of 24, terminals 5 of coil 16 and 8 of 22, and terminals 4 of coil 14 and 9 of coil 20 in a manner exactly analogous to the series connected circuit of FIG. 2.

In the B position, clappers 34, 36, and 38 mate with unconnected contacts and perform no function. Therefore, the connection of power supply 26 to the platens 36 and 38 produces no effect when platen 62 is in the B position.

When platen 62 is in the B position, therefore, the wiring connections, produced by the contacts, are exactly like those of FIG. 2, resulting in the high voltage mode. Since the power supply 26 is a low voltage source, it now appears to the motor that a half voltage supply is connected to it and it therefore generates one-eighth its normal h.p. and, when connected to a fan load, operates at approximately half its normal speed.

Other thermostats producing the same electrical results can be used which rely not on the expansion power of a fluid, but on the bending of bi-metals, the expansion of solid elements or any other temperature responsive function.

Push rod 15 could be activated by a timer motor, means activated by a photo-cell, means activated by a sound sensing device.

Another type of sensor for rationally exercising control over the high or low speed operation of the fan could be the ambient noise level measured at a point not affected by the noise emitted by the condenser itself. It is generally true that a sound cannot be detected when its intensity at the observer is equal to or lower than the ambient noise intensity. That means that an air cooled condenser which, in a noiseless environment, produces an intensity at the observer's location of 40dB could not be observed by the observer if the ambient noise level were 40 dB. Since reaction to the sound of mechanical devices is frequently subjective rather than objective, many emotions are involved in the reaction of a listener to sound. One observer may be willing to tolerate 80dB of rock and roll music and reject 40dB of a harmonious hum. Since the objective of applying a fan speed control is generally the reduction of complaints stemming from noise emitted by the condenser, it is only necessary to reduce the noise level below that ambient noise level which exists at the time. The most rational control, therefore, is a sound detecting device, sensing ambient noise and condenser noise and adjusted to reduce the fan speed only under those conditions where the ambient noise level drops more than 3dB below the sound intensity produced by the air cooled condenser.

I claim:

1. A forced air heat exchanger, comprising a heat exchange element with input power supply conductor means, utilizing fans positioned to drive air over said element, said fans being driven by alternating current motors connected in parallel to the conductor means, which motors operate at high speed when connected to a high voltage power supply and low speed when connected to a low voltage power supply, the improvement comprising a control and switch means actuated by the control, where said switch means, when actuated, alter-

nately connects the conductor means to the high and the low voltage power supplies.

2. An improvement as in claim 1 where the control is a thermostat.

3. An improvement as in claim 1 where the control is a timer.

4. An improvement as in claim 1 where the control is a photocell.

5. An improvement as in claim 1 where the control is a sound detector.

6. In a forced air heat exchanger including a heat exchange element, said exchanger including input power supply conductor means, a fan positioned to drive air over the element, an alternating current motor connected to the conductor means for driving the fan, which motor operates at high speed when connected to a high voltage supply and low speed when connected to a low voltage supply, the improvement comprising a control and automatic switch means actuated by the control which connects the conductor means alternately to the high and the low voltage power supplies.

7. An improvement as in claim 6 where the control is a thermostat.

8. An improvement as in claim 6 where the control is a timer.

9. An improvement as in claim 6 where the control is a photocell.

10. An improvement as in claim 6 where the control is a sound detector.

11. A forced air heat exchanger having a heat exchange element, first conductor means, fans driven by alternating current motors connected in parallel to said first conductor means, said fans positioned to force air over the element, said motors being of the type which operate at higher speed when connected to higher voltage and at lower speed when connected to lower voltage; wherein the improvement comprises second conductor means for connection to a higher voltage power supply; third conductor means for connection to a lower voltage power supply, a control, and switch means actuated by the control, said switch means operatively connected to the first conductor means, the second conductor means and the third conductor means, where the switch means, upon actuation by the control, electrically connects the first conductor means alternately to the second conductor means and to the third conductor means.

12. An improved heat exchanger as in claim 11 where the control is a timer.

13. An improved heat exchanger as in claim 11 where the control is a photocell.

14. An improved heat exchanger as in claim 11 where the control is a sound detector.

15. An improved heat exchanger as in claim 11 where the control is a thermostat.

16. In a forced air heat exchanger having a heat exchange element, first conductor means, a fan positioned to move air over the element, an alternating current motor connected to said first conductor means driving the fan, which motor operates at higher speed when connected to a higher voltage supply and at lower speed when connected to a lower voltage supply, the improvement comprising second conductor means for connection to a lower voltage power supply, third conductor means for connection to a higher voltage power supply, a control and switch means operatively con-

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nected to the first, second and third conductor means, said switch means, when actuated by the control, connects electrically the first conductor means alternately to the second conductor means and to the third conductor means.

17. An improved heat exchanger as in claim 16 where the control is a thermostat.

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18. An improved heat exchanger as in claim 16 where the control is a timer.

19. An improved heat exchanger as in claim 16 where the control is a photocell.

20. An improved heat exchanger as in claim 16 where the control is a sound detector.

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