UNITED TECHNOLOGIES CARRIER

Commercial Division
Carrier Corporation

BULLETIN: CA- SB-19-C-61-12
DATE: 10/20/61
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SERVICE BULLETIN

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SUBJECT:

BARBER-COLMAN ELECTRONIC CONTROL SERVICE GUIDE

PURPOSE: The purpose of this bulletin is to transmit the attached Barber-Colman Electronic Control Service Guide.

MACHINES AFFECTED: All 19C machines shipped after March 1961 having the re-designed Barber-Colman Electronic Controls.

PROCEDURE: The attachment is divided into two parts. Part I, pages 2 thru 10 contains a service guide to be used when making external checks before a control module is replaced or when proper control cannot be obtained.

Part II, pages 11 thru 18 contains a detailed description of the Barber-Colman Electronic Control and bridge circuit.

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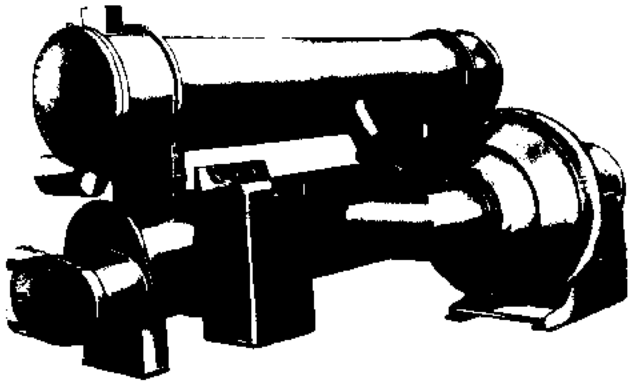
19C

Carrier

BARBER-COLMAN ELECTRONIC CONTROL SERVICE GUIDE



19C HERMETIC CENTRIFUGAL REFRIGERATION MACHINE

-5190A

PART I

BARBER-COLMAN ELECTRONIC CONTROL - SERVICE GUIDE

General Troubles

There are several basic steps which must be taken when servicing the 19C electronic controls. They are as follows:

1. All electrical connections must be checked for tightness.

2. All electronic tubes must be checked. Be sure the tubes are in their designated tube sockets.

3. On the chilled water module (proportioning amplifier) and on the relay module, the relays must act with the water temperature or all other efforts to stabilize this system will be unsuccessful. Therefore, observe that water temperature changes do actuate the relays.

4. The motor load control cannot be calibrated at full load unless the signal from the shunt resistor in the starter is between .45 and .55 volts at full load. This is the first item to check when trouble is experienced with the motor load module.

5. Always observe the operation of the relays as they may be a clue to the problem that exists.

6. If trouble is traced to any of the "pots" in the system, move "pot" wiper arm back and forth to wipe off possible oxidation.

7. Do not attempt to adjust the micro-relays. If the micro-relay is faulty, replace the entire relay.

The following summation of possible troubles with the 19C electronic control parallels the set-up procedure as outlined in the initial start-up instructions. After the trouble has been corrected, recalibrate the controls by following the procedure as outlined in the initial start-up instructions.

It is intended that this outline be used to differentiate between external and internal module troubles. If trouble is determined to be in the electronic components, they should be replaced.

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BARBER-COLMAN ELECTRONIC CONTROL

TROUBLE	CORRECTION
1. MOTOR LOAD CONTROL Assume capacity control knob in "hold" position and % current limit device in 100% position.	
a. Relay CR_2 de-energized and cannot be adjusted to energize at 100% full load amperage.	a. Voltage signal from resistor in starter between terminals 23 and 24 is below .45 volts. Check the voltage. This voltage must be between .45 and .55 volts at full load amps or module cannot be calibrated. May have an open circuit in micro-relay CR_2. Replace relay with new FYZA-119 micro-relay. Faulty CR_2 calibration potentiometer. Replace motor load module.
b. The full load signal to terminals 23 and 24 is not within .45 to .55 volt range.	b. The value of the resistor in the current transformer circuit starter is not correct. If the voltage is below .45, the resistance must be increased. If the voltage is above .55 the resistance must be decreased. Resize if a fixed resistor; change as required if a variable resistor. The value of the resistor in the current transformer circuit is normally on the order of .10 ohms to .20 ohms. If a resistor change is required, replace with one rated at 10 watts continuous duty. Warning: Do not attempt to make any adjustments on the current transformer circuit while the machine is operating. The secondary coil of an energized transformer should never be opened.

TROUBLE	CORRECTION
c. Relay CR_2 energized preventing vanes from moving toward the open position.	c. Electrical demand control knob set at less than 100% position. CR_2 calibration screw should be recalibrated. Faulty overload micro-relay. Replace with micro-relay FYZA-119. Signal from resistor and starter above .55 volts. (See Item 1-b above). Check for loose connections on module terminals and shunt resistor in starter. Replace motor load control.
d. Relay CR_2 de-energized and vanes will not open.	d. Check terminal 18 to ground for 115 volts. If zero volts, then trouble is with auxiliary contact in starter or loose wire. Check wiring to oil solenoid valves. With the capacity control knob in the "hold" position, terminal 21 to ground should read 115 volts. With the capacity control knob in the "higher" position the voltage from terminal 22 to ground should be 115 volts. Repeat these steps on the motor load module terminals 21 and 22 to ground for 115 volts. If either voltage from these two terminals to ground is zero volts, replace the micro-relay FYZA-119. If the voltage from terminal 21 and 22 to ground is still zero volts under the above conditions, trouble is in the capacity control switch. Replace chilled water module.
e. CR_2 (100%) relay energizes. CR_1 (105%) relay will not energize.	e. Check for loose connections on the module. Recalibrate the CR_1 calibration screw as outlined in the initial start-up instructions.

TROUBLE	CORRECTION
e. (Continued)	e. May have an open circuit in relay CR_1. Replace with new FYZA-119 micro-relay. Replace motor load control if relay will still not open at 105% of motor full load amps.
f. CR_1 (105%) relay energizes before CR_2 (100%) relay energizes.	f. Recalibrate CR_1 and CR_2 calibration screws as outlined in initial start-up instructions. Replace motor load micro-relays FYZA-119. Replace motor load control.
2. CHILLED WATER CONTROL (Proportioning Amplifier)	
a. Relays CRC and CRO on relay module will not operate properly. (Capacity control in manual position).	a. Place capacity control knob in higher and lower position and check operation of CRC and CRO. Check for loose connections at the relay module. Place a wire jumper between terminals G and RC on module. Relay CRC should operate. Place wire jumper between terminals G and RO on module. Relay CRO should operate. Replace relays CRO and CRC if relays do not function as above. Replace faulty relays.

TROUBLE	CORRECTION
b. Relay CRC and CRO on relay module will not operate properly. (Automatic position: assume operation of relays correct in manual position).	b. Check vacuum tubes 12AV7 and 12AX7. Replace if faulty. Check input voltage to proportioning amplifier. Install voltmeter on terminals T and X on the proportional amplifier. Use 12 volt AC scale. Move the chilled water thermostat knob from the low end of the scale to the high end of the scale. The pointer on the voltmeter should indicate a decrease and increase in voltage passing through a null (minimum voltage). If this null is not indicated on the voltmeter, the trouble is in the input to the amplifier or the output from the temperature bridge. Since the resistance element and vane potentiometer is part of this bridge, check same. Check voltage between terminals 29 and 30. Voltage should be approximately 6 volts. Zero volts indicates a short circuit in the resistance element. Approximately 12 volts indicates an open circuit. Replace the resistance element if faulty. Check shielding on wires 25, 26, 27, 29 and 30 to be grounded only to terminal 28 in the console. Braided shield wire to be 20 or 22 gage Beldon Wire & Cable Co. 8735-22-3 or equal. If above items check correctly and a proper null is reached as indicated on the voltmeter, then the input voltage to the chilled water module is correct. Remove cover from FTZA-115 microrelay. Operate machine manually and bring chilled water temperature to within the range of the chilled water

TROUBLE	CORRECTION
b. (Continued)	thermostat. Set capacity control knob to the "auto" position. When the chilled water thermostat is moved towards "colder" then the "Hi" micro-relay should energize. Moving the chilled water thermostat to "warmer", the "Lo" micro-relay should energize. If micro-relay does not operate as above, fault may be in the vacuum tubes. Check tubes and replace if necessary. If micro-relay is still inoperative, replace with new PTZA-115 micro-relay. Remove external wires 25, 26, 27 from follow-up potentiometer at terminal strip in console. Attach ohmeter to wire 25 and 26. With closed vanes, the resistance between 25 and 26 should be approximately 350 ohms and between wire 26 and 27 approximately 100 ohms. With the ohmeter installed on wires 25 and 26, rotating the potentiometer and vanes through full travel will decrease the resistance from approximately 350 ohms to approximately 100 ohms. If resistance readings indicate a broken wire or ground, replace potentiometer. Trace wiring to terminals 25, 26, and 27 to insure correct terminals are connected. Micro-relay CR_1 (105%) energized before CR_2 (100%). This causes both CRC and CRO to energize on pulldown if FLA is reached - recalibrate CR_1 and CR_2 calibration screws per initial start-up instructions. Check control wiring to be sure it is not run in same conduit with higher voltage wiring. Replace chilled water module.

TROUBLE	CORRECTION
c. Capacity balance will not null. (Reach minimum voltage. Assume Temperature Bridge has nulled correctly).	c. Chilled water temperature too high. Must be within range of chilled water thermostat. Use 12 volt AC scale on voltmeter. Lower scale may give false reading. Check shielded wire to the resistance element. Ground should be connected only to terminal 28 in console. Check for faulty tubes and replace if necessary. Replace chilled water amplifier.
d. Temperature Bridge will not null.	d. Check voltage between terminals 29 and 30. Voltage should be approximately 6 volts. Zero volts indicates a short circuit in the resistance element. Approximately 12 volts indicates an open circuit. Replace the resistance element if faulty. Check shielding on wires 25, 26, 27, 29 and 30 to be grounded only to terminal 28 in the console. Braided shield wire to be 20 or 22 gage Beldon Wire & Cable Co. 8735-22-3 or equal. Remove external wires 25, 26 and 27 from follow-up potentiometer at terminal strip in console. Attach ohmeter to wire 25 and 26. With closed prewhirl vanes, the resistance between 25 and 26 should be approximately 350 ohms and between wire 26 and 27 approximately 100 ohms. With the ohmeter installed on wires 25 and 26, rotating the potentiometer and vanes through full travel will decrease the resistance from approximately 350 ohms to approximately 100 ohms. If the above checks correctly, replace the temperature bridge.

TROUBLE	CORRECTION
e. Chilled water temperature hunting excessively.	e. Observe the operation of the chilled water relays with the changing water temperature. The relays must quickly sense a temperature change or any efforts to correct the hunting condition will not be successful. Use dielectric grease between the resistance element and the element well. Check for condensation at resistance element terminals. Use dielectric grease on the terminals. Check for air in the chilled water circuit. Solenoid F and G may be cross-wired. At vane hold position, F solenoid should be hot to the touch. Check for proper immersion of resistance element in leaving chilled water. Check for external effects on the water circuit such as changing GPM and quick acting bypass valves, etc. Throttle range may not be stabilizing the chilled water amplifier. Add more throttling range. Adding throttling range will change the control point. This is normal. Compensate for this shift by moving chilled water thermostat to "warmer". Chilled water thermostat can be recalibrated by placing capacity control knob to "hold" position. With chilled water temperature near design, set thermostat to actual temperature and adjust temperature bridge calibration screw until CRC is energized and CRO is de-energized.

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TROUBLE	CORRECTION
e. (Continued)	If machine controls at a higher chilled water temperature, check terminals 25 and 27 as the vane potentiometer may be wired backwards. Check the vane follow-up potentiometer 25 to 26 for approximately 350 ohms with vanes closed; 26 to 27 for approximately 100 ohms with the vanes closed. In addition, check for open or grounded potentiometer (See Item 2-b). If an increase in differential is required to obtain good control, use following as a guide: 470 ohms = 1¼F differential 330 ohms = 1½F differential The differential resistor is installed between terminals X and Y on the chilled water module. Replace chilled water micro-relays FYZA-115. Replace relays CRC and CRO. Replace chilled water amplifier.
3. REPLACING CHILLED WATER MODULE	
a. Chilled water module needs replacing, none immediately available.	a. Can operate machine by switching capacity control knob to manual position. Watch leaving chilled water temperature.

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TROUBLE	CORRECTION
4. REPLACING MOTOR LOAD MODULE OR MICRO-RELAYS	
a. Motor load module or micro-relays FYZA-119 need replacing but none immediately available.	a. Remove relay CRO. Place wire jumper between terminals 3 and 22 to open vanes. Remove jumper to stop and hold vanes in that particular position. Do not exceed full load amps. Watch leaving chilled water temperature.
5. MISCELLANEOUS	Relays CRC and CRO are identical. They can be interchanged to check their operation. The micro-relays cannot be interchanged. Check voltage of power source to chilled water amplifier across to terminals L1 and L2. Should be 115 volts.

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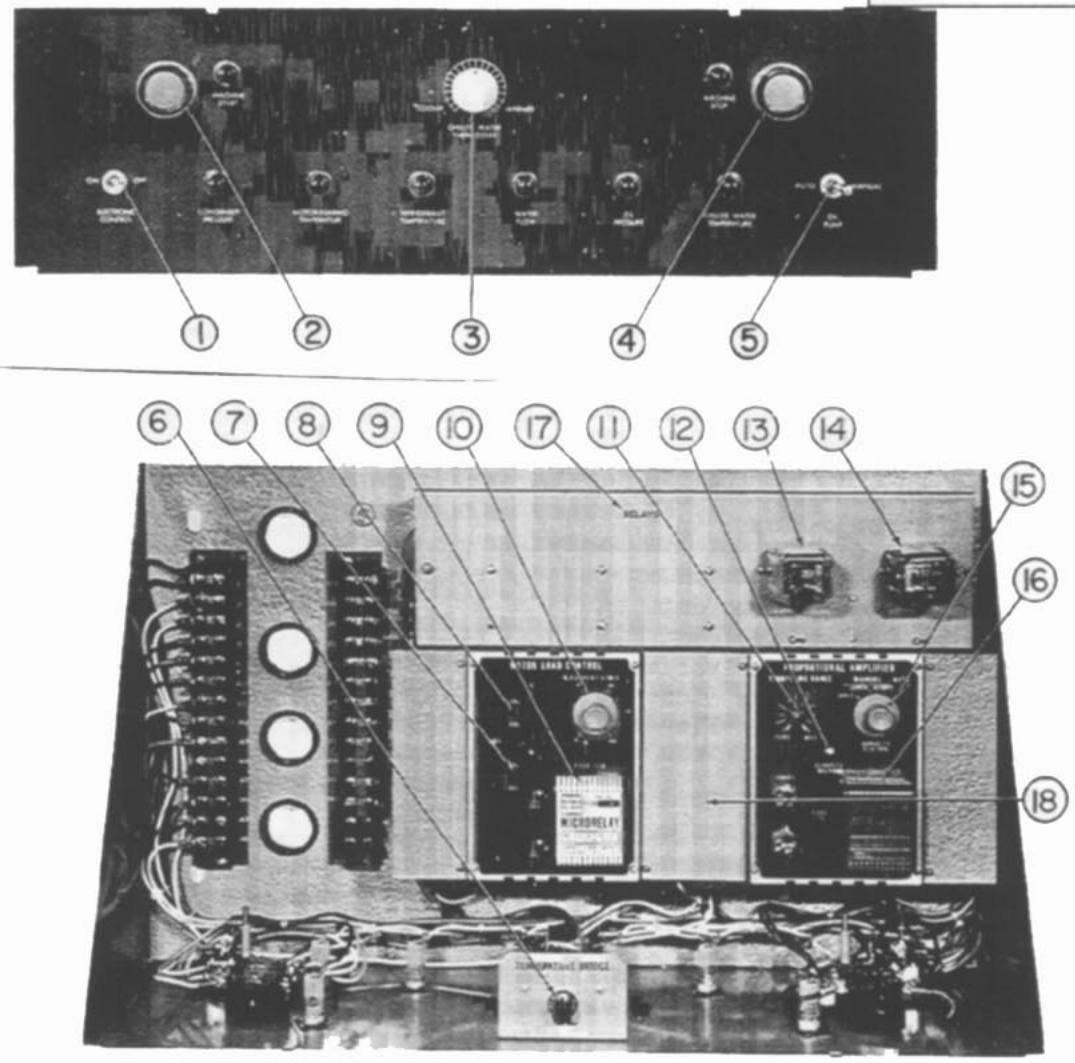

FIGURE I - BARBER-COLMAN ELECTRONIC CONTROL

1. Electronic Control On-Off Switch
2. Machine "Start" Button
3. Chilled Water Thermostat
4. Machine "Stop" Button
5. Oil Pump Automatic-Manual Switch
6. Calibration Adjusting Screw (Temperature Bridge)
7. CR1 Calibration Adjusting Screw (Motor Overload)
8. CR2 Calibration Adjusting Screw (Motor Overload)
9. Overload Micro-relay
10. Electrical Demand Control Knob
11. Throttling Range Adjusting Screw
12. Capacity Balance Adjusting Screw
13. CRO Relay
14. CRC Relay
15. Capacity Control Auto-Manual Switch
16. Chilled Water Micro-Relay
17. Relays R1, R2, R3 reading left to right (not shown)
18. Module terminals (not shown)

PART II

ELECTRONIC CONTROL SYSTEM

1. General Description

The electronic control system consists of two circuits; one for chilled water temperature and the other for motor overload, both of which position the prewhirl vanes through a hydraulic motor. Under normal conditions, the water temperature leaving the cooler is controlled by the chilled water module. A resistance element immersed in the chilled water is sensitive to temperature changes of leaving water from the cooler. The element is part of a bridge circuit* from which signals are strnegthened by an electronic amplifier which in turn activates mirco-relays. The micro-relays in turn operate the control relays CRC and CRO which open and close solenoid valves to feed or bleed oil from the hydraulic control motor. When the temperature of the water leaving the cooler increases, the vanes will move toward the open position. A decrease in temperature results in a movement toward the closed position.

Motor overload is detected by a current transformer and resistor in the starter. An increase in current flow causes a change in voltage drop across the resistor. This voltage is amplified sufficiently to activate micro-relays CR_1 and CR_2. These micro-relays are located in the circuit to override the chilled water control relays.

The console panel includes the machine start and stop buttons, chilled water thermostat control, electonic control on-off switch, oil pump switch and the indicator lights for the various safety controls. A capacity control switch for manually positioning the vanes is located on the chilled water module.

The vane position is indicated on the vane indicator assembly on the compressor. Enclosed in this housing is the "vane closed" switch which insures the prewhirl vanes are closed before the compressor motor will start. A potentiometer is included in this assembly to allow proportional feedback to the control circuit.

The solenoid valves controlling the hydraulic motor are so arranged that when de-energized they will provide oil pressure to one side of the piston and bleed the other side closing the vanes. This insures the vanes will close should the controls fail.

* For description of the electronic bridge circuit, see page 14.

2. Chilled Water Temperature Control Operation

The chilled water temperature is controlled by a sensing resistance element in the leaving chilled water line. A rise in temperature sends a signal through the chilled water amplifier to position the prewhirl vanes toward open. The inverse also occurs. The chilled water resistance element is part of a bridge circuit and any unbalance in the bridge caused by resistance change due to temperature change is detected by the amplifier.

Referring to Figure 2, if the water temperature is at the control point and the bridge circuit is in balance, then the chilled water micro-relay will be in the "hold" position and both relay coils CRC (normally closed) and CRO (normally open) will be de-energized.

Under this condition with solenoid valve "F" energized and solenoid valve "G" de-energized, both sides of the hydraulic piston are subject to oil pressure which keeps the piston in a fixed position.

If the water temperature rises above the set point, the micro-relay goes to the "higher" position and relay coil CRO is energized. This energizes solenoid valve "G" permitting oil to bleed from one side of the piston (Port B) while pressure on the lower side (Port A) forces the piston open until a new temperature equilibrium position is reached.

The micro-relay will then go to the "hold" position and relay coil CRO will be de-energized causing the vanes to stop in whatever position they happen to be in.

A similar action takes place if the water temperature drops below the set point. The micro-relay goes to the "lower" position energizing relay coil CRC which will de-energize solenoid valve "F" and bleed oil from the hydraulic motor. This allows the oil pressure from solenoid valve "G" to slowly close the prewhirl vanes until a new temperature equilibrium position is reached.

3. Motor Overload Controls

Motor overload is detected by a current transformer and resistor circuit in the starter. An increase in current flow causes a change in voltage across the fixed resistor. The voltage drop across the resistor is compared to a "reference" voltage supplied in the motor overload module circuit, the value of which is set to correspond to the rated current of the compressor motor. The motor overload relays are activated by the voltage difference (between "reference" voltage and actual voltage drop across the resistor) and are located in the circuit to override the chilled water control relays.

The voltage signal between terminals 23 and 24 should be between .45 to .55 volts when the motor reaches full load amperage.

Referring to Figure 2, if the motor current flow reaches 100% of full motor rating, a micro-relay (CR_2) will open de-energizing relay CRO and solenoid valve "G" and prevent the vanes from opening further.

If the motor current continues to increase and reaches approximately 105% of full motor rating, the micro-relay (CR_1) will close energizing relay CRO, de-energizing solenoid valve "F" causing the vanes to close and reducing the load until the current is down to approximately 103%. The micro-relay CR_1 will then open causing the vanes to stop moving.

When the motor current drops below approximately 97%, micro-relay CR_2 will de-energize and the chilled water control will take over controlling the prewhirl vanes by activating relays CRC and CRO.

4. Electronic Control Bridge Circuit

The 19C electronic control is essentially a Wheatstone bridge circuit as illustrated in Figure 3. (A Wheatstone Bridge is a device used to determine the value of an unknown resistance). Voltage is applied to two legs of the bridge circuit and when the total resistance on each side of the bridge is equal, the bridge circuit will be in balance and the electronic amplifier to ground will read zero volts. Under these conditions the vanes will be in the "hold" position.

When the chilled water temperature changes, the resistance value of the resistance element will change and thus the resistance side (A) of the bridge will be different than side (B). This will produce a voltage drop between terminals X and Y or electronic amplifier and ground, and the control relays will be activated. An increase in chilled water temperature increases resistance and correspondingly a decrease in chilled water temperature decreases resistance.

This same reasoning applies to the control point adjustment and the calibration knob. Changing either one of these variable potentiometers during the adjustment of the 19C control will change the resistance of one side of the bridge and thus shift the point at which the bridge is in balance to a different chilled water temperature.

A throttling range feature is incorporated and is part of the amplifier circuit. (Not shown in Figure 3). If the throttle range adjustment is turned to its counter-clockwise stop, it has the effect of removing the vane potentiometer from the control circuit. However, if the throttle range adjustment is set for a portion of its travel, the operation of the vanes and potentiometer will override the bridge output causing the vanes to stop before the chilled water temperature reaches the set point. This prevents "hunting" of the chilled water temperature.

5. Proportioning and Floating Control

(a). General

Proportional and floating control are incorporated in the 19C electronic control system. Proportional control is generally used on comfort air conditioning applications. At partial loads it provides a lower leaving chilled water temperature and therefore a lower relative humidity in the condition spaces.

Floating control provides a constant leaving chilled water temperature. However, it is strictly an on-off control and considerable hunting of chilled water temperature may result when floating control is used on a changing load condition.

(b). Proportional Control

Proportional control permits the leaving water temperature to drop in proportion to the load as shown in Figure 4 by adding throttling range. A throttling range is used to prevent hunting. The added throttle range resistance causes the amplifier to sense that the chilled water is hotter than it actually is, thus will cool to below the set point by the amount of throttle range added. For example, assume proportional control is set to regulate to 45 F at full load. With a 3 F throttle range, the machine controls the leaving water at 42 F when the vanes are in the closed position.

In most instances only a minimum amount of throttle range is desirable for good control and system performance. The throttling range is adjustable from 0 to 10 on the re-designed Barber-Colman control.

Limits govern the vane position when the temperature is changing. The upper limit as shown in Figure 4 shows vane positions when the temperature is increasing and the lower limit shows vane positions when the temperature is decreasing. The area between the limits is called the "dead zone". As long as the leaving water temperature remains in this zone, the vanes will be stationary.

The addition of throttling range will cause a shift in the chilled water control point. The electronic controls should be adjusted to obtain design chilled water temperature at full load conditions.

(c). Floating Control

Floating control does not incorporate the throttling range adjustment and regulates the leaving chilled water within the differential setting of the design temperature under steady operating loads. Under fluctuating load conditions, floating control has a tendency to over-position the capacity prewhirl vanes which may result in a hunting chilled water temperature. See Figure 5.

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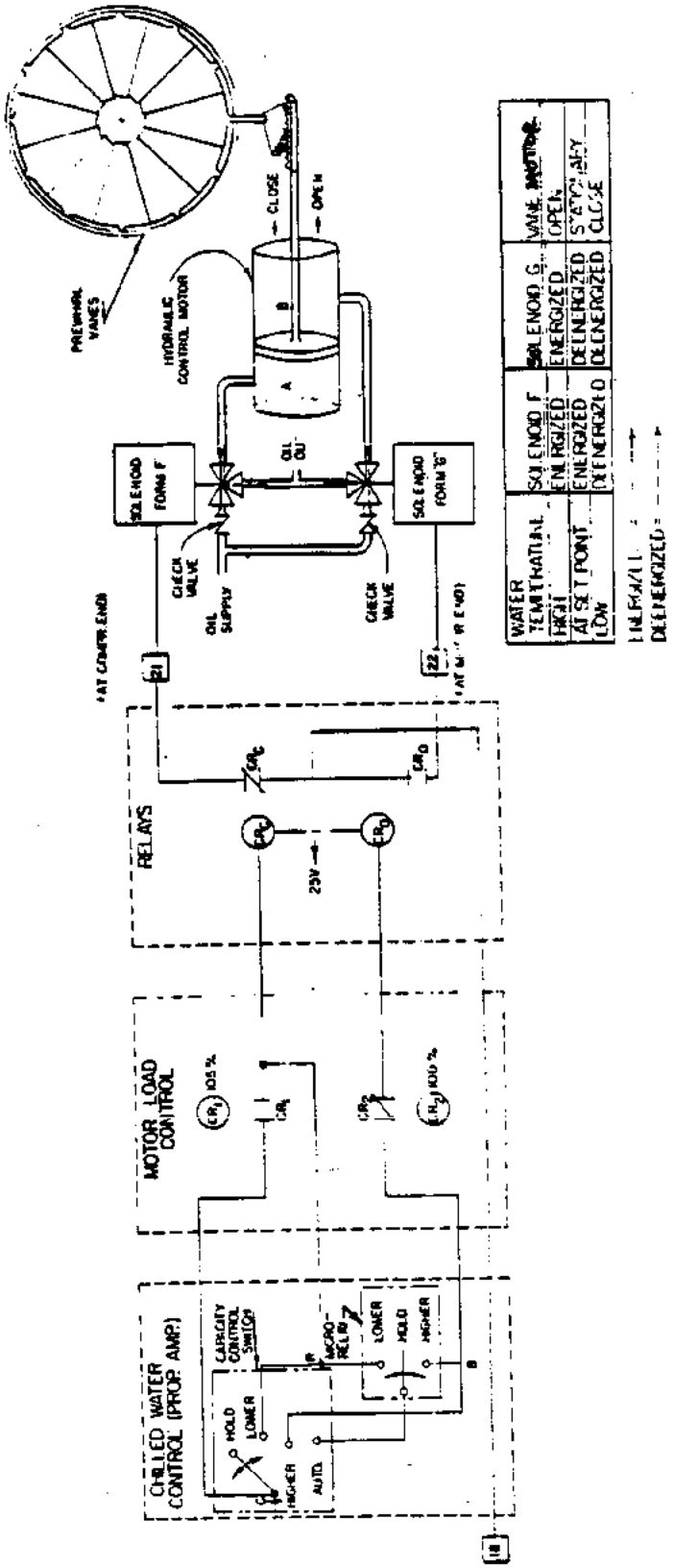

FIGURE 2
BARBER-COLMAN CONTROL DIAGRAM

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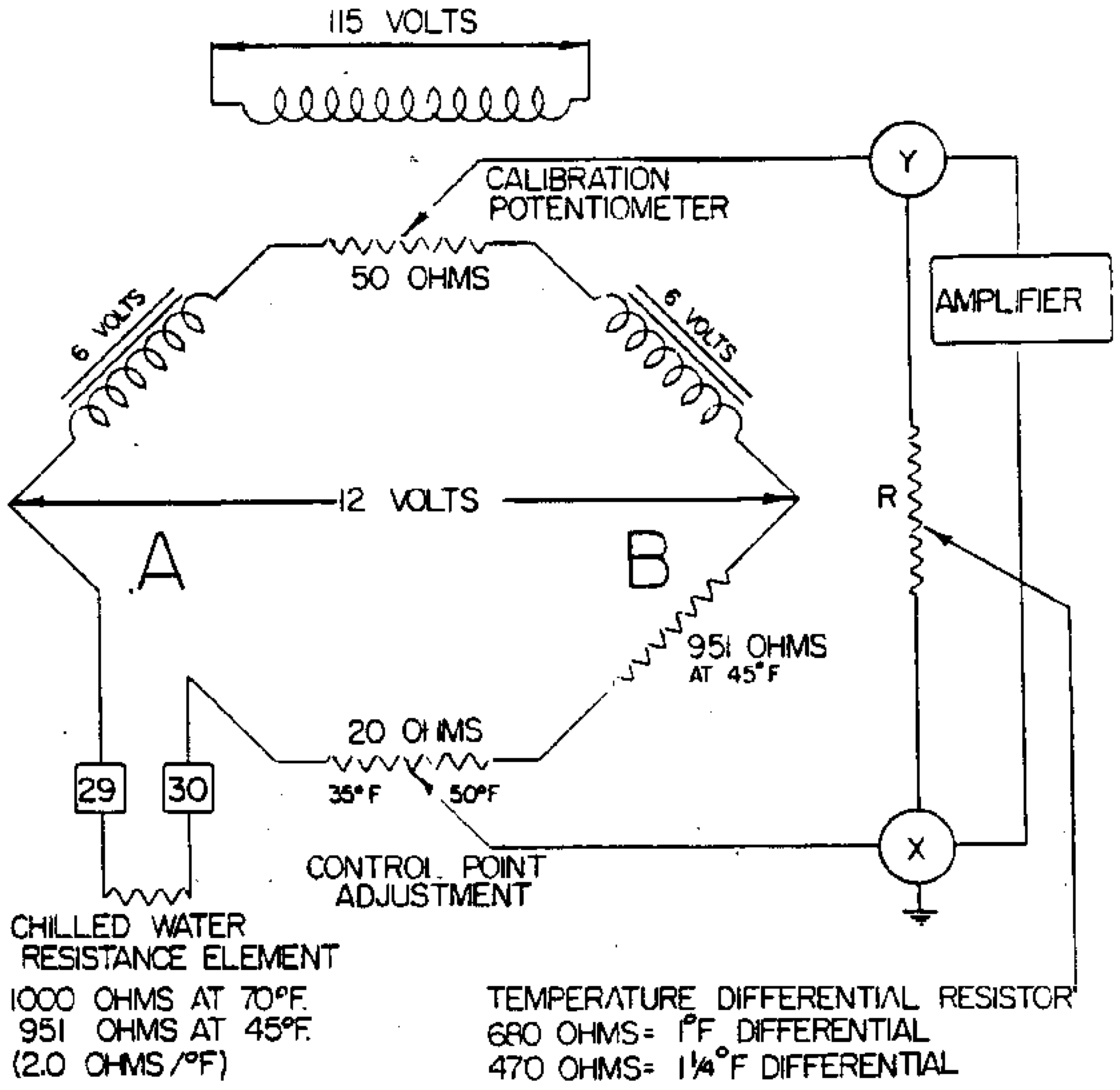

FIGURE 3
BRIDGE CIRCUIT
BARBER-COLMAN ELECTRONIC CONTROL

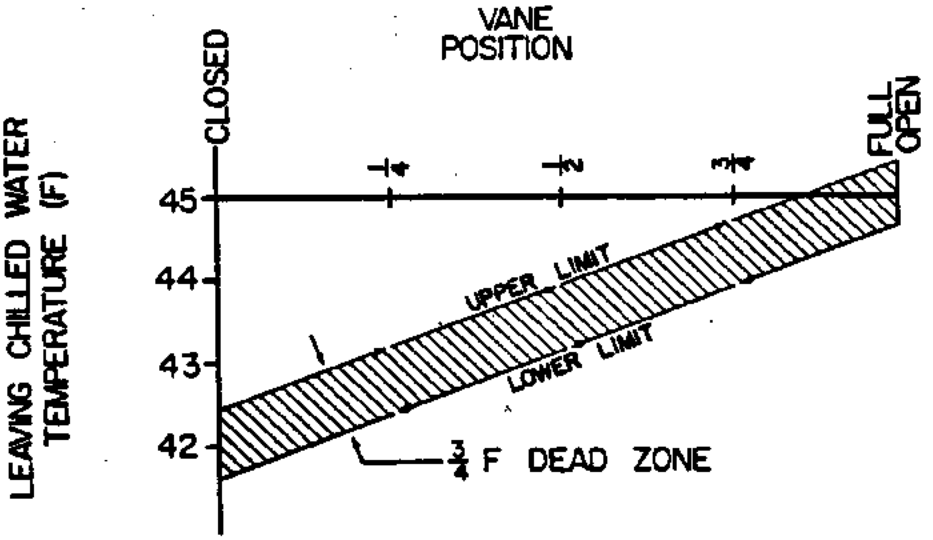

FIGURE 4
PROPORTIONING CONTROL
WITH 3 F THROTTLING RANGE

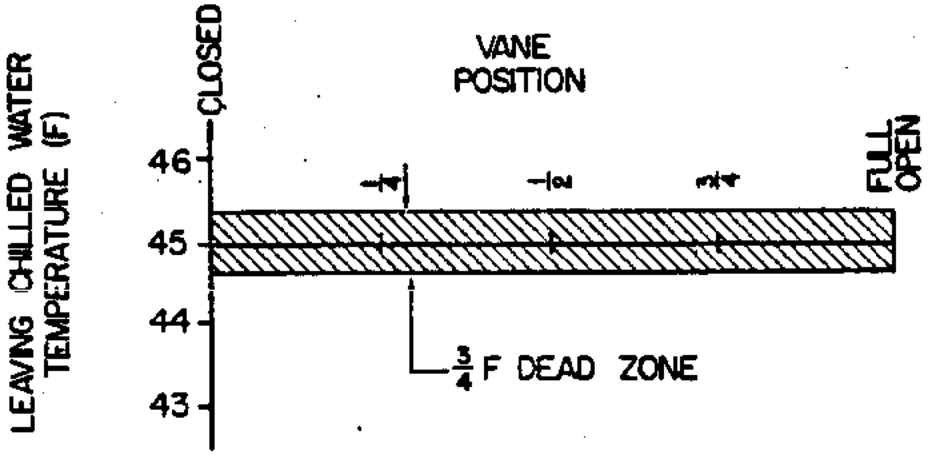

FIGURE 5
FLOATING CONTROL