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TWO PHASE INTERFACE EXCITER

by

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## ABSTRACT

A study underway to measure the diffusion of solutes across the interface of two immiscible liquids requires a means of gently agitating the interface without violently mixing it. A device using a vertically reciprocated paddle having variable size, frequency, and amplitude is described.

## RÉSUMÉ

Pour réaliser une étude visant à mesurer la diffusion de solutés à travers l'interface entre deux liquides non miscibles, il faut un moyen d'agiter légèrement l'interface sans produire un brassage violent. On décrit un appareil utilisant une pale de dimension variable qui se déplace de façon alternative dans l'axe vertical et dont la fréquence et l'amplitude du mouvement sont réglables.

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## 1.0 INTRODUCTION

Dr. A. Chau, Environmental Contaminants Division, is commencing work on a project to determine diffusion rates of solutes across the interface boundary of two immiscible or different density solvents. Part of the work will require gently moving the interface in a known and reproducible manner. The MANTEC group was asked to build a device which would excite the interface with paddles of various areas, which could be moved with variable frequencies, and amplitudes.

## 2.0 SPECIFICATIONS

In conjunction with Dr. Chau, a specification list, as follows, was derived.

Paddle diameter	2.0 cm to 10.0 cm
Amplitude of motion	
(1/2 peak to peak motion	0 to 2.0 cm
Frequency	.17 Hz to 6.80 Hz
Immersed materials	type 304 or 316 stainless steel
Wave form	sine wave

## 3.0 DISCUSSION

The finished unit is shown in Figure 1. Construction of the frame and structure is of 6061-T6 or 6063-T6 aluminum alloy for strength and corrosion resistance combined with lightness. Safety shields are of polycarbonate.

The operating mechanism is driven by a variable speed gear motor governed by a Silicon Controlled Rectifier (S.C.R.) controller.

The oscillatory device is a modified Scotch Yoke mechanism having an adjustable throw and providing true simple harmonic motion,

unlike a crank mechanism which only approaches S.H.M. at infinite connecting rod lengths.

Combinations of materials were chosen which were corrosion and chemical resistant, but which were self-lubricating to eliminate the danger of oil or grease contaminating the experiment.

A variety of paddles were supplied, both solid and perforated, and having varying stem lengths. Further supplies can be produced in any shape required if the diameter is held to under 10.0 cm.

#### 4.0 OPERATING INSTRUCTIONS

The speed of the unit can be adjusted between 10 and 408 rpm, corresponding to frequencies of .17 Hz and 6.80 Hz, by simply turning the dial on the controller. A full explanation of the motor controller can be found in the User's Manual included in Appendix 1. Note that when connecting the motor to the controller the yellow plug must be oriented correctly and that it is very important that the green ground wire be connected. The system can be operated on any 115 V grounded circuit capable of supplying in excess of 1.0A.

Adjustments of the throw, one half of the total excursion, of the stirrer are made by stopping the unit at the top of its stroke, and shutting off the power. An appropriate allen key is then inserted through the hole in the rear shield and the locking grubscrew eased off. A straight bladed screwdriver is then inserted through the top and used to turn the adjusting screw until the pointer lines up with the desired throw, mm, as shown on the scale. The allen wrench is then used to relock the sliding block, and is removed.

Stirrers are held in place with a grubscrew on the vertical shaft. If glass stirrers are desired, a small piece of soft plastic should be inserted ahead of the screw and the screw tightened very gently to avoid breaking them.

Do not operate the system with any covers removed or with any damaged electrical cables or connectors.

Do not attempt to combine large throws with high frequency operation or excessive shaking will result.

The whole unit can be raised and lowered on its stand to accommodate various sized containers and it is locked in place with two swing bolts.

Standard laboratory rods and hardware can be used to secure it to a bench or steady it as required.

## 5.0 CONCLUSIONS

This unit has the capability of being used to agitate fluids from very soft and slow to moderately strong and quick in small containers.

It can also excite waves at the interface in a large container if used at slow speeds, especially at resonance conditions.

A variety of special paddles can be mounted to give various effects in widely differing containers.

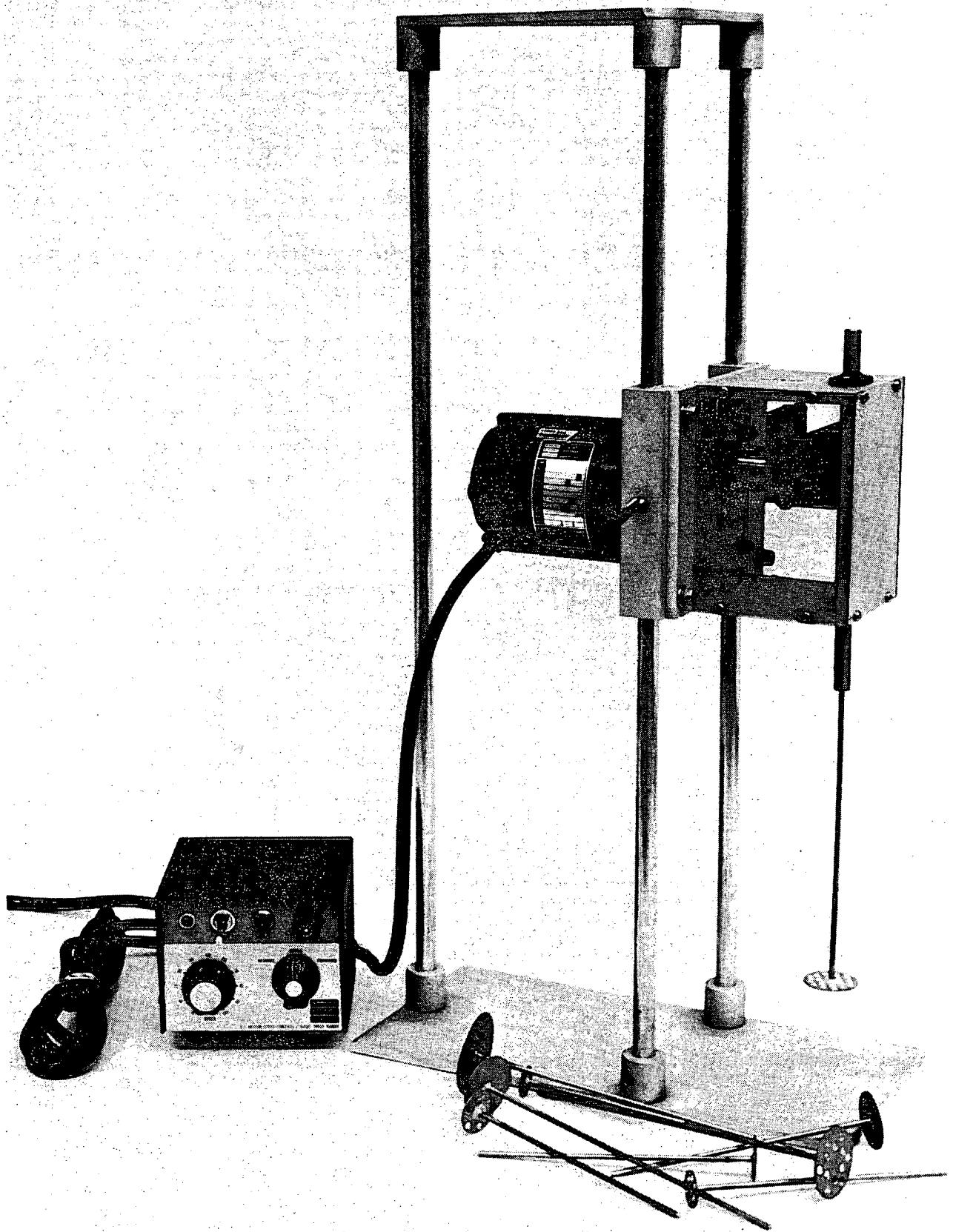
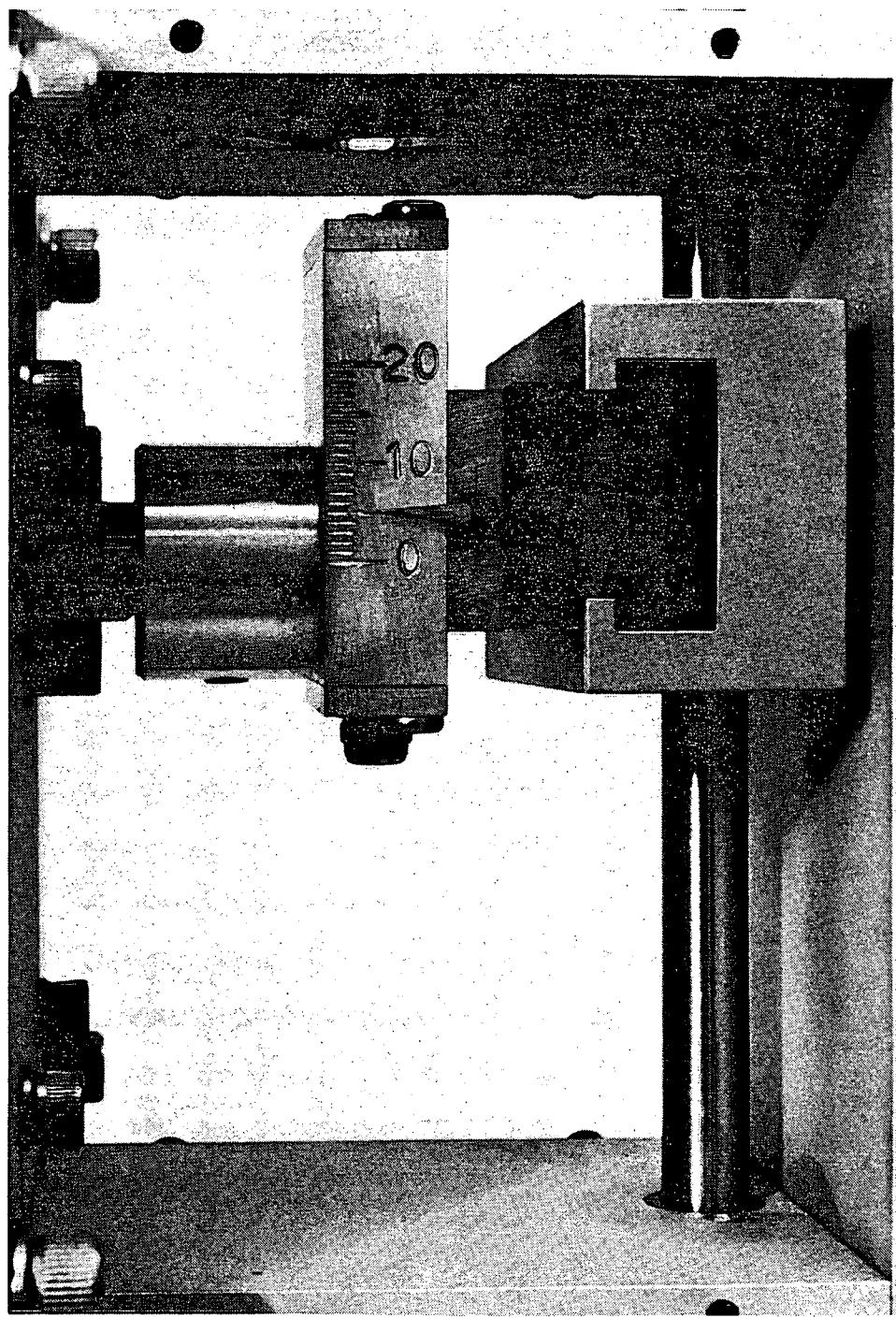


FIGURE 1

PHOTOGRAPH OF UNIT



**FIGURE 2**

**CLOSEUP OF SCOTCH YOKE**

**APPENDIX 1**

User's Manual  
Shunt Wound Motor  
Speed/Torque Controls  
(115V 50/60 Hz)

BODINE  
ELECTRIC  
COMPANY

BODINE ELECTRIC COMPANY  
2500 W. Bradley Place  
Chicago, Illinois 60618  
Phone: 312 478-3515  
Telex: 25-39346

BODINE<sup>®</sup>  
ELECTRIC  
COMPANY

## NOTES

- (1) **WARNING**—No work should be performed on the control while the control is attached to the A-C line.
- (2) Normal field repairs should be limited to replacing the entire printed circuit board assembly. Bodine P.C. boards are built to comply to U.L. recognition requirements. If assurance of continued compliance is desired, then all repairs to these boards should be done by the Bodine Electric Company. If equivalent parts are not used in the repair or replacement of defective components and if repairs are not made in a safe manner, then improper spacings and potential fire and/or shock hazards may be created.
- (3) Emergency field type repairs should only be made by qualified electronic technicians. (Repairs made by persons not authorized by the Bodine Electric Company void warranty.)
- (4) This manual does not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance—and no warranty of fitness for purpose is expressed or implied. Should further information be desired or should particular problems arise which are not covered sufficiently for the user's purpose, the matter should be referred to the Bodine Electric Company.
- (5) The issuance of this manual does not confer to the recipient any license to manufacture under any patents owned or controlled by the Bodine Electric Company (reference U.S. Patent No. 3,475,672).

All data subject to change without notice. Copyright © 1978 Bodine Electric Co.

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### BODINE LIMITED WARRANTY

The Bodine Electric Company warrants all products manufactured by it to be free of defects in workmanship and materials when used under Normal Operating Conditions and when applied in accordance with applicable specifications. This warranty shall be in effect for a period of twelve months from the date of purchase or eighteen months from date of manufacture, whichever comes first.

The Bodine Electric Company will repair or replace at its option, any of its products which has been found to be defective and is within the warranty period, provided that the product is shipped freight prepaid, with previous authorization, to Bodine's plant in Chicago, Illinois 60618 U.S.A., or to the nearest Bodine Authorized Service Center. At its option, all return shipments are F.O.B. Bodine's plant or Authorized Service shipper, except products to or from Bodine.

The warranty is in lieu of buy other expressed or implied warranty—including (but not limited to) any implied warranties of merchantability and/or fitness for a particular use or purpose.

Bodine's liability under this warranty shall be solely limited to repair or replacement of the Bodine product. Within the warranty period and Bodine shall not be liable, under any circumstances, for any consequential, incidental or indirect damages or expenses associated with the warranted products.

Commutator and/or brush wear and its associated effects are a normal occurrence and are not covered by this warranty unless otherwise agreed to by Bodine in writing. Any Bodine product which is damaged due to misuse, abuse, negligence or has been modified or damaged without the knowledge of written consent of Bodine, is not covered by this warranty.

Congratulations...and thanks on your selection of a Bodine Motor Speed Control. With your new control you will find yourself enjoying the same high performance and relatively trouble free operation that have been characteristic of Bodine products since 1905. We call it ADE (After Delivery Economies).

The Bodine Electric Company prides itself on the quality of design and manufacture of its products. Great care is taken in an attempt to provide products free of defective design, workmanship, or materials. It will be considered a favor to have cases of unsatisfactory service from Bodine products brought to our attention.

## RECEIVING INSPECTION

Examine for damage from shipment before connecting. Any claim(s) for shipping damage should be made to the freight carrier.

**Encased Controls** come with schematic diagram, mounting template and mounting hardware which consists of (4) brackets and (4) #6 (.137) x .250" long sheet metal (self-tapping) screws.

**Chassis Controls** come with schematic diagram, mounting template, control-to-motor cable with receptacle, and speed control potentiometer with dial plate and knob.

	SPEED CONTROL TYPE Encased	USER'S MANUAL CODE
Basic Speed Range	BSH-200	BSH-250
	ASH-400	ASH-450
	ASH-500	ASH-550
	ASH-600	ASH-650
Extended Speed Range	ASH-201	ASH-401
Basic Speed Range and Torque Control	ASH-402	ASH-502
	ASH-602	ASH-602

\*This information is on the nameplate of your Bodine Speed Control.

The User's Manual Code shown above will direct you to the specific information pertaining to your Control. Unless otherwise specified by the Code, all information is considered general and applies to all the above Controls.

**Example: Your Control is BSH-200 and the Code is (A).**

In the text, you may read:

"Resistance between black and red leads should be [(A) (1) 115 to 140; (B) (K) 21 to 26; (C) (Y) 10 to 15; (D) (Z) 7 to 12] ohms"

In this example, (A) and (D) have the same value—"115 to 140." Following Code (A), you should read:

"Resistance between black and red leads should be 115 to 140 ohms."

## HOW TO USE THIS MANUAL

The Bodine Shunt Wound Adjustable Speed/Torque Drive System requires a minimum amount of maintenance and attention to keep it in good operating condition. The system consists of a shunt wound drive (motor or gearmotor) and a perfectly matched SCR control! Your control unit may be of the encased type or chassis type. Both utilize the same high quality components.

This manual contains general and specific information on the following types of Bodine Speed Controls.

## SAFETY

"The use of electric motors and generators, like that of all other utilization of concentrated power, is potentially hazardous. The degree of hazard can be greatly reduced by proper design, selection, installation, and use, but hazards cannot be completely eliminated. The reduction of hazard is the joint responsibility of the user, the manufacturer of the driven or driving equipment, and the manufacturer of the motor or gearmotor." ■

Bodine products are designed and manufactured to comply to applicable safety standards and in particular to those issued by ANSI (American National Standards Institute), NEMA (National Electrical Manufacturers Association), U.L. (Underwriters Laboratories, Inc.), and CSA (Canadian Standards Association).

Most Bodine Products are "third party approved" with respect to construction. Shunt Wound chassis-type controls "recognized by U.L., Inc." are designated by having a number within a circle (e.g. ①, ②) in the upper right hand corner of their nameplates. In addition, most products are CSA certified. If you need specific information regarding the "third party approval" status of Bodine products, contact the nearest Bodine representative, or the home office.

However, since even well-built apparatus can be installed or operated in a hazardous manner, it is important that safety considerations be observed by the user. With respect to the load and environment, the user must properly select, install, and use the apparatus—for guidance on all three aspects see safety standards publication No. ANSI C51.1/NEMA MG-2. ■

## SELECTION

Before proceeding with the installation, the user should review the application to confirm that the proper drive and speed control has been selected. This should be done after reading this notice and all applicable safety standards. If in doubt, contact your Bodine Representative or the Home Office if there is no Representative in your area. Any selection or application suggestions made by Bodine are only to assist the customer—and in all cases, determination of fitness for purpose or use is solely the customer's responsibility. ■

Unless otherwise agreed to by Bodine, all control nameplate readings are based on the following *normal operating conditions*:

1. Duty—8 hours per day; 5 days per week, without frequent reversals or starts and stops.
2. Ambient temperature should not exceed 40°C (104°F) for all *enclosed* controls. For chassis-type controls, maximum ambient is 50°C (122°F).
3. Voltage—Within 10% of nameplate rating.
4. Frequency—Within 5% of nameplate rating.
5. Combined variation of voltage and frequency—Within a total of 10% providing frequency variation does not exceed 5%.

Consult Bodine if variations from the above conditions are contemplated.

■ Standards Publication No. ANSI C51.1/NEMA MG-2 "Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators."

Available from:

National Electrical Manufacturers Association  
2101 L Street, N.W.  
Washington, D.C. 20037, U.S.A.

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It is the responsibility of the equipment manufacturer or individual installing the apparatus to take diligent care in installing it. The National Electrical Code (NEC), sound local electrical and safety codes, and when applicable the Occupational Safety and Health Act (OSHA) should be followed when installing the apparatus to reduce hazards to persons and property.

Wiring—For wire sizes and electrical connections refer to the National Electrical Code (NEC)—Article 430—"Motors, Motor Circuits, and Controllers" and/or applicable local area codes. If extension cords are used, they should be kept short for minimum voltage drop and optimum performance.

## A. MOUNTING

**Enclosed Control Only—Hardware**, mounting template and instructions are provided with the control for sidewall (right or left), ceiling, or back-wall mounting. Use of the hardware provided automatically allows clearance for proper ventilation between the control unit and the mounting surface. The other surfaces of the control should be kept as open as possible to permit the control to ventilate. Ambient temperature should not exceed 40°C (104°F).

**Chassis Control Only**—The mounting template provided can be used to facilitate mounting of the control. The control may be mounted in any position. Ambient temperature should not exceed 50°C (122°F).

### WARNING

User must provide proper enclosure for chassis type controls. Control chassis circuitry is not at ground potential. No work should be performed on or close to the control while it is connected to the A-C line.

## B. CONNECTIONS

Follow nameplate for voltage, frequency, and phase of power supply. When connecting make sure that your control and drive unit are securely and adequately grounded—failure to ground properly may cause serious injury to personnel. If you have questions regarding connections, contact Bodine, providing serial number (NO) and (TYPE) information shown on the nameplate of the unit.

### WARNING

No work should be performed on the control while the control is connected to the A-C line. This caution also applies to the brushes of the motor. The motor must be disconnected from the control or the control de-energized before examining or replacing brushes.

### Enclosed Control Only—

1. Before making any connections, the on-off switch should be in the off position. Power connection is to standard 115 volt 50/60 Hz A-C grounded receptacle. A transformer should be used if line voltage differs by more than 10%.
2. Control receptacle and motor plug connectors must match in color or the motor will not operate.
3. GROUNDING: Before attempting to operate the control, the single pin plug (green) of the motor cable must be connected to the mating receptacle of the control cable to provide proper grounding of the motor frame.
4. For remote operation, control-to-drive leads may be extended to [ⒶⒷⒸⒹⓇⓇ] [ⓧⓧ 100; ⓒⓧ 50] feet without serious loss of speed regulation.
5. The control is supplied with a Bussman-Type ABC [Ⓐ① 3; Ⓛ⑥⑧ 6; Ⓜⓧ 8; Ⓝⓧ 15] AMP fuse for short circuit protection. A circuit breaker is also provided for overload protection.

### Chassis Control Only—

1. Basic terminal connection diagram for chassis controls is provided on page 8. Optional items for controls are packaged separately with their individual connection instructions. Refer to these instructions when connecting the optional items.
2. Power connection is to a standard 115 volt 50/60 Hz A-C source. It is recommended that a double pole, single throw (DPST) switch be used with the control for maximum safety when the control is de-energized. The input power should be off while making other connections in the system. A transformer should be used if line voltage differs by more than 10%.
3. Control and motor cable connectors must match in color or the motors will not operate.
4. GROUNDING: Chassis frame must be grounded with respect to the power source. The motor cable's single pin plug (green) must be connected to the mating receptacle of the control cable and control cable's green lead must be grounded to the chassis. This provides a ground connection to the motor frame.

## USE

### Safety Considerations

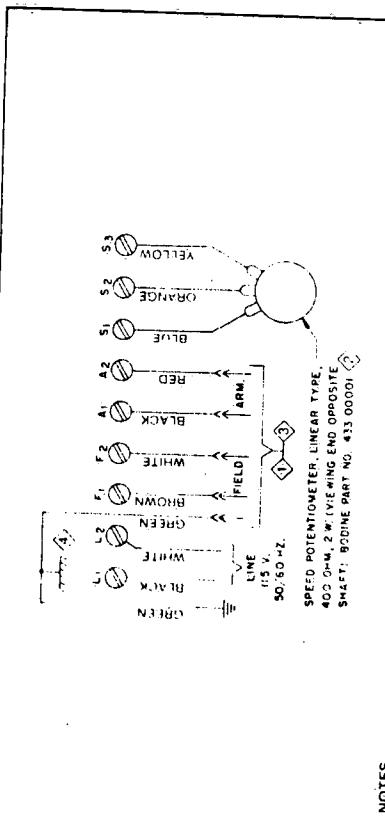
The chance of electric shocks, fires, or explosions can be reduced by giving proper consideration to the use of grounding, thermal and over current protection, type of enclosure, and good maintenance procedures.

The following information on safety considerations is not purported to be all-inclusive and the aforementioned references should be consulted.

1. Chassis controls must be properly guarded or enclosed to prevent possible human contact with "live" circuitry.
2. No work should be performed on the control unless it is disconnected from the power source. If an A-C line switch is used, the double pole, single throw type (DPST) should be used.
3. No work should be performed on the motor (including examining and replacing brushes) unless the control is disconnected from the power source or the motor is disconnected from the control.
4. Both the control and the motor should be properly and securely grounded. See the section entitled "INSTALLATION." If the user provides his own enclosure for a chassis or P.C. board control, it should be grounded also.
5. Do not insert objects into the ventilation openings of products.
6. Sparking of brushes in commutator type motors can be expected during normal operation. In addition, enclosures may eject flame in the event of a failure. Therefore, avoid, protect from, or prevent the presence of flammable or combustible materials in the area of motors, gearmotors and controls.
7. Bodine totally enclosed products are not explosion proof or dust ignition proof nor does Bodine offer products for hazardous locations (flammable/explosive gas, vapor, dust). When dealing with hazardous locations, an approved explosion proof or dust-ignition proof product is the recommended approach. Exceptions are allowed by the National Electrical Code: The NEC and the NEMA safety standard should be studied thoroughly before exercising this option.
8. Ventilated products are suitable for clean, dry locations where cooling air is not restricted. Enclosed products are suitable for dirty, damp locations. For outdoor use, washdowns, etc., enclosed products must be protected by a cover while still allowing adequate air flow.
9. Moisture will increase the electrical shock hazard of electrical insulation. Therefore, consideration should be given to the avoidance of (or protection from) liquids in the area of controls. Since Bodine does not offer a

### CONNECTION DIAGRAM — CHASSIS CONTROLS ONLY

#### BASIC TERMINAL CONNECTIONS FOR ALL CHASSIS CONTROLS



NOTES:  
① Control-To-Motor cable supplied is 18' long with 5 No 18 ga conductors. Extension cable may be used (Bodine Part No. 433 0007) with minimum changes in speed regulation and starting torque.

② No 18 ga leads recommended for minimum change in factory calibration leads provided by user.

③ Connection diagram shows armature connected for C.W. rotation. For C.C.W. rotation, transpose A. and A. connection. This is general start.

④ Green ground leads to be connected to steel chassis frame.

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A

Therefore, consideration should be given to the avoidance of (or protection from) liquids in the area of controls. Since Bodine does not offer a

## **STARTING**

### **A. Precautions Before Starting**

1. Before attempting to start, check all connections and fuses.
  2. Proper consideration should be given to rotating members: Before starting, be sure keys, pulleys, etc. are securely fastened. *Proper guards should be provided to prevent hazards to personnel while rotating.*
  3. Other mechanical considerations include proper mounting and alignment of products and safe loads on shafting and gearing. Do not depend upon gear friction to hold loads.
- 
- ### **B. Precautions When Starting**
1. The motor/gearmotor should be test-started in an unloaded state (because of possible reaction torque, the drive should be securely mounted when starting—even when unloaded).
  2. If the drive unit does not start promptly and run smoothly, disconnect at once.
  3. If unable to correct the problem, contact your purchase source, or a Bodine Authorized Service Center, describing the trouble in detail. Include the serial number, type, and other nameplate data. Do not dismantle the product—unless authorized by Bodine, removing screws voids the warranty.

### **B. Precautions When Starting**

1. The motor/gearmotor should be test-started in an unloaded state (because of possible reaction torque, the drive should be securely mounted when starting—even when unloaded).
2. If the drive unit does not start promptly and run smoothly, disconnect at once.
3. If unable to correct the problem, contact your purchase source, or a Bodine Authorized Service Center, describing the trouble in detail. Include the serial number, type, and other nameplate data. Do not dismantle the product—unless authorized by Bodine, removing screws voids the warranty.

### **C. Starting Procedures for Encased Controls Only**

1. With ON-OFF switch still in OFF position, set FORWARD-BRAKE-REVERSE switch at BRAKE. Set speed potentiometer at "0."
2. Switch power ON. Pilot light should light.
3. Set to either FORWARD OR REVERSE. Motor should not operate with speed potentiometer at "0."
4. Turn speed potentiometer until motor rotates. Adjust for desired speed.

**[①② ONLY]** For extended range speed, turn STANDARD speed potentiometer past "100" to actuate the extended range switch. Adjust EXT. RANGE potentiometer for desired speed.

5. If motor does not operate with pilot light on, check motor cable connections and depress circuit breaker button. (Note: If circuit breaker trips, motor is probably overloaded.) If fuse is blown due to excessive motor loading replace only with fuse of proper type and rating as indicated on the decal on the bottom of the control. If fuse is blown and motor was not locked or stalled, do not replace fuse since this may indicate a damaged control. Refer to the section entitled "Trouble Shooting—Preliminary." If unit still does not operate, return both motor and control to your distributor with a description of the malfunction.

**[③④⑤ ONLY]** Turn TORQUE potentiometer clockwise to actuate switch and adjust to desired torque level. If torque level is unknown, turn TORQUE potentiometer to "0" and set speed potentiometer to desired level. If rotation does not occur (load exceeds torque setting), check to see that motor is not locked or stalled. If safe to do so, increase the torque potentiometer setting until motor drives the load. Readjust torque and speed for desired operating levels.

### **D. Starting Procedures for Chassis Controls Only**

1. With input power OFF, set speed potentiometer at ZERO. If a Forward-Brake-Reverse (FBR) switch is used, set at BRAKE position.
2. Turn input power ON. (If FBR switch is used, set to forward or reverse.) Motor should not operate while speed potentiometer is set at zero.
3. Turn speed potentiometer until rotation occurs. Adjust for desired speed.

4. If motor does not operate, check all connections, check for over-loaded motor. If circuit breaker is used, depress button. (NOTE: Tripping of circuit breaker indicates an overloaded motor.) If fuse is blown and motor was not locked or stalled, do not replace since this may indicate a damaged control. If fuse is blown due to excessive motor loading, replace only with fuse of proper type and rating as indicated on the control identification plate. If unit does not operate after above checks, return both motor and control to your purchase source, or a Bodine Authorized Service Center, with a description of the malfunction.

## **PRINCIPLES OF OPERATION**

### **Basic Speed Control**

Bodine's unique circuitry converts the 115 V, 50/60 Hz A-C supply voltage to filtered, full-wave, near unity form factor D-C current for the drive unit. This essentially pure D-C permits wider speed range and smoother operation at low speed. It also provides longer brush life and less heating in the motor.

For a given field voltage and motor load, motor speed tends to increase as the armature voltage is increased; and decrease as the armature voltage is decreased. Following this principle, the control circuitry maintains a constant motor speed, at any particular speed setting, by varying the voltage input to the armature to compensate for speed changes due to fluctuations in motor load and line voltage. Without a control, the motor speed would tend to slow down with increased load or decreased voltage. If a patented circuit, armature voltage and current (proportional to motor load) are sensed. The difference ( $V - IR$ ) is proportional to the motor counter EMF or speed of the motor. This voltage is compared with a Zener regulated reference voltage. If the "speed voltage" is less than the reference voltage due to loading, the SCR conduction angle will be increased to provide more voltage to the armature and thus increase the armature speed. The externally connected speed potentiometer is used to adjust the reference voltage and therefore the desired drive speed.

The field supply voltage is obtained directly from a full wave bridge rectifier. The armature supply voltage is obtained from the same circuit except that it is controlled by an SCR (Silicon Controlled Rectifier). The voltage level, transmitted through the SCR to the armature, is phase controlled by a triggering circuit which in turn is dependent on the reference voltage.

The feedback circuit also detects and compensates for line voltage variations. This line voltage variation is sensed and a corrective signal is applied to cause a change in armature voltage and thus maintain a constant motor speed.

The operating characteristics of both the motor and the control would be affected by variations in ambient temperature if temperature compensation was not included. The control circuitry was designed, however, to minimize this effect in the control. In addition, the motor temperature is sensed by means of the motor field current which varies as the field resistance changes with temperature. The armature voltage is then automatically adjusted to compensate for the expected change in motor speed.

### **[J][K] ONLY Basic Speed Control with Extended Speed Range**

To obtain the extended speed range feature, a variable resistance is switched in series with the motor field winding. Increasing the resistance weakens the field and causes the motor speed to increase. In the extended speed range, load should be reduced so as not to exceed the rated horsepower of the motor.

### **[X][Y][Z] ONLY Basic Speed Control with Torque Control:**

The torque control feature is sometimes referred to as "torque limiting" or "current limiting." It limits the maximum torque that the drive can produce by limiting the maximum amount of current that the armature can draw. For a fixed field strength, motor torque is directly proportioned to the armature current.

The current limiting circuit operates independently of the speed potentiometer. Armature current is sensed through a resistor. When the pre-set armature current limit is reached, the current in the SCR triggering circuit is diverted from the normal gating circuit. Cutting back on the gating will limit the firing of the SCR, reduce the voltage to the armature, and therefore limit the motor output torque.

The torque control feature also provides "soft starting" (controlled acceleration) of loads that are essentially inertial in nature. Furthermore, it can provide a measure of protection in the event of an overload on the motor.

The torque control feature can be disengaged from the rest of the circuitry providing maximum torque capability by means of a built-in switch at the "high" end of the torque control potentiometer.

## **INTERNAL ADJUSTMENTS**

There are three "trimming" type potentiometers (denoted as "MIN," "MAX," and "REG") on the control's circuit board. These potentiometers are considered internal to the control. They have been factory adjusted for optimum performance and require no further adjustment by the user. Tampering with these components is not recommended.

However, if the application requires special settings, the following instructions are provided:

### **B. Maximum Speed Adjustment:**

The "MAX" trim pot is factory adjusted so that maximum rated speed is obtained at the highest dial setting of the external speed pot.

Maximum speed can be decreased by turning the "MAX" trim pot [Ⓐ Ⓛ Ⓜ Ⓝ Ⓞ Ⓟ Ⓠ Ⓡ Ⓢ clockwise; ⓒ Ⓣ Ⓤ Ⓥ Ⓦ Ⓧ Ⓨ Ⓩ ⓐ counter-clockwise]. Voltage between S<sub>2</sub> & S<sub>1</sub> will then be less than [Ⓐ Ⓛ Ⓝ 3.4; ⓒ Ⓣ Ⓤ 3.5; ⓔ Ⓩ ⓐ 3.7; ⓒ Ⓣ Ⓤ 3.8; ⓔ Ⓩ ⓐ 3.6] VDC.

#### **WARNING**

Use only a non-metallic or insulated adjustment tool (screwdriver) for internal adjustments. Circuit components are not at ground potential and accidental short circuiting and shock hazard may occur with conducting tools. This adjustment should be made only by qualified service personnel.

#### **CAUTION**

Users should not attempt to adjust "MAX" trim pot so as to give higher than the top rated speed since transistor damage can result in addition to a degradation in top speed performance. If top rated speed is exceeded, voltage between S<sub>2</sub> - S<sub>1</sub> will be greater than [Ⓐ Ⓛ Ⓝ 3.4; ⓒ Ⓣ Ⓤ 3.5; ⓔ Ⓩ ⓐ 3.7; ⓒ Ⓣ Ⓤ 3.8; ⓔ Ⓩ ⓐ 3.6] VDC.

### **C. Regulation Adjustment**

The "REG" trim pot is used to adjust the feedback ratio and consequently the regulation. This is a very critical adjustment which can affect the control stability and can also affect both the "MIN" and "MAX" settings. The user should not tamper with it if at all possible. However, if it has been turned out of adjustment for any reason, the following steps can be followed to obtain an approximation of the original factory settings.

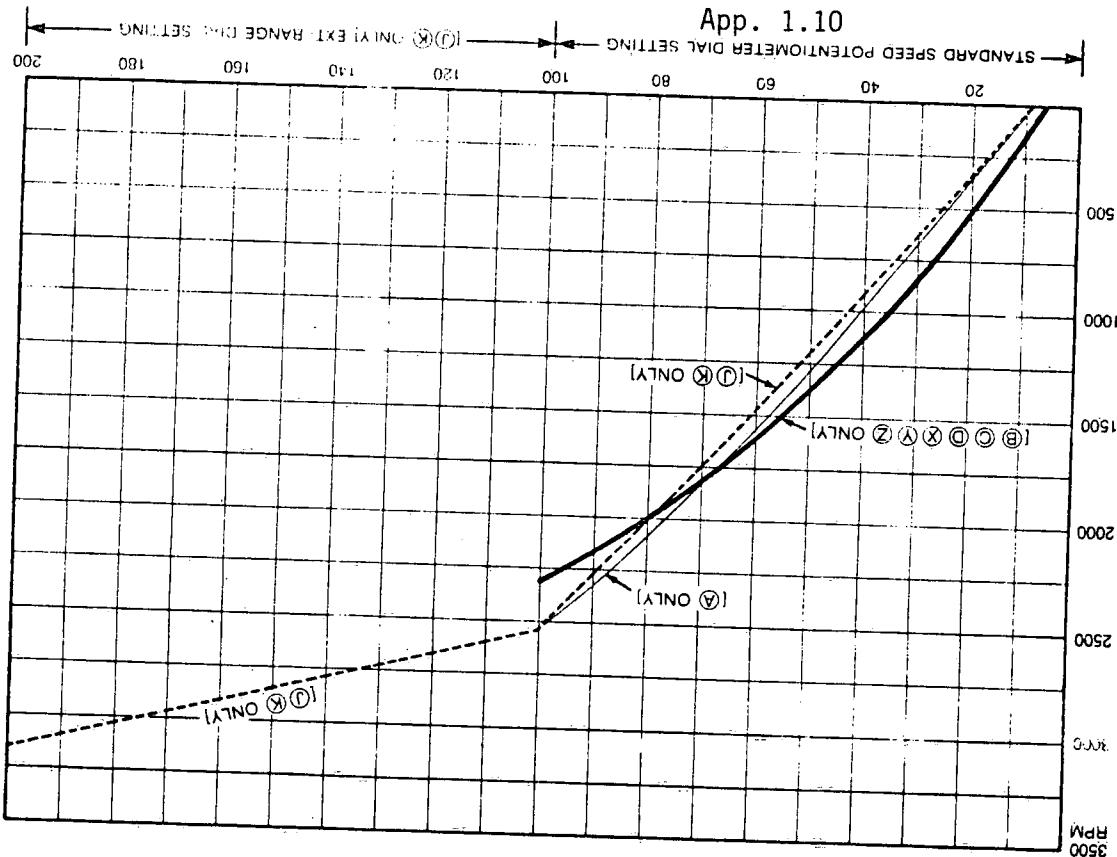
#### **[Procedures for all except Ⓛ Ⓜ]**

1. Input power to control should be exactly 115 VAC for calibration.
2. The proper motor, shown on the control nameplate, with no load must be connected to the control.
3. Turn "MIN" trim pot fully counterclockwise. (This gives zero speed at zero external speed potentiometer setting.)
4. Turn external speed potentiometer to "100."
5. Adjust "MAX" trim pot such that the voltage across S<sub>1</sub> and S<sub>2</sub> is [Ⓐ Ⓛ 3.4; ⓒ Ⓣ 3.5; ⓔ Ⓩ 3.8; ⓔ Ⓩ ⓐ 3.6] VDC.
6. Adjust "REG" trim pot such that the voltage across A<sub>1</sub> and A<sub>2</sub> is [Ⓐ Ⓛ 125; ⓒ Ⓣ 130; ⓔ Ⓩ 135; ⓔ Ⓩ ⓐ 129] VDC.

NOTE: "MIN" and "MAX" adjustments may have to be repeated several times since the two settings are interrelated.

## SPEED POTENTIOMETER CALIBRATION

A slight degree of non-linearity exists between speed potentiometer setting and motor speed. In applications where special dial settings, such as RPM or Ft/Minute must reflect the motor speed accurately, the following graph can be used as a guide:



### [Procedures for (J)(X) only]

1. Input power to control should be exactly 115 VAC for calibration.
2. The proper motor, shown on the control nameplate, with *no load* must be connected to the control.
3. Turn the "MIN" trim pot to the center position.
4. Set the STANDARD speed pot at "100"; EXT. RANGE pot at "100."
5. Adjust the "MAX" trim pot such that the voltage across S<sub>1</sub> and S<sub>2</sub> is [(J) 3.4 (K) 3.7].
6. Turn the STANDARD speed pot to "10." Turn the "MIN" trim pot clockwise until motor shaft stops rotating.
7. Turn the STANDARD speed pot to "100." Readjust the "MAX" trim pot to [(J) 3.4 (K) 3.7] across S<sub>1</sub> and S<sub>2</sub>.
8. Adjust the "REG" trim pot to obtain [(J) 125; (K) 138] VDC across the armature terminals A<sub>1</sub> and A<sub>2</sub>.
9. Turning the EXT. RANGE pot clockwise should cause a change in field voltage from approximately 100 VDC to 60 VDC.

## MAINTENANCE

**IMPORTANT**—Before servicing or working on equipment, disconnect power source (this applies especially to equipment using automatic restart devices instead of manual restart devices and when examining or replacing brushes on brush-type motors/gearmotors).

Clean regularly to prevent dirt and dust from interfering with ventilation.

### A. Control

The control unit should not require maintenance under normal operating conditions.

### B. Motors

Under normal operation, motor bearings in general do not require relubrication for a period of 5 years or 10,000 hours (whichever is first). However, for severe duty, more frequent bearing maintenance is required. Lubricate per Bodine Form P/N074-00045 (included with every motor or gearmotor shipment and available from Bodine upon request).

Normal maintenance of motor brushes is required. The brushes should be replaced before they are less than 0.25 inch (6mm) in length. The commutator requires periodic cleaning with a clean dry cloth and if necessary, use No. 0000 or finer sandpaper. Brush springs must always provide sufficient pressure to minimize excessive arcing and wear.

### CAUTION

After inspecting the brushes, make sure that the motor brush caps are replaced and retightened properly.

## TROUBLE SHOOTING—PRELIMINARY

### WARNING

Disconnect the control from the power source before any work is performed.

The following checks should be made first:

1. Line voltage must be 115 VAC  $\pm$  10%, 50/60 Hz.
2. Make sure all connections are correct and tight.
3. Check for motor overload. Depress circuit breaker button if one is used. If circuit breaker trips, motor is overloaded. If there is no circuit breaker, an overload will blow the line fuse; replace it with the same type as shown on the control nameplate.
4. If fuse is blown and motor was not locked or stalled, disconnect the power to the control and verify that proper fuse has been used.

If the fuse value is correct and no problem has been found from the preceding checks, refer to the following discussions of *Symptoms and Possible Causes*:

### A. Motor Does Not Run

- (a) Open A-C line—Line cord should be replaced.
- (b) Open S2 of the speed potentiometer—Check for an open circuit.
- (c) Open armature/Open field—With the motor disconnected from the control, check for an open armature or open field at the motor plug connector. Use the diagrams on page 20 to identify the pin locations of the color coded armature leads (red and black) and field leads (white and brown).

Armature resistance between the black and red leads should be [Ⓐ ⓒ 115-140; ⓑ ⓒ 21-26; ⓑ ⓒ 10-15; ⓑ ⓒ 7-12] ohms.  
Motor field resistance should be approximately [Ⓐ ⓒ 1200; ⓑ ⓒ 10; ⓑ ⓒ 760; ⓑ ⓒ 880] ohms.

**MOTOR PLUG CONNECTOR PIN DETAILS**

<b>Yellow Plug</b>	<b>Blue Plug</b>
Black	Red
Brown	Black
	Brown
	White
<b>[Ⓐ Ⓜ ONLY]</b>	
<b>Red Plug</b>	<b>Brown Plug</b>
Black	Red
Red	Black
White	Brown
Brown	White
<b>[Ⓒ Ⓡ ONLY]</b>	

**B. Motor runs at max. speed, no speed control:**

Open exists in S1 or S3 of the speed potentiometer—check for an open circuit.

**C. Fuse blows:**

Grounded or shorted armature—With the motor disconnected from the control, check resistance between motor frame and armature leads (black and red). If reading is not infinity, the armature is grounded. Resistance between black and red leads should be [Ⓐ Ⓛ 115-140; Ⓝ Ⓞ 21-26; Ⓟ Ⓠ 10-15; Ⓡ Ⓢ 7-12] ohms; if not, armature is shorted.

**D. Fuse blows when running:**

Overload condition—Check line current. More than [Ⓐ Ⓛ 1.4; Ⓝ Ⓞ 3.5; Ⓟ Ⓠ 5.0; Ⓡ Ⓢ 9.0] amps generally indicates an overload.

**E. Erratic Motor Performance**

Faulty Brushes or Commutator—Erratic performance can be caused by brushes that are incorrectly seated (thereby generating an abnormal amount of arcing) or by a commutator that is badly burned. This may be misinterpreted as a faulty control. Therefore, check for proper brush seating, brush length (see MAINTENANCE) and commutator condition to insure that these are not the causes of the erratic condition.

- (d) No armature voltage—With the motor connected to the control, the voltage across A1-A2 on the terminal strip of the chassis controls, or the black and red leads on Forward-Brake-Reverse switch of the encased controls, should be [Ⓐ Ⓛ 0-125; Ⓝ Ⓞ 0-130; Ⓟ Ⓠ 0-135; Ⓡ Ⓢ 0-129] VDC, depending on the speed potentiometer setting.
- (e) No field voltage—For encased controls, checking for field voltage by the user is not recommended since leads for such purpose are not easily accessible. For chassis controls, field voltage can be checked across F1-F2 on the terminal strip with the motor connected to the control. The reading should be approximately 100 VDC.

**[Ⓓ Ⓤ ONLY]** F1-F2 voltage should be about 100 VDC with EXT. SPEED set 100, and 60 VDC with EXT. SPEED set at 200.

**WARNING**

After inspection, make sure the brushes, springs and brush caps are properly replaced so they will not vibrate loose thereby creating shock hazards and a possible short circuit.

## TROUBLE SHOOTING—IN-DEPTH

(This section is for qualified electronic servicemen only.)

If the problem has not been located while following the preceding section, the following table of *Symptoms* and *Probable Causes* may provide further help. Refer to the schematic diagram that comes with the control. Repair should only be attempted by qualified personnel since extensive damage can be done by persons not experienced in working with printed circuit boards and components. Printed circuit and other heat sensitive parts can be ruined or impaired by excessive heat in the soldering operation. Repairs not authorized by Bodine voids warranty.

### WARNING

Disconnect the control from the power source before any repair work is performed. Before servicing P.C. boards employing capacitors, always discharge the capacitor(s) by placing a conductor across its terminals before touching the terminals with any part of your body.

### CAUTION

Circuitry is not at ground potential. Grounded tools or probes will damage the control and create electrical shock hazards. Use only insulated or non-conducting tools.

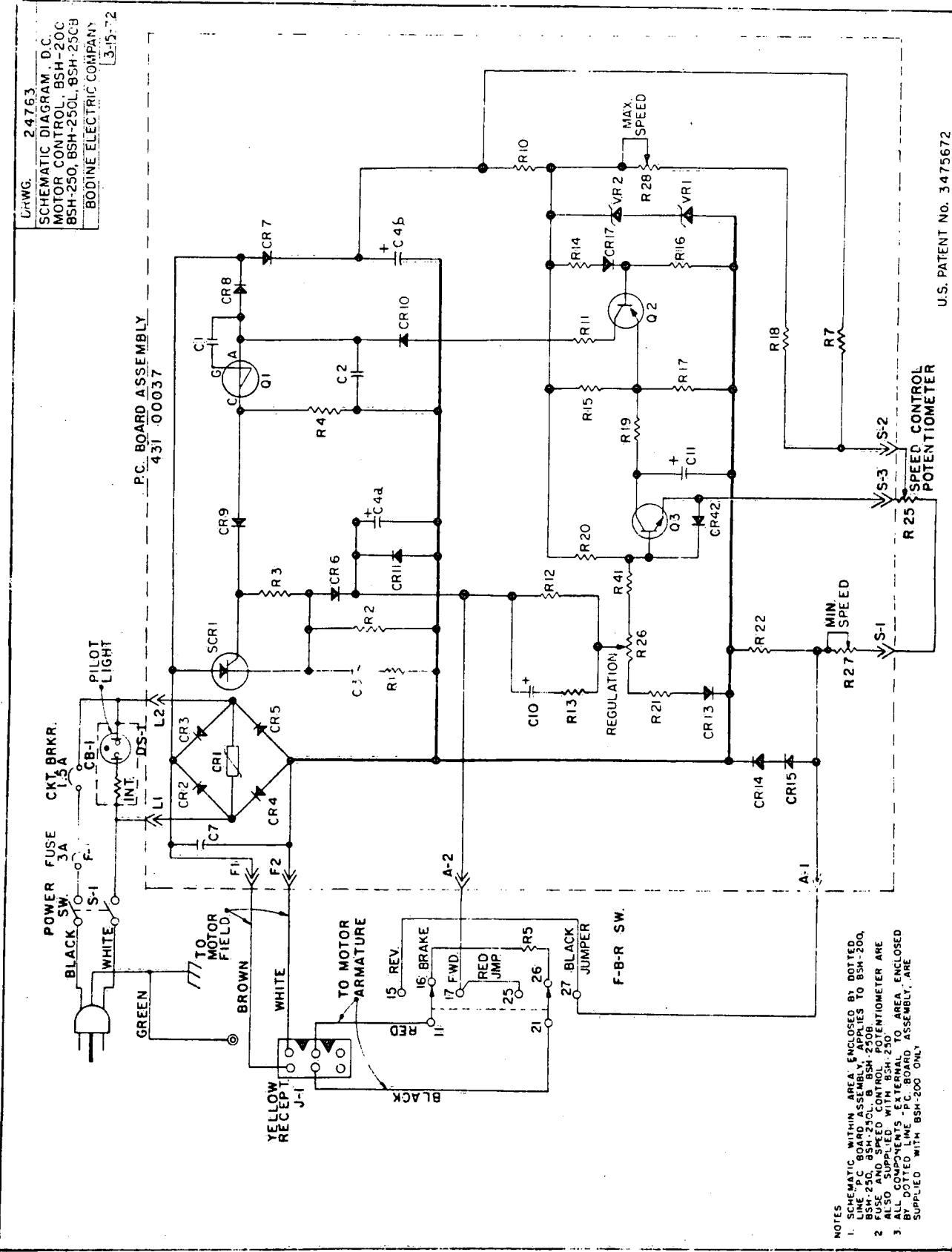
Motor runs at maximum speed, no speed control.	<b>Q-3</b> Base to emitter. SCR Anode to Cathode; Anode to Gate. <b>Q-2</b> [EXCEPT (J)(K)] Base to collector; emitter to collector.	<b>Q-3</b> Base, collector or emitter. <b>CR-17</b> [EXCEPT (J)(K)]
Motor runs at zero speed potentiometer dial setting.	<b>CR-13</b>	<b>R-22</b> [(A)(J)(K) ONLY]
Erratic performance, oscillation or poor regulation.	<b>C-10</b> [EXCEPT (A)(J)(K)] <b>CR-6</b> [EXCEPT (A)(J)(K)]	<b>C-10</b> <b>C-11</b> <b>CR-2</b> <b>CR-3</b> <b>CR-4</b> <b>CR-5</b> <b>CR-13</b> [EXCEPT (A)(J)(K)] <b>CR-14</b> [EXCEPT (A)(J)(K)] <b>R-22</b> [EXCEPT (A)(J)(K)] <b>VR-1</b> [(A)(J)(K) ONLY] <b>VR-2</b> [(A) ONLY]
		<b>R-9</b> [EXCEPT (A)(J)(K)]
		<b>CR-14</b> <b>CR-10</b> [(A)(J)(K) ONLY] <b>CR-15</b> [(A) ONLY]
		<b>CR-1</b> <b>CR-2</b> <b>CR-3</b> <b>CR-4</b> <b>CR-5</b> <b>CR-8</b> <b>CR-9</b> <b>CR-10</b> <b>CR-11</b> <b>C-3</b> <b>C-4A</b> <b>C-5</b> [(C)(J)(Y)(Z) ONLY] <b>C-6</b> [(Y)(Z) ONLY] <b>CR-6</b> [(A)(J)(K) ONLY]

SYMPTOM	Shorted Component	PROBABLE CAUSE Open Component
Motor does not run.	<b>C-11</b> <b>Q-1</b> Gate to Cathode or Anode; Cathode to Anode. <b>Q-2</b> Base to emitter. <b>Q-3</b> Base to collector; emitter to collector. <b>VR-1</b> <b>VR-2</b> [EXCEPT (J)(K)] <b>CR-17</b> [EXCEPT (J)(K)]	<b>R-10</b> <b>Q-1</b> Cathode or Anode. <b>Q-2</b> Base, collector or emitter. SCR Gate, Cathode or anode <b>CR-6</b> <b>CR-7</b> <b>CR-9</b> <b>CR-10</b> <b>CR-11</b> <b>C-3</b> <b>C-4A</b> <b>C-5</b> [(C)(J)(Y)(Z) ONLY] <b>C-6</b> [(Y)(Z) ONLY] <b>CR-6</b> [(A)(J)(K) ONLY]

# BSH - 200/250 Schematic Diagram

(P.C. BOARD #431 00037 ONLY)

Rev. 12-23-76 (MIB 3-2-78 C, 6-8-79 (MID 6-25-79) (N.E.)





PRINTED CIRCUIT BOARD COMPONENTS  
FOR BSH-200 AND ALL BSH-250  
CHASSIS TYPE CONTROLS  
HAVING BOARD NUMBER 431 00037  
IMPORTANT - READ NOTES 1 THRU 5

FORM P/N  
074 00034  
SECTION 8005  
PAGE 207  
1079

BOARD REFERENCE	DESCRIPTION	BOARD REFERENCE	DESCRIPTION
C1	Capacitor .033 MFD, 50 WVDC, 10%	R1	Resistor - 15 Ohms, 2W, 10% (Wire Wound)
C2	Capacitor .22 MFD, 50 WVDC, 10%	R2	Resistor - 6K Ohms, 5W, 10% (Wire Wound)
C3	Capacitor .068 MFD, 200 WVDC, 10%	R3	Resistor - 330 Ohms, 1/4W, 5% (Metal Glaze)
C4	Capacitor - Bodine P/N 433 00080 (Available only from Bodine)	R4	Resistor - 330 Ohms, 1/4W, 5% (Metal Glaze)
C7	Capacitor .05 MFD, 500 VAC	R5	Resistor - 100 Ohms, 3W, 10% (Wire Wound)
C10	Capacitor - 10 MFD, 200 WVDC	R7	Resistor - 56K Ohms, 1/2W, 10% (Carbon)
C11	Capacitor - 60 MFD, 15 WVDC	R10	Resistor - 6K Ohms, 7W, 5%, Bodine P/N 433 00145 (Available only from Bodine)
CR1	Varistor - Type GE V130LA2	R11	Resistor - 12K Ohms, 1/2W, 10% (Carbon)
CR2	Diode - Bodine P/N 433 00155 (Available only from Bodine)	R12	Resistor - 10K Ohms, 2W, 5% (Metal Glaze)
CR3	Diode - Bodine P/N 433 00155 (Available only from Bodine)	R13	Resistor - 6.8K Ohms, 1/2W, 10% (Carbon)
CR4	Diode - Bodine P/N 433 00155 (Available only from Bodine)	R14	Resistor - 475 Ohms, 1/4W, 1% (Metal Glaze)
CR5	Diode - Bodine P/N 433 00155 (Available only from Bodine)	R15	Resistor - 475 Ohms, 1/4W, 1% (Metal Glaze)
CR6	Diode - Bodine P/N 433 00155 (Available only from Bodine)	R16	Resistor - 3.24K Ohms, 1/4W, 1% (Metal Glaze)
CR7	Diode - Type 1N4003	R17	Resistor - 5.11K Ohms, 1/4W, 1% (Metal Glaze)
CR8	Diode - Type 1N4005	R18	Resistor - 1.5K Ohms, 1/2W, 10% (Carbon)
CR9	Diode - Type 1N4005	R19	Resistor - 6.2K Ohms, 1/2W, 5% (Carbon)
CR10	Diode - Type 1N4003	R20	Resistor - 9.09K Ohms, 1/4W, 1% (Metal Glaze)
CR11	Diode - Type 1N4003	R21	Resistor - 200 Ohms, 1/4W, 1% (Metal Glaze)
CR12	Diode - Type 1N914	R22	Resistor - 3.3 Ohms, 5W, 5% (Wire Wound)
CR14	Diode - Type 1N4003	R25	Potentiometer - 400 Ohms, 2W, 10%
CR15	Diode - Type 1N4003	R26	Potentiometer - 200 Ohms, 1/4W (Carbon Element)
CR17	Diode - Type 1N914	R27	Potentiometer - 100 Ohms, 1/4W (Carbon Element)
CR42	Diode - Type 1N914	R28	Potentiometer - 2K Ohms, 1/4W (Carbon Element)
Q1	Unilateral Switch - Type 2N4990	R41	Resistor - 200 Ohms, 1/4W, 1% (Metal Glaze)
Q2	Transistor - Type 2N4125	SCR1	Silicon Controlled Rectifier - Type 2N4188 - metal case, or Teccor Type S4008L - plastic case
Q3	Transistor - Type 2N4123	VR1	Zener Diode - Type 1N5235B
		VR2	Zener Diode - Type 1N5235B

## NOTES:

- (1) **WARNING** - No work should be performed on the control while the control is attached to the A-C line.
- (2) Normal field repairs should be limited to replacing the entire printed circuit board assembly. Bodine P.C. boards are built to comply to U.L. recognition requirements. If assurance of continued compliance is desired, then all repairs to these boards should be done by the Bodine Electric Company. If equivalent parts are not used in the repair or replacement of defective components and if repairs are not made in a safe manner, then improper spacings and potential fire and/or shock hazards may be created.
- (3) The above parts list is provided only for emergency field type repairs and then only by qualified electronic technicians using electrically nonconducting tools. (Repairs made by persons not authorized by the Bodine Electric Company void warranty.)
- (4) This "Parts List" does not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance - and no warranty of fitness for purpose is expressed or implied. Should further information be desired or should particular problems arise which are not covered sufficiently for the user's purpose, the matter should be referred to the Bodine Electric Company.
- (5) The issuance of this "Parts List" does not confer to the recipient any license to manufacture under any patents owned or controlled by the Bodine Electric Company (reference U.S. Patent No. 3,475,672).

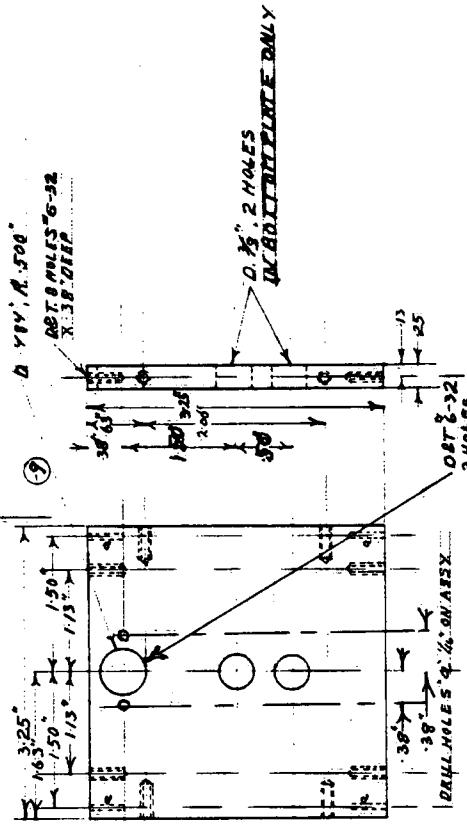
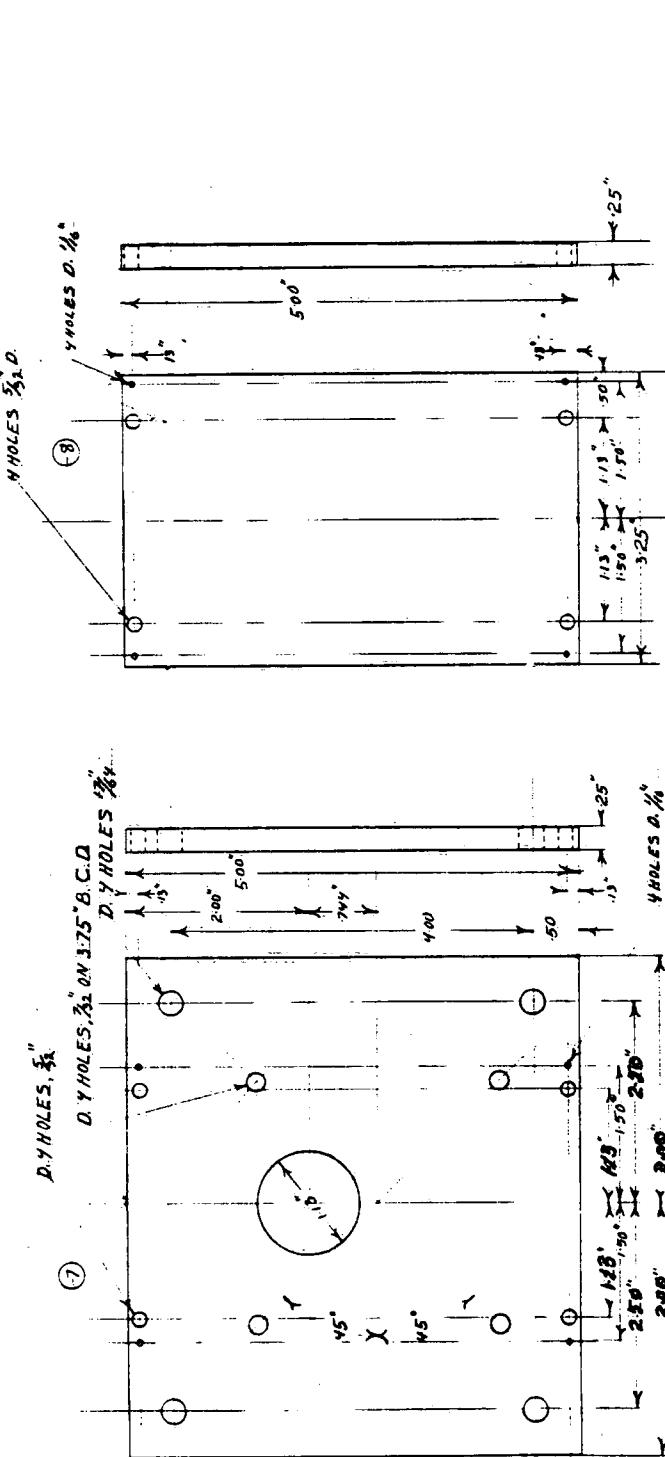
ALL DATA SUBJECT TO CHANGE WITHOUT NOTICE

Printed in U.S.A.

**APPENDIX 2**



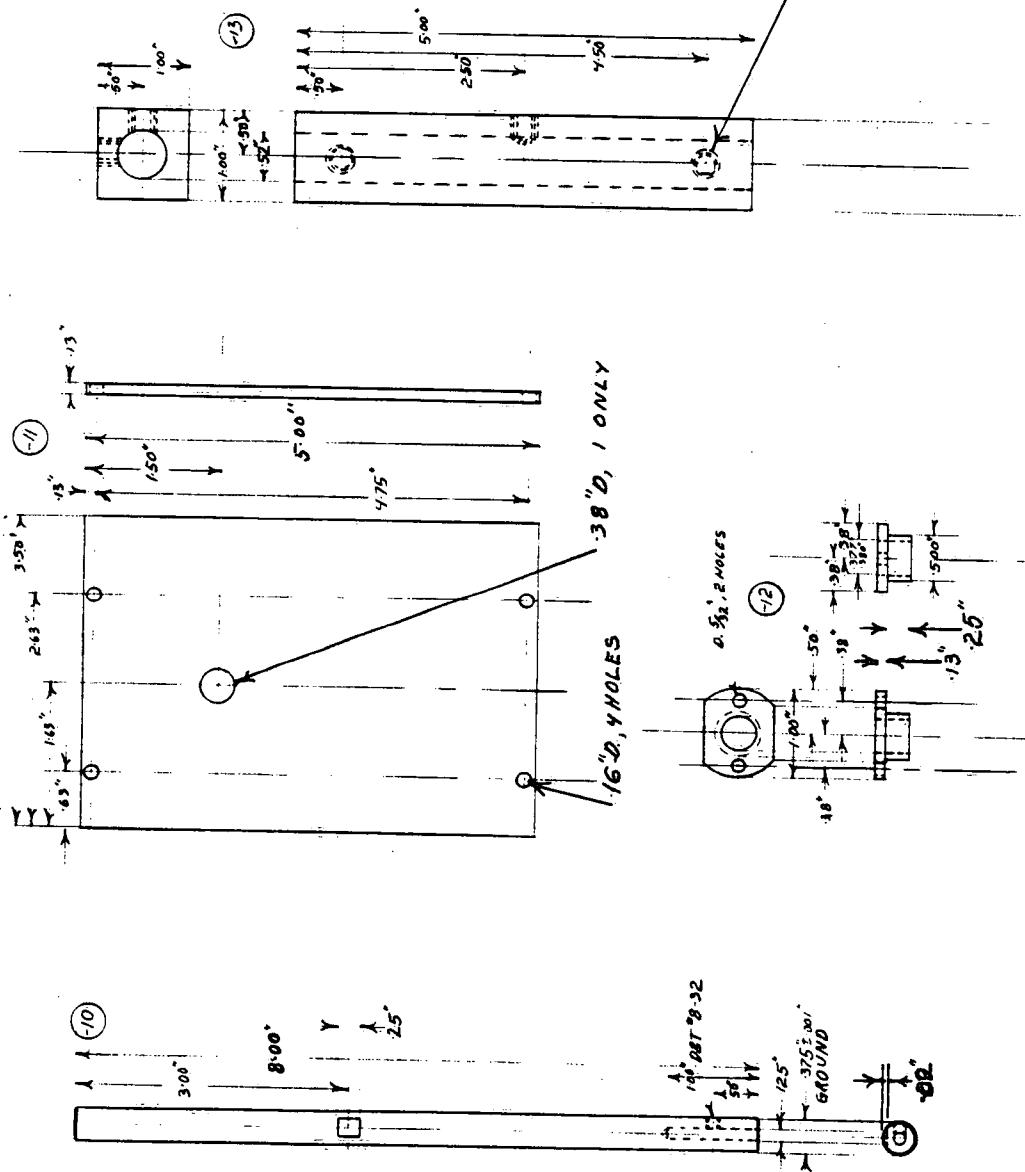
PART NO.	DESCRIPTION	QTY
-6	SILVER, 304 SS.	1
-7	M/T PLATE, 606-176 ALUM	1
	6-.32 X 1/2" K/N SS. MISC.	20
	10-.32X1/2" K/N SS. MISC.	5
	NO LOCMASTER, S.S.	4
-8	LOCKWISER, S.S.	20
	1/4" X 1/2" SS. ROLL PINS	16
-8	FLARE PLATE, 606-176 ALUM	1
-9	TOP BOTTOM PLATE, 606-176 AL	2
DSH-200	DOOR ELECT. MOTOR CONTROLLER	1
NSN-1103	BODINE 1/6 HP. ELEC. MOTOR	1
	74-20 X 28 1/2" SS. SATIN GRANITE	1



UNDER CONTRACTS SIGNED  
 THREE PLACE DIMENSIONS ± 0'  
 TWO PLACE DIMENSIONS ± 0'  
 CHARGES ± 0'  
 R. CHAMBERS  
 8 RADIALS  
 100-000  
 AA NUMBER  
 LATIONS  
 NOTE D

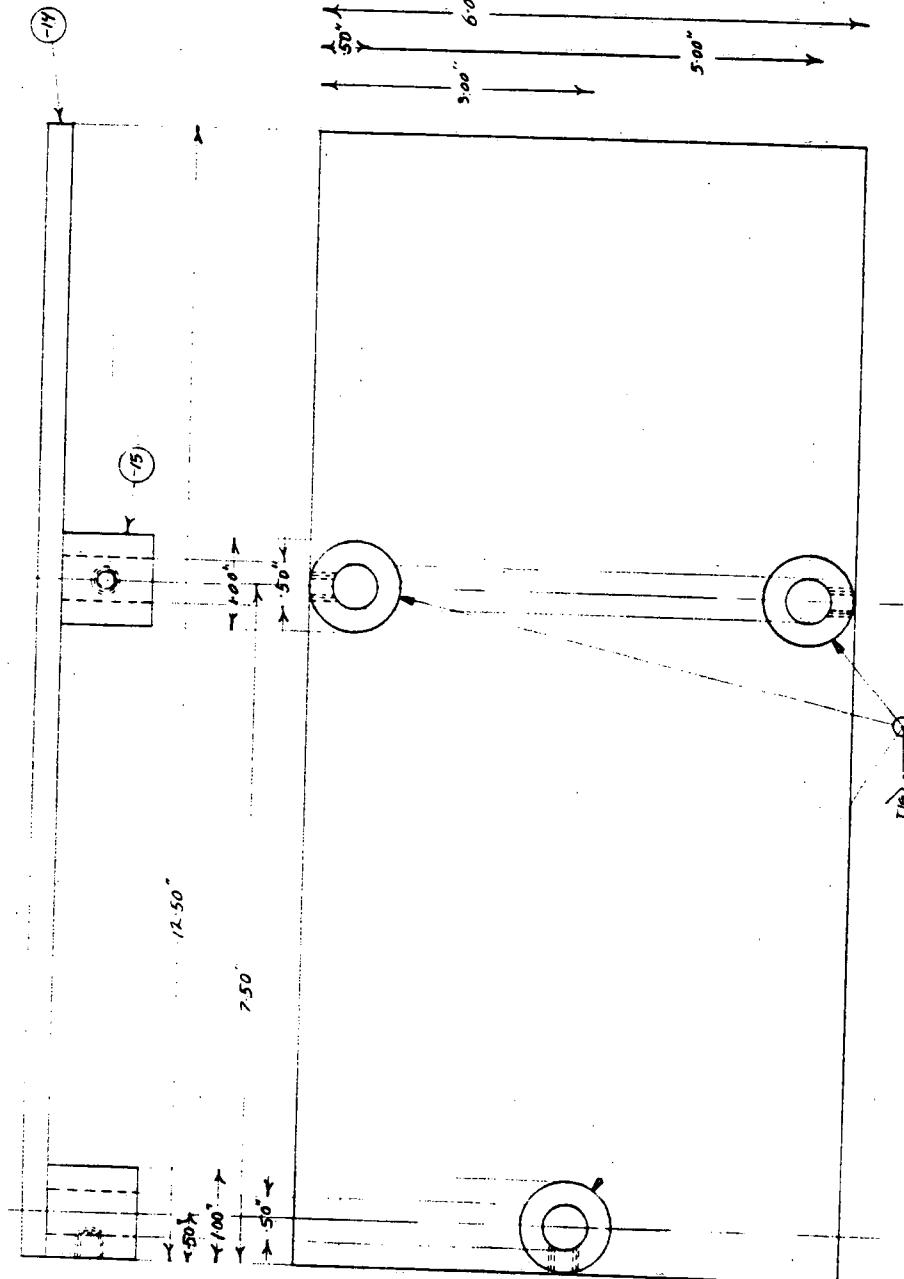
PART NO.	DESCRIPTION	QTY
-10	IND. .375 O. 25 S.M. STARTING	1
-11	C. COVERS, 1/8" POLYCARBONATE	2
W-22 X 1/8" SS. GROMMET		
-12	BEARINGS, 5/16" O.D. 1/4" I.D.	1
66-12 X 3/8" SS. MACH SCREW		
-13	HOISTS, 1/8" 50' STAINLESS STEEL	2
1/4" NC. X 1/4" HELICOIL		
1/4" NC. X 5/16" SS. NUT & NYLON		
1/4" SS. LOC WASHER		
1/4" SS. PLAT WASHER		
1/4" ACC. X 1/8" SS. THIMBLE SCREW		

	Environment Canada	Environment Canada
Canada Centre for Inland Waters	Centre Canadian des Eaux Intérieures	
<b>THE TWO PHASE INTERFACE EXCITER</b>		
<b>DETAILS</b>		
DESIGNED BY <i>J.P.</i>	CHECKED BY <i>J.P.</i>	APPROVED BY <i>J.P.</i>
DRAWN BY <i>J.P.</i>	CHECKED BY <i>J.P.</i>	DRAWING NO. <i>M/E-5208-4</i>
SCALE <i>1:500</i>	DATE <i>10/10/01</i>	SHEET OF <i>1</i>



MATERIAL SPECIFICATIONS			
A-370-D			
ITEM NO.	DESCRIPTION	DATE	REVISION
1	0.229 DIMENSIONS ADDED	2/25/65	IV

PARTS LIST		QTY
PART NO.	DESCRIPTION	
-14	4" X 1/2" PLATE 6" X 12-3/8"	1
-15	1" X 1/2" 60-DEG. 7/8" AL. BAR	3
	1/2" - 20 X 1/4" 35° GRUBSCREW	3
	1/2" - 20 X 1/4" 35° NELLICOL	3
	STICKON RUBBER FEET	4
	6-32 X 5/60 SS. EN. M.S. 1.07MM	18



**NOTE:** "6-32 X .500" F.H. S.S. MACH. SCREWS  
MAY BE SUBSTITUTED FOR WELDS



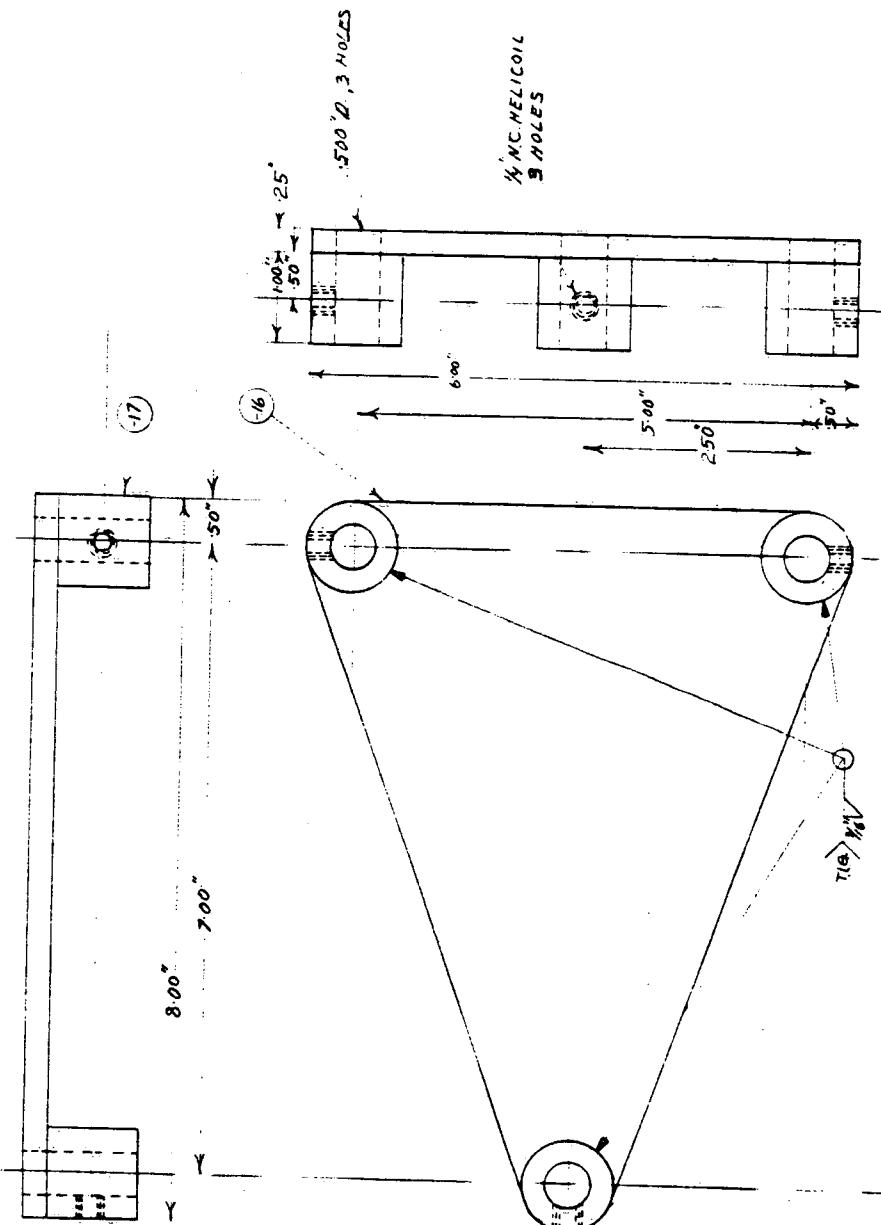
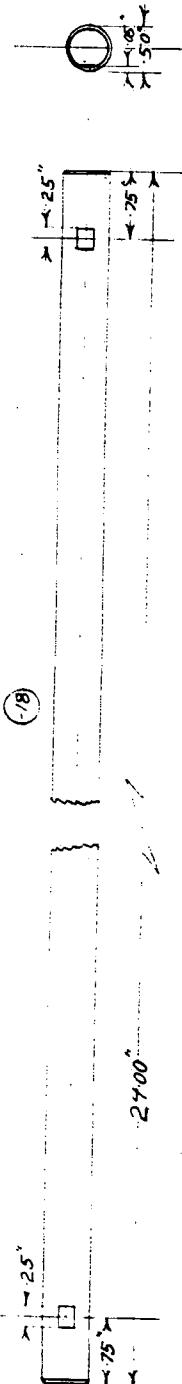
**Environment  
Canada**  
**Centre Canadien  
des Eaux Intérieures**

DESIGNED BY <i>J.C.</i>	CHECKED BY <i>J.C.</i>	APPROVED BY <i>J.C.</i>	36-642
DRAWN BY <i>J.C.</i>	CHECKED BY <i>J.C.</i>	DRAWING NO. <i>M.E.-5208-5</i>	
SCALE <i>FULL</i>	DATE <i>01/06</i>	SHEET OF <i>1</i>	

UNLESS OTHERWISE SPECIFIED		± .01"	
TOLERANCE ON THREE PLATE DIMENSIONS		TOLERANCE ON TWO PLATE DIMENSIONS	
TOLERANCE ON ANGLES		TOLERANCE ON ANGLES	
EXTERNAL CORNER CHAMFER		0.13	0.03
INTERNAL CORNER RADII		0.10	0.02
LEADS		0.05	0.01
FINISH			
MATERIAL SPECIFICATIONS		AS NOTED	
1	BY-08-29	NOTE ADDED	
NO.	DATE	DESCRIPTION	REVISION

THE JOURNAL OF CLIMATE

PARTS LIST	
PART NO.	DESCRIPTION
-16	14" X 60" T-6 AL. PLATE 6 X 8"
-17	1/2" X 60" X 76 AL. BAR X 1"
-18	1/8" X 60" X 76 AL. BAR X 2 1/2"
46-204-2555	HEICOLES
3	1/2" X 20 X 25 S. GRADScrews
3	1/2" X 25 S. GRADScrews



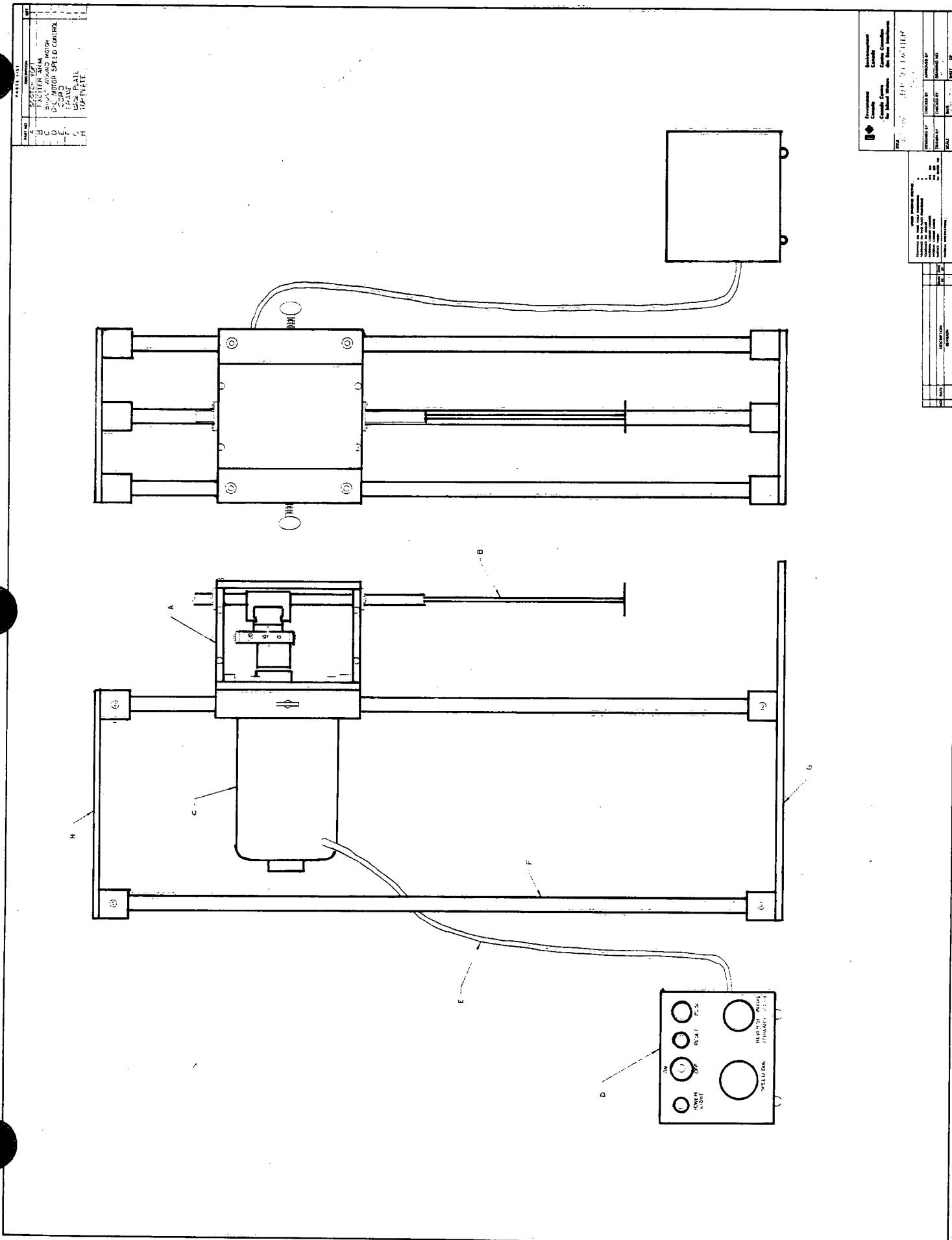
NOTE: SUBSTITUTE #6-32 X .500" F.H. SS. MACH.  
SCREWS FOR WELDING IF DESIRED.

Environment  
Canada  
Centre Canadien  
pour l'Ambiance  
des Eaux Intérieures

PROJ. # 36-642  
APPROVED BY \_\_\_\_\_  
DRAWING NO. AIE-5208-6  
CHECKED BY \_\_\_\_\_  
DATE 5/1/06  
SCALE FULL  
SHEET OF 1/16

UNLESS OTHERWISE SPECIFIED  
TOLERANCE ON THREE PLATE DIMENSIONS  
TOLERANCE ON TWO PLATE DIMENSIONS  
TOLERANCE ON ANGLES  
INTERNAL CORNER RADIUS  
INTERNAL CORNER RADIUS  
SURFACE FINISH  
MATERIAL SPECIFICATIONS  
AS NOTED

NO.	DATE	DESCRIPTION	APPROVED BY	CHECKED BY	DRAWN BY	SCALE
1	5/22/06	NOTE ADDED	J. G.	J. G.	J. G.	FULL



9759