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# OPERATION MANUAL FOR THE MARK I MODEL OF THE LASER ABSOLUTE GRAVIMETER

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16. Abstract

Discrepancies exist between the established "Potsdam" gravity values and subsequent measurements. Greater precision can be obtained by utilization of an absolute gravimeter. An absolute gravimeter using the principles of a Michelson Interferometer, an invention of Dr. O. K. Hudson, is under development at NASA's Marshall Space Flight Center, Huntsville, Alabama. The installation, operation, and maintenance of the Mark I ( Laboratory Model ) Laser Absolute Gravimeter is discussed in this document. As of this publication time, the Potsdam value has now been corrected to approximately 13.8 milligals.

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# TABLE OF CONTENTS

# LIST OF ILLUSTRATIONS

TECHNICAL MEMORANDUM X-53856

# OPERATION MANUAL FOR THE MARK I MODEL OF THE LASER ABSOLUTE GRAVIMETER

## INTRODUCTION

The purpose of this report is to provide a detailed description of the work associated with the Mark I Laser Absolute Gravimeter, and to discuss installation, operation, and maintenance of this instrument.

A scientific breakthrough appears imminent in the precise measurement of absolute gravity. Heretofore, the standard used for the value of "g" has been the "Potsdam values," which are absolute measurements established in Potsdam from 1894 to 1904. Subsequent measurements have shown the "Potsdam values" to be high by an amount between 8 to 20 milligals (1 milligal = $10^{-3}$ cm/sec$^2$). These measurements, incidentally, reflect too many discrepancies. Greater precision can only be attained by an absolute gravimeter which provides determination of error to an accuracy of not less than 1 or 2 milligals. An absolute gravimeter (utilizing the principle of a Michelson interferometer), an invention of Dr. O. K. Hudson, is being developed at NASA's Marshall Space Flight Center, Huntsville, Alabama. A key point of this gravimeter development is not only the accuracy per measurement of "g," but also the consistent repeatability accuracy for an unlimited number of measurements. The Mark I laboratory model yielded measurements of one part in $10^{-5}$. Precisions of one part in $10^{-7}$ are anticipated in later models.

Significant advantages of this instrument over prior equipment include; (1) greater precision of "g" value in a short measurement time, (2) absolute measurements can be made on the lunar surface without requirements for earth return calibration, and (3) the approach used assures independence of environment with regards to variables such as temperature, wind, dust, vibration, and radiation.

The experiment now under way is divided into two phases. Phase I, now nearing completion, is the development of a working laboratory model, and Phase II includes the design and fabrication of a portable prototype flight model which can be hand carried by an astronaut for use on the lunar surface.

# EQUIPMENT DESCRIPTION

## General

The Laser Absolute Gravimeter (Figs. 1, 2, and 3) is basically a Michelson Interferometer in which one arm, referred to as the "bird," is a free falling mass in a vacuum environment. By the use of a laser that produces a light beam, which is coherent over long distances and the wavelength is accurately known, it becomes possible to know simultaneously both the distance fallen and time required by the bird. Having these data, the acceleration of gravity is easily computed.

Experimentally, interference fringes are counted by the output of the Michelson Interferometer using a suitable photodetector. The passage of an interference fringe causes the photodetector to produce an output pulse. These pulses are counted electronically. The vacuum in the chamber is created by the Gravimeter vacuum system.

## Detailed

### LASER

The light source originates from a helium-neon continuous wave laser (Fig. 1) emitting radiation at a wavelength of 0.633 microns. This monochromatic light is highly collimated and has a beam divergence of 10 milliradians. A collimating lens (Fig. 2) is also mounted on the laser to further decrease beam divergence. A polarizing filter is provided that can be adjusted for best fringe contrast. The laser unit emits a power of 100 microwatts and is capable of a frequency stability of ±1 mHz per day as provided by a servo control system. A more specific discussion of the laser is given in Appendix A.

### OPTICAL SYSTEM

The optical system (Fig. 3) consists of the components through which the laser beam passes or is reflected. The laser beam emanates from the laser, passes through the polarizing filter and collimating lens, and is projected through a beam splitter. At the beam splitter the light breaks into two paths, one to the mirror in the bird and the other to a fixed mirror. The beam is reflected from both mirrors and reunites in the beam splitter from which it is dispersed to the photodetector.

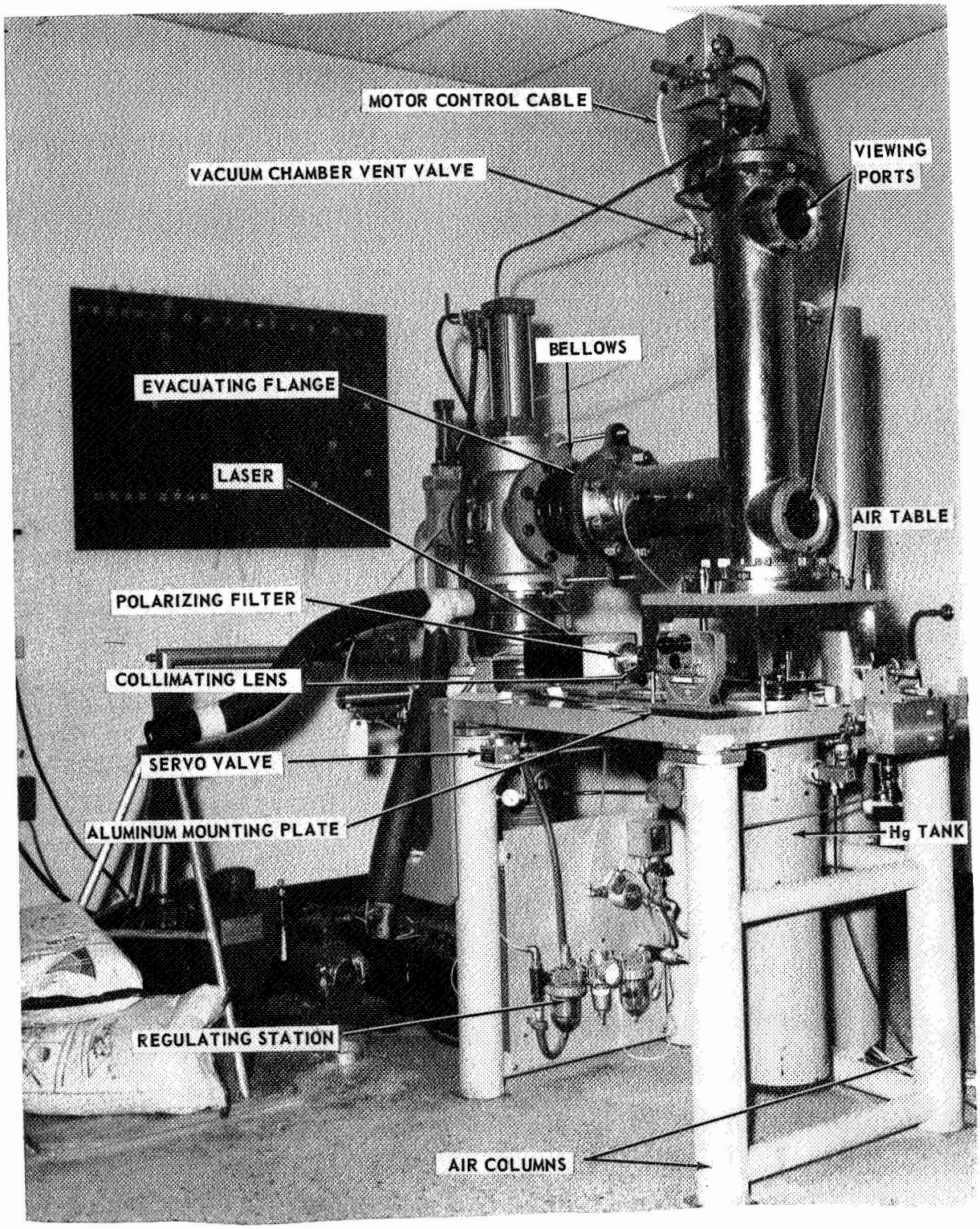


Figure 1. Laser absolute gravimeter.

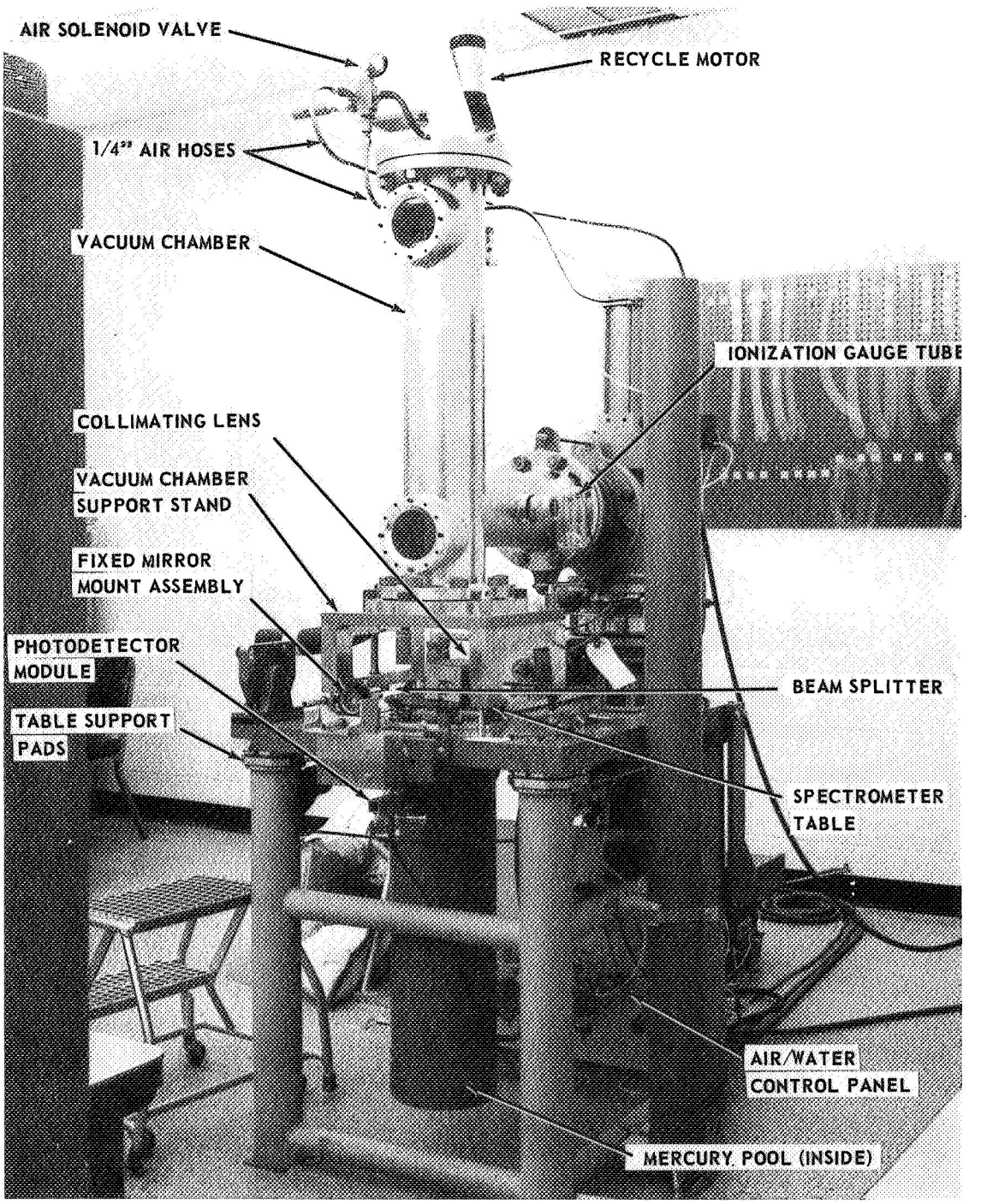


Figure 2. Gravimeter and controls.

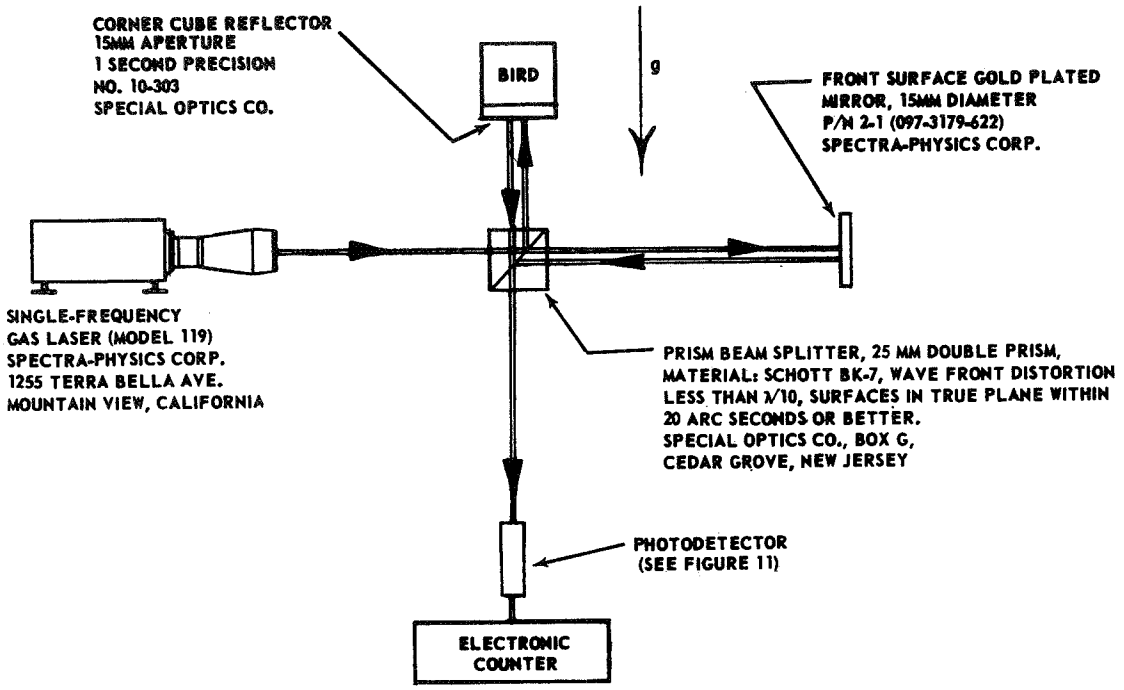


Figure 3. Principle of operation of laser gravimeter.

Beam Splitter

The beam splitter consists of two wedge-shaped pieces of glass cemented together to produce a glass cube. Its function is to split the laser beam into two beams of equal intensity. One path leads to the fixed mirror, and the other path to the mirror in the "bird." The beam is retro-reflected from each of these two mirrors, reenters the beam splitter, and is recombined to form a single beam passing through the bottom side of the beam splitter into the photodetector. A beam splitter with perfect optical characteristics which sustains no loss of efficiency would have 25 percent of the original laser beam power after recombination of the returned beams. The cube is mounted on an adjustable plate which can be moved linearly on a vertical axis, rotated around the same axis, or tilted about any horizontal axis by means of four adjustable screws.

Fixed Mirror

The fixed corner cube mirror receives one of the two resultant laser beams from the initial beam split and reflects this beam back to the beam splitter. The mirror is assembled so that it may be rotated around a horizontal and vertical axis, as well as moved linearly in a horizontal and vertical direction matching the "Brewster Window" with the fixed mirror.

Brewster Window

The laser beam passes from the beam splitter to the "bird" in the vacuum chamber and back to the beam splitter again, through a quartz plate called the "Brewster Window." This window, located in the bottom of the vacuum chamber, is inclined at the "Brewster Angle" (55 degrees 30 minutes). This prevents undesirable interference fringes which would otherwise be caused by reflections from the window surface parallel to the "g" vector, and it also reduces the amount of reflected light. The window is clamped against an O-ring to achieve a vacuum seal.

Corner Cube

After passing through the "Brewster Window" from the beam splitter, the laser beam is reflected by the corner cube reflector (the mirror mounted in the "bird"). Light reflected from the corner cube is parallel to the incoming light to a precision of ±1 second of arc. If the corner cube reflector is rotated about an axis through its optical center, it will tolerate a few degrees of rotation without producing angular rotations of the beam reflected from the "bird."

Mercury Pool

The correct alignment of the laser beam (passage of the beam from the corner cube to the photodetector) with the gravity vector is essential to the measurement of "g." The coincidence of the laser beam with the gravity vector is attained primarily by adjustment of the air-table through the servo valves. In order to judge the degree of misalignment that may be present, a mercury pool (Fig. 4) has been constructed in the bottom of a tank. This cylindrical tank is bolted to the bottom surface of the air-servo table. The photodetector, located in the upper part of the tank, can be moved through an opening cut in the tank, thereby permitting the laser beam to continue down to the mercury pool. The surface of the pool should be parallel to the air-servo table and perpendicular to the gravity vector. The exact coincidence of the laser beam and gravity vector is measured by placing a thin metal plate with a small hole at a 45 degree angle over the mercury pool. In order to achieve perfect alignment, the incident beam from the beam splitter and the reflection of light from the surface of the mercury pool must coincide as they pass through the hole. The surface of the mercury pool is covered by a layer of viscous oil to prevent vibrations from influencing the reflection from the mercury pool surface. After correct alignment has been attained, the photodetector may be placed back in its position in the tank.

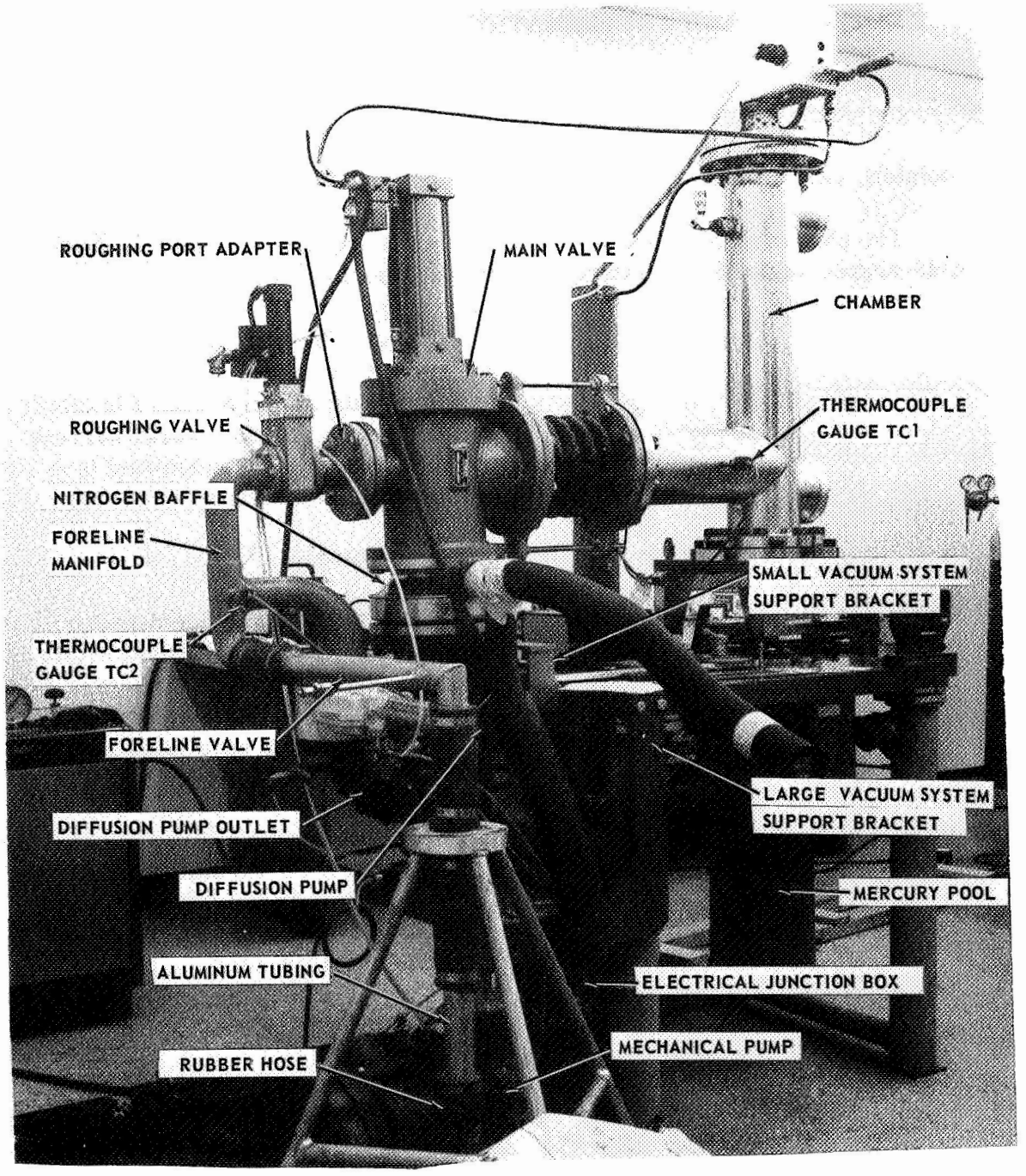


Figure 4. Gravimeter — rear view.

## LIGHT DETECTION AND AMPLIFICATION

The light detection and amplification system consists of photomultiplier and photodiode modules and a signal amplifier.

### Photomultiplier Module

The photomultiplier module (Fig. 5) contains a front surface (included at a 45-degree angle) which intercepts the two superimposed laser beams from the beam splitter. The mirror directs the light onto the cathode of the photomultiplier tube which is located within the photomultiplier module. The interference fringes generate small current variations which are transmitted by a coaxial cable to the signal amplifier.

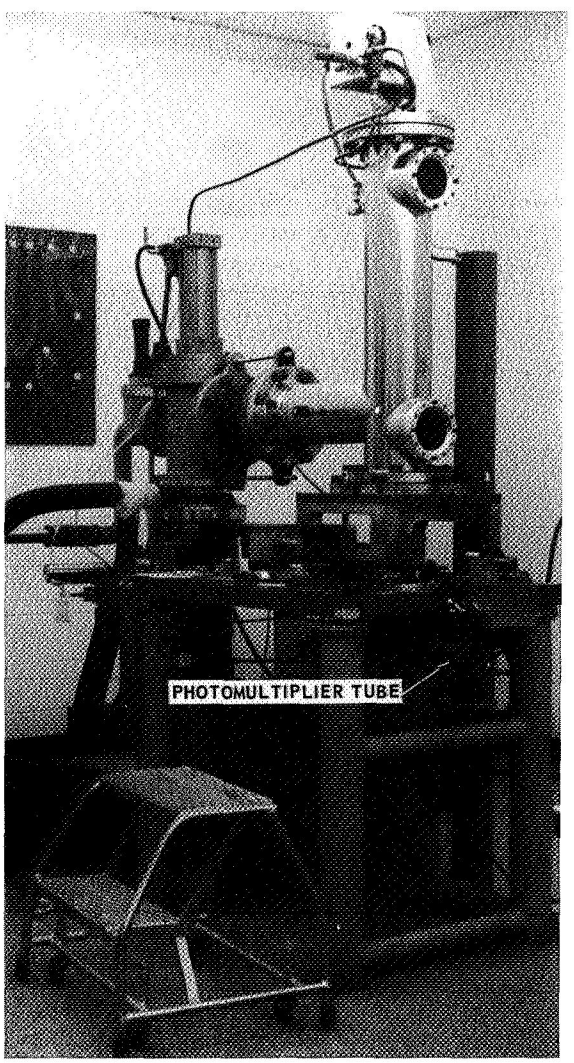


Figure 5. Photomultiplier module.

### Photodiode Module

A silicon photodiode detector and preamplifier is constructed within a module that is identical and interchangeable with the photomultiplier module. The unit is used when the laser beam is of a relatively small diameter and is very intense. The preamplifier contains a direct coupled Nuvistor amplifier and emitter follower. A separate cable is used to feed power for the unit from a regulated supply in the instrumentation rack.

### Signal Amplifier

The signal amplifier provides approximately 65-dB voltage gain for the photodetector module output signal. The signal amplifier is a commercial wideband amplifier modified for provision of high voltage to the photomultiplier tube. A schematic diagram of both probes and the amplifier modification is shown in Figure 6.

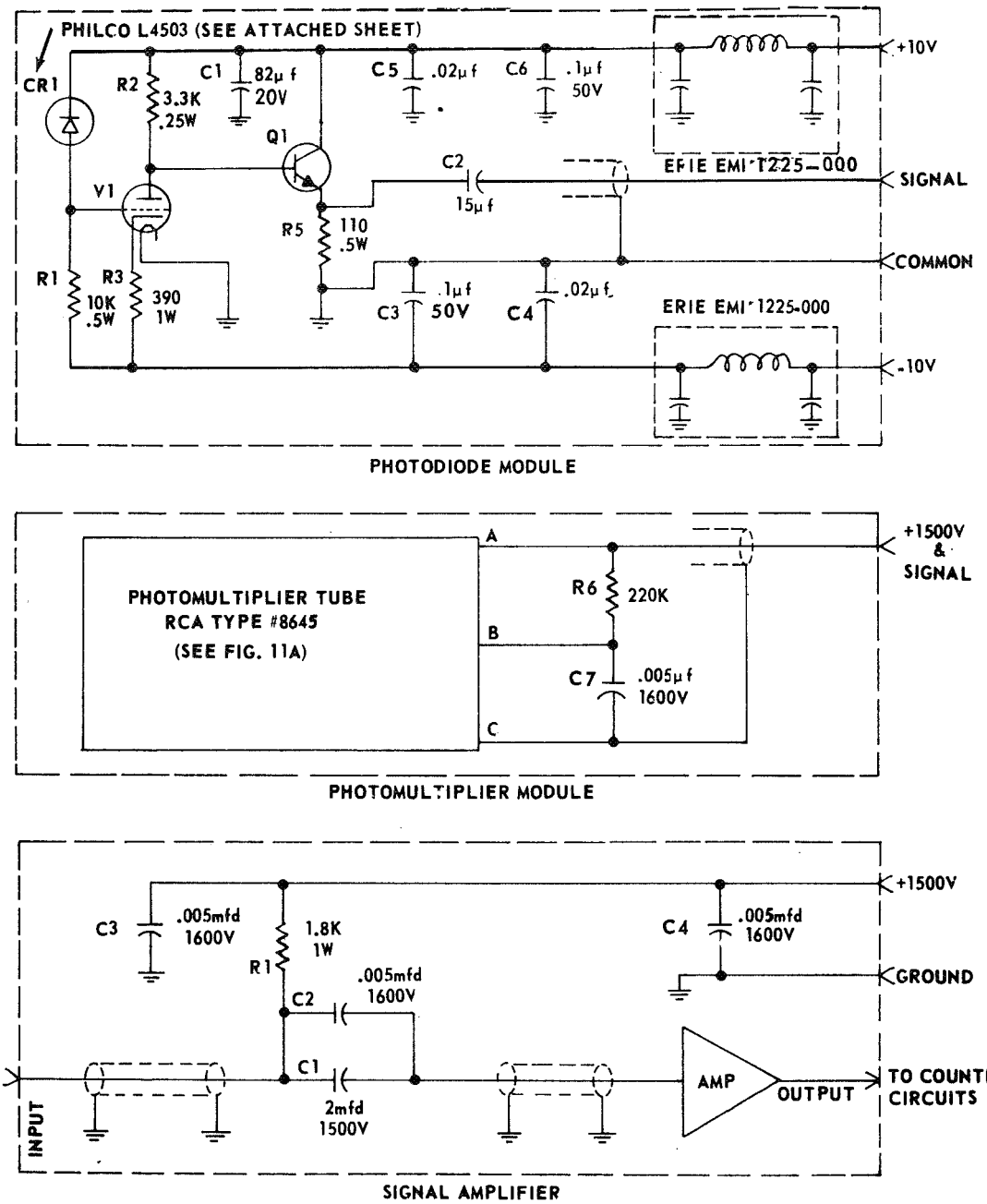


Figure 6. Schematic diagram of light detector modules and signal amplifier.

## "BIRD" RELEASE AND RECYCLE MECHANISM

The "bird," at the termination of its fall, is caught in a cup located at the bottom of the vacuum chamber and is then mechanically relifted to the top of the vacuum chamber for another drop. This operation is controlled manually from the instrumentation rack (Fig. 5) by a "reset" switch. A description of this feature follows.

### Bird Mechanical Design

The "bird" (Fig. 7) is designed to be easily caught in a cup at the bottom of its fall, and reset at the top of the vacuum chamber. The bird consists of two parts held together by small screws. It is machined of Delrin AF which is a high-impact, nonmagnetic plastic. A hole through the bottom of the bird permits entrance and exit of the laser beam. The top of the bird contains a slot which houses a 3.18-mm (0.125-inch) sapphire ball. The bird support arm supports the bird in the drop position at the top of the tank.

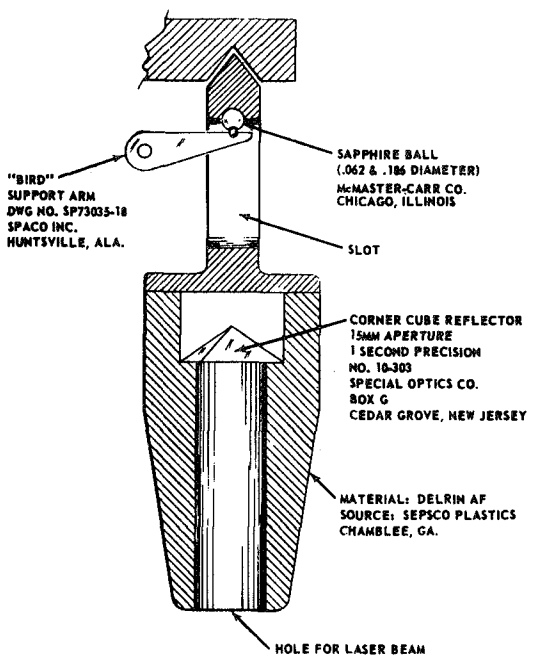


Figure 7. Bird in position on support arm.

### Release Mechanism

The bird support arm is controlled by a release mechanism (Fig. 8). The release mechanism is pneumatically operated to prevent the possibility of electrical disturbances. Fast release of the "bird" is necessary to avoid any influence on the "bird." A Delrin shaft is attached to an actuator and coupled to a horizontal rod. The bird support arm and two pinion gears (meshed with a pair of fixed rack gears) are also coupled to the horizontal rod. The release operation is activated when air pressure pushes the actuator downward; the actuator thus pushes the Delrin shaft downward; and this action pushes the horizontal rod downward. As the actuator extends, the bird support arm is simultaneously moved downward linearly and rotated. The simultaneous motion results in a rapid acceleration of the bird support arm. After the bird has been set in its ready position at the top of the vacuum chamber, air pressure is released and, with the help of a return spring, the support arm returns to its position in the slot in the bird.

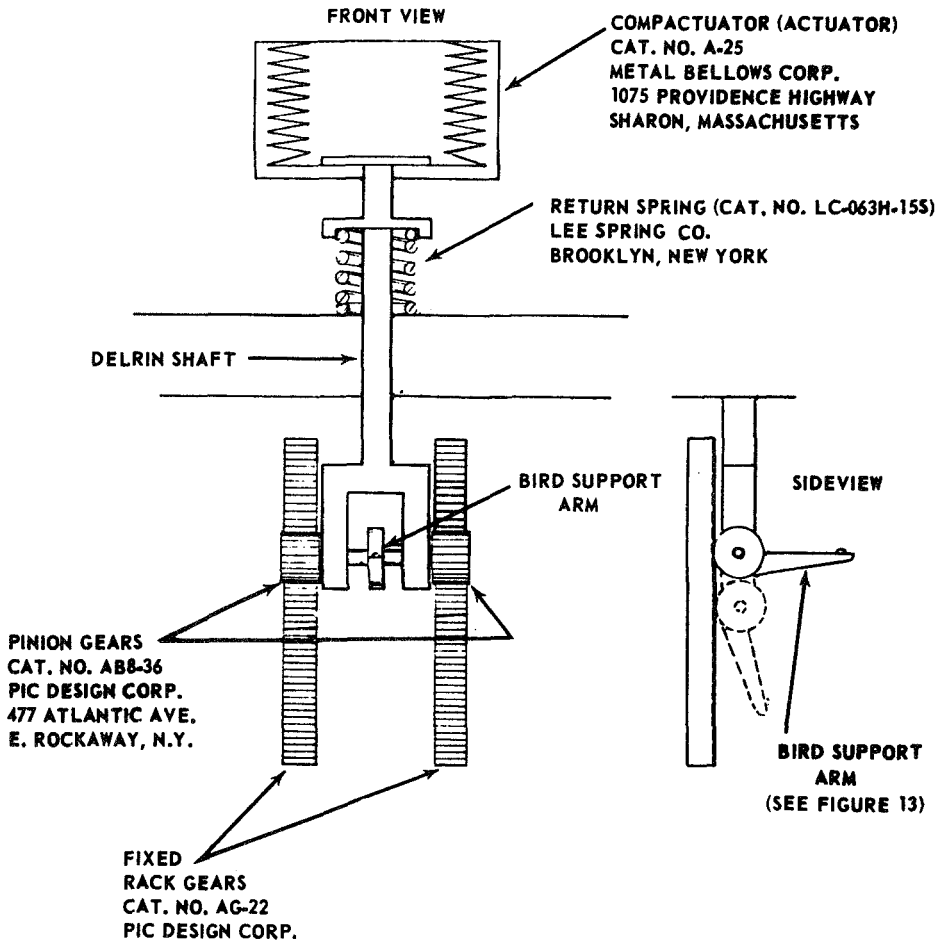


Figure 8. Detail of release mechanism.

Recycle Mechanism

Catcher. The "bird" falls into a cup-shaped receptacle, called the catcher (Fig. 9), which is designed to accept the bird at various attitudes other than vertical. In the event the "bird" does not come to rest vertically, the catcher will rotate about a vertical axis, if necessary, to reorient the bird in the opening at the top of the chamber known as the caming surface. The catcher is mounted in the catcher assembly which is coupled to a ball-screw shaft and guide rod A.

Drive Mechanism. The drive mechanism consists of the ball screw shaft which supports the catcher assembly, a shaft seal, a flexible coupling, and a drive motor (Fig. 9). Rotation of the drive motor causes the catcher assembly to move up or down the fall path by means of the ball screw shaft and guide rod A. Guide rod A prevents any rotation of the catcher assembly.

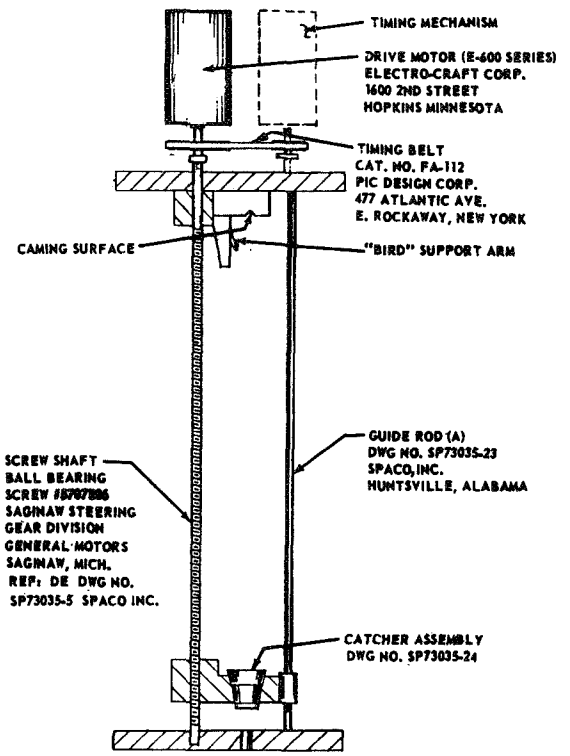


Figure 9. Recycle drive mechanism (back view).

Timing Mechanism. Through the use of a timing belt, the drive motor not only controls the movement of the catcher assembly but also the movement of the cam actuator assembly which moves up and down an auxiliary screw shaft. The timing mechanism (Fig. 10) is located outside the vacuum chamber. The auxiliary screw shaft, which has a nine-to-one ratio of the ball screw shaft in the vacuum chamber, controls the operation of air valves and the stopping or reversing of the drive motor. A cam on the cam actuator assembly moves in a helical path as the drive motor rotates to depress two microswitches located at each end of the cam travel. The cam actuator assembly, which is timed so that the cam depresses the microswitches at the beginning and end of the travel of the catcher assembly, moves in opposite directions to the catcher assembly. The timing belt also drives a 20-turn potentiometer which varies the speed of the drive motor during the cycle. Guide rod B prevents any rotation of the cam actuator assembly.

Motor Control System. The system that controls the recycle mechanism consists of the electrical sequence, and the motor control panel from which the power originates.

Electrical Sequence. The power applied to the motor control system is actuated by the "reset" switch on the motor control panel in the instrumentation rack (Fig. 11). After gradually returning the bird from its fall position and reducing to a low speed at the end of the lift, the drive motor reaches maximum

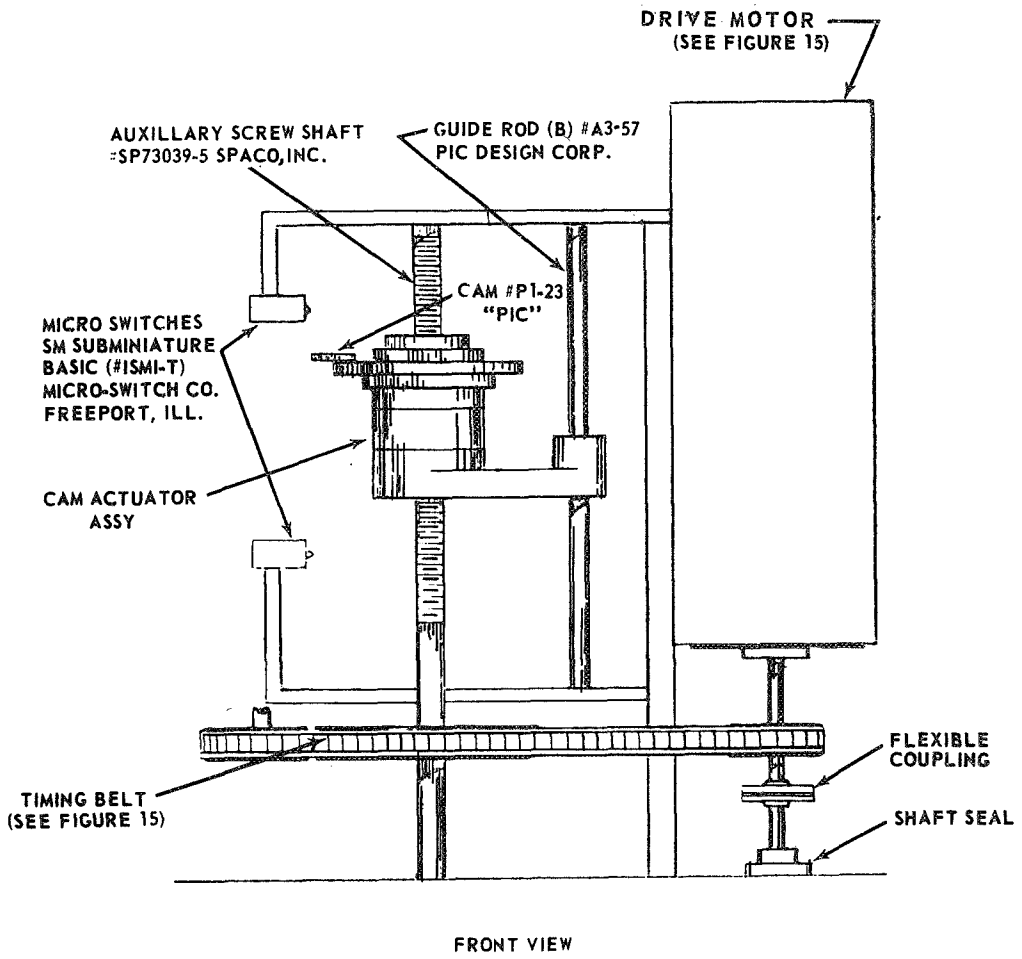


Figure 10. Timing mechanism details.

speed at the midpoint of the lift. The motor speed follows a cosine function curve and is controlled by a potentiometer. After the "bird" has been set into position for re-hanging, the cam presses the bottom microswitch which operates a solenoid valve in the air system causing the bird support arm to return to its set position. The microswitch also operates a latching relay which reverses the direction of the drive motor. The catcher assembly is then lowered in the vacuum chamber by the drive motor. The cam is timed to depress the top microswitch which cuts off all electrical power, and again a latching relay reverses the direction of the drive motor. The system is now ready for another drop.

Motor Control Panel. Except for the microswitches and solenoid valve located above the vacuum chamber, the motor control panel contains all the

electrical apparatus for control of the recycle function. The major components of the motor control panel contain all the electrical apparatus for control of the recycle function. The major components of the motor control panel include: the dc power supplies for the drive motor, amplifier, and latching relays previously mentioned; an amplifier to control the speed of the drive motor; relays to perform switching operations (reversing the direction of the drive motor) during the recycle sequence; and a pneumatic system to operate the bird support arm.

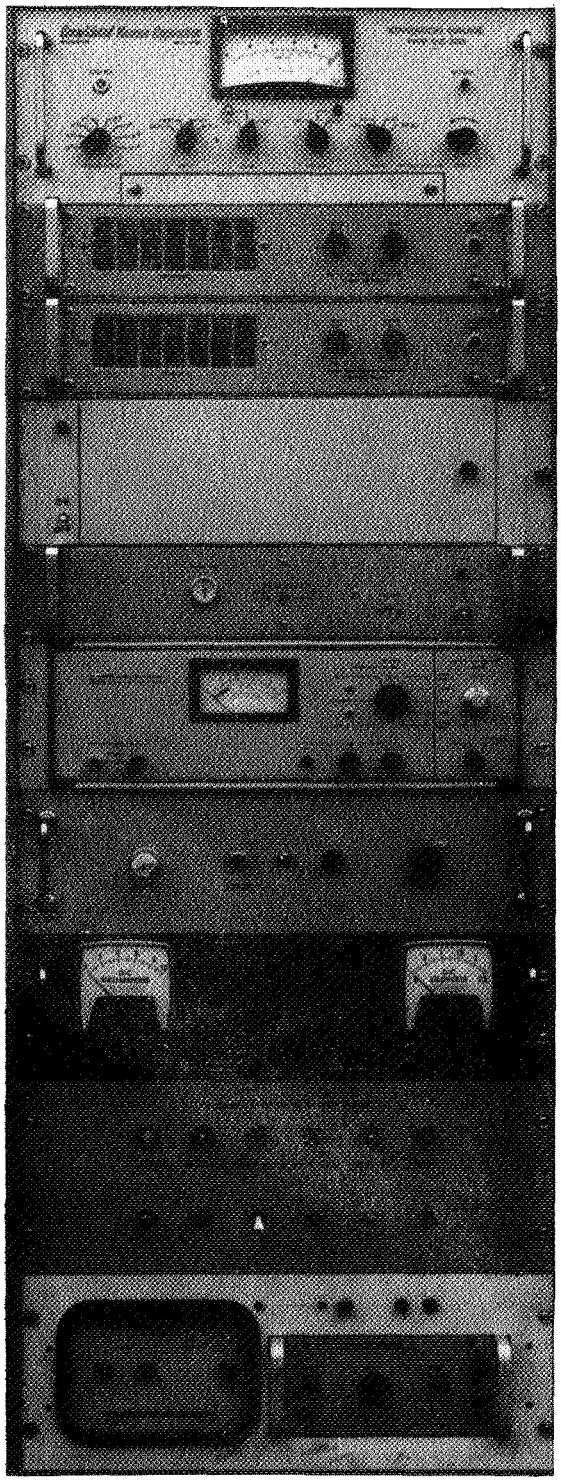

Figure 11. Instrumentation rack.

## PNEUMATIC TABLE SUPPORT SYSTEM

An air-suspended table is utilized to isolate the gravimeter from seismic vibrations. This table is supported by four metal legs (air columns) which are sealed with bellows. The air entering these legs forces a piston up in each column. The length of each column is individually controlled by servo-valves shown in Figure 1. Each air servo-valve is controlled by a lever in contact with the appropriate corner of the table. The "raising of the piston" maintains a constant level with varying loads on the table.

## DATA COLLECTION

The data collection system consists of the following functions:

1. detection of fringes by the photodetector

2. translation to fringe counting circuit and simultaneous measurement of time for n fringes to occur

3. reading of time measurement via digital output on two electronic counters.

The bird initially falls a certain distance which does not enter into the measurement but delays the measurement until a "free-fall" condition is established. The initial distance now used is $(2^{14})(\lambda/2)$ . The bird then falls through a consecutive equal distance. The distances, each equal to $n(\lambda/2)$ where n is the number of interference fringes counted, are used for the measurement of "g." Time is measured by two Hewlett-Packard Model 5275A-100 MHz counters, whose time base is supplied by a 1 MHz horsepower model 101A oscillator. The full fall path, which contains approximately 2 million fringes, is 66.9 cm. Table 1 lists several usable fall path lengths.

TABLE 1. USABLE PATH LENGTHS

| Binary Lengths (Counts) | Fringes Contained in Binary Length | Path Length (cm) |
|---|---|---|
| $2^{20}$ | 1 048 576 | 33.1874 |
| $2^{19}$ | 524 288 | 16.5937 |
| $2^{18}$ | 262 144 | 8.2969 |
| $2^{17}$ | 131 072 | 4.1484 |
| $2^{16}$ | 65 536 | 2.0742 |
| $2^{15}$ | 32 768 | 1.0371 |
| $2^{14}$ | 16 384 | 0.51855 |

In the case of $2^{19}$ fringes, the significant figure of the counter A will spill over and must be added to the display. The actual time sets the state counter to state 3, pulses the counter A to stop, and pulses counter B to start for the final distance measurement. Then n fringes later, the binary counter reads "full," which sets the state counter to zero and stops counter B.

Counters A and B now read the time that the bird fell the two consecutive, equal distances. These times are then read into an equation such that if RA = time read from counter A, and RB = time read from counter B, then "g" value = $2n(\lambda/2)$ RA - RB/RARB(RA + RB) $\times 10^{-16}$ sec.

The input trigger in the logic circuitry requires a signal of at least 0.5 v msec to 50 ohms, and will operate at frequencies as high as 30 MHz. The output amplifiers produce a 4-to-5v negative pulse with a leading edge rise time of approximately 5 nsec for the initial 3 volts, which meets the requirements of the Hewlett-Packard counters. The overall system will operate at frequencies as high as 21 MHz, although the present drop distance of 66.9 cm produces a maximum frequency of 11.5 MHz. For the long path lengths of $2^{19}$ and $2^{20}$ fringes, there is an insufficient display capacity in the 100 MHz counters which display 6 decimal digits, whereas the full reading would require 7 digits. The most significant figure must be assumed.

The control logic which supplies the gate pulse to start and stop each counter, consists of an input trigger amplifier which is driven by the photocell amplifier, a 20-bit binary counter, a 20-bit input decoder, a four state control counter, four 4-input decoders, and four output amplifiers which provide the start and stop pulses to the time interval counters.

After the "reset" button on the Recycle Motor Control panel has been pushed, the state counter located in the Data Collection Logic Chassis is set to state 1. Then the 20-bit binary counter that measures the three distances through which the "bird" drops and registers "full" (1111 1111 1111 1111 1111) when 2n or n fringes have been counted is set to 63/64 of full or (1111 1011 1111 1111 1111). Thus, after the initial distance of $(2^{14})(\lambda/2)$ fringes have been counted [one count for each fringe $(\lambda/2)$] the 20-bit binary counter will read "full." The decoder gates an impulse to the state counter which advances it to a state of 2. A pulse is also fed to the output amplifier which in turn supplies a pulse to start counter A, which counts the time required for the bird to fall through n fringes. At this point the 20-bit binary counter is "full" and would be 0.1XXXXXXX, where XXXXXXX is the seven digit display on the counter. For $2^{20}$ fringes there is a spill over of 0.2 for counter A, thus giving a time of 0.2XXXXXXX. Counter B for $2^{20}$ fringes would have 0.1 added, making the time read 0.1XXXXXXX.

The photocell amplifier and input trigger cut off below about 500 Hz, but, because the bird achieves the velocity corresponding to this frequency when it has fallen a distance of 0.004 cm $(\lambda/2)$, the effect on the initial distance is negligible.

## VACUUM SYSTEM

The Gravimeter Vacuum System, used for pumping down the vacuum chamber, is capable of vacuum levels in the $10^{-7}$ torr (1 torr = 1 cm of Hg) range, dependent on leakage and the outgassing load.

The vacuum system consists of electrically controlled, air-operated valves, oil diffusion pump, and the mechanical pump used for roughing and as a backing pump for the diffusion pump. Other components include gauges, a gauge control panel, water, air, associated wiring, and pipes.

The appendixes contain manufacturing manuals on system components. Schematics of the water-cooling system for the diffusion pump and the pneumatic control system are shown in Figures 12 and 13, respectively.

Vacuum Chamber

The vacuum chamber is a device in which a high vacuum is created so the bird, which has its fall path in the chamber, will not be disturbed by air resistance. The chamber is made of stainless steel and is 5.5 inches in diameter and 35 inches in height (Fig. 2). A vacuum of up to $10^{-7}$ torr can be maintained in the chamber.

Main Vacuum System Components

The main vacuum system components consist of a water-cooled, oil diffusion pump (Fig. 4), backed by a mechanical pump (Fig. 4). Condensable vapors that might go through these pumps are trapped by an $LN_2$ cryo-baffle (Fig. 4).

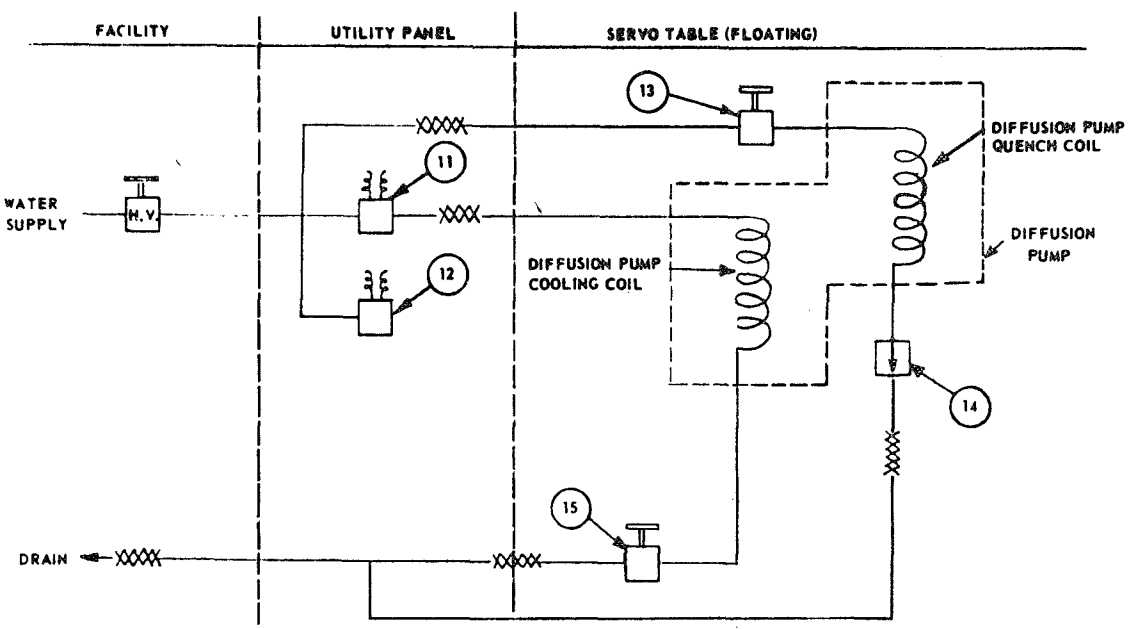


Figure 12. Diffusion pump cooling system.

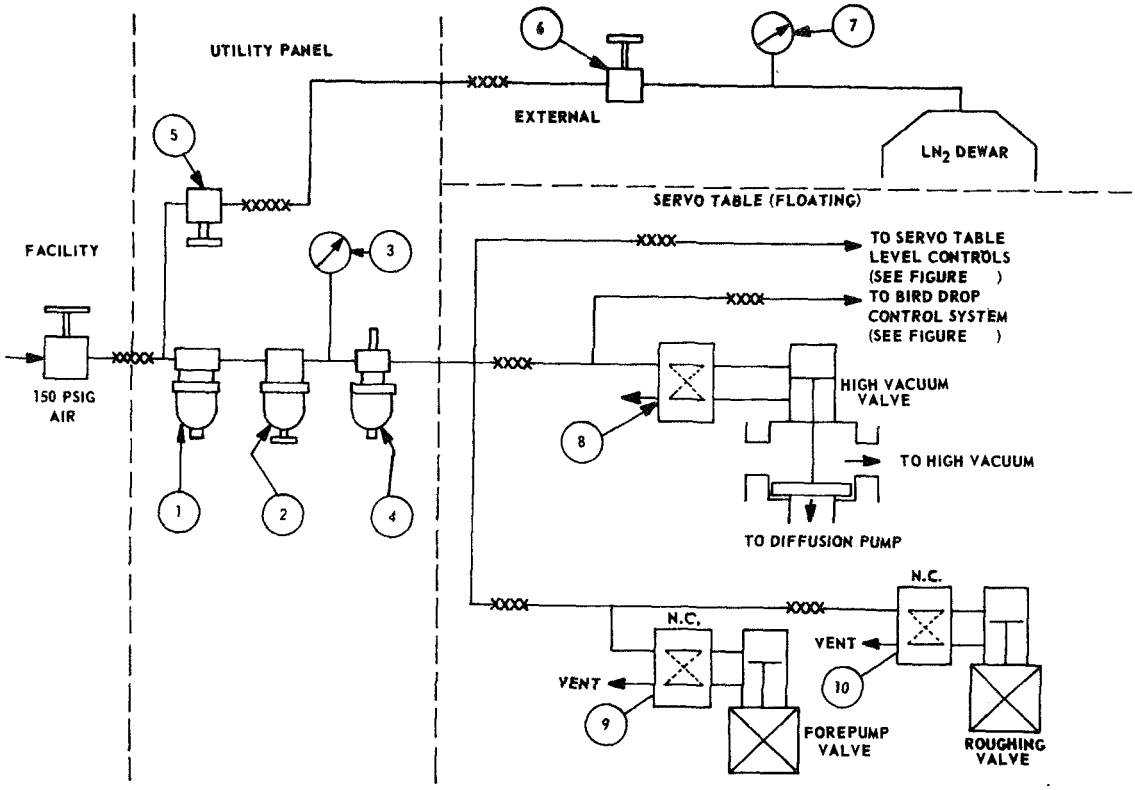


Figure 13. Pneumatic control system.

Mechanical Pump. The mechanical pump is a Welch-Duo-Seal Model 13997B consisting of two-stage, vented exhaust with a free air displacement of 425 liters per minute and blank off pressure of $1 \times 10^{-4}$ torr. The pump is equipped with a 1-hp, 230-v, single-phase motor, and a belt guard. A detailed description is presented in Appendix A.

Diffusion Pump. The oil diffusion pump is a water-cooled CVC Model PMC-6B which is rated at 1400 liters per second. The pump is charged with 800 cc of convoil-20 oil and requires a foreline pressure of 35 microns or less. A detailed description is presented in Appendix B.

$LN_2$ Cryo-Baffle. The $LN_2$ Cryo-Baffle is in a NRC Model 0315-1-006 with a rated conductance of 1200 liters per second below $10^{-4}$ torr. Detailed information is contained in Appendix C. The $LN_2$ Control is a CVC type GS-100 controller and additional details are presented in Appendix D.

High Vacuum Valves. The vacuum system contains four vacuum manually operated valves; three are air-operated and the fourth is vacuum vented.

Roughing Valve. The roughing valve (Appendix E) is used to bypass the diffusion pump during initial chamber roughing. This valve is an air-operated, 2-inch sliding-gate valve (CVC type VCS-23A).

Foreline Valve. The foreline valve (Appendix F) is located between the diffusion pump and the mechanical pump and isolates the diffusion pump from the foreline manifold (Fig. 4). This valve is an air-operated, 3-inch sliding-gate valve (CVC type VST-33M2).

Main Valve. The main valve (Appendix G) isolates the diffusion pump and $LN_2$ cryo-baffle from the vacuum chamber. This valve is an air-operated, right angle poppet valve (Stokes Model 217-25).

Vacuum Vent Valve. The vacuum vent valve (Fig. 1), a manually operated needle valve, is located on the main vacuum chamber and is used to return the chamber to atmospheric pressure.

Vacuum Monitoring Components

The pressure in the vacuum system is monitored with a combination ionization and thermocouple gauge control unit which has a pressure capability of between 2 and $2 \times 10^{-10}$ torr.

Vacuum Gauge Control. The vacuum gauge control unit is a CVC Type GIC-200, with a pressure range of $2 \times 10^{-12}$ torr. The gauge circuit has an adjustable control for automatic filament protection. A detailed description is presented in Appendix H.

Thermocouple Gauge Tube. The thermocouple gauge tube is used in the range of 1 torr to $1 \times 10^{-3}$ torr. The vacuum system contains two thermocouple gauge tubes, one of which monitors the vacuum chamber pressure and the other the foreline pressure. The gauge tubes are CVC Type GTC-004.

Ionization Gauge Tube. The ionization gauge tube (Fig. 2) is a hot filament type with a pressure range of $1 \times 10^{-3}$ to $2 \times 10^{-10}$ torr. This tube is a CVC Type GIC-017-2.

Vacuum System Control. The vacuum system control is composed of two units, the control panel (Fig. 11) and a junction box. The control panel houses the vacuum system operating controls and the vacuum system components, and the input power have their connection point in the junction box. Though primary power for the vacuum system is 240 volts, 60 cps, one-half of this power is used for the control voltage throughout the vacuum system.

Figure 14 is a schematic of the control panel and Figure 15 is a schematic of the junction box along with the vacuum components which are controlled within it. In Figure 14, switch S1 picks up relay K3 which applies power to the control panel. Switches S2, S3, and S4 operate relay K4, which is locked by an auxiliary contact, and applies power to the liquid nitrogen baffle controller. Switch S2 also picks up relay K1 located in the junction box, which in turn applies power to the mechanical pump motor. Relay K4 is used to prevent activation

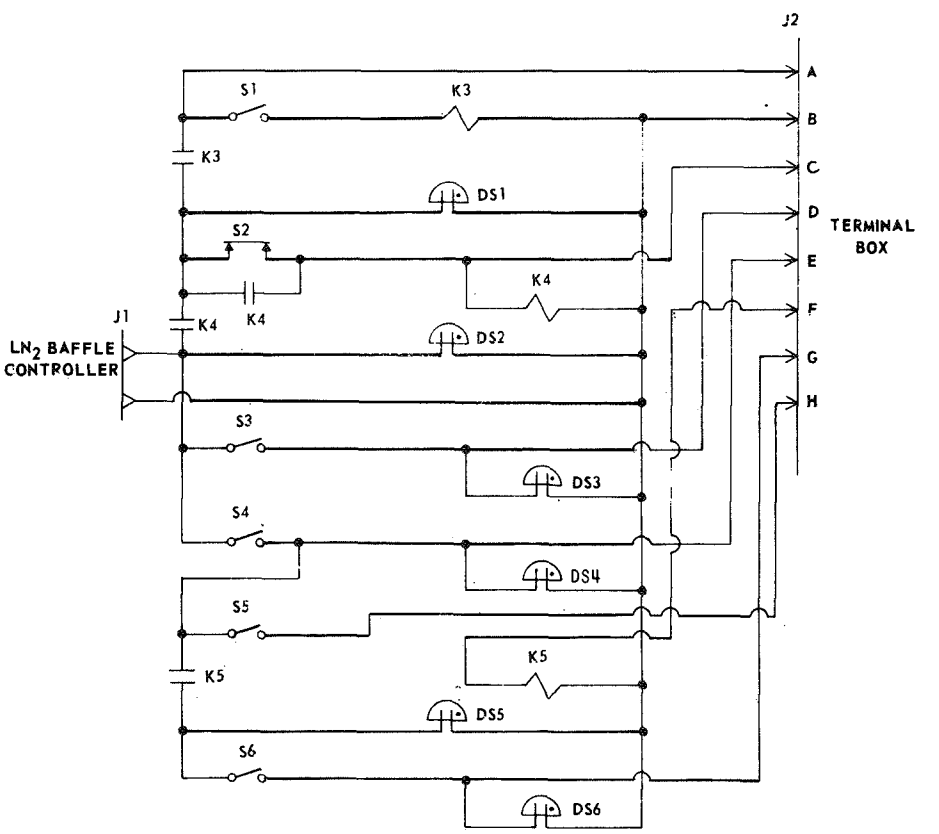


Figure 14. Vacuum control panel.

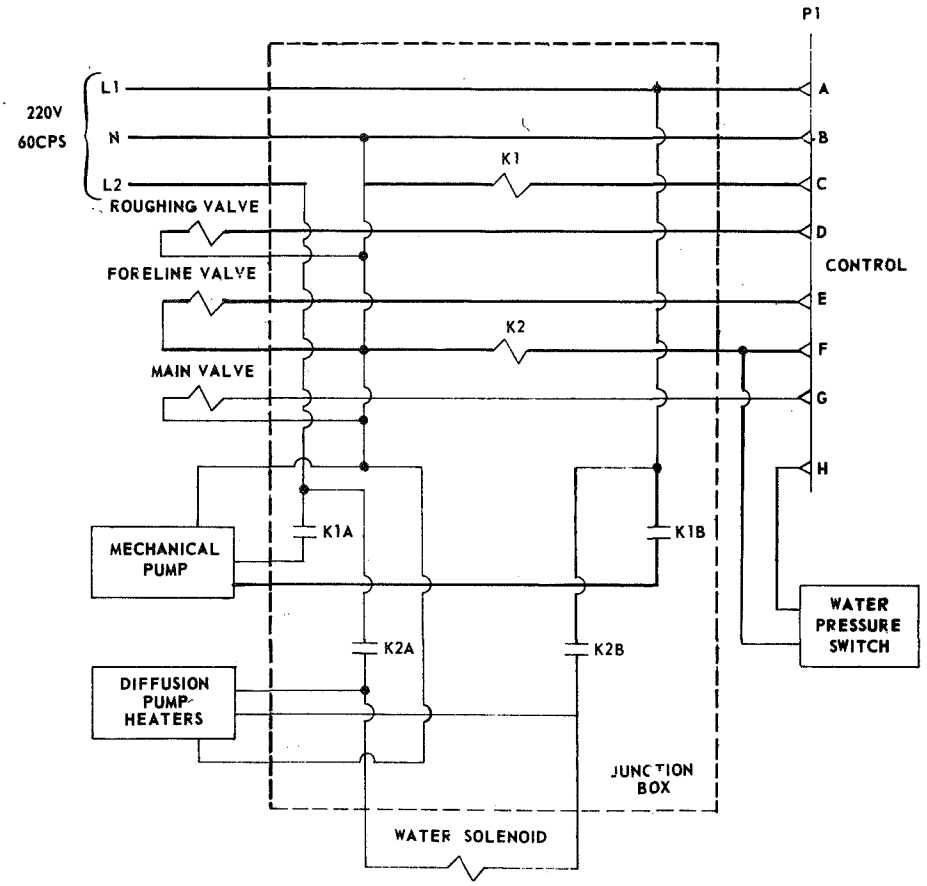


Figure 15. Junction box connections.

on any remaining system components unless the mechanical pump is operating. Should a loss of power occur, K4 will drop out and remain out upon resumption of power. The liquid nitrogen baffle controller will begin filling the cryo-baffle with liquid nitrogen if the controller is turned on when switch S2 is pushed. Switch S3 operates the roughing valve and the S4 switch operates the foreline valve. Switch S5 picks up relays K2 and K5 in the junction box, provided there is sufficient water pressure. Relay K2 applies power to the diffusion pump heaters and simultaneously picks up the cooling water solenoid allowing water to circulate through the pump cooling coils. Switch S5 is devoid of power until the S4 switch is engaged. This prevents diffusion pump operation until the foreline valve is open. Switch S5 is another interlock which prevents main valve activation unless the diffusion pump is operating. Switch S6 energizes the main valve. All connections in the junction box are made on terminal boards to facilitate additions and changes.

Seals. All seals in the vacuum chamber are O-rings designed for high-vacuum surface. The O-rings are located at the three main chamber flanges, two viewing windows, the Brewster angle window, and the shaft seal.

Bellows. The vacuum chamber, which must not be restricted in movement because of proper alignment procedures, has flexibility with the use of a bellows (Fig. 1).

# EQUIPMENT INSTALLATION

## Gravimeter

### AIR TABLE BASE

The four air columns (Fig. 1) of the table are installed firmly in contact with the floor. A shim is used to level the tops of the table support pads (Fig. 2). The air/water control panel (Fig. 2) is mounted on the inside of the table legs by using tapped mounting holes. The junction box is mounted on the rear side of the control panel. Air and water lines are connected to the control panel.

### AIR TABLE

The air table (Fig. 1) is centered on the four table support pads and the large vacuum system support bracket is bolted in position using tapped holes in one end of the air table.

### VACUUM CHAMBER

The vacuum chamber support stand (Fig. 2) is mounted in position on the air table with three main legs which are adjusted until the surface of the stand is parallel to the top of the air table. After adjusting the 3 legs, 4 bolts are added to secure the stand to the air table. The vacuum chamber is then mounted on the stand with the evacuating flange (Fig. 1) on the lower end and the viewing ports facing the outside of the table. The bottom flange is secured with a con-O-ring (all surfaces of the flange should be clean) and an O-ring should be lubricated with Apezion grease.

## RECYCLE MECHANISM

Position the ball screw-catcher assembly with the drilled end of the shaft inserted into the bushing attached to the shaft seal coupling. When the holes are aligned, drive the taper pin into place, securing the shaft. Insert the guide rod A through the hole in the catcher assembly and into the plastic bushing in the release mechanism block. Place the lubricated con-O-ring on the top flange of the vacuum chamber, and carefully lower the top assembly into position. Using the lower viewing port for access, guide the rod and ball screw bearing into position in the lower plate. Tighten the bolts in the upper flange.

## MERCURY TANK

The mercury tank is bolted to the bottom of the air table, directly beneath the spectrometer table (Fig. 2). The hole for the photodetector module is facing the same direction as the viewing ports. A ceramic dish is filled with clean mercury to a depth of at least 5 cm. The dish is then carefully laid in the bottom of the tank by way of an opening at the lower end of the tank. The photodetector module is then slid into the frontal hole until flush and tightened with a set screw.

## LASER

The laser aluminum mounting plate (Fig. 1) is attached to the end of the table opposite the vacuum chamber by 2 U-brackets on either end of the laser plate. The small vacuum system support bracket is now bolted on the same end of the table.

## BEAM SPLITTER

The vacuum chamber is mounted beneath the spectrometer table which consists of an aluminum plate with a large hole in its center and a black anodized plate with a hole in its center. The aluminum plate is set on the air table and three coil springs are placed over three holes in the aluminum plate. The black anodized plate is then bolted on top of the springs by three adjustment bolts through each of the two plates and the springs. The beam splitter fits on a pad which is placed on the hole in the top plate and held firmly by four posts and hold-down springs.

FIXED MIRROR

The fixed mirror is installed into the micrometer gimbal assembly and tightened with set screws. The gimbal assembly is installed in a mounting hole on the front edge of the air table by using a large coil spring and washer above the table, and a bushing, washer, and knurled adjustment knob below the table.

EQUIPMENT RACK

All electronic equipment is installed in the instrumentation rack according to the engineering assembly drawing (SP73041). The motor control cable (Fig. 1) is connected to the recycle assembly and the two quarter-inch copper air hoses (Fig. 2) are connected to the air solenoid valve (Fig. 2) at the top of the vacuum chamber. The engineering drawing should be rechecked for correct connections of cables and hoses before applying electrical power or air pressure.

FINAL CHECKOUT

Apply air pressure and check operation of release mechanism. After placing the bird in the catcher and pressing the start switch, the bird support arm should be checked to see if it is in the down position. After removing the timing belt from its motor sprocket. the catcher is taken to the top of its path by manually turning the drive shaft; the top of the bird should just touch the top of the caming surface cavity in which it latches. After turning the drive shaft an additional one-fourth turn, the timing shaft should be set so that the cam just contacts the lower microswitch. The catcher assembly is then set at the bottom of the chamber by manually turning the drive shaft in the opposite direction. The cam should hit the upper microswitch before the catcher assembly hits the bottom position. The release and recycle mechanism should then be checked.

## Vacuum System Installation

PRELIMINARY

The discussion which follows deals with the mechanical installation of the vacuum system.

NOTE: Before inserting a con-O-seal or O-ring between any flanges, the flanges should be cleaned, and then lubricated with vacuum grease.

Install the diffusion pump on the large vacuum support bracket. Install a con-O-seal and bolt the $LN_2$ cryo-baffle to the diffusion pump with eight bolts.

Install the O-ring between main valve and cryo-baffle.

Install the roughing port adapter to the main valve after installing a con-O-ring between them. Then attach the roughing valve to the roughing port adapter after inserting a con-O-seal.

The diffusion pump should now be charged with 800 cc of diffusion pump oil. Then the foreline valve is installed at the diffusion pump outlet.

The foreline manifold is attached to the roughing valve after a con-O-seal has been inserted and to the foreline valve after an O-ring has been inserted. Clean the ends of the aluminum tubing and insert it into the foreline manifold. and connect it to the mechanical pump. Rubber hoses are clamped to the tubing with worm-screw clamps to keep down vibration from the mechanical pump. Vacuum grease is then applied around these rubber hoses. A vibration isolator is attached to the rear mechanical pump to further decrease vibration. The bellows flange is connected to the main valve with an O-ring and to the lower vacuum chamber flange with a con-O-seal.

The mechanical pump is mounted on a formed steel base which is supported on rubber bumpers. The pump should be located in a clean, well-ventilated area on a firm foundation with adequate space for normal maintenace.

The motor of the single-phase mechanical pump is wired for 230 v ac, 50 cps and rated at 1 hp per 1725 rpm. The black and white wires in the power cord are connected to the K1 contactor in the control junction box. Connect the green wire in the power cord to ground.

## GAUGES AND CABLES

The vacuum gauge control panel in the instrumentation rack requires four cables plus a power cord. The power cord is plugged into the plug mold in the control console in the instrumentation rack. Two cables are utilized with the ionization tube. One is used for the filament and grid and connects to the bottom of the gauge tube; the other (coaxial) cable is clipped to the plate extension at the top of the ionization tube. The thermocouple gauge tubes require one cable each. The gauge tube in the main chamber connects to the vacuum gauge controller by way of a cable (labeled TCI). The gauge tube in the foreline manifold connects by way of a cable (labeled TC2) in the control console. The vacuum system control cable is wired to the junction box and plugs into the vacuum system control panel.

## WIRING AND POWER REQUIREMENTS

The vacuum system requires 230 v ac (single phase). The diffusion pump, mechanical pump, and water solenoid valve are wired for 230 v ac. The pneumatically operated valves and controls are wired for 110-v ac operation. Main power is distributed to the individual components from the junction box by plugging into a 230-v ac polarized receptacle.

## WATER REQUIREMENTS

For cooling, the diffusion pump requires a minimum of one quart of water per minute at an inlet temperature of 293°K (20°C). A water supply and drain are connected to the 9.52-mm (0.375-in.) tube connections located on the air/water control panel.

## AIR REQUIREMENTS

An 80 to 125 psi air supply is connected to the regulating station (Fig. 1) located on the control panel. Air is distributed from the regulating station to various components with a shutoff valve in the supply line.

## LIQUID NITROGEN

The $LN_2$ controller controls the liquid nitrogen to the $LN_2$ cryo-baffle and is located in the control console. A temperature-sensing element is located in the baffle exhaust connection for temperature regulation. The power cord for the $LN_2$ controller is plugged into the back of the vacuum control panel.

## ALIGNMENT

### Air Table

Admit air to the table legs through the table air regulator. The required inlet pressure for the present weight is 80 psi. Then, using a bubble level, set the air table to a level condition by adjusting the air-servo valves. Then level the spectrometer table and the laser mount.

### Vacuum Chamber

Hang a plumb line from the bird release to below the position for the 45-degree aperture in the lower tank. For this, the Brewster window, bird, and beam splitter must be removed and the detector module must be moved out of the way.

Loosen the four tank table hold-down bolts located at the bottom of the air table.

Loosen, but do not remove, the bolts connecting the bellows and the vacuum chambers. Adjust the tank table legs until the plumb line passes through the center of the hole for the Brewster window. Be sure that the bellows does not exert any pressure on the chamber during this operation.

Tighten the tank table hold-down bolts, being sure the chamber does not move out of plumb. Pull the bellows up to the chamber by adjusting the bellows adjusting studs. Tighten the connecting bolts of the bellows and vacuum chamber, being sure the vacuum chamber is not moved out of plumb. Loosen the four bolts supporting the lower tank and adjust this tank until the plumb line passes through the centers of the apertures then tighten the support bolts.

Laser and Beam Splitter

Turn on the laser and remove the stationary mirror. Project the laser beam onto a screen placed 4.6 to 6.1 m (15 to 20 ft) from the laser. Adjust the lens system so that the beam has the same diameter at all points between the laser and the screen.

Replace the stationary mirror and position it in the center of its course. Adjust the laser so that the plumb line is in the center of the beam and the beam impinges on the stationary mirror. Then remove the plumb line and replace the beam splitter and Brewster window.

Suspend the bird from the support arm and move the beam splitter to a position that causes the beam to pass through the center of the Brewster window and the center of the opening in the bird for the beam. Clamp the beam splitter into position and replace viewing ports. Adjust the beam splitter and air table to a position that causes the image from the bird to remain stationary as the bird falls. Begin chamber evacuations.

# OPERATIONS

The operations of the Laser Absolute Gravimeter consists of an operational set up, preliminary checkout, starting procedure, and shut-down procedure.

## Operational Setup

1. Plug power cord into a 230-v ac power source. All electrical equipment should be turned on 30 minutes prior to operation.

2. Turn the laser on standby for warm-up.

3. The oscillator, logic circuit, and time-interval counters are turned on by toggle switches.

4. Turn on power switch on vacuum gauge control panel.

5. Turn on motor control panel.

After the vacuum system has been started it is operated through the following sequences:

ROUGHING

While the main valve is closed, the mechanical pump evacuates the system through the roughing valve. During roughing, the system pressure is reduced from atmospheric pressure to a pressure of 35 microns or less.

HIGH-VACUUM PUMPING

In high-vacuum pumping, the roughing valve is closed and the main valve and foreline valve are opened allowing the diffusion pump, which is backed by the mechanical pump, to operate.

VENTING

The mechanical pump and diffusion pump are valved off from the system by the main and roughing valves. The system is vented by opening the manually operated vent valve.

## Preliminary Checkout

If the mechanical pump has been idle for some time, manually turn the pump through one complete cycle. If the pump cannot be rotated by hand, see Appendix A.

Open the water main shut-off valve. The water supply line is equipped with a pressure switch which will not allow the diffusion pump heater to be turned on unless water is available.

Open the main air supply valve and set the regulator station on the control panel to approximately 100 psi.

Check to see that all toggle switches on the vacuum control panel are in the "off" position. The mechanical pump switch is a monitory push-button type with an interlock relay and will be "off" when the power is off.

The pneumatically actuated valves are closed when the electrical power is off. Only the manually operated vent valve should be checked to see if it is in the "closed" position.

## Starting Procedure

After preliminary checks have been made, the following procedures are followed:

Plug the vacuum system power cord into a 230-v ac power source.

All electronic equipment should be turned on and warmed up for 30 minutes by first turning the laser on standby for warm-up and then turning on the oscillator, logic circuit, and time interval counters by associated toggle switches.

Now, turn on power switch on vacuum gauge control panel and turn on motor control panel.

Check air table to see if it is "on air;" if not, put it "on air."

Vent-valves and viewing ports should be closed.

Quench-water of diffusion pump should be turned off with the quench-water valve.

Turn on the power switch located on vacuum system control panel.

Start mechanical pump by pressing switch, the "power-on" indicator light should be on after pressing switch. Check oil level in the mechanical pump while it is running.

Turn the vacuum gauge on the control panel to TC2 and wait until the pressure in the foreline reads zero microns.

Open the roughing valve with the associated toggle switch on the vacuum control panel. The indicator light should be on.

Turn on the power to the diffusion pump heaters with associated toggle switch on the vacuum control panel. The water-cooling solenoid is wired in parallel with the diffusion pump heaters. Check to see if water is flowing from the drain connection. The indicator light of the pump should be on.

Wait until TC1 and TC2 indicates less than 5 microns.

After the diffusion pump heaters have been on for 15 to 20 minutes [outlet water temperature approximately 323.15°K (50°C)] and the pressure at the thermocouples is below 5 m (5 microns), open the main valve and immediately close the roughing valve.

After the pressure on the thermocouple gauge meter drops to 1 micron or less, the filament switch on the ionization guage control may be turned to "on" position with the pressure range switch in the $10^{-4}$ position.

Correction of air table level can be made by checking coincidence of the laser beam with its reflection off of the mercury pool. A white card is placed beneath the beam splitter to check the fringe pattern. Adjust the laser frequency as described in the laser manual in Appendix A.

Both time interval counters are reset to zero by pressing the reset switch on the Data Collection Logic Chassis.

The bird is released by pressing the start switch on the motor control panel. The reset lights on both time-interval counters should be on at the conclusion of the drop.

The time from each counter is then noted, and preparation for the next drop is begun.

## Shutdown Procedure

To shut the system down,

1. Close the main valve.

2. Turn off the diffusion pump heaters.

3. Close the foreline valve.

4. Turn off power at the vacuum system control panel stopping the mechanical pump.

5. Open quench-water valve for 20 minutes.

# MAINTENANCE

The following is a maintenance schedule for recommended intervals for performing preventative maintenance on the vacuum equipment. (For major repairs, refer to the manufacturer's maintenance manuals in the appendixes.)

1. Check oil level of air lubricator — weekly.

2. Drain air filter — as required.

3. Check oil level of mechanical pump — weekly.

4. Change oil in mechanical pump — semiannually.

5. Change oil in diffusion pump — annually or as required.

# APPROVAL



# OPERATION MANUAL FOR THE MARK I MODEL OF THE LASER ABSOLUTE GRAVIMETER

By William M. Greene and James Yarbrough

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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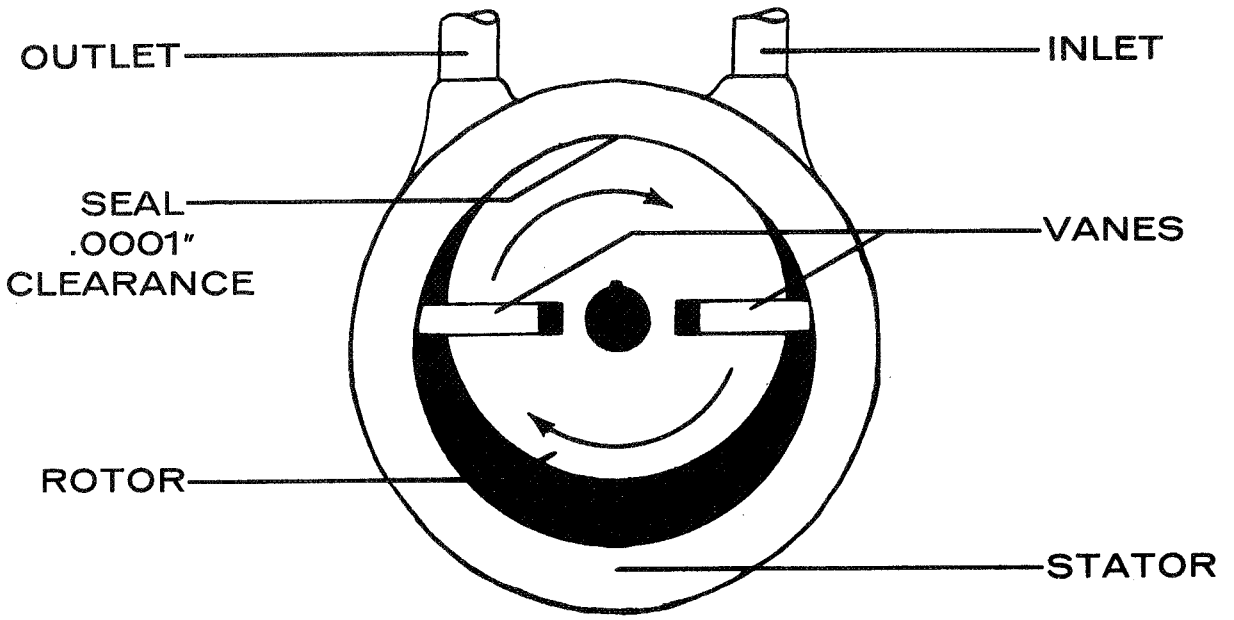
# APPENDIX A

# MECHANICAL PUMP

# INDEX




# PRINCIPLES OF OPERATION

Each stage of the Welch Duo-Seal Pumps consists of a rotor, mounted concentrically on the drive shaft and positioned eccentrically in a cylindrical stator. The contact area of the rotor and stator is called the SEAL. It is a cylindrical seat machined into the stator, with the same radius as the rotor, and located between the inlet and outlet of the pump. The rotor is fitted with two spring loaded, diametrically-opposed vanes which move in and out of their slots, always pressing against the inner surface of the stator ring. Any wear on the vanes is reduced to a very insignificant amount because of a thin oil film which lubricates all parts of the pump. As a vane leaves the seal, it sweeps the air from the crescent-shaped space and forces it out the one-way exhaust valve. This operation is repeated twice each revolution, reducing the pressure in the vessel connected to the intake, thereby achieving a higher and higher vacuum. A patented feature called the Duo-Seal provides a by-pass at the seal. This by-pass carries the last increment of gas, which may escape the port, back to the exhaust stage. It eliminates the possibility of entraining the gas into the intake stage and re-pumping it.

The operating combination of stator, rotor and vanes constitutes the vital part of the pump. One of these units is used in a single-stage pump. In a two-stage pump, two of these units are connected in series and mounted on a common drive shaft for better ultimate vacuum.

## VENTED EXHAUST

The presence of water or other vapors in the vacuum system can be very detrimental to the performance of the pump. They may contaminate the oil, and if corrosive, they will damage the pump parts. One method of removing such vapors is using cold traps between the pump and vacuum system. A vented exhaust valve on the pump will give additional protection.

The vented exhaust minimizes the condensation of vapors in the compression cycle of the exhaust stage by introducing an adjustable flow of atmospheric air. The diluting effect of the admitted air lowers the partial pressure of the vapor below its saturation pressure at the operating temperature of the pump. This prevents condensation and the vapors are expelled with the exhaust gases.

The vented exhaust is also helpful in removing condensed vapors from previously contaminated oil. Method of use and adjustment is described on page 5 under "Operation".

# UNPACKING

Remove the pump from the shipping case with care. If any damage has occurred, file claim with the carrier immediately. Always save the shipping container for carrier inspection.

If it is necessary to communicate with your dealer or The Welch Scientific Company, please include your order number, pump catalog number and serial number to expedite replacement. *Do not return the pump to the factory* without obtaining shipping instructions.

# INSTALLATION

## MOUNTING

Welch Pump-Motor Sets are furnished mounted on formed steel bases, supported on rubber bumpers. These units should be placed on a firm foundation. See instructions for No. 1392 and No. 1392A Mechanical-Diffusion Pump Combinations at the end of this section.

All Duo-Seal Pumps have supporting legs drilled for mounting bolts.

The pump should be located in a clean area with good ventilation, and as close as possible to the vacuum system to which it will be attached. Adequate space should be allowed around the pump for normal maintenance, such as oil changes, belt adjustments, etc. Before operation, check belt tension and pulley alignment.

The pumps are air-cooled, eliminating the need for cooling water.

## ELECTRICAL

Care should be taken to insure that the electric motor is connected to the correct voltage, phase and frequency. Check the motor wiring connection by removing motor plate and comparing connections with diagram on inside of plate. Pump-motor sets (other than explosion proof and 3 phase motors) are furnished with a switch and cord. The cord can be plugged directly into the proper receptacle.

If the electric motor to be used is not furnished by Welch, be sure that the motor, belt and pulley will operate the pump at the proper speed.

Check the rotational direction of the motor before connecting belt to pump pulley.

## CONNECTION TO SYSTEM

The connecting line between the pump and the vessel to be evacuated should be as short as practical and as free from bends as circumstances permit. The inner diameter should be at least as large as the inside diameter of the pump intake. (See page 14, "Vacuum Connections and Fittings.")

A good vacuum-tight joint between the pump intake and connecting line can readily be made by sliding the correct size, heavy-walled rubber tubing (Welch No. 5518B) over the intake nipple. Insert the connecting line into the tubing so it butts flush against the nipple. Use of worm-screw band clamps is desirable, and/or sealing with vacuum wax or "Leak-Lock" (Welch Catalog No. 1372).

For permanent connections, remove either or both the intake nipple and exhaust dust cap, and screw the piping into the connections. See Page 14 for thread dimensions. Use a sealant such as "Glyptal" or "Leak-Lock" on the intake threads.

## OIL LEVEL AND TYPE

To insure efficient operation, low maintenance and freedom from unnecessary noise and oil vapors, it is extremely important to use the proper type and quantity of oil. Welch Duo-Seal Oil has been specially developed over a period of years, to have the required viscosity, low vapor pressure and chemical stability. The vacuum guarantee on Welch Pumps applies only when Duo-Seal Oil is used. A sufficient supply of oil is furnished with each pump. Additional Duo-Seal Oil (Welch Catalog No. 1407K) is available in quart and gallon plastic bottles and in five gallon cans.

After pump has been running for at least fifteen minutes, check the oil level. It should be maintained between the oil-level marks, with the pump in operation. In general, the oil level will be slightly higher while the pump is running than when it is stopped. If the oil level gradually rises during prolonged operation, water or other vapor is condensing in the pump. When this occurs, the vented exhaust valve, on pumps so equipped, should be opened to purge the oil, or the oil should be changed.

The No. 1404 Pump does not have an oil-level window. In this pump the oil-level mark may be seen by removing the top plate. This requires the removal of two screws. In all No. 1404 Pumps, the top plate must be removed to add oil to the reservoir.

An explanation of the effect of too much or too little oil and oil contamination is contained on page 7, under the heading, "Oil Changes and Levels".

## RECOMMENDED ACCESSORIES

Belt guards totally enclose the pulleys and belts, and are strongly recommended for the protection of personnel working near the pumps. Belt guards are furnished with mounted Nos. 1397 and 1398 Pumps and are available for all others. To service belts or pulleys, the outer half of the guard can be removed or folded down, depending on type. This can be done without use of tools. All pump bases made in the last five years have been predrilled to accept guard brackets. Older bases require drilling of two holes.

Exhaust filters are available for attachment to the exhaust port in place of the dust cap. Their use is recommended when it is necessary to operate the pump with relatively high gas flows. Any oil-sealed mechanical vacuum pump tends to discharge oil mist from its exhaust port when it is operating at high flow. Oil droplets entrained in the discharge air are removed by the combined action of a two-stage filter element. One stage consists of multiple layers of fine wire screen and the other of a special fiber. Oil is drained from the element, back through the discharge connection into the oil reservoir of the pump.

EXHAUST FILTERS:

No. 1417 for Nos. 1399, 1400, 1405, 1406 and 1410 Vacuum Pumps. (2" diameter x 4¾" high, ¾ - 20 male thread)

No. 1417A for Nos. 1402 and 1403 Vacuum Pumps. (6" diameter x 7½" high, 1 - 20 male thread)

No. 1417B for No. 1397 Vacuum Pump. (7" diameter x 10" high, 1-¾ - 20 male thread)

REPLACEMENT FILTERS:

No. 1417F for 1417 Filter; No. 1417G for No. 1417A Filter; No. 1417H for No. 1417B Filter.

BELT GUARDS

No. 41-0791 for No. 1397; No. 41-2496 for No. 1398; No. 1399G for No. 1399; No. 1400G for Nos. 1400 and 1410; No. 1404G for Nos. 1404 and 1406; No. 1405G for Nos. 1402, 1403 and 1405.

## INSTALLATION OF Nos. 1392 & 1392A

These combinations consist of a No. 1400B Duo-Seal Pump with motor and a modified, two-stage metal diffusion pump, mounted on a common base. Installation is the same as that for other Welch Duo-Seal Pumps with the following additional requirements.

Connect diffusion pump intake (large diameter) to the vacuum system, preferably by brazing or silver soldering. Use as short a connection as possible with as large a diameter as possible.

Connect diffusion pump heater and electric motor to 115 V, 60 cycle power supply, with separate cords and switches provided.

Connect diffusion pump to coolant supply. No. 1392 uses a water-cooled diffusion pump and requires 0.08 G.P.M. of water at normal temperatures. Connect water supply to tubing at intake stack. The No. 1392A uses an air-cooled diffusion pump. For best results a small blower or fan with a capacity of 20 C.F.M. should be used to direct air across the cooling fins, impinging first on the intake stack.

Check system for leaks before filling diffusion pump with pump fluid.

Fill the diffusion pump with 55 c.c. of No. 1391K Octoil Pump Fluid supplied. This may be accomplished by removing the drain plug, starting the mechanical pump and sucking the pump fluid into the boiler through a clean length of rubber tubing. Use a new drain plug gasket and replace drain plug while the mechanical pump is running. Turn off mechanical pump. More complete instructions are furnished with the Nos. 1392 and 1392A pump assemblies.

# OPERATION

## GENERAL PROCEDURES

1. Remove intake and exhaust port plugs and install dust cap in exhaust port.
2. Check the oil level before operating and check it periodically during operation.
3. Use only clean Duo-Seal Vacuum Pump Oil.
4. All Welch Pumps, except No. 1404, contain an air filter screen in the intake port to prevent foreign particles from entering the pump. Greatest possible care should be exercised to exclude foreign particles from the intake line.
5. If corrosive vapors or excessive water vapor is evolved in the vacuum process, a cold trap should be placed in the vacuum line to prevent damage to the pump mechanism and contamination of the oil.
6. When the pump is not being used and is disconnected from the vacuum system, plug the intake to keep out dirt.
7. Carefully check connection and vacuum system for leaks.
8. Periodically check V-belt tension and pulley alignment. V-belt should be adjusted so that a firm downward pressure at the middle of the span will cause a deflection of ½" to ¾".

## START-UP PROCEDURES

1. Turn on power, with intake closed (to minimize splashing).
2. Check for proper direction of rotation.
3. Check oil for proper level, with pump running.
4. The gurgling noise, characteristic of mechanical vacuum pumps when operating at high pressures, should disappear after a few seconds. If it does not, check to see if oil level is too low, or if there is a leak in the connecting lines.
5. Open intake to the vacuum system.

### Nos. 1392 and 1392A Mechanical-Diffusion Pump Combinations START-UP

1. Turn on mechanical pump and evacuate the system to less than 500 microns.
2. Turn on diffusion pump coolant and heater (fresh oil will evolve the gases dissolved in it and this will tend to increase system pressure temporarily). The diffusion pump requires 20 to 30 minutes to reach normal operating temperature and full pumping capacity. If system pressure does not decrease within a few minutes after diffusion pump reaches operating pressure, turn off heater and recheck system for leaks.

## VENTED EXHAUST

Vented exhaust valves are supplied with No. 1397, 1398, 1399 and 1402 Pumps, and they are available as optional accessories for the No. 1400 and 1405 Pumps. Vented exhaust valves can be field-mounted on any No. 1400 or 1405 Pumps which have serial numbers higher than 25500-0 and 26157-5 respectively. Single-stage pumps, other than the No. 1399, are not adaptable to the use of the vented exhaust.

The vented exhaust is used to prevent, or minimize, the condensation of vapors in the pump. Condensed vapors raise the vapor pressure of the oil, reducing the vacuum obtainable. These vapors can also form sludges with the oil, causing corrosion and eventual freeze-up. The vented exhaust is also used to purge previously condensed vapors which will generally re-evaporate as they are exposed to the low pressure of the intake cycle. Recondensation in the compression cycle is prevented by operating the pump with the vented exhaust valve open.

A vented exhaust is not equally effective on all vapors encountered in vacuum processing, so it does not always entirely eliminate contamination of the oil. It does, however, reduce the contamination so oil changes are not needed as frequently.

The vented exhaust valve consists of a hollow stem with a metal ball closure fitting into a conical seat in the valve port housing.

A fixed passage through the stem includes a ball check valve which prevents back-flow of air in the final compression stages. Counter-clockwise rotation of the valve stem unseats the ball, opening an air passage to the exhaust opening in the pump. One full turn of the valve stem fully opens the valve. Any fraction of a turn will open the valve correspondingly. Newer model pumps have a needle valve at the top of the valve stem to control the flow of air into the valve stem. These needle valves can be finely adjusted to any position between fully open and fully closed.

To eliminate water and other condensed vapors from forming in the pump, open the vented exhaust valve. This is done by loosening the knurled lock-ring and turning the valve stem one full turn counter-clockwise . . . tighten lock-ring. The needle valve, included on new pumps, is opened by turning counter-clockwise far enough to handle the volume of vapor. Experience with the system will enable the operator to quickly determine the proper needle valve position. As the volume of vapors diminish, the needle valve should be closed progressively. Older pumps are not equipped with a needle valve. On these older pumps, turning the valve stem one full turn counter-clockwise will give maximum venting — fractions of a full turn will give a corresponding amount of venting. When valve is fully closed, the pump will produce the highest possible vacuum under the existing conditions. If not needed, the vented exhaust valve should be closed. It is closed by turning the stem clockwise until fully seated, then adjust lock-ring seal accordingly. Finger pressure is sufficient to seat the needle valve and valve stem for a leak-tight seal.

## SHUTDOWN PROCEDURES

1. Close the pump intake.
2. Turn off power.
3. Bleed in air through intake.
4. Cover intake nipple if pump is disconnected from vacuum system.
5. If pump is going to be out of service for a prolonged period, drain the oil and fill with new Duo-Seal Oil to prevent the possibility of corrosion from contamination.

### Nos. 1392 and 1392A Mechanical-Diffusion Pump Combinations SHUTDOWN

1. Turn off diffusion pump heater.
2. Continue cooling until diffusion pump boiler is cool enough to touch.
3. Shut off coolant supply.
4. Turn off mechanical pump.
5. Admit air to diffusion pump intake.

*NOTE—To avoid decomposition, do not expose diffusion pump fluid to pressures above 1 mm Hg (Torr), while hot. If pressure rises above 1 mm Hg, turn off pump heater immediately and maintain cooling of pump.*

# ROUTINE MAINTENANCE

The need for routine maintenance of the pump is usually quite apparent. In most cases the problems can be solved with very little down time. The following paragraphs cover the most common of these problems. Routine maintenance for the Nos. 1392 and 1392A mechanical-diffusion pump assemblies is at the end of this section. Major repair, requiring the disassembly of the pump, is covered later in this manual, starting on page 11.

## DRIVE PROBLEMS

If pump will not run, turn off switch. Check the fuse and electrical connections to be sure power is present to the motor. If power is present, proceed as follows: Remove V-belt. Rotate motor pulley and pump pulley clockwise, by hand. If motor is stuck, it will have to be replaced or repaired. If pump is jammed, it will have to be disassembled (see "Major Repairs," page 11). If the motor turns freely by hand, turn on switch, with V-belt removed. If the motor does not work, it will

have to be replaced or repaired. If the motor operates normally and the pump pulley turns freely, replace V-belt and check the belt tension. A firm downward pressure at the middle of the belt span will cause a deflection of ½" to ¾" when the tension is correct. To increase or lessen the tension, loosen motor mounting bolts and slide motor away from or toward the pump. If the belt is too tight, it will cause excessive wear on the pump. It it's too loose, it will slip, reducing the pump's efficiency and cause excessive belt wear. Lubricate motor as directed on motor plate. The motors furnished with Welch Pumps are sleeve-bearing type. With normal use they require lubrication about every three years.

Periodically check the set screws on the pulleys and tighten if necessary.

## VACUUM PROBLEMS

A decrease in the vacuum system's efficiency will be apparent by a decrease in the ultimate vacuum attainable, and/or an increase in the time required for evacuation. This failing is usually caused by leakage or unusual out-gassing. It is rarely the fault of the pumping system.

To operate at maximum efficiency, the system must be thoroughly clean. Check all connections for leaks, as outlined on page 15, "Leak Detection". If the system is completely clean and free from leaks, and unwarranted vacuum problems still exist, the pump should be checked.

The most common cause of a mechanical pump's loss in efficiency is contamination of oil. It is caused by condensation of vapors and by foreign particles. Condensed vapors increase the vapor pressure, reducing the ultimate vacuum attainable. Foreign particles and some vapors form sludges with the oil. These sludges impair sealing and lubrication, and can cause eventual "freeze-up". A vented exhaust is helpful in removing vapors, especially water, but it is not equally effective on all foreign substances; therefore, periodic oil changes are necessary to maintain efficient operation of the system. The required frequency of changing oil varies, depending on the particular system. Experience with the process will help you determine the normal period of operation before an oil change is necessary.

## OIL CHANGES AND LEVEL

To change oil, disconnect the pump from the system, if possible. Warm the oil by operating the pump with the intake closed, for approximately 15 minutes. Stop the pump and remove the oil drain cap. Most of the oil will drain out freely. USE CAUTION — *oil will be hot!* The small residue remaining in the pump can be forced out by turning the pump pulley by hand, with the exhaust port closed and intake open. The oil will spurt out suddenly and should be deflected into the drain pan. *Extensive operation with the exhaust port sealed should be avoided, as excessive internal pressure may loosen the shaft seal.*

After removing all oil, close the drain and pour 3 or 4 ounces of clean Duo-Seal Oil into the intake port. Open exhaust port and run pump for a short period to completely circulate the new oil. Drain the flushing oil and force out residue, as above. Repeat flushing with new Duo-Seal Oil until flushing oil remains clean and free of color and foreign matter.

WARNING—Do not use solvents or light flushing oils. Their complete removal is difficult and their higher vapor pressures will prevent the attainment of high vacuum.

If the oil has thickened or contains sludges, it is advisable to remove the oil reservoir case and thoroughly clean out the case with clean, lint-free rags. In replacing the oil case, varnish a NEW gasket and position on the pump case. Tighten all screws uniformly. Also replace the shaft seal as explained under the heading, "Oil Leakage".

After the pump is completely flushed, refill by pouring new Duo-Seal Oil into the exhaust port. Fill to proper level indicated on the sight glass. Replace dust cap.

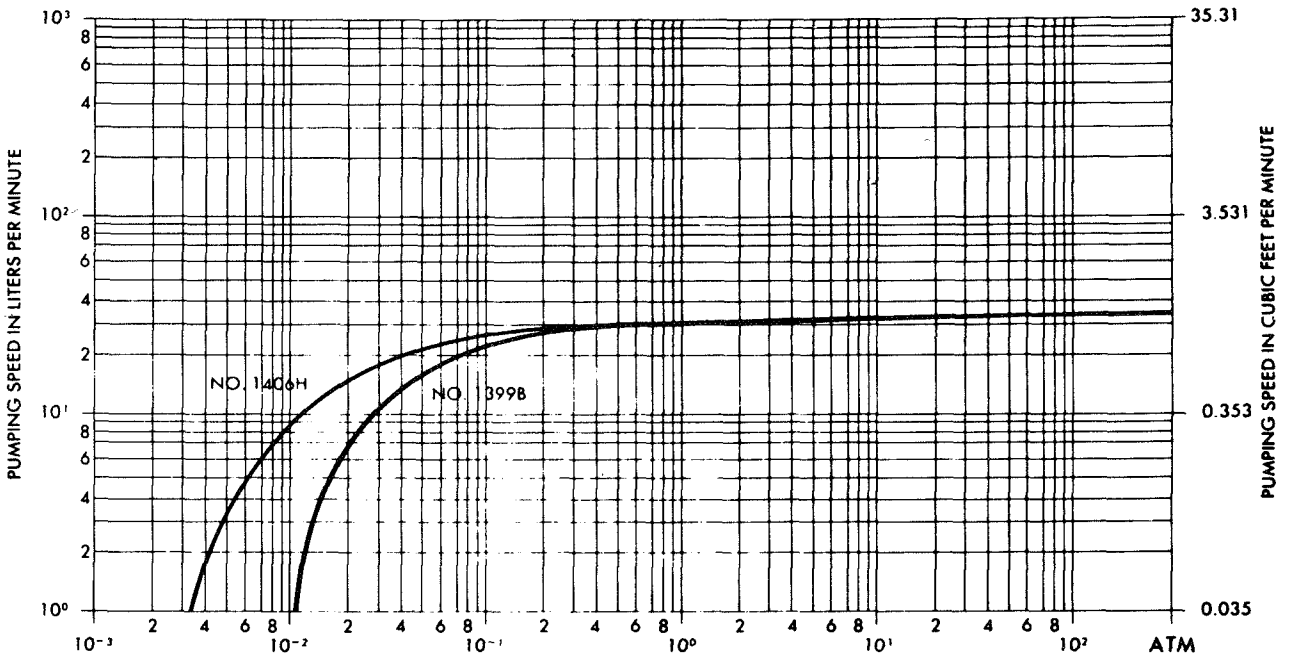
A gurgling noise is characteristic when high pressure air is drawn through the pump. It should disappear quickly as the intake pressure is reduced. If the pump continues to gurgle, the oil level may be too low. Insufficient oil does not give proper sealing or lubrication. Add oil through the exhaust port until it reaches the proper level. The oil level should be maintained between the marks on the sight glass, with the pump running. Level will drop when pump is stopped.

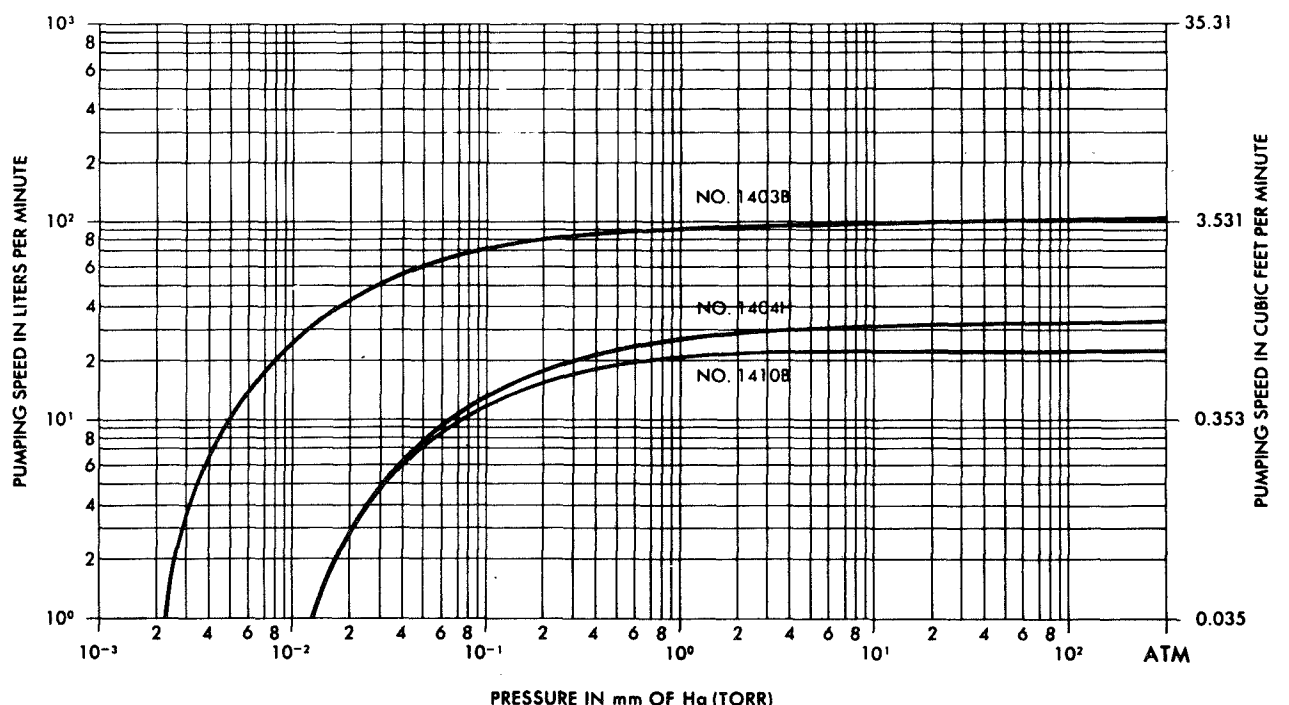
## OIL LEAKAGE

Leakage of oil is readily apparent and easily corrected. The areas affected are:

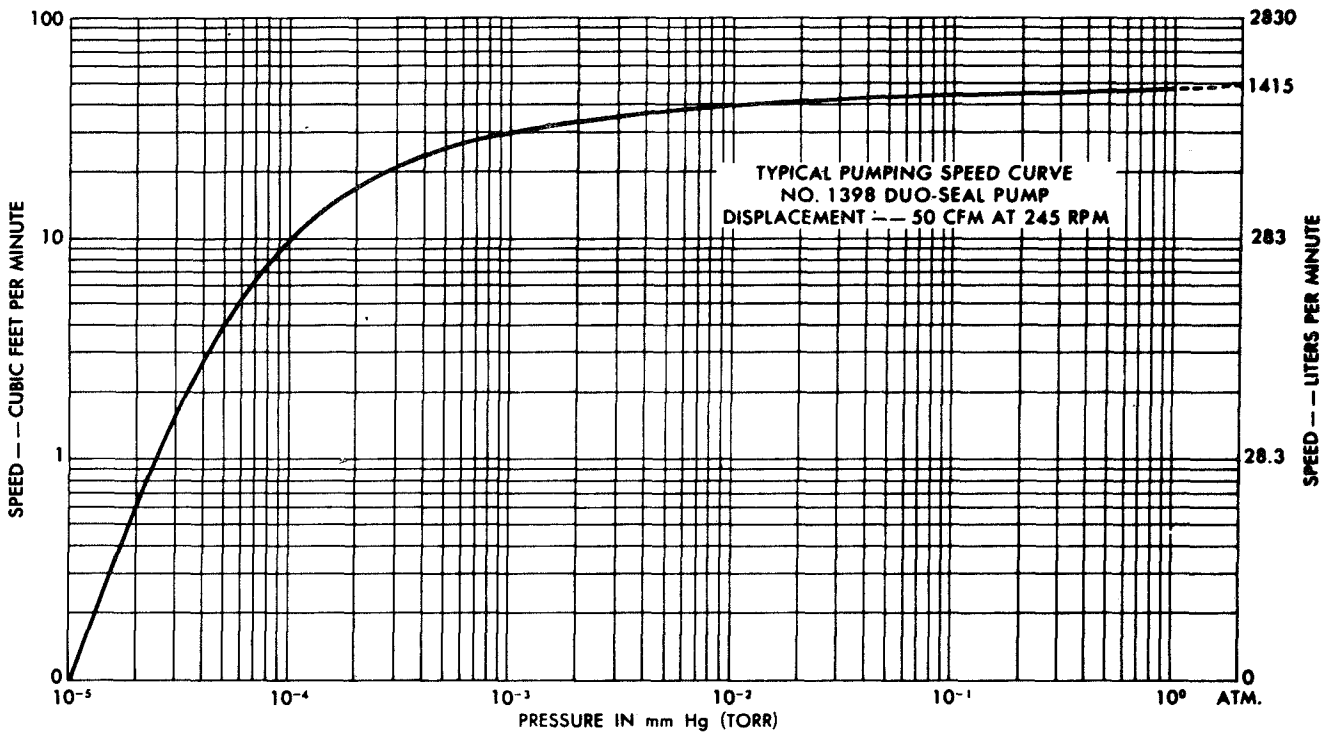
SHAFT SEAL—To replace shaft seal, drain oil, remove the pump pulley and key, and all parts of the seal. Clean the shaft and inspect it for any burrs or nicks. Carefully hone any damaged areas with fine emery paper. Hone the key way to remove sharp edges. Place new gasket on the pump casing (do not use cement). Carefully slide the replacement seal over the shaft and position against the pump housing. Align screw holes and tighten screws uniformly. *Instructions are included with replacement seals.*

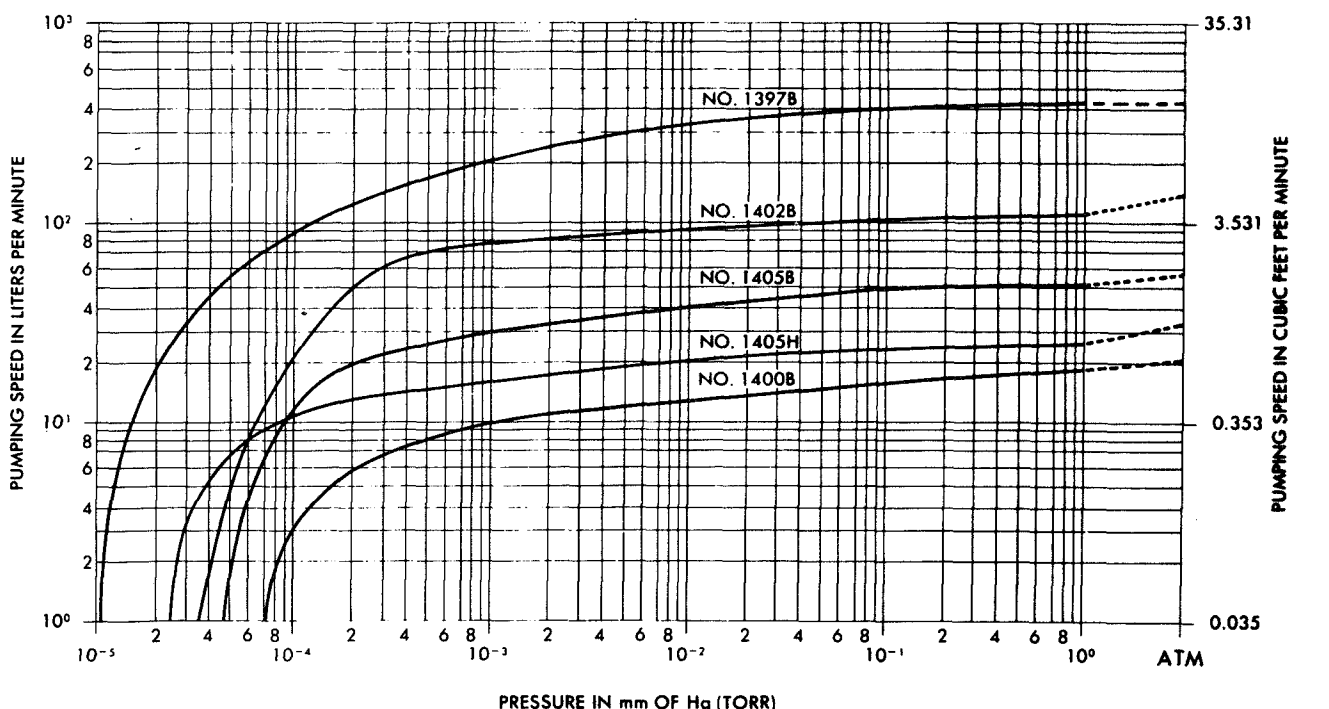
## WELCH *DUO-SEAL* VACUUM P



# UMP PERFORMANCE CURVES



OIL LEVEL SIGHT GAUGE—Unless the glass disc is damaged, it is generally only necessary to replace the inner and outer rubber gaskets. Drain oil and remove all parts of the oil level gauge. Insert new inner tension washer into counterbored seat in casing. Place glass disc in position. Mount new outer rubber washer over glass disc and into seat. Place oil window cover into position and tighten the 4 fillister head screws uniformly. The oil level gauge on the No. 1406 Pumps consist of a glass disc mounted in a metal ring. This assembly is mounted by pressing it into the opening in the case. A damaged unit can be easily knocked out.

OIL DRAIN CAP—Should a leak develop at the oil drain, replace the rubber disc within the drain cap. The old disc can be pried out with a stiff wire or pointed tool. Press the new disc firmly into the cap.

OIL CASE—If oil leaks at the oil case seal, drain the oil from the pump and remove case and gasket. Thoroughly clean the sealing surfaces of the case and pump. Varnish a new gasket and place in position. Mount case and thoroughly tighten all screws.

## VENTED EXHAUST

Should the seat of the needle valve wear so that it will not seal with hand pressure, the valve stem should be replaced.

## AIR FILTER REMOVAL AND CLEANING

With the exception of No. 1404 Pumps, all Welch Duo-Seal Pumps are equipped with an air filter screen. It is located below the pump intake port and functions as a trap for solids, which could cause damage to the pump. Such particles are usually the result of an implosion in the vacuum system. Unless the screen has been damaged, the filter may be removed and cleaned in the following steps:

1. Turn off the pump. (Drain oil in No. 1406 Pump)
2. Remove the intake cover.
3. Lift out air filter. (The air filter on the No. 1398 is a two piece screen attached to the intake elbow.)
4. Tap filter on clean disposable surface to remove solid particles. If further cleaning is required, rinse thoroughly in clean acetone followed by a rinse in clean alcohol and then a rinse in distilled water. Dry in stream of hot, dry air.
5. Replace the cleaned filter in intake area.
6. Use a new intake cover gasket and coat both sides with varnish. (The 1398 has a rubber O-ring rather than a gasket that should be replaced.)
7. When varnish is tacky, mount gasket in position on pump casting.
8. Replace intake cover and tighten screws evenly.
9. Fill pump with clean Duo-Seal Oil (Check level after running pump for a few minutes.)

### Nos. 1392 and 1392A Mechanical-Diffusion Pump Combinations

The No. 1400 mechanical pump should be maintained and repaired as directed in the preceding instructions. The following procedures should be followed as routine maintenance of the diffusion pump.

OIL CHANGE—The pump fluid should be inspected periodically for color change and odor. If the fluid is slightly darkened and has no odor, a simple change of fluid is normally all that is needed. Follow the technique described under "Installation Procedures". If the fluid has developed a noticeable odor, it is recommended that the pump be cleaned in the following method.

CLEANING—Remove diffusion pump from system. Thoroughly drain oil through drain outlet (slight warming is helpful). Rinse pump with acetone and fill with a 50% solution of Caustic Soda (use care in handling). By using pump heater, boil Caustic Soda solution in pump for approximately 30 minutes. Drain caustic solution and rinse with clean, hot water. Rinse with acetone and dry with stream of warm, dry air. Replace drain plug and reinstall pump in system (replace drain plug gasket each time a plug is removed). Fill pump with 55 cc. of new "Octoil" pump fluid.

PUMP HEATER—If burn-out occurs, the heater can easily be removed and replaced. Remove holding nut at bottom of boiler and lower heater to remove. *Additional instructions are included with the pump.*

## CHECKING PUMP PERFORMANCE

An excellent criterion of the condition of a mechanical pump is the ultimate vacuum it will achieve. This can be easily measured by connecting a suitable gauge to the intake of the pump and operating the pump until the highest vacuum reading is obtained.

This procedure can be used as a quick test to determine the need for maintenance and repair. Also, as a final test after all the necessary routine maintenance procedures have been followed. If the pump does not achieve or closely approach the performance of a new pump, the need for major repair is clearly established. Welch Duo-Seal Pumps are fully tested at the factory with upright, untrapped McLeod gauges. Other gauges, such as the Pirani or Thermocouple vacuum gauges can be used if allowance is made for the inherent difference in readings. See "Vacuum Techniques" in this manual for the explanation of gauges.

# MAJOR REPAIRS

## WELCH REPAIR SERVICE

With proper care, Welch Duo-Seal Vacuum Pumps can be depended on to give many years of reliable service. Should major repairs, which require disassembly of the pump mechanism, become necessary, it is strongly recommended that the pump be returned to the factory for reconditioning.

The basic working parts of Duo-Seal Pumps are machined to very close tolerances and require assembly on special fixtures, and with special tools by mechanics who are highly skilled at this work. It is our experience that the majority of pumps repaired by others fail to operate with maximum efficiency. It is usually still necessary to return them to the factory for proper repair.

The Welch Scientific Company maintains complete repair departments strategically located at the addresses shown on the back page. These facilities are well equipped and staffed with experts to insure prompt reconditioning of all returned pumps. Broken, worn, scored or corroded parts are replaced with new parts and the pump is thoroughly run-in and tested until it exceeds the performance requirements of the original guarantee.

## WELCH EXCHANGE SERVICE

A rapid pump exchange service is offered by Welch through all of its offices to save customers the normal down-time required for factory reconditioning. A pool of reconditioned pumps is maintained for this service. Under this plan, a customer's repairable pump will be replaced by a factory reconditioned pump of the same catalog number. The prices for this exchange are as follows (subject to change without notice):

| PUMP CAT. NO. | REPLACEMENT CHARGE PLUS CUSTOMER'S REPAIRABLE PUMP | PUMP CAT. NO. | REPLACEMENT CHARGE PLUS CUSTOMER'S REPAIRABLE PUMP |
|---|---|---|---|
| 1397 | $225.00 | 1403 | $90.00 |
| 1398 | 500.00 | 1404 | 70.00 |
| 1399 | 45.00 | 1405 | 95.00 |
| 1400 | 60.00 | 1406 | 70.00 |
| 1402 | 135.00 | 1410 | 45.00 |
| F. O. B. Our Plant or Branch | | | |

*Exchange Service Instructions*—Simply order a factory reconditioned replacement pump of the same catalog number as the pump you wish to replace. It will be shipped to you immediately. Your pump may then be returned to the factory in the same container. You will be billed the full price of the replacement pump, at time of shipment. On receipt of your pump at the factory, a credit memorandum will be issued to you, covering the difference between the billed charge and the exchange allowance for your pump.

If your pump is not a standard model, the cost of parts and labor necessary to convert it to a standard model will be added to the cost of the replacement pump. If your pump is not repairable, you will be notified. You may then purchase a new pump and return the replacement to us when you receive the new unit. *Return the pump only—do not send motor or base.*

## REPLACEMENT PARTS ORDERING INSTRUCTIONS

The parts list on the next page includes all of the items necessary to affect the repairs or replacements described in this manual. The numeral in parentheses, preceeding the part number, indicates the total quantity required of the item. When ordering replacement parts, list the quantity required, the part number and description. Shipment will be made immediately from stock.

# REPLACEMENT PARTS AND NUMBERS

## REPLACEMENT PARTS LIST

| DESCRIPTION OF PARTS | PUMP CATALOG NUMBERS AND PART NUMBERS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1397 | 1398 | 1399 | 1400 | 1402 | 1403 | 1404 | 1405 | 1406 | 1410 |
| **EXHAUST PORT DUST CAP.** | 41-1501 | | 41-1345 | 41-1345 | 41-0612 | 41-0612 | | 41-1345 | *41-1345 or 1151C | |
| **INTAKE** | | | | | | | | | | |
| Nipple | 41-1493 | | 41-0920 | 41-0920 | 41-0993 | 41-0993 | 41-0924 | 41-1274 | 41-0920 | 41-0920 |
| Nipple Washer | 41-0961 | | | | 41-0491 | 41-0491 | 41-0570 | 41-0409 | | |
| Cover Gasket | 41-1495 | | 41-2375 | 41-0383 | 41-0234 | 41-0234 | | 41-1308 | 41-1310 | 41-0258 |
| Air Filter Screen | 41-0937 | 41-2523 41-2524 | 41-0306 | 41-0890 | 41-0660 | 41-0660 | | 41-0891 | 41-0877 | 41-0306 |
| **OIL CASE GASKET** | 41-1496 | 41-2518 | 41-1052 | 41-1052 | 41-0403 | 41-0403 | | 41-1308 | | 41-1052 |
| **OIL DRAIN CAP** | 41-1151 | 41-2499 | 41-1166 | 41-1166 | 41-1166 | 41-1166 | 41-1166 | 41-1166 | 41-1166 | 41-1166 |
| **OIL DRAIN CAP DISC** | 41-1172 | | 41-1192 | 41-1192 | 41-1192 | 41-1192 | 41-1192 | 41-1192 | 41-1192 | 41-1192 |
| **OIL LEVEL GAUGE** | | | | | | | | | | |
| Tension Washer | 41-1266 | 41-1266 | 41-1266 | 41-1266 | 41-1266 | 41-1266 | | 41-1266 | | 41-1266 |
| Glass Disc | 41-1268 | 41-1268 | 41-1268 | 41-1268 | 41-1268 | 41-1268 | | 41-1268 | 41-0555 | 41-1268 |
| Outer Gasket | 41-1267 | 41-1267 | 41-1267 | 41-1267 | 41-1267 | 41-1267 | | 41-1267 | | 41-1267 |
| Window Cover | 41-1061 | 41-1061 | 41-1061 | 41-1061 | 41-1061 | 41-1061 | | 41-1061 | | 41-1061 |
| **SHAFT SEAL** | 41-1491 | 41-2491 | 1401E | 1401E | 1401D | **1401A or 1401E | 1401E | 1401E | 1401E | 1401E |
| Gasket | 41-1494 | 41-2515 | included | included | included | included | included | included | included | included |
| Screws | (4)2-01-6120 | 2-01-0110 | included | included | included | included | included | included | included | included |
| **VALVE, EXHAUST** | | | | | | | | | | |
| Clock Spring | 41-2161 | | 41-1239 | 41-1239 | 41-2161 | 41-0695 | (2)41-1239 | 41-1281 | 41-1281 | 41-1239 |
| **VALVE, EXHAUST STAGE PRESSURE RELIEF** | | | | | | | | | | |
| Clock Spring | 41-0992 | 41-2506 | | | 41-0992 | 41-0992 | | | | |
| Steel Ball | 4-40-1200 | 4-40-2000 | | | 4-40-1200 | 4-40-1200 | | | | |
| **VALVE, FIRST STAGE CONVERSION** | | | | | | | | | | |
| Gasket | 41-1508 | | | | | | | | | |
| O-Ring | 41-1507 | 41-1507 | | | | | | | | |
| Spring Unit | 41-1504 | 41-1504 | | | | | | | | |
| Bellows | 14-1505 | 41-1505 | | | | | | | | |
| Valve | | | | | (2)41-2157 | | | | | |
| Spring | | | | | (2)41-2158 | | | | | |
| **VALVE, FIRST STAGE PRESSURE RELIEF** | | | | | | | | | | |
| Valve | 41-2248 | 41-2398 | | | | | | | | |
| Spring | 41-2244 | 41-2507 | | | | | | | | |
| Tension Strip | 41-2247 | 41-2485 | | | | | | | | |
| **PRESSURE CROSS** | | | 1399T | | | | | | | 41-1186 |
| Adapter | | | | | | | | | | 41-1184 |
| **PUMP PULLEY** | 41-1492 | 41-2510 | 41-2192 | 41-2191 | 41-2174 | 41-2194 | 41-2194 | 41-2194 | 41-2194 | 41-2 |
| Key | 41-1490 | 41-2514 | 41-0624 | 41-0624 | 41-0624 | 41-0624 | 41-0624 | 41-0624 | 41-0624 | 41-0 |
| **DUO-SEAL OIL** | 1407K | 1407K | 1407K | 1407K | 1407K | 1407K | 1407K | 1407K | 1407K | 1407K |
| **EXHAUST FILTER** | 1417B | 41-2495 | 1417 | 1417 | 1417A | 1417A | | 1417 | 1417 | 1417 |
| Repl. Element | 1417H | 41-2516 | 1417F | 1417F | 1417G | 1417G | | 1417F | 1417F | 1417F |
| **VENTED EXHAUST VALVE** | included | included | included | 1414 | included | | | 1414A | | |
| Repl. Stem Assembly | 41-2289 | 41-2497 | 41-2289 | 41-2289 | 41-2348 | | | 41-1258 | | |
| O-Ring | 41-2364 | | 41-2364 | 41-2364 | | | | 41-2364 | | |
| **MOUNTING PARTS** | | | | | | | | | | |
| **BASE** | 41-1475 | 41-2475 | 41-0752 | 41-0788 | 41-2052 | 41-0779 | 41-1295 | 41-0794 | 41-0753 | 41-0788 |
| Rubber Feet | (4)41-0588 | | (4)41-0929 | (4)41-0929 | (4)41-0929 | (4)41-0929 | (4)41-0929 | (4)41-0929 | (4)41-0929 | (4)41-0929 |
| Screws | (4)2-01-0312 | | (4)2-02-5708 | (4)2-02-5708 | (4)2-02-5708 | (4)2-02-5708 | (4)2-02-5708 | (4)2-02-5708 | (4)2-02-5708 | (4)2-02-5708 |
| Nuts | (4)2-35-3800 | | | | | | | | | |
| **PUMP** | | | | | | | | | | |
| Bolts | (4)2-01-0516 | (8)2-01-0520 | (4)2-01-0312 | (4)2-01-0312 | (4)2-01-0312 | (4)2-01-0312 | (2)2-01-0312 | (4)2-01-0312 | (4)2-01-0312 | (4)2-01-0312 |
| Washers | (4)2-63-0593 | (8)2-63-0593 | (4)2-61-3100 | (4)2-61-3100 | (4)2-61-3100 | (4)2-61-3100 | (2)2-61-3100 | (4)2-61-3100 | (4)2-61-3100 | (4)2-61-3100 |
| Nuts | (4)2-31-2521 | (8)2-31-2521 | (4)2-35-3800 | (4)2-35-3800 | (4)2-35-3800 | (4)2-35-3800 | (2)2-35-3800 | (4)2-35-3800 | (4)2-35-3800 | (4)2-35-3800 |
| **MOTOR** | **1 H.P.** | **3 H.P.** | **⅓ H.P.** | **⅓ H.P.** | **½ H.P.** | **½ H.P.** | **⅓ H.P.** | **⅓ ½** | **⅓ H.P.** | **⅓ H.P.** |
| Mounting Strips | (2)41-0669 | | (2)41-0670 | (2)41-0670 | (2)41-0669 | (2)41-0669 | (2)41-0670 | (2) (2) 41-0670 41-0669 | (2)41-0669 | (2)41-0669 |
| Bolts | (4)2-01-0312 | | (4)2-01-0312 | (4)2-01-0312 | (4)2-01-0312 | (4)2-01-0312 | (4)2-01-0312 | (4)2-01-0312 | (4)2-01-0312 | (4)2-01-0312 |
| Pulley or Clutch | 41-0995 | 41-2513 | 41-2377 | 41-0549 | 41-1277 | 41-1247 | 41-0549 41-1181 | 41-1181 41-1277 | 41-0549 | 41-0549 |
| **V-BELT** | (2)1397A | (4)41-2512 | 1399A | 1400A | 1405A | 1405A | 1406A | 1405A | 1406A | 1400A |
| **CORD, POWER, 115V** | 41-2500 | | **41-1058** | **41-1058** | **41-1058** | **41-1058** | **41-1058** | **41-1058** | **41-1058** | **41-1058** |
| **230V** | 41-2551 | | **41-1057** | **41-1057** | **41-1057** | **41-1057** | **41-1057** | **41-1057** | **41-1057** | **41-1057** |
| **BELT GUARD** | 41-0791 | 41-2496 | 1399G | 1400G | 1405G | 1405G | 1404G | 1405G | 1404G | 1400G |

*Use No. 1151C Dust Cap on all Model 1406 Pumps with serial number below 3956
**Use No. 1401A Shaft Seal on all Model 1403 Pumps with serial number below 5132

## No. 1392 and 1392A MECHANICAL-DIFFUSION PUMP COMBINATION REPLACEMENT PARTS

| DESCRIPTION OF PARTS | No. 1400 DUO-SEAL PUMP (SEE LARGE TABLE, THIS PAGE) | No. 1392 DIFFUSION PUMP (Water-Cooled) | No. 1392A DIFFUSION PUMP (Air-Cooled) |
|---|---|---|---|
| **DIFFUSION PUMP** | | 1391 | 1394 |
| Heater—135 Watt, 115 Volt | | 1391H | 1391H |
| Octoil Pump Fluid | | | |
| 150 ml. | | 1391K | 1391K |
| 500 ml. | | 1391L | 1391L |
| Silicone Pump Fluid | | | |
| DC-702—200 ml. | | 1391T | 1391T |
| —500 ml. | | 1391R | 1391R |
| DC-703—200 ml. | | 1391U | 1391U |
| —500 ml. | | 1391S | 1391S |
| DC-704—500 ml. | | 1391W | 1391W |

# PUMP SPECIFICATIONS

## PUMP PERFORMANCE

A vacuum pump is best described by its pumping speed, in volume per unit of time, at various pressures. *Example: 100 liters/minute at 0.1 micron.* This measurement is independent of the vacuum system with which it is used. An examination of the speed curves on pages 8 and 9 will show that Welch Duo-Seal pumps maintain high volumetric efficiency, almost down to their ultimate vacuums. Another important feature of a vacuum pump is the ultimate vacuum that it can obtain.

The above data is necessary to determine the proper size and type to best obtain the desired results, with a specific vacuum system.

## WELCH DUO-SEAL VACUUM PUMP SPECIFICATIONS

| PUMP CAT. NO. | ULT. PRESSURE mm Hg (McLeod) | FREE AIR DISPLACE. (liters/min.) | NO. OF STAGES | APPROX. PUMP SPEED (RPM) | VENTED EXHAUST | OIL CAPACITY (milliliters) | PUMP PULLEY DIA. | RUBBER TUBING BORE | INTAKE PORT THREAD |
|---|---|---|---|---|---|---|---|---|---|
| *1392 | $1 \times 10^{-6}$ | 600.($1 \times 10^{-4}$) | | | | 55 | | | |
| 1397 | $1 \times 10^{-4}$ | 425. | 2 | 365 | Included | 1230 | 12″ | 1-5/8″ | 1-3/4″–20 |
| 1398 | $1 \times 10^{-4}$ | 1400. | 2 | 245 | Included | 2500 | 19″ | | |
| 1399 | $1.5 \times 10^{-2}$ | 35. | 1 | 750 | Included | 450 | 7″ | 7/16″ | 3/8″ IPS |
| 1400 | $1 \times 10^{-4}$ | 21. | 2 | 450 | Optional | 550 | 7″ | 7/16″ | 3/8″ IPS |
| 1402 | $1 \times 10^{-4}$ | 140. | 2 | 525 | Included | 2200 | 10″ | 13/16″ | 1″–20 |
| 1403 | $5 \times 10^{-3}$ | 100. | 1 | 375 | | 1400 | 10″ | 13/16″ | 1″–20 |
| 1404 | $2 \times 10^{-2}$ | 33.4 | 1 | 300 | | 2300 | 10″ | 5/8″ | |
| 1405B | $1 \times 10^{-4}$ | 58. | 2 | 525 | Optional | 250 | 10″ | 5/8″ | 3/4″–20 |
| 1405H | or $5 \times 10^{-3}$ | 33.4 | 2 | 300 | Optional | 250 | 10″ | 5/8″ | 3/4″–20 |
| 1406 | $5 \times 10^{-3}$ | 33.4 | 1 | 300 | | 60 | 10″ | 5/8″ | 3/8″–IPS |
| 1410 | $2 \times 10^{-2}$ | 21. | 1 | 450 | | 450 | 7″ | 7/16″ | 3/8″–IPS |

*No. 1392 Mechanical Pump Specifications are the same as No. 1400 in table. 946 Milliliters = 1 Quart
No. 1392 Diffusion Pump Specifications are listed in table.

## MOTOR SPECIFICATIONS FOR WELCH DUO-SEAL VACUUM PUMPS

### (to operate pump at proper speed)

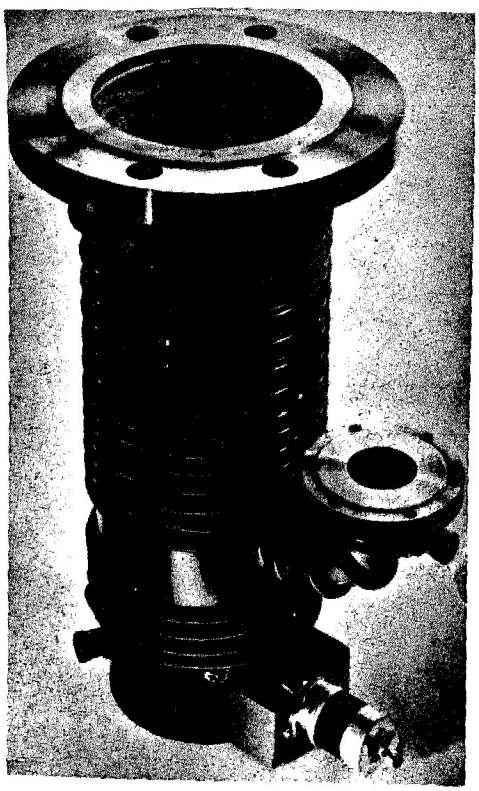
| PUMP CAT. NO. | MOTOR RATING | | MOTOR PULLEY | | BELT GUARD |
|---|---|---|---|---|---|
| | H.P. | R.P.M. | DIAMETER | BORE | |
| 1397B | 1 | 1725 | 2-1/2″ | 5/8″ | Included |
| 1398M | 3 | 1160 | 4″ | 1-1/8″ | Included |
| 1399B | 1/3 | 1725 | 3″ | 1/2″ | Optional |
| 1400B | 1/3 | 1725 | 2″ | 1/2″ | Optional |
| 1402B | 1/2 | 1725 | 3″ | 5/8″ | Optional |
| 1403B | 1/2 | 1725 | 2-1/4″ | 5/8″ | Optional |
| 1404H | 1/3 | 1725 | 2″ | 1/2″ | Optional |
| 1405B | 1/2 | 1725 | 3″ | 1/2″ | Optional |
| 1405H | 1/3 | 1725 | 2″ | 1/2″ | Optional |
| 1406H | 1/3 | 1725 | 2″ | 1/2″ | Optional |
| 1410B | 1/3 | 1725 | 2″ | 1/2″ | Optional |

N.B. When ordering motor, specify voltage.

# APPENDIX B

# DIFFUSION PUMP

CVC Instruction Manual
No. 6-70-B
Revision No. 1



# Consolidated Vacuum Corporation

ROCHESTER NEW YORK

## DIFFUSION PUMPS, TYPES PMC-PMCS
## MODELS B & C - 2C, 4B, 6B, 10C

TABLE OF CONTENTS

## 1.0 INTRODUCTION

This instruction manual is designed to aid you not only in the installation of this equipment but throughout its working life. How well it aids you depends upon how thoroughly you read and make reference to it. Since your warranty does not cover damage resulting from abuse and from errors in installation, it is to your advantage to read this manual as comprehensively as possible. Further assistance is available if necessary. (See Assistance from CVC).

The Table of Contents reveals the plan and scope of this manual.

### Description of PMC-PMCS-2C, 4B, 6B, and 10C Diffusion Pumps

Basically the PMC pump you have purchased consists of an inlet flange, casing and forearm (enclosed in cooling coils), outlet flange, heater and nozzle assembly. Pump fluid is not included in the purchase price of the pump and must be ordered as a separate item (see the attached literature).

The PMC is constructed of carbon steel, and the PMCS of stainless steel. The flanges (inlet and outlet), each have raised step seal areas for sealing with the elastomer Con-O-Ring gaskets supplied with the pump.

The pump size is indicated by the particular model number; for example, the 2C model pump is of nominal 2" size, the 4B of nominal 4" size, etc.

"B & C" Model PMC pumps feature cooling coils around the boiler area of the pump casing to provide rapid cooling of the fluid during shut down. A Dri-Cap® Shield is also supplied (except in the PMCS-2C where it would unduly restrict the plateau speed of the pump), as an integral part of the nozzle assembly. Its purpose is to minimize backstreaming of fluid vapor from the pumping area. This shield cap may be easily removed should higher pumping speeds be desired.

230 volt cartridge heaters are available for converting these pumps to operation with electrical service other than the standard anticipated for them. This conversion is discussed in Section 4.5 of this manual.

# 2.0 INSTALLATION

## 2.1 Specifications

| Specifications | Pump Sizes | | | |
|---|---|---|---|---|
| | 2" | 4" | 6" | 10" |
| Inlet Connection | Flange | Flange | Flange | Flange |
| O.D. | 4" | 9" | 11" | 16" |
| I.D. | 2-1/4" | 5-1/4" | 7" | 12" |
| Thickness | 5/8" | 15/16" | 1" | 1-3/16" |
| Bolt Circle | 3-5/16" | 7-1/2" | 9-1/2" | 14-1/4" |
| No. of Holes | 6 | 8 | 8 | 12 |
| Hole Diameter | 11/32" | 3/4" | 7/8" | 1" |
| Outlet Connection | Tubing | Flange | Flange | Flange |
| O.D. | 3/4" | 4" | 7-1/2" | 7-1/2" |
| I.D. | --- | 1-5/8" | 2-13/16" | 2-13/16" |
| Thickness | --- | 9/16" | 15/16" | 15/16" |
| Bolt Circle | --- | 3-5/16" | 6" | 6" |
| No. of Holes | --- | 6 | 4 | 4 |
| Hole Diameter | --- | 11/32" | 3/4" | 3/4" |
| Cooling Connections | 1/8" FPT | 1/4" FPT | 1/4 FPT | 1/4 FPT |
| Nozzle Material | Aluminum | Aluminum | Aluminum | Aluminum |
| Casing Material | Stainless Steel | * | * | * |
| Heater Voltage (Rated) | 115 V. | 115 V. | 115 V. | 230 V. |
| Heater Wattage (Rated) | 300 W | 1200 W | 1800 W | 4500 W |
| Pump Fluid (Quantity) | 80 cc | 400 cc | 800 cc | 1500 cc |
| Net Weight | 5 lbs. | 28 lbs. | 46 lbs. | 146 lbs. |
| Water Flow (Nominal Rate) | 1/20 gpm | 1/6 gpm | 1/4 gpm | 3/5 gpm |
| Over-all Height | 11-3/16" | 16-5/8" | 20-1/2" | 28" |
| Flange to Flange Height | 3-1/2" | 7-1/2" | 7-1/2" | 15-1/4" |
| Flange Center to Flange Center | 3" | 5-1/2" | 8-1/2" | 11-3/4" |

* Type PMC - Carbon Steel
* Type PMCS - Stainless Steel

2.2 Unpacking and Preparation (Refer to Figure I)

Equipment is normally shipped F. O. B. Rochester, New York. Directly after receipt, this equipment should be unpacked and inspected for shipping damage. Damage in transit is the responsibility of the transportation company and should be reported to them.

Each pump is packed so that it may be stored as received (after initial inspection) if its use is not immediately required.

The following steps should be completed to prepare the pump for set-up:

1. Remove the protective coverings from the pump inlet and outlet and the plastic Caplugs from the connections for the cooling and Quench coils.

2. Remove any packing materials from the inside of the pump.

3. Lift the nozzle assembly out of the casing.

4. Rinse the nozzle assembly, the inside of the casing, and the hollow cylindrical sleeves with petroleum ether* or benzene*.

5. Rinse the same items first with acetone*, then with isopropyl* alcohol

6. Remove all traces of alcohol with oil-free compressed air.

7. Place one sleeve over each of the finned heater housings which extend upward from the bottom of the pump casing.

8. Replace the nozzle assembly in the casing making sure it is seated firmly on the bottom of the casing.

9. Wipe the inlet and outlet flanges to remove all foreign particles.

10. It is desirable that the Con-O-Ring gasket be lubricated with a very light coat of Celvacene® vacuum grease.

*CAUTION: Solvents recommended in this manual may be toxic and/or flammable. Suitable precautions should be observed in using them.

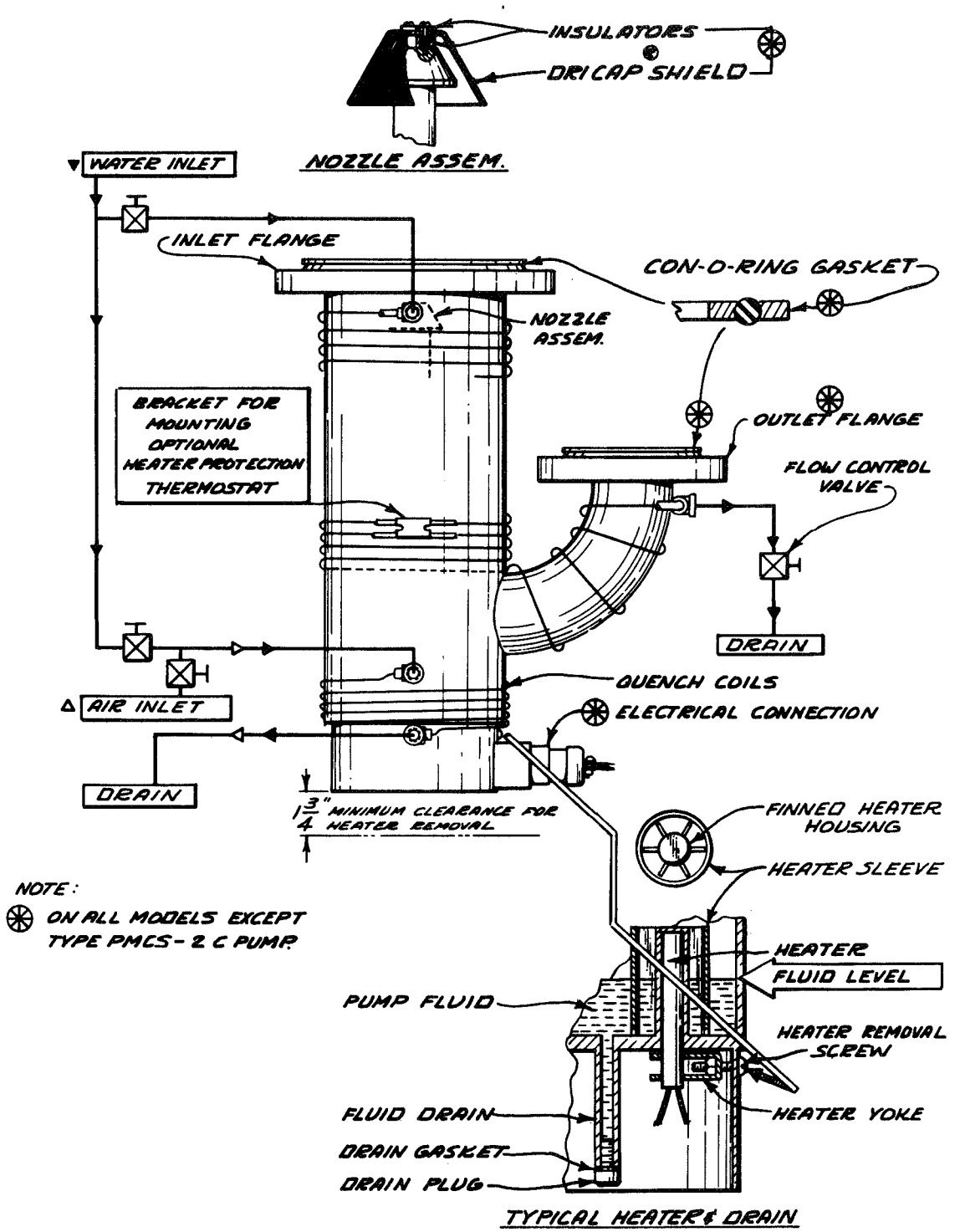



FIG. 1 TYPICAL DIFFUSION PUMP & COOLING SCHEMATIC TYPE PMC

## 2.3 Connections: (Refer to Figure I ).

### 2.3.1 Vacuum Line Connections

Install the pump so the casing is in a vertical position. Bolt the inlet flange, with the Con-O-Ring gasket positioned, to an ungrooved mating flange attached to the vacuum line. Tighten all bolts to finger tightness then use a wrench to successively tighten pairs of bolts which are opposite each other on the flange. This produces even compression over the entire contact surface of the sealing gasket. The pump is designed so it can be safely suspended by the flange without providing additional support.

Use the same procedure for the outlet.

For further information and recommendations on vacuum piping, connections, and gauging, See Appendix I.

### 2.3.2 Cooling Connections (Refer to Figure I)

The PMC pumps require water cooling at a nominal inlet temperature of 20° C. Refer to Section 2.1 for the nominal water flow requirements applicable to your particular pump. The FPT connector just below the pump inlet flange is the water inlet; the water outlet is the FPT connector on the outlet arm. The upper connector of the boiler quench coil is for supply line connection and the lower for drain line connection.

It is often advantageous to use a solenoid-operated inlet valve wired to the forepump switch as an on-off control for the water.

1. For the Upper Pump Casing

   Install a valve in the water discharge line. This valve is needed to turn the water on and off. The valve must also be used to adjust the rate of flow to the recommended value each time the water is turned on. If your pump is being installed in a production unit where failure to adjust the rate of flow of cooling water could have serious results, place a valve in the inlet line as shown

in Figure I. The discharge valve can be regulated to establish and maintain the proper flow rate; the inlet valve can be used as an on-off control.

2. For the Boiler Quench Coil

A. Connect both a water supply line and a compressed air line to the upper connector of the coil. Both water and air lines should be provided with shut-off valves. The air supply line is utilized to blow the quench coil free of water before energizing the pump heaters.

B. Connect an adequate drain line to the lower connection.

NOTE: It is not essential to the successful operation of the pump that the boiler quench coils be connected. This feature is provided solely for rapid shut-down of the pumps. On some CVC systems this is not connected. It is imperative that the two Caplugs be removed.

2.3.3 Electrical Connections

PMC-PMCS pumps utilize cartridge-type heaters. These heaters are inserted up in the wells in the bottom of the pump boiler. Each heater, with the exception of the 2C, is wired to a plug assembly mounted on the side of the heater guard at the bottom of the pump. The heater wires of the 2C may be connected to a switch or directly to the service cord. The recommended procedure for replacing heaters is presented in Section 4.4., Step 3.

To wire the PMC-4B, 6B or 10C pump, first separate the male and female parts of the power plug assembly. Connect the necessary supply (See Specifications table for volts and wattages) to the female part of the connector plug. CVC recommends that a switch be installed in the line for turning the pump heaters on and off. The purpose of the plug is to permit installation and removal of the pump from the system for cleaning, etc., without the service of a skilled electrician; it is not intended for use as an on-off switch.

The actual heater input of a diffusion pump has an important effect on pump performance. To assure optimum pump operation check the voltage and current to the power supply at or near the pump heater plug to determine whether the recommended operating wattage is available.

2.3.4 Diffusion Pump Backing Requirements

Since diffusion pumps cannot compress gases to atmospheric pressure a forepump, such as rotary, oil sealed mechanical pump, must be employed to further compress the gas load delivered by the diffusion pump. Thus the mechanical pump is also known by one of its primary functions, as a backing pump.

Selection of a mechanical pump to back a given diffusion pump will be determined by (1) the customer's performance requirements, (2) the forepressure characteristics of the diffusion pump (which may be different for different gases), and by (3) the foreline impedance. Because of these variables, the exact mechanical pump rating which is most suitable for your particular application cannot be stated here. Table I lists the required backing speeds at the outlet flanges, of PMC pumps both for normal operating range and for operation at high throughputs.

TABLE I

Backing speed required for air and $H_2$ at the outlet flange for:

| | Normal Operating Range | Utilizing pumps high throughput |
|---|---|---|
| PMCS 2C | 1.5 CFM | 5 CFM |
| PMC (S) 4B | 5 CFM | 30 CFM |
| PMC (S) 6B | 10 CFM | 80 CFM |
| PMC (S) 10C | 20 CFM | 100 CFM |

$\frac{CFM}{2.12}$ = liters/sec.

## 2.4 Leak Testing the System

1. Refer to the data supplied with your mechanical pump for information on cooling rate, starting procedure, adjusting the oil flow rate, and ultimate pressure.

2. Start the mechanical pump.

3. Check the ultimate pressure of the mechanical pump. A pressure which is equal or nearly equal to that listed in the manufacturer's data indicates that the system is leak tight. Thermo-conductivity gauges will indicate higher pressures than those given in the mechanical pump manufacturer's data. A high ultimate pressure indicates that the pump is not performing properly or that the system leaks.

   A. If the system is valved, isolate the mechanical pump from the remainder of the system and test the pump alone to make sure it is performing properly.

   B. Open the entire system to the mechanical pump. After an interval of pumping (the length of this interval for a particular pump depends primarily on the size of the system) the pressure should approximate that obtained in step 3.

4. Valve off the system and check the rate of pressure rise (See Appendix II, Section 8.3).

## 2.5 Charging the Pump with Fluid

Make certain all containers, funnels, tubing, etc., that will come in contact with the fluid are clean, to avoid contaminating it.

Several types of pump fluid are available for use in diffusion pumps. The general characteristics of each of these fluids and the general effects of the fluid on the pump performance differ as indicated in Table II. The fluid quantity requirements of the various size PMC pumps are shown in the Specifications (Section 2.1).

TABLE II

| Pump Fluid Type | Recommendations* |
|---|---|
| Convoil-20 | General purpose fluid |
| Convalex®-10<br>DC-705 | For low ultimate pressures and high resistance to decomposition |
| DC-704 | For high resistance to decomposition |

*See attached literature for further details.

2.5.1 Methods of Charging the Pump

Select whichever of the following techniques will cause the least disturbance of the seals.

1. By pouring the fluid down through the forearm:

   A. Remove the foreline connections.

   B. Pour the required amount of fluid into the foreline port.

   C. Reconnect the foreline.

2. By pouring the fluid in through the pump inlet:

   A. Pour the required amount of fluid down the inside of the casing wall. If there is interference in the form of valving, etc., select an alternate method or remove the pump from the system.

   B. Reinstall the pump in the system.

3. By drawing fluid up through the boiler drain:

   A. Place the required quantity of fluid in a clean container.

B. With the system at atmospheric pressure, remove the boiler drain cap.

C. Start the mechanical pump.

D. Slowly draw the fluid from the container into the boiler through a length of clean tubing connected to the boiler drain.

WARNING: After the fluid is in the pump DO NOT allow air to be continually drawn into the pump.

E. Remove the tubing and quickly replace the drain cap.

F. Turn off the mechanical pump.

2.5.2 Storage of Pump Fluids

1. Light-sensitive fluids should be stored in tightly stoppered, brown glass bottles.

2. All fluids should be stored in clean, tightly-closed, plainly labeled containers.

# 3.0 OPERATION

## 3.1 Start-Up Procedure

1. Start the mechanical pump.

2. Open appropriate valves to the pump foreline. Adjust the water cooling (quench coil OFF) rate for the diffusion pump. See Section 2.1. Outlet temperature should be approximately 50° C if either Convoil-20 or DC-704 is used.

3. Turn on the diffusion pump heaters. Warm up time is dependent upon pump size, water cooling temperature, etc. A small quantity of dissolved gas will be liberated from the warming fluid causing a short duration pressure rise.

4. Check the inlet pressure of the diffusion pump after it has been operating for a short interval. It should be in the ion gauge range.

## 3.2 Performance Check

1. Pump performance data should be recorded each time the pump is operated. This performance record will indicate a need for maintenance or repair before the pump performance deteriorates. A gradual increase in the ultimate pressure of the mechanical pump or the diffusion pump may indicate fluid or system contamination or leakage. The following performance characteristics should be recorded daily.

   A. Ultimate pressure of the mechanical pump (blanked off if possible).

   B. Ultimate pressure of the diffusion pump.

   C. Time required to reduce the pressure in the system to the required operating value.

   D. Cooling water temperature, in and out.

   E. Monitor heater current if convenient.

## 3.3 Shut-Down Procedure

1. Turn off the diffusion pump heaters.

2. Turn on the water supply to the boiler quench coil (if utilized).

3. Allow the diffusion pump to cool until the boiler bottom is cool to the touch, then turn off all cooling water.

4. If the boiler quench coil was used to expedite the cool-down, blow all traces of water out of the coil. Failure to do this will result in a build up of mineral deposits.

5. It is now safe to break vacuum (Recommended practice is to break vacuum by bleeding gas to the system on the intake side of the diffusion pump. This removes the chance of mechanical pump fluid being forced into the diffusion pump).

CAUTION: If air is accidentally admitted to the hot diffusion pump and the pressure rises above 1 torr, the pump heaters should be turned off and the quench coil activated. Ordinarily damage to the hot fluid will be negligible as long as the temperature is not caused to rise above the normal operating temperature as would be the case if the heaters were not turned off and the vaporization suppressed by the presence of gas at pressures above 1 torr.

## 3.4 Need for Spare Parts

If a supply of spare parts is stocked, down time can be minimized. All parts which should be stocked for your pump are indicated on the parts list.

# 4.0 MAINTENANCE

If pump operation meets your requirements (as evidenced by the results of the Performance Check), no further attention need be given to the pumping system at this time. Monitoring the daily performance records will indicate the need for corrective action. A routine periodic inspection should also be made.

## 4.1 Periodic Inspection Procedure

This procedure should be performed at regular intervals. The length of the interval depends upon the particular installation and can best be determined by experience. An interval of approximately 14 operating days may be used as a starter. This can be extended contingent upon satisfactory system performance.

1. Check the quantity and condition of the diffusion pump fluid. Replace or add fluid as indicated. Loss of fluid may be caused by:

   A. Periodic or continuous lack of proper cooling.

   B. Excessive operation above the recommended maximum inlet pressure.

   C. A horizontal inlet line which does not allow migrating fluid to return to the diffusion pump.

2. Check the heater input.

   If an ammeter in the heater line indicates a low amperage, one or more heaters may have burned out. See Section 4.4, step 3 for the recommended replacement procedure.

## 4.2 Cleaning Procedure

This procedure is used when pump fluid is changed as well as when the pump is dirty.

1. Remove the pump from the system.

2. Remove the nozzle assembly and heater sleeves from the casing.

3. Remove all traces of pump fluid from the nozzle assembly and casing. The following Table III list recommended solvents for the basic types of pump fluid. Refer to "CAUTION" on page 8.

TABLE III

| Type of Fluid | Pump Fluid Trade Names | Solvent |
|---|---|---|
| Ester Fluid | Octoil ®, Butyl Phthalate | Acetone |
| Hydrocarbon Fluid | Convoil | Benzene or "Skelly F" |
| Polyphenyl Ether* | Convalex®-10 | Xylene (followed by Methyl-Ethyl-Ketone) |
| Silicone Fluid | DC-702, -703 and DC-704, -705 | Toluene or trichlorethylene |

4. Remove all traces of solvent from the nozzle assembly and casing by rinsing them with acetone, then isopropyl alcohol.

5. Use dry, oil-free compressed air to remove all the solvent from the nozzle assembly and casing.

6. Replace heater sleeves and the nozzle assembly in the casing. Make certain it is properly centered and is resting squarely on the bottom of the casing.

7. Connect the pump to the system.

8. Leak-test the system as outlined in Section 2.4.

*U.S. Patent No. 3, 034, 700.

9. Charge the pump in the manner described in Section 2.4. The pump is now ready for operation.

4.3 Special Procedures

1. To remove tars from the nozzle assembly and casing interior:

   A. Degreasing, scrubbing with steel wool, or sand blasting may be required if tars are very heavy.

   B. Follow such with an acetone rinse, etc.

2. To remove crystals resulting from decomposed ester fluids.

   A. Degrease.

   B. Clean with detergent.

   C. Rinse with water.

   D. Rinse with acetone.

3. To replace cartridge heaters:

   A. Disconnect the heater leads.

   B. Loosen the heater retainer with the screw on the side of the heater guard.

   C. Remove the burned out heater.

   D. Dip the replacement heater in milk of magnesia. This is important because it prevents the heater from seizing in the well.

   E. Insert the replacement heater in the well and tighten the heater retainer.

   F. Reconnect the heater leads.

4.4 Removing the Dri-Vap® Shield from the Nozzle Assembly

As has already been stated, the PMCS-2C has not been provided with a Dri-Cap® shield. Consequently, this section need not concern the owner of such a pump.

The PMC (S)-4B, 6B, & 10C pumps do have Dri-Cap® shields factory installed on their respective nozzle assemblies. Thes can be removed when the highest pumping speed is desired and when slight back-streaming of pump fluid presents no problem. This is done in the following manner:

4.4.1 Dri-Cap® Shield removal from the PMC(S)-4 & 6B.

1. Pry off the cap retainer (push-on speed nut).

2. Lift the Dri-Cap shield and two ceramic insulators off the stud on which they are positioned. Store these parts in a safe place.

4.4.2 Dri-Cap® shield removal from PMC(S)-10C.

This is accomplished by unscrewing three slot head screws and lifting the Dri-Cap shield and the insulators beneath it up off of the nozzle assembly. Store these parts for possible use at a later date.

4.5 Converting to 230 Volt or 460 Volt Operation

230 Volt, 300 watt cartridge heaters are available from CVC (See Replacement Parts) for direct conversion of the pump for use with 230 or 460 volt service. The cartridge substitution is accomplished as described in Section 4.3, No. 3 and as is illustrated in Figure 1.

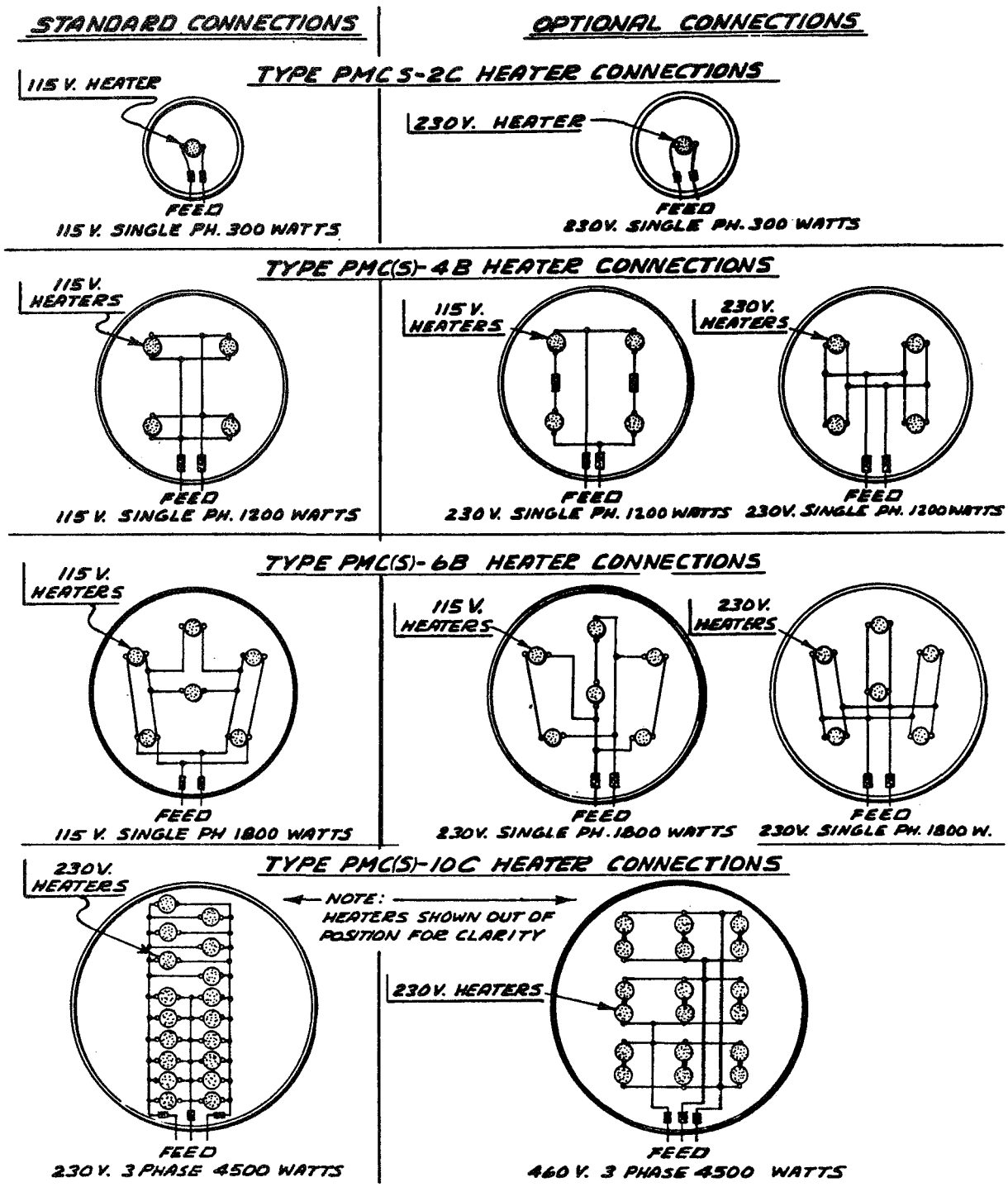



FIG. 2 STANDARD & OPTIONAL HEATER CONNECTIONS FOR PMC PUMPS

| | PMCS-2C | PMC(S)4B | PMC(S)6B | PMC(S)10C |
|---|---|---|---|---|
| No. of heaters | 1 | 4 | 6 | 18 |
| Power | 300 W | 1200 W | 1800 W | 4500 W |
| Service | | | | |
| 1$\phi$ @ 115 V | STD. | STD. | STD. | |
| 1$\phi$ @ 230 V | * | * | * | |
| 3$\phi$ @ 230 V | | | *(#) | STD. |
| 3$\phi$ @ 460 V | | | *(#) | * |
| 1$\phi$ @ 460 V | | *(#) | *(#) | |
| (#) - Plug not usable | | | | |

In cases where the electrical connector plug cannot be used, the larger plug used on the PMC-10C can be substituted. The customer will, however, have to develop his own mounting technique.

Refer to Figure 2 when wiring the cartridge heaters for the proper service.

* The asterisks indicate the conversions possible.

## 5.0 TROUBLE SHOOTING TABLE

Check the accuracy of the vacuum gauges used on the system before attempting to locate the cause of poor ultimate pressure.

| Trouble | Possible Cause | Remedy |
|---|---|---|
| Deterioration of Operating pressure (or cycle time) | Component pump malfunctioning | Blank off the pump successively from the mechanical pump through the diffusion pump to check for satisfactory operation. |
| | Leakage | Refer to Appendix II. |
| | System Contamination | Clean as needed. |
| Poor ultimate pressure | Insufficient time of operation | |
| | Leak in system | Refer to Appendix II. |
| | | Refer to manufacturer's instructions for mechanical pump. |
| | Insufficient or excessive diffusion pump heater input. | Make certain heater input is properly adjusted. |
| | Insufficient or excessive diffusion pump cooling | Make certain inlet temperature is as specified in Section 2.3.2, i.e., 20° C. |
| | Water in quench coil | Blow coil free of water. |
| | Excessive forepressure | Check foreline for leaks. Check the mechanical pump performance. |

| Trouble | Possible Cause | Remedy |
|---|---|---|
| | Vapor pump fluid contaminated with mechanical pump oil or damage by exposure of the hot fluid to excessive pressure or process contamination. | Drain diffusion pump boiler and refill with new fluid. |
| | Dirty process system | Clean the system. |
| Periodic Surges in inlet pressure of diffusion pump. | Heater input too high. | Check required heater input and adjust accordingly. |
| | Too much or too little fluid in pump. | Make certain pump boiler contains only recommended quantity of fluid. |
| | Outgassing of fluid. This is characteristic of some fluids during initial use. | Age fluid by operating pump. |
| | Too much grease or oil in the gasket groove of the inlet flange. | Remove pump from system and wipe groove dry. |
| | Loose or leaky boiler drain gasket. | Tighten drain plug or replace gasket. |
| Cracking noise in boiler. | This is not harmful unless accompanied by a decline in pump performance. | |

CONSOLIDATED VACUUM CORPORATION
Rochester, New York 14603
6-70-B/R9-66/EHF/tb

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## REPLACEMENT PARTS LIST FOR THE 6-INCH OIL DIFFUSION PUMP, TYPES PMC, PMCS-6B

MINIMUM ORDER BILLING OF $10.00 PER ORDER. PLEASE INCLUDE PART NUMBER AND DESCRIPTION OF EACH PART ORDERED.

| Description | Part No. |
|---|---|
| Cartridge Heater, 115 V., 300 W | 65192 |
| Cartridge Heater, 230 V., 300 W | 65192-1 |
| Gasket for Drain Plug, Copper | 261122-2 |
| Con-O-Ring Gasket, Buna-N 6" | 265056-6 |
| Con-O-Ring Gasket, Buna-N 3" | 265056-3 |
| Nozzle Assembly | 261725 |
| SUPPLY ITEMS: | |
| NOTE: See attached ADVANCE ORDER BLANK for fluid supplies. | |
| Celvacene® Vacuum Grease (Medium) 1/4 lb. | 269352-11 |
| O-Ring, 6" replacement, Buna-N | 70011-42 |
| O-Ring, 3" replacement, Buna-N | 70011-20 |
| O-Ring, 6" replacement, Viton-A | 264091-19 |
| O-Ring, 3" replacement, Viton-A | 264091-17 |
| Thermostat | 264727 |

# APPENDIX C

# LIQUID NITROGEN CRYO-BAFFLE

CIRCULAR CHEVRON CRYO-BAFFLES

SERIES 0315-1

# INSTALLATION, OPERATING AND MAINTENANCE INSTRUCTIONS

## GENERAL

The NRC Series 0315-1 Circular Chevron Cryo-Baffles includes many significant improvements over its well established and widely accepted predecessor, the C315 series. Critical dimensions have been retained so that this series of cryo-baffles is completely "retrofit" for existing systems. The characteristics of minimum overall height, optical capacity, and maximum conductance capacity have been preserved.

The new traps have an improved inner structure design. Thermal losses are reduced by using a single coaxial feed and vent tube and a new suspension concept. An anti-migration barrier has been added without affecting the outstanding performance features. The trap envelope is made of two special stainless steel pressings with automatic heliarc welded joints. A unique fill and vent adapter (with probe guide) permits many alternative ways of supplying coolants to the central reservoir. This is rated for 125 psi internal pressure.

Before installing the cryo-baffle, the user is advised to read this installation and operating instruction carefully. Familiarity with the product will insure correct use and optimum performance.

Figure 1 shows the general design features of the 0315-1 family of cryo-baffles. Table I outlines performance characteristics.

## INSTALLATION

1. Remove the protective covers from the inlet and outlet flanges of the trap. Avoid damaging the sealing surfaces in handling.

2. Remove all transit packing, i.e. VPI paper, from the trap interior.

3. Keep interior surfaces of the trap clean, before and during installation. Contamination adds unnecessarily to the system gas load. Insure that the O-ring groove and sealing ring are clean and free from foreign matter.

   NOTE: The rugged design of the cryo-baffle eliminates the need for special supports or precautions against distortion when installing the trap between the system port flange and the compatible diffusion pump.

Table II provides essential dimensional data and related information.

4. Install the trap with its axis vertical and the O-ring grooved system port mating flange uppermost.

   Locate the fill and vent tube in the most accessible and convenient direction for convenience of fitting the special adapter and coolant source. (Refer to "Filling the Trap").

   Insert mounting bolts with washers and secure the flanged joint finger tight. Then tighten bolts in a cyclic pattern for even gasket compression.

5. For the flanged joint to the diffusion pump inlet use bolts of the lengths specified in Table II. Insure that the lower flange sealing face and pump inlet O-ring groove and sealing ring are clean. Finger tighten bolts initially. Follow this by tightening in a cyclic pattern for even gasket compression.

   CAUTION: DO NOT use bolts longer than specified, to avoid damage to the trap housing by excessive protrusion through the lower flange.

6. Install the fill and vent adapter as described in the following paragraphs depending on the selected mode of furnishing coolant to the trap.

Filling the Trap

Each trap is furnished with a fill and vent adapter (with probe guide) as shown in Figure 2. The adapter consists of a modified compression fitting elbow with two tubes silver soldered into the body. The larger of the tubes (5/16" OD) may be used to provide a positive guide for the probe of an automatic level controller. The diameter of the flexible level sensing probe must be 0.225 inch or less. Other connections of the adapter are used for fill and vent as described below. The adapter may be used for several modes of supplying the trap reservoir with coolant and offers simplicity with maximum flexibility. Figure 2 and Figure 3 illustrate commonly used arrangements for manual gravity filling and for pressurized filling with level sensing respectively. The adapter kit includes a length of "poly-flex" plastic tubing, which must be cut to length and fitted depending on the mode of trap filling.

1. Gravity (non-pressurized) Filling. (Figure 2)

   Filling is accomplished by feeding liquid nitrogen through the inlet "A" of the adapter. Venting takes place from both tubes and vent gases may be guided away by plastic tube extensions. To install the adapter for this mode of filling proceed as follows:

a. Cut "poly-flex" tubing to the length (b) of Table III corresponding to the model number of the trap used.

b. Slide the square cut end of the "poly-flex" tubing over the end of the smaller diameter (longer) tubing projecting from the adapter until the end abuts the end of the larger diameter (shorter) one.

c. Unscrew compression nut (B) and slide it, with its back-up and ferrule along the adapter tubes.

d. Insert "poly-flex" tubing and gently ease the adapter into the trap connection. Guide the nut, back-up and ferrule over the trap connection tube. Continue to insert until the end of this tube is firmly seated in the counter bored entry of the adapter.

e. Orient connection (A) of the adapter as suggested in Figure 2. Slide ferrule and back-up into position preparatory to securing the compression joint to the trap. Firmly hold the adapter body and complete the compression joint by torquing nut 1 1/4 turns.

f. The vent tubes may be bent apart to permit direction of vent gases or facilitate attachment of tube extensions if desired.

g. Slowly fill trap to keep initial vent gas generation low.

NOTE: When reservoir is chilled, vent gas will be at a minimum. To "top off" the trap, continue to fill until liquid appears as a steady stream from the larger of the two tubes projecting from the adapter.

2. Pressurized Filling Figure 3

The same installation procedures apply for pressurized filling with or without automatic level control.

Filling is accomplished by connecting the $LN_2$ supply to the end of the smaller diameter tube of the adapter. Venting takes place through the orifice at "A". Vent gases may be directed or guided away by orientation of the adapter port (A) or by connecting a suitable tube extension to it.

To install the adapter for this mode of filling, proceed as follows:

a. Cut "poly-flex" tubing to the length (A) of Table III corresponding to the model number of the trap used. Trim excess from the square end, if necessary.

b. Slide the square cut end of the "poly-flex" tubing over the end of the smaller diameter (longer) tubing projecting from the adapter, until the end abuts the end of the larger diameter (shorter) one.

c. Unscrew compression nut (B) and slide it, with its back-up and ferrule along the adapter tubes.

d. Insert "poly-flex" tubing and gently ease the adapter into the trap connection. Guide the nut, back-up and ferrule over the trap connection tube. Continue to insert until the end of this tube is firmly seated in the counter bored entry of the adapter.

e. Orient connections (A) of the adapter as suggested in Figure 3. Slide ferrule and back-up into position preparatory to securing the compression joint to the trap. Firmly hold the adapter body and complete the compression joint by torquing nut 1 1/4 turns.

f. The fill and guide tubes may be bent apart for convenience of making appropriate connections.

NOTE: When the trap is chilled, vent gas evolution will be at a minimum. To "top off" the trap continue to fill until liquid appears as a steady stream at the vent port (A).

3. Use of an Automatic Level Control

The flexible probe (less than 0.225 diameter) is inserted through the sensor guide tube (larger) of the adapter until the low level sensing junction is in the desired position.

4. Other Applications

The fill and vent adapter may similarly be used for recirculating type of refrigeration cooling of the trap reservoir. The trap is thereby adaptable to mechanical refrigeration using a suitable heat transfer fluid or to closed cycle $LN_2$ cooling. For this type of system the level probe guide tube must be sealed off, preferably at the end near the trap. A silver soldered plug closure is recommended.

Helpful Suggestions

1. Avoid operating the trap before the majority of water vapor in the system has been pumped away. Lowest pressures are obtained when chilling of the trap is delayed until the system pressure is in the $10^{-4}$ torr range.

2. For optimum trap performance the use of a water cooled baffle between it and the diffusion pump is recommended.

3. Do not expose a "cold" trap to atmospheric condition to avoid water vapor condensation within the vacuum envelope as well as the inner surfaces of the reservoir and fill tube.

   Always defrost and "reheat" the trap thoroughly before exposure to atmosphere. At the end of trap operation "blow" the excess coolant ($LN_2$) from the reservoir. Follow this with thorough reheating, using warm nitrogen or warm dry air circulation through the fill tube and reservoir.

4. To clean the trap remove the entire assembly from the system.

   Immerse the trap in trichlorethylene and rinse thoroughly.

   Follow this by a rinse in isopropyl alcohol or Freon TF. Remove all cleaning agent from the trap body and reservoir interior. Thoroughly dry the unit for several hours using clean warm air or a gentle bake in an oven at approximately 170°F.

5. The standard trap is furnished with a Buna O-ring gasket for the inlet flange. Optional gasket rings are available, made of Butyl or of special cross section metal. These may prove desirable for use in unbaked and baked systems with specially low pressure capabilities. Consult the nearest NRC Sales Office for specific recommendations.

Attachments:

Tables I, II, III
Figures 1, 2, 3

NRC EQUIPMENT CORPORATION
Newton Highlands, Massachusetts 02161

## REPLACEMENT PARTS

| Trap Model Number | O-Ring Inlet Gasket Buna * | O-Ring Inlet Gasket Butyl + | O-Ring Inlet Gasket Viton A+ |
|---|---|---|---|
| 0315-1-004 | 6608-90-436 | 6608-93-436 | 6608-92-436 |
| 0315-1-006 | 6608-90-443 | 6608-93-443 | 6608-92-443 |
| 0315-1-010 | 6608-90-453 | 6608-93-453 | A608-92-453 |

*Furnished standard

+Available option

JLF:dd
612015

NRC EQUIPMENT CORPORATION
Newton Highlands, Massachusetts 02161

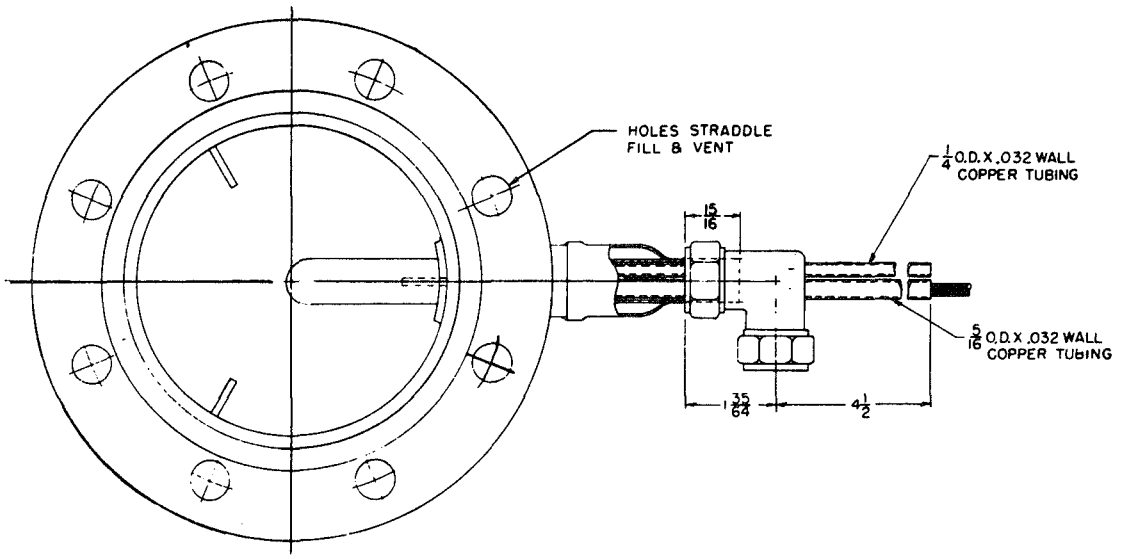
TABLE I

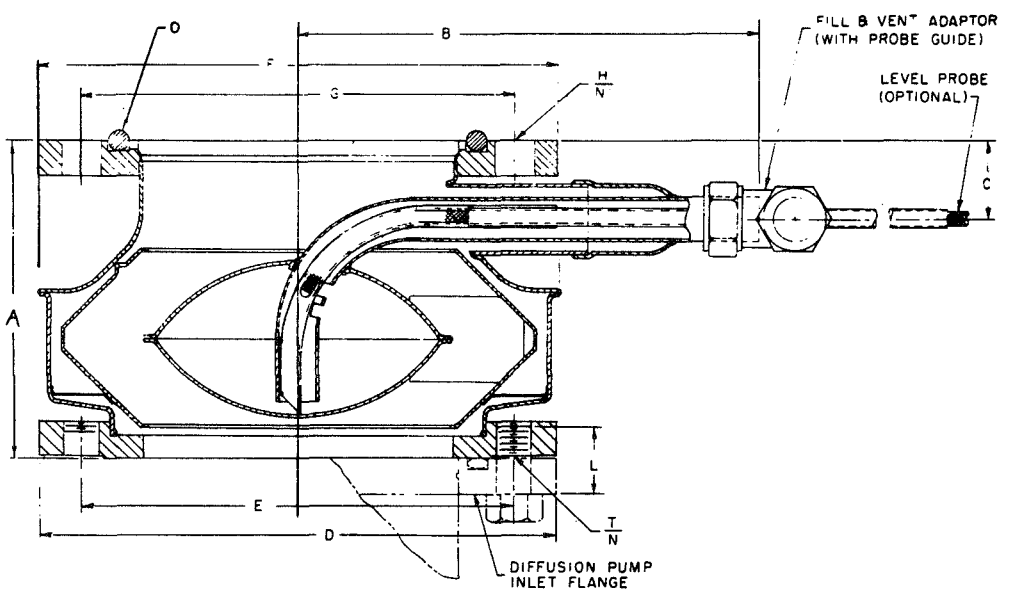
| Model No. | Conductance* below $10^{-4}$ torr liters/sec. | Capacity of reservoir cc | App. $LN_2$ required to cool & initially fill reservoir cc | App. $LN_2$ consumption rate (at ult.press) cc/hr. | App.holding time for $LN_2$ charge** hrs. |
|---|---|---|---|---|---|
| 0315-1-004 | 550 | 500 | 800 | 120 | 3.5 |
| 0315-1-006 | 1200 | 1000 | 2000 | 200 | 4.5 |
| 0315-1-010 | 3000 | 1750 | 3500 | 500 | 3.5 |

*Based on the use of components above and below the baffle and of essentially the same ID as the baffle inlet and outlet.

**Determined by significant temperature rise of $LN_2$ reservoir with water baffle below liquid nitrogen baffle.

CIRCULAR CHEVRON CRYO-BAFFLE
SERIES 0315-1



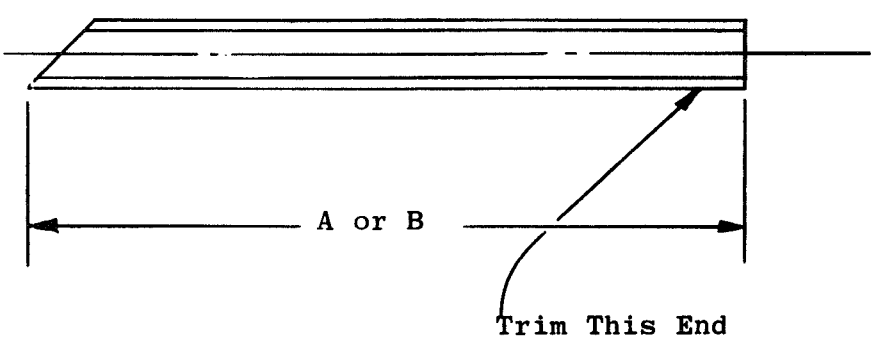




| COLD TRAP SIZE | A +1 −1/32 | B | C | D FLANGE DIA. | E BOLT CIRCLE | F FLANGE DIA. | G BOLT CIRCLE | H HOLE SIZE | NI NO. OF HOLES | T TAP SIZE | N NO. OF HOLES | O O RING NUMBER | L BOLT LENGTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4" | 5 1/2 | 8 | 1 3/8 | 9 | 7 1/2 | 9 | 7 1/2 | 11/16 | 8 | 5/8-11 | 8 | 3917-63 | 1 1/4 |
| 6" | 6 | 9 | 1 1/2 | 11 | 9 1/2 | 11 | 9 1/2 | 13/16 | 8 | 3/4-10 | 8 | 3917-70 | 1 1/2 |
| 10" | 7 | 11 3/8 | 1 1/2 | 16 | 14 1/4 | 16 | 14 1/4 | 1 | 12 | 7/8-9 | 12 | 3917-80 | 1 1/2 |

## TABLE III

| Trap Model No. | Nominal Trap Size | "Poly-flex" Feed Tube | |
|---|---|---|---|
| | | A | B |
| 0315-1-004 | 4 | 7 | 4 1/2 |
| 0315-1-006 | 6 | 8 | 5 1/2 |
| 0315-1-010 | 10 | 11 1/2 | 8 |

Replacement Part Number (Basic) 0181-86364-2



# APPENDIX D

# $LN_2$ CONTROLLER

CVC Instruction Manual
No. 10-17-A
Revision No. 2


# Consolidated Vacuum Corporation

ROCHESTER NEW YORK

GS-100 CONTROLLER

TABLE OF CONTENTS

# GS-100 CONTROLLER

## 1.0 INTRODUCTION

As originally developed, the GS-100 was primarily a liquid nitrogen level controller, hence the sensor device supplied with each unit. More recently this equipment has been found ideally suited to many other purposes.

You will note by scanning the Table of Contents that this manual covers usage both with various types of vacuum gauges and with the liquid nitrogen sensor supplied with the GS-100; therefore, your particular application will determine which sections of the manual should be disregarded, and which should be studied before installation, operation, and servicing of this equipment.

## 2.0 DISCUSSION

### 2.1 Operating Principle

The GS-100 utilizes a high-gain, magnetic-amplifier-type control circuit responding to input signals from conventional vacuum gauges or the $LN_2$ sensor. The output of the control circuit drives a power relay for alarm or control purposes.

The operation of this control circuit is simple and reliable. Power is fed from the power line through the transformer, through the gate windings and rectifiers of the magnetic amplifier to the control relay. Under normal conditions, the cores of the magnetic amplifier are unsaturated. Very little power passes through to the relay, and the coil is de-energized. When a small current, provided by a connected high-vacuum gauge or other metering circuit, flows through the control (input) winding of the magnetic amplifier, the cores become magnetically saturated. Current passes freely to the relay and the coil energizes. Because of the high power gain of the magnetic amplifier, about $2 \times 10^5$, a very small current in the control winding will operate the relay and the GS-100 controller can be connected in series with all types of metering circuits without appreciable effect on their calibration.

A bias coil permits adjustment of the relay trip point. This coil carries a fixed current which biases the cores magnetically to a preset level. Thus the input coil furnishes only the additional energy required to complete the magnetic saturation. The relay can be operated by any input current throughout the 0 to 200 microamp range by proper adjustment at the bias current. Pilot lights indicate the position of the relay contacts.

## 2.2 Applications

The GS-100 also has the features required for controlling the liquid nitrogen level in a high-vacuum trap or baffle. Each unit is supplied with a bobbin-type sensing element which covers the -25°C to -196°C range. When this element is installed in the outlet connection of a liquid-nitrogen-cooled baffle, it senses temperature changes and provides a signal to the GS-100. The controller output can then be used to open or close a solenoid operated valve in a liquid nitrogen supply line.

CVC offers a complete package for liquid nitrogen level control applications which, in addition to the GS-100 and sensing element, includes a flow regulation valve for use at the outlet connection of the baffle, a solenoid valve to start and stop the flow of liquid nitrogen, insulation, tubing and connections for joining the baffle to a standard container of liquid nitrogen. Two models are available. One, Type BC-003, is used with 50-liter, unpressurized, liquid-nitrogen Dewars. The other, Type BC-013, is for use with the 100-liter pressurized tanks of liquid nitrogen. Both are recommended for use with CVC's BC type baffle.

# 3.0 INSTALLATION

CVC equipment is normally shipped F. O. B. Rochester, New York. Directly after receipt, this equipment should be unpacked and inspected for shipping damage. Damage in transit is the responsibility of the transportation company and should be reported to them.

## 3.1 Specifications

### 3.1.1 Physical:

| | |
|---|---|
| Weight | 7 pounds |
| Dimensions | 4-1/2" high x 6-1/2" wide x 4-8/8" deep |

3.1.2 Electrical:

| | |
|---|---|
| Power Requirements | 115 volts, 60 cycle, 15 watts, AC |
| Input (Control Winding) Resistance | 10 ohms |
| Signal Level to Trip Relay | Adjustable from 0 to 200 microamps |
| Power Sensitivity | $3.6 \times 10^{-10}$ watts |
| Relay Differential | Adjustable from 6 microamps (max. sensitivity) to 100 microamps (min. sensitivity). |
| Temp. Sensitivity (change in trip point) | Less than 1 microamp per degree C |
| Relay Output (3-pin connector, back panel) | 115 volts at 0.25 amps available from either N. O. or N. C. relay contacts. |

3.1.3 Liquid Nitrogen Sensor:

| | |
|---|---|
| Sensing Element Control Range ($LN_2$). | $-25^{\circ}C$ to $-196^{\circ}C$ (160 ohms to 28 ohms respectively). |

3.1.4 Accessory Panel Mounting:

| | |
|---|---|
| Panel Kit GTC-002 | 8-3/4" high x 19" wide |

3.2 Panel Mounting Kit (Accessory)

3.2.1 An accessory kit, Type GTC-002, is available for panel mounting. The kit consists of:

1. An aluminum relay rack panel 8-3/4 inches high by 19 inches long; this panel has a cutout in the center. The GS-100 cabinet fits into this cutout.

2. A rubber gasket with a U-shaped cross-section which fits the edge of the panel cutout.

3. Two angle mounting brackets for attaching the GS-100 to the panel.

4. All hardware required for mounting the GS-100.

3.2.2 Use the following procedure for panel mounting:

1. Place the U-shaped gasket in position over the edge of the cutout portion of the panel.

2. Unscrew the rubber feet on the cabinet and remove them.

3. Position the holes in the longer leg of either of the identical mounting brackets over the tapped holes in the cabinet.

4. Replace the rubber feet; they will hold the bracket firmly against the GS-100.

5. Insert the GS-100 through the cutout portion of the control panel so the front edge of the cabinet is flush with the front side of the rubber gasket.

6. Fasten the lower bracket to the panel by inserting one of the #10-32 x 1/2 truss-head machine screws through each of the holes in the panel and bracket (from the front side of the panel). Place a lock washer and nut on each screw and tighten securely.

7. Fasten the short leg of the upper bracket to the control panel using the method described in the previous step.

8. Make certain the cabinet is horizontal, then mark the location of the two holes in the upper bracket on the top of the cabinet.

9. Unscrew the four rubber feet from the gauge cabinet, remove the cabinet from the panel and slip the chassis out through the rear of the cabinet.

10. Drill a hole in the top of the cabinet at each of the marked locations, using a #29 (.136) tap drill.

11. Replace the chassis in the cabinet.

12. Replace the cabinet in the panel. Make sure the front edge of the cabinet is flush with the front edge of the gasket.

13. Replace the four rubber feet.

14. Fasten the upper bracket to the GS-100 cabinet using the two #8-3/8 tapping screws.

3.3 Use with Gauge Circuits (See Figures 1, 2, & 3) (for control at a pressure).

Note: When used with any gauge, except a thermocouple gauge, the relay is energized above the trip point and de-energized below it. With a thermocouple gauge it is de-energized above the trip point and energized below it.

3.3.1 Cable Connections

The GS-100 control coil must be connected in series with the meter circuit of the CVC gauge providing the input signal.

Remove wires 23 and 20 from pins F and E of connector J-1 inside the gauge. Connect the input signal from the CVC gauge to pins F and E, observing the polarity indicated.

Connect the power supply cord to your 115 volt 50/60 cycle power source.

3.3.2 Checkout

Do not connect the GS-100 output (P-1) to your equipment until you are certain of the trip point and span as related to the function which you wish to control.

1. Pump your vacuum system down to the pressure range at which you desire to trip the GS-100.

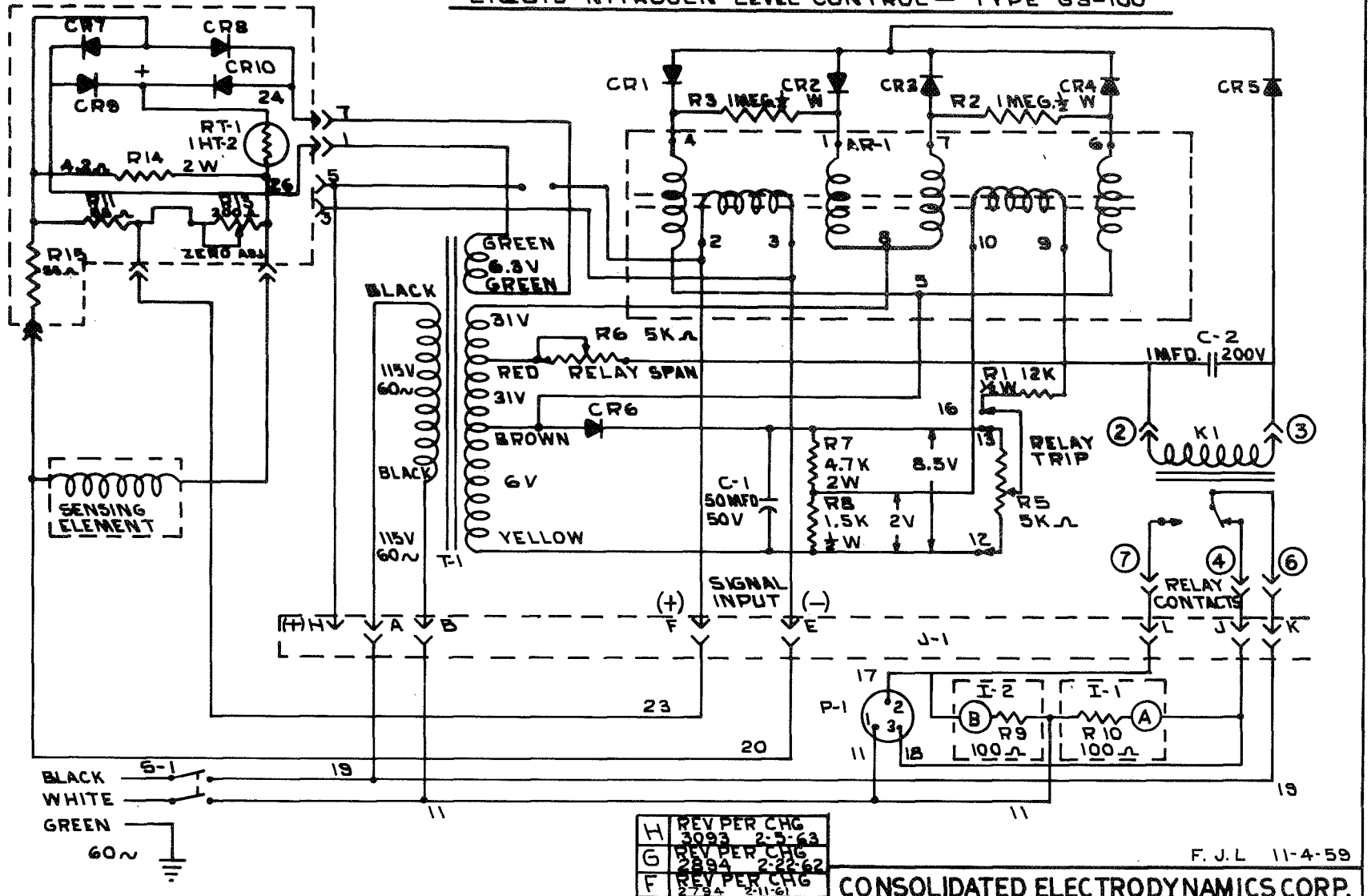
2. Turn on the GS-100 with the toggle switch on the front panel.

3. Observe lights A and B on the front panel:

   When A is illuminated, the relay is de-energized.

   When B is illuminated, the relay is energized.

# LIQUID NITROGEN LEVEL CONTROL — TYPE GS-100




| | | | |
|---|---|---|---|
| H | REV PER CHG 3093 2-5-63 | J | REV PER CHG 3661 12-31-64 |
| G | REV PER CHG 2894 2-22-62 | B | REV PER CHG 2284 12-11-59 |
| F | REV PER CHG 2794 2-11-61 | | |
| E | REV PER CHG 2781 7-13-61 | | |
| C | REV PER CHG 2554 10-10-60 | | |

F. J. L 11-4-59

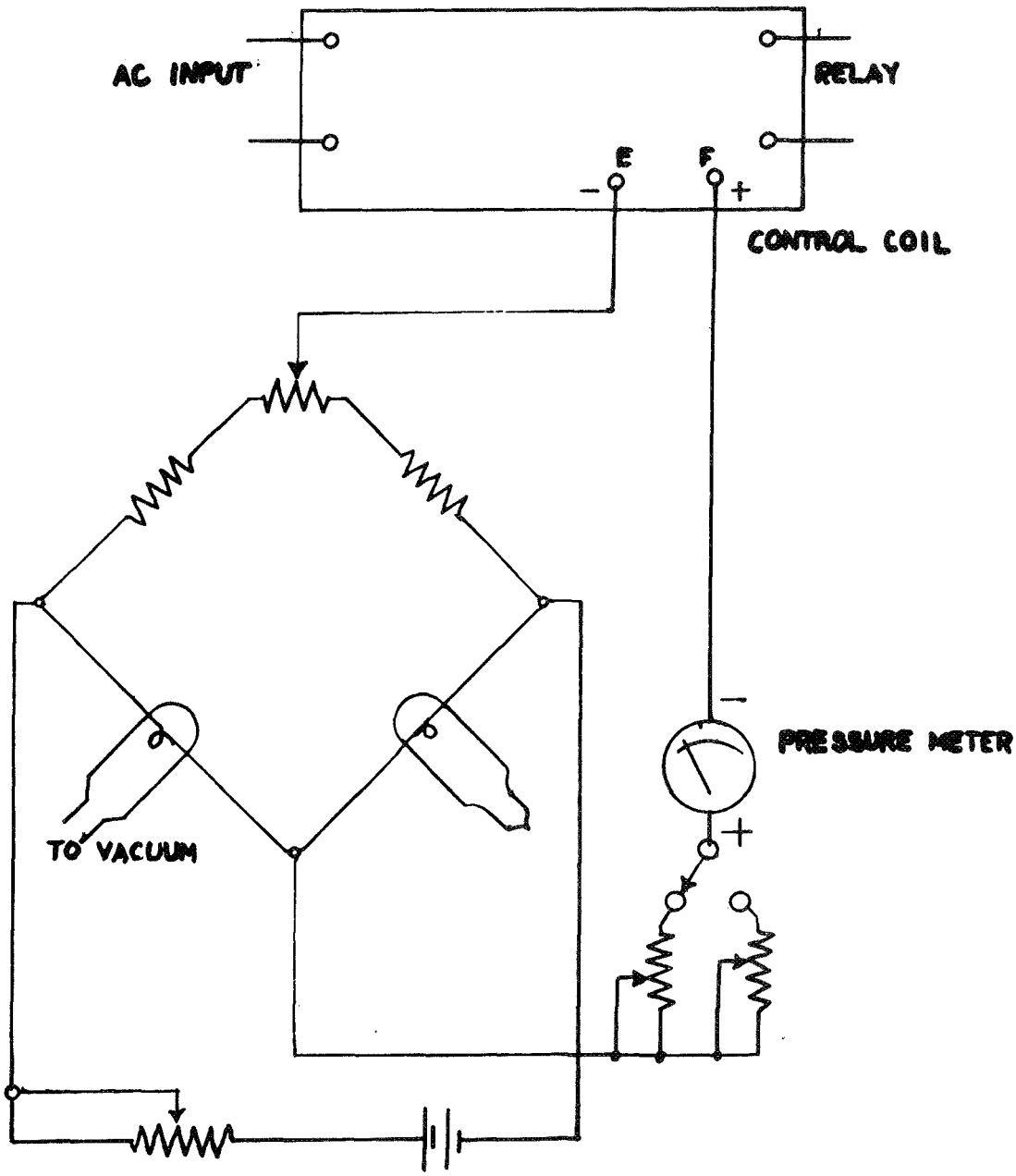
**CONSOLIDATED ELECTRODYNAMICS CORP.**
ROCHESTER DIVISION
**ROCHESTER 3, NEW YORK**

LIQUID NITROGEN LEVEL CONTROL

SCHEMATIC — ELECTRICAL C 67770-J

GS-100

MAGNETIC AMPLIFIER

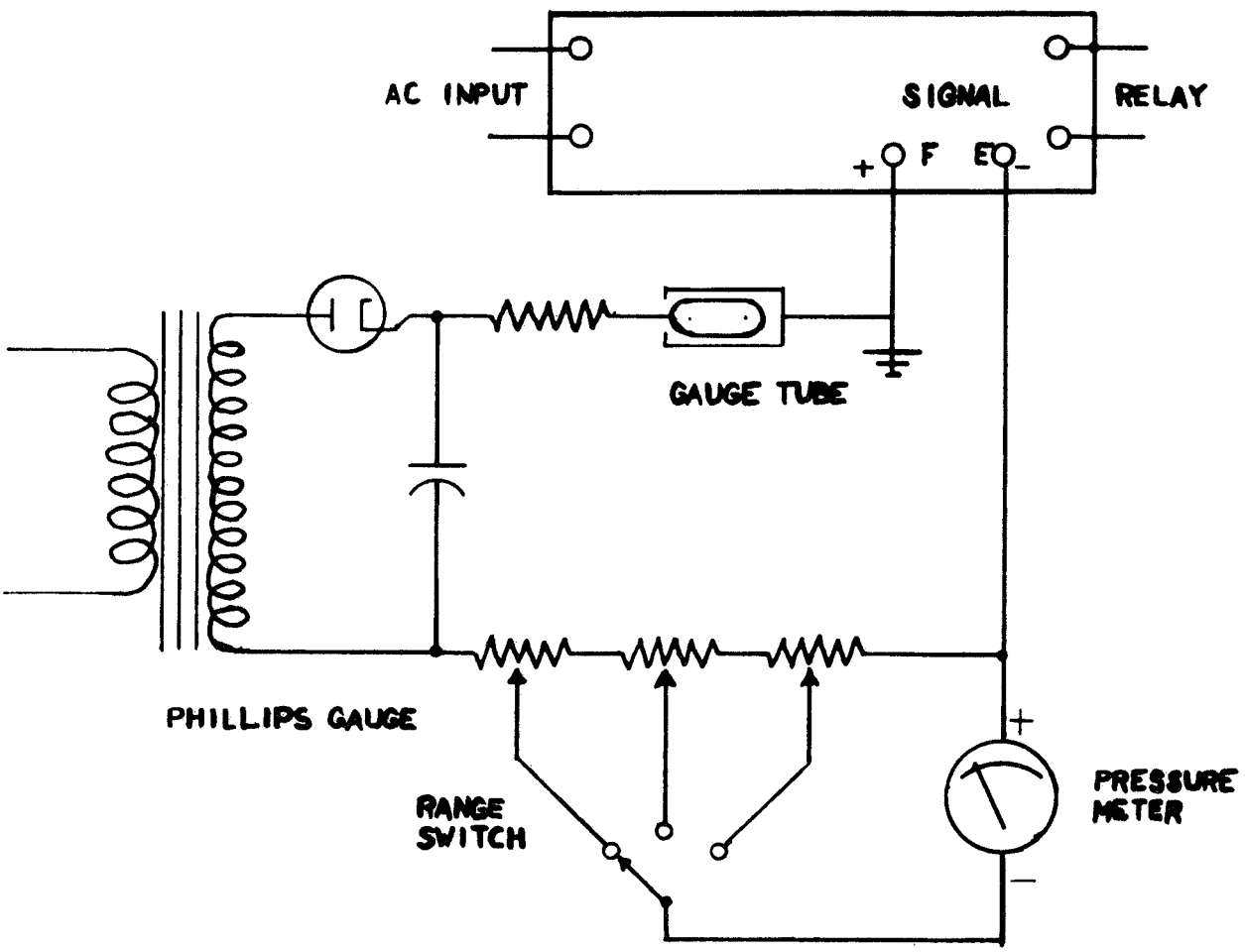



NOTE: Hot filament ionization gauges can also be connected to in the above manner by connecting the control each in series with the pressure meter.

FIGURE 2

GS-100

MAGNETIC AMPLIFIER




NOTE: Range switching has no effect upon relay control trip point.

CAUTION: Because of the High Voltage associated with the Phillips Gauge, make sure that it is electrically dead before making any connections to the GS-100.

FIGURE 1

4. Set the trip point and span as determined by your application:

   (a) The relay trip adjustment (R-5) is made on the front panel.

   (b) The span adjustment (which is preset fully counter-clockwise for the maximum span) will probably have to be turned clockwise to reduce the span and thereby provide a quicker acting on-off control. This relay span control (R-6) is located within the control case and is accessible by removing the back panel.

NOTE: The zero adjustment control (R-13) located on the back panel provides temperature range selection for liquid nitrogen control applications and so has no effect when the liquid nitrogen sensor is disconnected.

5. When the GS-100 is adjusted to provide the control output at the desired trip point and to cut out at the desired point (as indicated by lights A & B), connect the equipment which you wish to control to the output receptacle (P-1) on the rear panel.

## 3.4 The GS-100 Used for Liquid Nitrogen Control

The type GS-100 controller is supplied with a sensing element consisting of a bobbin wound with fine copper wire. The GS-100 is adjustable and can be set to operate at any temperature in the -25°C to -196°C range. The temperature of liquid nitrogen is covered in this range.

3.4.1 The three adjustable controls (potentiometers) on the GS-100 are the Zero Adjust Control (R-13), the Relay Span Control (R-6), and the Relay Trip Control (R-5).

3.4.1.1 Zero Adjust Control - The Zero Adjust Control (R-13), is located on the back panel of the unit. This control selects the temperature range in which the desired trip point falls. When looking at the back panel and turning the Zero Adjust Control clockwise, the temperature control point is raised; this will turn OFF the flow of the

liquid nitrogen. Turning the Zero Adjust Control counterclockwise lowers the temperature control point; this will turn ON the flow of liquid nitrogen, if the liquid nitrogen is not flowing.

3.4.1.2 Relay Span Control - The Relay Span Control (R-6) (Potentiometer) is located inside the control case. This control should be set for maximum span by turning the potentiometer fully counterclockwise; this adjustment is made at CVC.

3.4.1.3 Relay Trip Control - The Relay Trip Control (R-5) is located on the front panel of the unit and tends to reduce the effect of the Relay Span Control; it should be turned fully counterclockwise when facing the front of the unit; this adjustment is also made at CVC.

3.4.2 Install the sensing element on the system. The sensing element (a bobbin of fine copper wire) should be positioned in the coolant outlet line of the baffle.

NOTE: If your GS-100 was not supplied as part of a BC-003 or BC-013 liquid nitrogen level control package, and you are connecting it for use in a liquid nitrogen level control, it is advisable to install a valve in the coolant outlet line between the sensing element and the baffle. This valve should be a plate type valve with a small hole drilled through the plate. By closing this valve after the coolant reservoir of the baffle is full, the loss of liquid nitrogen due to evaporation will be reduced.

3.4.3 Connect the sensing element to the GS-100. The plug on the end of the sensing element cord fits the smaller of the two receptacles on the back panel of the GS-100.

3.4.4 To control the flow of liquid nitrogen, install a solenoid valve in the coolant inlet line of the baffle. CVC recommends a normally-closed, two-way solenoid valve for this purpose. Connect this valve to pins 1 and 2 of the three-pin connector on the back of the GS-100 cabinet. The relay contacts provide 115 volts, 0.25 amp for operating the solenoid valve. If your solenoid valve has a higher power requirement, an intermediate relay is necessary.

3.4.5 In order that the GS-100 may serve as a completely automatic liquid nitrogen level control, you must provide tubing to conduct the liquid nitrogen from the container to the baffle. The solenoid valve mentioned in step 3.4.4 should be installed in this tubing as close as possible to the $LN_2$ supply. If your liquid nitrogen is stored in standard Dewar flask, means should be provided for pressurizing the flask to facilitate the initial filling of the baffle. Air pressure of 2 psig is required to start the flow of fluid. A pressure gauge and a pressure relief valve should also be included in the tubing. All connecting lines and fittings should be insulated. If you use pressurized tanks of liquid nitrogen, pressurizing is not necessary.

3.4.6 Adjust the trip point for required operating temperature.

The following facts may be helpful in performing this procedure. You can start the flow of liquid nitrogen by unplugging the sensing element from the GS-100 (solenoid open). You can stop the flow of liquid nitrogen by turning off the toggle switch on the GS-100 control panel; this de-energizes the relay and closes the solenoid. You can operate the GS-100 (for adjustment purposes) without affecting the flow of the liquid nitrogen by unplugging the solenoid valve from the GS-100.

3.4.6.1 As previously mentioned, the Zero Adjust Control has been factory-set at approximately 21 ohms, so that the trip point will fall at the lower end of the -25°C to -196°C temperature range of the unit. Do not readjust this control unless you are using some coolant (other than liquid nitrogen) which has a temperature in the upper portion of the overall temperature range. Turning the control clockwise raises the temperature of trip point.

3.4.6.2 Set the Relay Trip Control full counterclockwise for maximum sensitivity; set the Relay Span Control fully counterclockwise for maximum span (maximum resistance). The directions for setting the controls is determined by facing each control.

3.4.6.3 Plug the power supply cord of the GS-100 into a 115 volt convenience outlet. Turn on the toggle switch of the GS-100. Light B will come on. Admit liquid nitrogen to the system until it flows past the sensing element which cools and causes the relay to trip out. When this occurs, light B goes out and light A comes on.

3.4.6.4 Adjust the Relay Trip Control until the relay trips in (as indicated by light B coming on and light A going out) at the desired temperature.

3.4.6.5 If the time required to fill the coolant reservoir of the baffle is too long (i.e., if the temperature is too low at which light A comes on and light B goes out), adjust the Relay Span Control to decrease the span.

## 3.5 Liquid Nitrogen Control Packages, Types BC-003 & BC-013

Refer to Figure 4 (BC-003) and Figure 5 (BC-013) during the following procedure:

3.5.1 Install the exhaust control unit (item 6 in Figure 4) on the outlet of the baffle reservoir as shown in Figure 4 (BC-003) or Figure 5 (BC-013) (Item 2 in Figure 5).

3.5.2 Connect the inlet of the baffle to the head section of the BC-003 or BC-013 using the seamless copper tubing as shown in Figure 4 (BC-003) or Figure 5 (BC-013).

3.5.3 Install the insulating tubing as shown in Figure 4 and 5. The copper tubing should slant downward slightly (approximately 5°) from the head section to the baffle. The insulation should fit snugly around all tubes. Cut the pieces of insulation to fit the installation as shown in Figure 4 or 5, allowing about 2 or 3 inches extra length on each piece of insulation. Slide the inner insulation over the metal lines and fittings. To position the outer insulation, slide it over the inner insulation while compressed air is blown between the two layers of insulation to expand the outer layer.

3.5.4 Connect the sensing element lead to the GS-100 cabinet.

3.5.5 Connect the solenoid valve to the GS-100 by plugging the connecting cable into the receptacle in the back panel of the cabinet.

3.5.6 Plug the GS-100 power supply cord into a suitable convenience outlet.

3.5.7 Adjust the GS-100 as required, following the instructions in Section 3.4.6.

3.5.8 Turn off the GS-100 toggle switch.

3.6 Operational Steps for Liquid Nitrogen Control

3.6.1 Type GS-100

3.6.1.1 At the proper point in the pumping cycle of your vacuum system, start liquid nitrogen flowing into the baffle. If a standard Dewar flask of nitrogen is used, it must be pressurized to start the flow.

3.6.1.2 Turn on the GS-100 toggle switch.

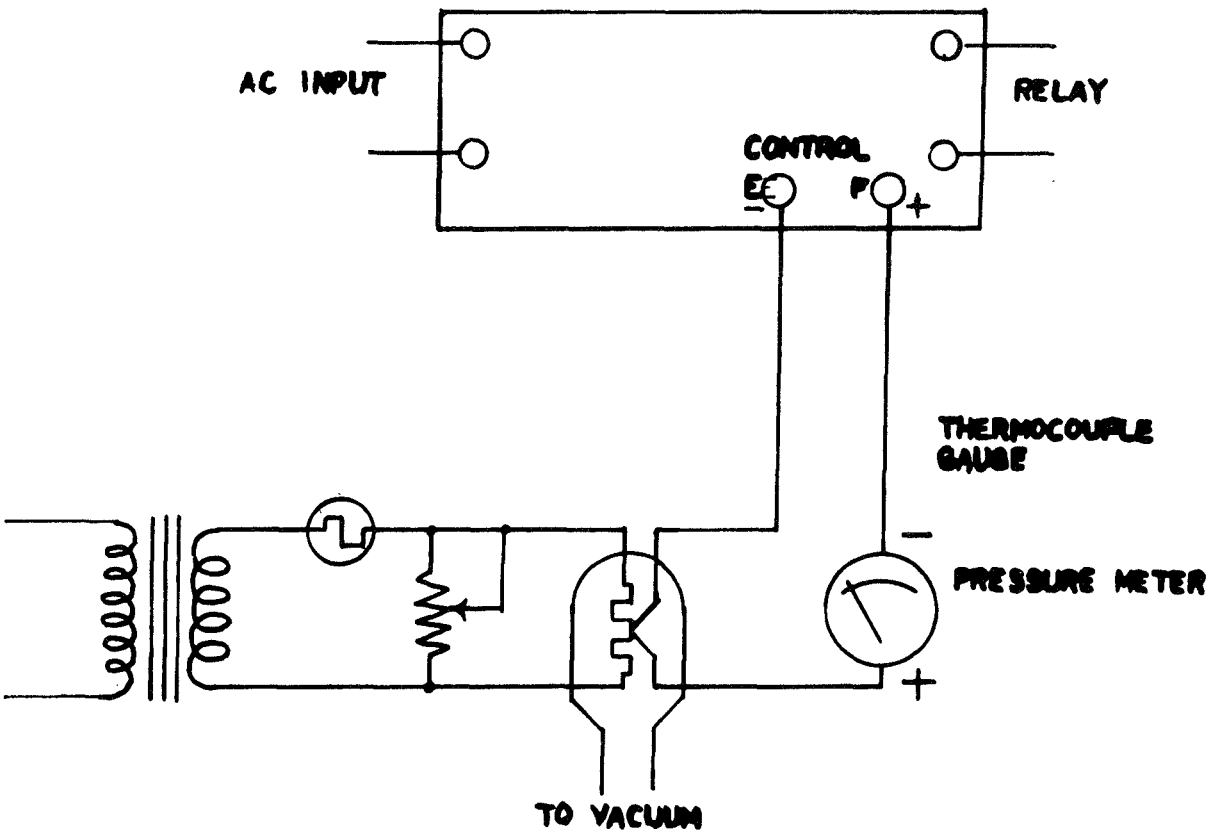
3.6.1.3 If a flow control valve is installed at the coolant outlet of the baffle as recommended by CVC, open the valve wide.

3.6.1.4 When the baffle chamber is full, as evidenced by liquid nitrogen flowing from the coolant outlet, close the flow control valve.

3.6.1.5 As the liquid nitrogen vaporizes, and the temperature rises, the sensing element becomes warmer. When the temperature rises to a certain level, the sensing element signals the magnetic amplifier, which in turn opens the solenoid valve in the filling line. This admits liquid nitrogen to the reservoir of the baffle and the temperature of the outlet drops. When the temperature reaches a certain value, the signal from the sensing element to the magnetic amplifier is changed sufficiently to cause the magnetic amplifier to close the solenoid valve in the filling line.

GS-100

MAGNETIC AMPLIFIER

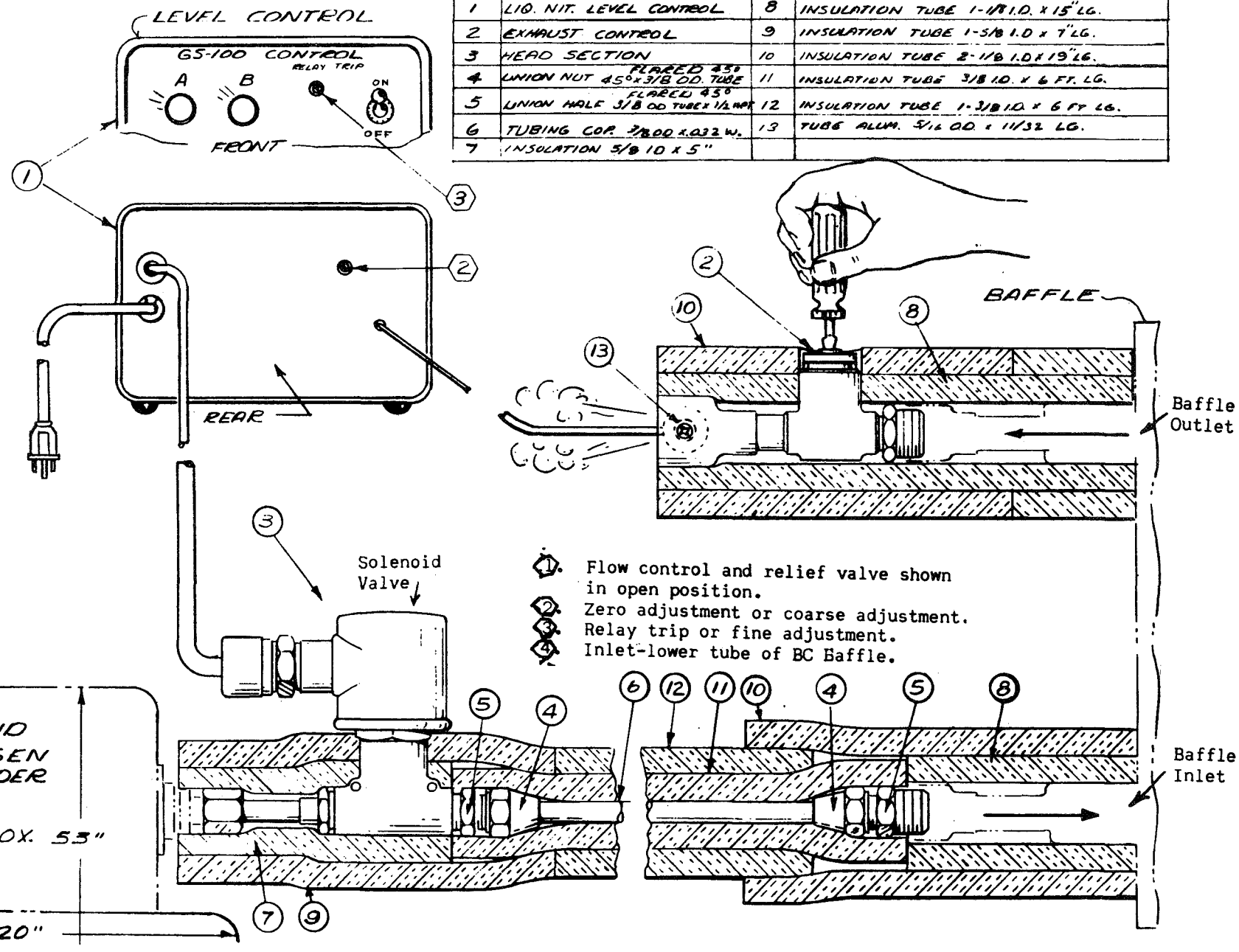


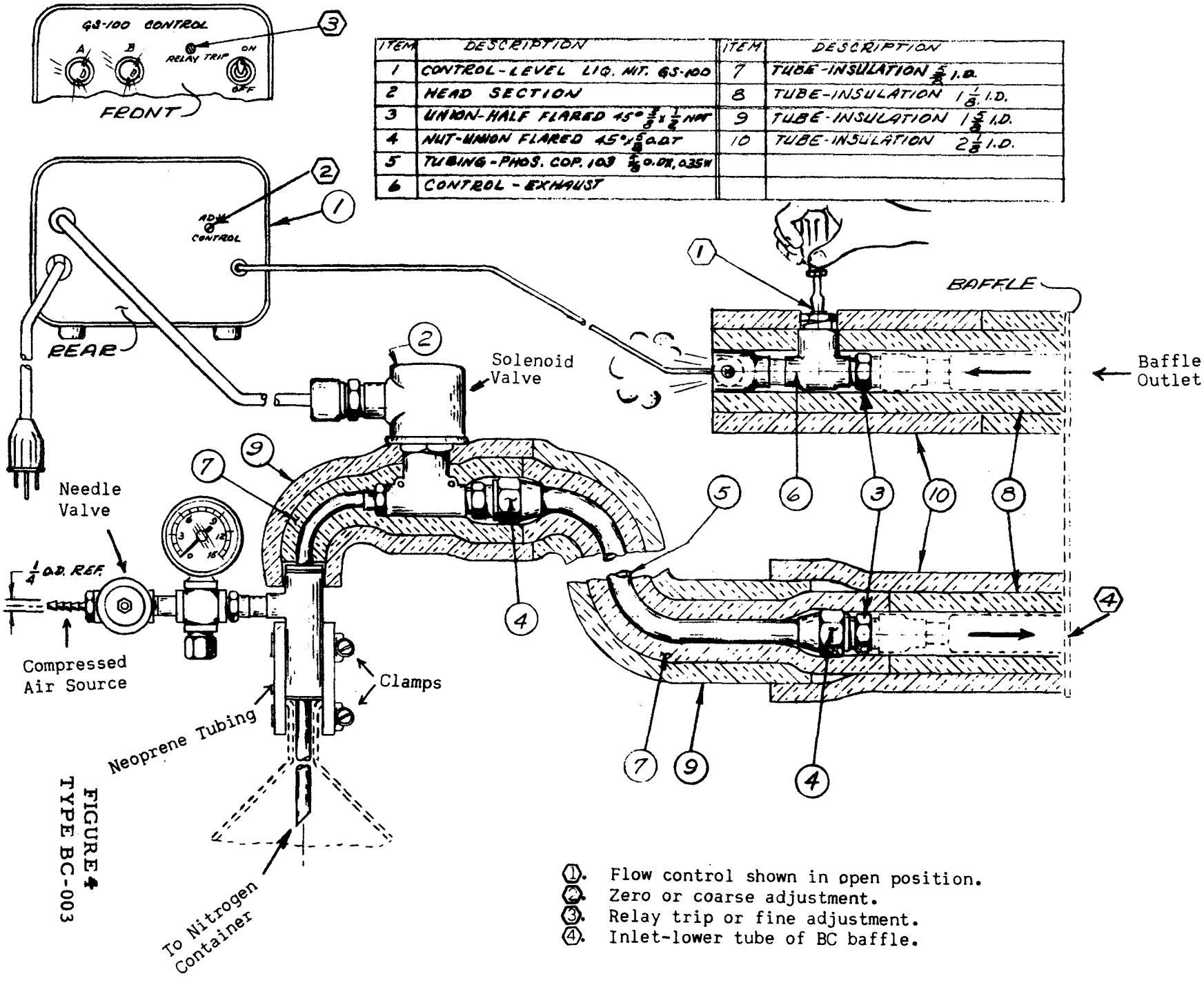

NOTE: Recalibrate thermocouple gauge following connection of GS-100.

FIGURE 3

FIGURE 5 -TYPE BC-013

| ITEM | DESCRIPTION | ITEM | DESCRIPTION |
|---|---|---|---|
| 1 | LIQ. NIT. LEVEL CONTROL | 8 | INSULATION TUBE 1-1/8 I.D. X 15" LG. |
| 2 | EXHAUST CONTROL | 9 | INSULATION TUBE 1-5/8 I.D x 7" LG. |
| 3 | HEAD SECTION | 10 | INSULATION TUBE 2-1/8 I.D x 19" LG. |
| 4 | UNION NUT 45° FLARED 45° x 3/8 OD. TUBE | 11 | INSULATION TUBE 3/8 I.D. X 6 FT. LG. |
| 5 | UNION MALE 3/8 OD TUBE FLARED 45° x 1/2 MPT | 12 | INSULATION TUBE 1-3/8 I.D. X 6 FT LG. |
| 6 | TUBING COP. 3/8 OD x .032 W. | 13 | TUBE ALUM. 5/16 OD. x 11/32 LG. |
| 7 | INSOLATION 5/8 ID x 5" | | |






| ITEM | DESCRIPTION | ITEM | DESCRIPTION |
|---|---|---|---|
| 1 | CONTROL-LEVEL LIQ. MIT. GS-100 | 7 | TUBE-INSULATION $\frac{5}{32}$ I.D. |
| 2 | HEAD SECTION | 8 | TUBE-INSULATION $\frac{1}{8}$ I.D. |
| 3 | UNION-HALF FLARED 45° $\frac{3}{8} \times \frac{1}{2}$ NUT | 9 | TUBE-INSULATION $\frac{3}{32}$ I.D. |
| 4 | NUT-UNION FLARED 45° $\times \frac{5}{8}$ O.D.T | 10 | TUBE-INSULATION $2\frac{1}{8}$ I.D. |
| 5 | TUBING-PHOS. COP. 103 $\frac{1}{8}$ O.DX. 035W | | |
| 6 | CONTROL-EXHAUST | | |

FIGURE 4
TYPE BC-003

1. Flow control shown in open position.
2. Zero or coarse adjustment.
3. Relay trip or fine adjustment.
4. Inlet-lower tube of BC baffle.

It is not necessary to continue admitting compressed air to the flask for these routine fillings. After the initial filling, the pressure of the vaporized nitrogen within the flask is sufficient to fill the baffle. A pressure of 1 psig on the gauge will raise the liquid nitrogen approximately 34 inches.

3.6.2 Type BC-003

3.6.2.1 Make certain the 1-inch neoprene tubing with the clamp at each end is in place at the top of the filler tube. The filler tube is the straight piece of tubing which extends downward below the pressure gauge.

3.6.2.2 Insert the filler tube on the end of the head assembly into the neck of a 50-liter liquid-nitrogen-filled Dewar Flask or some other liquid nitrogen container which can be pressurized (See Figure 4).

3.6.2.3 Slide the neoprene tubing over the liquid nitrogen flask. Tighten both hose clamps.

3.6.2.4 Adjust the flow control valve (the valve attached to the outlet tube of the baffle) so the screw driver slot in the top of the valve is parallel to the outlet tube. In this position the valve is open and allows the nitrogen boil-off gas to escape readily. If the valve is left closed, pressure will build up in the baffle reservoir and slow the filling process considerably.

3.6.2.5 Connect a source of compressed air to the needle valve on the head assembly.

3.6.2.6 Turn on the GS-100 toggle switch.

3.6.2.7 At the proper point in the vacuum pumping cycle, open the needle valve and admit compressed air to the head assembly until the pressure of 2 psig is shown on the gauge. (2.5 psig if the upper pressure limit of the relief valve). Then close the needle valve.

3.6.2.8 Approximately 5 minutes are required to fill the reservoir of a 4-inch type BC baffle.

3.6.2.9 When the reservoir of the baffle is filled as indicated by an overflow of liquid nitrogen, adjust the flow control valve on the outlet connection so that the screw driver slot is perpendicular to the outlet line. In this position the valve is closed. A small hole has been drilled in the valve plate to relieve excessive pressure build-up in the baffle reservoir system. This prevents loss of liquid nitrogen during refilling due to overflow caused by the slight time lag inherent in the sensing element.

3.6.2.10 As the liquid nitrogen vaporizes and the level drops, the sensing element becomes warmer. When the temperature rises to a certain level, the sensing element signals the magnetic amplifier which in turn opens the solenoid to the reservoir of the baffle and the temperature of the outlet drops. When the temperature reaches a certain point, the sensing element signals to the amplifier to close the solenoid valve in the filling line. It is not necessary to admit compressed air to the flask for these routine fillings. After the initial filling, the pressure of the vaporized nitrogen within the flask is sufficient to fill the baffle. A pressure of 1 psig on the gauge will raise the liquid nitrogen approximately 34 inches.

3.6.3 Type BC-013

3.6.3.1 Connect the head section solenoid valve to the pipe fitting at the outlet of a standard 100-liter pressurized tank of liquid nitrogen (Airco Type AR-L or ARL-C or Linde Type LS-110B). See Figure 5.

3.6.3.2 Adjust the flow control valve (the valve attached to the outlet tube of the BC baffle) so the screw driver slot in the top of the valve is parallel to the outlet tube. In this position the valve is open and allows the nitrogen boil-off gas to escape readily. If the valve is left closed, the filling process will be slowed considerably.

3.6.3.3 Turn on the GS-100 toggle switch.

3.6.3.4 Approximately 5 minutes are required to fill the reservoir of a 4-inch type BC baffle.

3.6.3.5 When the reservoir of the baffle is filled as indicated by an overflow of liquid nitrogen, adjust the flow control valve on the outlet connection so that the screw driver slot is perpendicular to the outlet line. In this position the valve is closed. A small hole has been drilled in the valve plate to relieve excessive pressure buildup in the baffle reservoir system. This prevents loss of liquid nitrogen during refilling due to overflow caused by the slight time lag inherent in the sensing element.

3.6.3.6 As the liquid nitrogen vaporizes and the level drops, the sensing element becomes warmer. When the temperature rises to a certain level, the sensing element signals the magnetic amplifier which in turn opens the solenoid to the reservoir of the baffle and the temperature of the outlet drops. When the temperature reaches a certain point, the sensing element signals to the amplifier to close the solenoid valve in the filling line.

## 4.0 TROUBLE SHOOTING

4.1 If liquid nitrogen is wasted by the unit, check for a frozen solenoid, also check the sensitive relay for defects. If replacement of the relay does not correct the trouble, check the magnetic amplifier.

4.2 The sensing element may also be checked by measuring for 200 ohms resistance at room temperature by itself.

## 5.0 ASSISTANCE FROM CVC

5.1 EQUIPMENT ASSISTANCE SERVICE IN THE FIELD. CVC offers two kinds of Equipment Assistance Service to customers. The first kind is equipment service in the field, and the second kind is in-plant service. Equipment Assistance Service in the field consists of two types: (1) Emergency Service, (2) Scheduled Service.

1. Emergency Service - The emergency service is one of the most important services offered by CVC. Emergency service takes top priority over all other services offered. If a CVC vacuum system does not operate, call your CVC field sales offices to get a CVC customer engineering representative to the equipment as soon as possible.

2. Scheduled Service - The second kind of Equipment Assistance Service offered by CVC is the Scheduled Service. The lead time needed for scheduling this service is approximately ten days. This lead time is necessary for evaluating the situation and planning the length of time the CVC customer engineering representative will spend at the customer's plant. This lead time also will provide time for arranging a mutually convenient schedule.

   Scheduled Service is useful if CVC vacuum equipment requires modification or modernization. If difficulty is encountered in rebuilding, repairing, cleaning, reassembling, or installing accessories on CVC equipment, Scheduled Service will resolve the situation. The service can also be utilized if CVC vacuum equipment must be moved to a new location. Another reason for obtaining this service is a checkout of the CVC vacuum equipment.

The two types of Equipment Assistance Service do not include process assistance, nor service connections as electrical or water service. These the customer must provide.

5.2 EQUIPMENT ASSISTANCE SERVICE IN THE PLANT - The second kind of Equipment Assistance Service offered is in-plant service. This in-plant service consists of two types: (1) Instruction (2) Gauge Calibration.

1. Instruction - Instruction on CVC vacuum equipment for the most part is given at the CVC plant. On many occasions, vacuum-equipment instructions have been given at the customer's plant. This instruction is given on the customer's specific vacuum system and also included (1) the latest vacuum technology, (2) the range of system usefulness, and (3) optional suggestions for efficient system operation. The scheduling of this instruction is coordinated between customer and CVC.

2. Gauge Calibration - The second type of Equipment Assistance Service that is given at CVC is gauge calibration. The frequency of CVC gauge calibration depends on the cleanliness of the process on which the gauge is used. The scheduling of gauge calibration is coordinated between the customer and CVC. This coordinated schedule gives a minimum time loss because of gauge absence from the customer's vacuum system.

5.3 OBTAINING EQUIPMENT ASSISTANCE SERVICE - Wherever there is a need for Equipment Assistance Service or information about the various services offered, the CVC field sales office will gladly schedule the services. Field Sales Offices are listed on the following page.

## 6.0 CONSOLIDATED VACUUM CORPORATION SALES OFFICES AND LOCATIONS

Albuquerque, New Mexico 87101
141 Wyoming, N.E.

Atlanta, Georgia 30305
3272 Peachtree Road, N.E.

Needham Heights, Mass. 46494
45 Fourth Avenue

Des Plaines, Ill. 60018
3150 Des Plaines Avenue
Room 25

Columbus, Ohio 43212
1350 West Fifth Avenue

Van Nuys, California 91401
5430 Van Nuys Blvd.
Suite 314

Dallas, Texas 75207
433 Regal Row

Springfield, New Jersey 07081
26 Linden Avenue
P. O. Box 142

Palo Alto, California 94303
4015 Fabian Way

Philadelphia, Pennsylvania 19145
2010 Oregon Avenue

Rochester, New York 14603
1775 Mt. Read Blvd.

Minneapolis, Minnesota 55410
7100 France Avenue
Suite 23

## CONSOLIDATED VACUUM INTERNATIONAL-SERVICE AND SALES OFFICE LOCATIONS

B&H Ltd.
14 Commercial Rd.
Woking, Surrey, England

B&H GmbH
Frankfurter Strasse
Postbox 345
Friedberg, West Germany

## 7.0 REPLACEMENT PARTS LIST FOR THE TYPE GS-100 CONTROLLER

MINIMUM ORDER BILLING OF $10.00 PER ORDER. PLEASE INCLUDE PART NUMBER AND DESCRIPTION OF EACH PART ORDERED.

| Description | Elec. Schem. No. | Part No. |
|---|---|---|
| Amplifier, Magnetic | AR-1 | 65864 |
| Capacitor, 50 mfd. 50 V | C-1 | 65896 |
| Capacitor, 1 mfd. 200 V | C-2 | 62449 |
| Connector, Printed Circuit | J-1 | 60190-10 |
| Diode - Rectifier, IN-3074 | CR-1, -5 | 261023-6 |
| Diode - Rectifier, IN-48 | CR-6 | 261023-2 |
| Diode - Rectifier, F-2 | CR-7, -10 | 261023-4 |
| Pilot Light, Omni Glow, 115 V | I-1, -2 | 67268 |
| Potentiometer, 5K, 1/4 Watt, W.W. | R-5, -6 | 66973-1 |
| Potentiometer, 200 Ohms, 1/4 Watt | R-13 | 66973-5 |
| Relay, S.P.D.T. | K-1 | 65863 |
| Resistor, 12K, 1/2W | R-1 | 7138-1235 |
| Resistor, 1.1 Meg., 1/2W | R-2, -3 | 7138-1155 |
| Resistor, 4.7K, 1/2W | R-7 | 7138-4725 |
| Resistor, 1.5K, 1/2W | R-8 | 7138-1525 |
| Resistor, 100K, 1/2W | R-9, -10 | Supplied with I-1, -2 |
| Resistor, 55 Ohms, 1/2W, 1% | R-11, -15 | 60245-16 |
| Resistor, Precision, 4.2 Ohms, 2 Watt W.W. | R-14 | 60208-10 |
| Switch, Toggle, D.P.S.T. | S-1 | 66505 |
| Transformer, Power | T-1 | 65862 |
| Tube, Ballast, JHT 2 | RT-1 | 67349 |

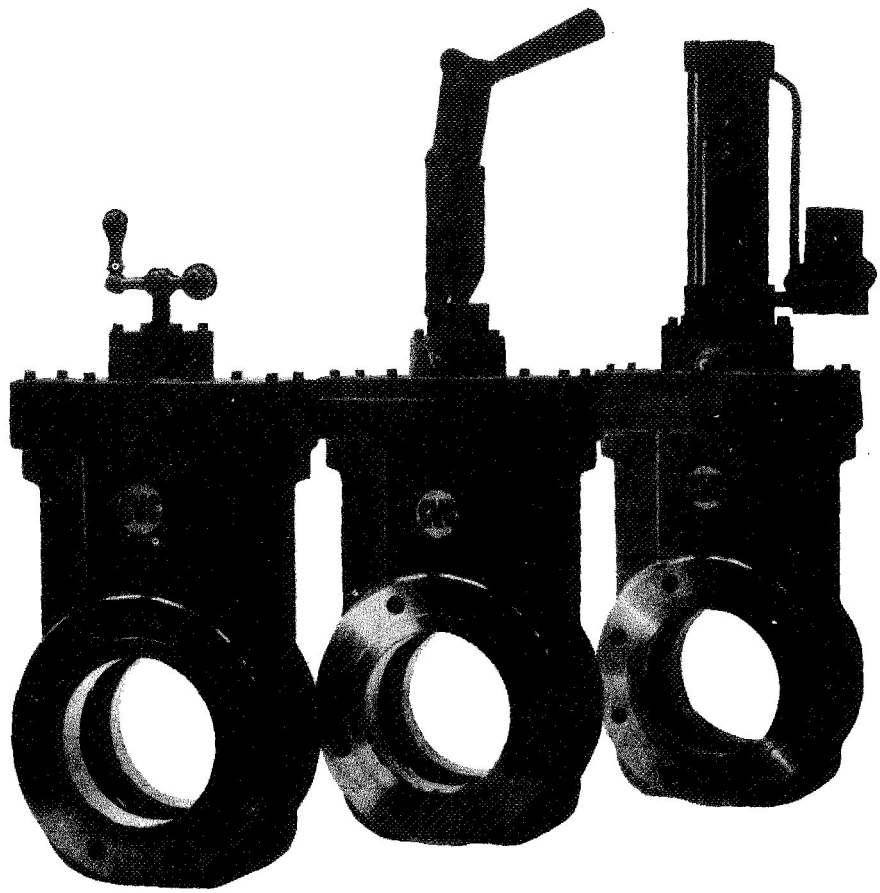
### ACCESSORIES FOR TYPE GS-100 CONTROLLER

| Description | | |
|---|---|---|
| BC-003 Automatic Liquid Nitrogen Filler for Dewar: | | |
| Gauge, Pressure | 1 | 67949 |
| Sensing Element, 200 at 25°C. 28 at -194°C | 1 | 68060 |
| Valve, Flow Regulator, w/vent | 1 | 68037 |
| Valve, Pressure Relief | 1 | 67982 |
| Valve, Solenoid | 1 | 267787 |
| BC-013 Automatic Liquid Nitrogen Filler for Pressurized Cylinders: | | |
| Gauge, Pressure | 1 | 67949 |
| Sensing Element, 200 at 25°C. 28 at 194°C. | 1 | 63060 |
| Valve, Flow Regulator, w/vent. | 1 | 68037 |
| Valve, Pressure Relief | 1 | 67982 |
| Valve, Solenoid | 1 | 267787 |

# APPENDIX E

# ROUGHING VALVE

CVC Instruction Manual
No. 10-21-F
Revision No. 3



# Consolidated Vacuum Corporation

ROCHESTER NEW YORK

## GATE VALVES
## TYPE, VCS--A & B

TABLE OF CONTENTS

# INSTALLATION AND OPERATING INSTRUCTIONS FOR THE GATE VALVE, TYPE VCS--A & B

## 1.0 GENERAL INFORMATION

These instructions contain the information required to install and operate the type VCS---A & B high vacuum valves. The valves are suitable for use between a processing chamber and a diffusion pump as a high-vacuum valve for pressures into the $10^{-7}$ torr range or as a roughing or backing valve between a chamber or a diffusion pump and a mechanical pump.

The 2-inch, 4-inch and 6-inch sizes of the type VCS valves are available with manual throttling, manual quick-acting, or pneumatic operators. Charted below are the type numbers corresponding to each.

| | Screw Action | Quick Acting | Pneumatic Acting |
|---|---|---|---|
| VCS | 21-A | 22-A | 23-A |
| VCS | 41-B | 42-A | 43-A |
| VCS | 61-B | 62-A | 63-A |

Included with each valve are two Con-O-Ring seals. VCS valves are normally supplied with Buna-N elastomer seals which withstand temperatures to 107° C. Viton-A seals are available and withstand temperatures to 204° C. If the valve is used near a vapor pump which uses Butyl Phthalate, a plate gasket of Convaseal or Viton-A is recommended.

## 2.0 UNPACKING

Inspect the shipping carton and the valve for damage. All equipment is normally shipped F. O. B. Rochester, New York. Damage in transit is the normal responsibility of the transportation company and should be reported to them. Remove all wrapping from the valve and Con-O-Rings.

## 3.0 INSTALLATION

### 3.1 Vacuum Line Connections

1. Wipe each of the connecting valve faces to remove any particles which might cause leaks.

2. Wipe each Con-O-Ring gasket to remove any foreign particles, spread a very thin film of Dow Corning High Vacuum Grease on each O-Ring and position the re-assembled Con-O-Ring on the connecting face of the valve flange.

3. Position each face of the VCS valve to a mating connector attached to the system. The 4- and 6-inch valves are designed to connect directly with the ASA 150-pound fittings. Adapter flanges (drilled and tapped plates with gasket grooves) are available for connecting these valves to those CVC pumps which do not have ASA standard flanges.

   The 2-inch valves do not have ASA standard flanges; these valves are designed to connect with CVC flange design.

4. Place fasteners in the connecting flanges. Tighten in a criss-cross pattern to assure that an even pressure is applied over the entire flange area.

## 3.2 Service Connections for a Pneumatically-Operated Valve

Connect an air supply line to the solenoid valve. Use an air supply of 50 lbs. psig if atmospheric pressure assists in closing the valve. Use a pressure of 70 lbs. psig if it works against the closing operation. Be sure air supply lines are adequately sized for the total number of valves that may be operated at any one time. Filtered and lubricated air is recommended for maximum valve life and minimum maintenance.

The 115 volt, 60-cycle solenoid valve uses approximately 10 watts. Make electrical connections to the solenoid as shown in Figure 1. Install a toggle switch or equivalent in the power supply line for operating the valve solenoid.

## 3.3 Conversion of a Pneumatically-Operated Valve from a Normally-Closed to a Normally-Open Valve

All pneumatically-operated type VCS valves are supplied as normally-closed valves. This means that the vacuum valve is held closed by air pressure when the solenoid valve is de-energized. To convert a normally-closed valve to a normally-open valve, follow this procedure.

1. Disconnect the compressed air supply from the solenoid valve. (See Figure 1).

2. Disconnect the air line compression fitting at the solenoid end of the cylinder.

3. Unscrew solenoid valve from air cylinder at pipe nipple connection.

4. Move the elbow compression fitting in the solenoid valve to the former nipple position.

5. Screw the solenoid valve on the air cylinder nipple using the valve port previously occupied by the elbow compression fitting.

6. Reshape the air cylinder line and connect it to the compression fitting in the solenoid valve.

## 4.0 OPERATION

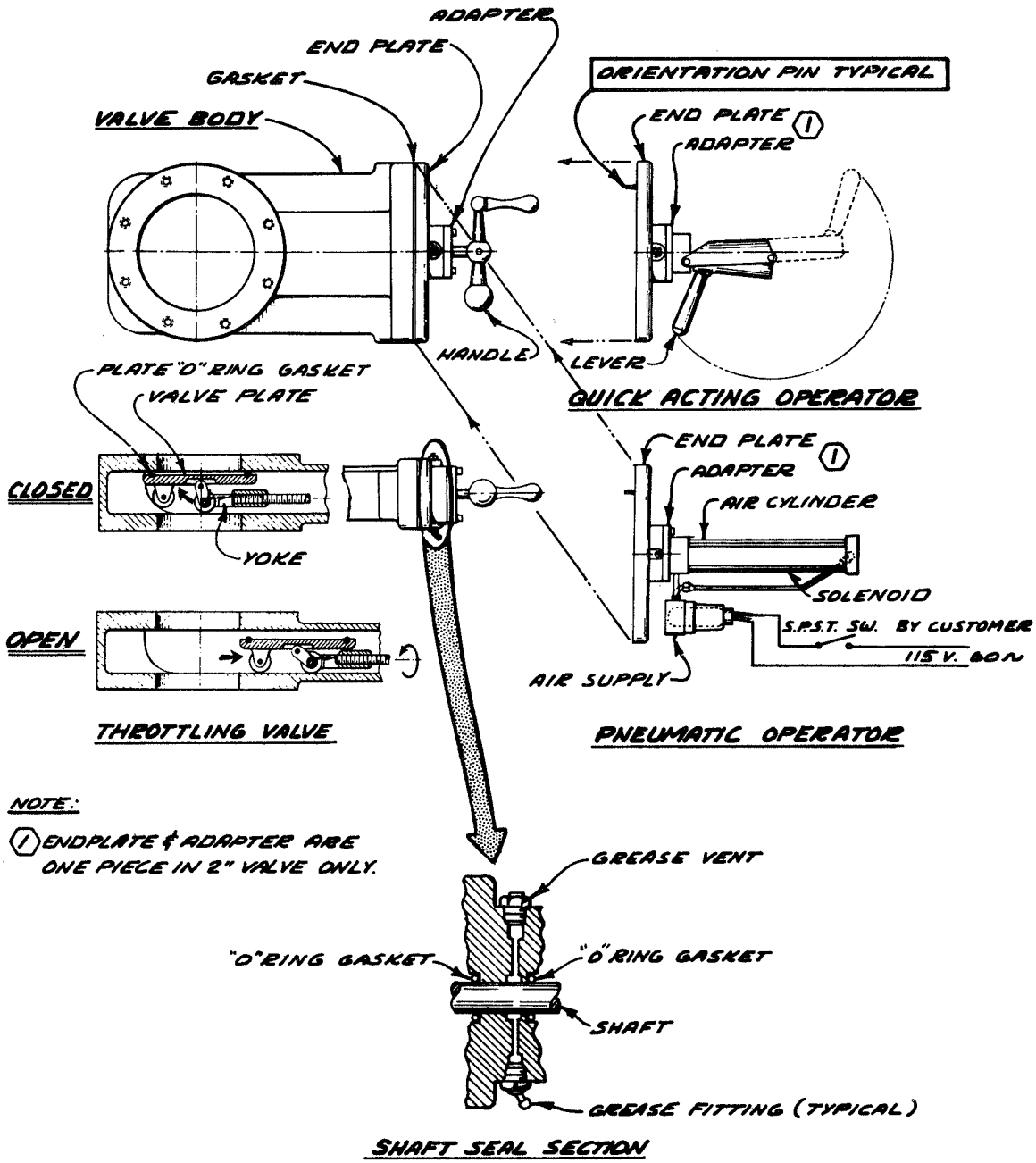
Open the manual throttling valve by turning the handwheel in a counterclockwise direction until the free action ceases. Open the manual quick-acting valve by moving the operating handle as shown in Figure 1. The pneumatically-operated valves are opened and closed by means of the toggle switch (furnished by customer) described in Section 3.2 of these instructions.

## 5.0 LUBRICATION

1. Periodically add Dow Corning #55 Pneumatic Grease to the shaft seal fitting until grease shows at the vent fitting on the opposite side. (See Figure 1).

2. Whenever valves are disassembled as for gasket replacement, it is desirable to lubricate the wheels, pins and links of all valves plus the threaded shaft of the throttling valves. CVC recommends using a mixture of Molybdenum Disulfide and Convoil-20 pump fluid.

3. Only the quick-acting valves have additional shaft guide bushings. Lightly lubricate the shaft on the vacuum side with Dow Corning High Vacuum Grease and lubricate the bushing on the atmosphere side with a few drops of light oil.




## TYPICAL VCS TYPE VALVES

FIG. 1

## 6.0 MAINTENANCE

### 6.1 General

Valves will operate for long periods if cleanliness and lubrication are maintained. Foreign particles on any sealing surface may cause leaks. After prolonged usage, the toggle valves may require readjustment to compensate for wear in linkage.

### 6.2 Gasket Replacement of End Plate and Valve Plate

Eventually the O-Ring gasket sealing the valve plate and the end plate gasket may need replacement. (See Figure 1). The need for new gaskets is indicated by leaks or by a loss of elasticity in the gaskets.

1. Remove the screws which fasten the end plate to the valve body and separate the end plate and shaft assembly from the valve body.

2. Remove old gaskets and clean all metal sealing surfaces with acetone or some similar solvent.

3. Lubricate all new gaskets with a very thin film of Dow Corning High Vacuum Grease before assembling the valve.

4. Assemble the valve by reversing the procedure of steps 1 and 2.

### 6.3 Shaft Seal Replacement

6.3.1 For 2", 4" and 6" Throttling Valves (Type VCS-21A, 41B, 61B) proceed as follows:

1. Remove the screws which fasten the end plate to the valve body (See Figure 1). Separate the end plate with valve plate and yoke assembly from the valve body.

2. Remove the handle.

3. Unbolt the shaft retainer from the end plate boss and slide it off the shaft.

4. Slide the shaft out through the end plate only far enough to expose the split washer retainers. Remove them.

5. Remove the shaft from the vacuum side of the end plate. DO NOT SLIDE THE SHAFT THREADS THROUGH THE END PLATE.

6. Remove the "O"-Rings and discard.

7. Clean the end plate base and O-Ring grooves. Lubricate the new O-Rings with a very thin film of Dow Corning High Vacuum Grease.

8. Reassemble in reverse order.

9. Fill the grease fitting with Dow Corning #55 Pneumatic Grease.

6.3.2 For 2", 4" and 6" Quick-Acting Valves (Type VCS-22A, 42A, 62A) as follows:

1. Remove the screws which fasten the end plate to the valve body (See Figure 1). Separate the end plate with valve plate and yoke assembly from the valve body.

2. Unscrew the valve plate and yoke assembly (See Figure 1) from the shaft. (NOTE approximate location of the plate assembly on the shaft threads to help in reassembly).

3. On 4" and 6" valves, remove screws from the adapter. Then remove the shaft with adapter and quick-acting lever on the atmosphere side of the end plate.

   On 2" remove the pin from the quick-acting lever assembly at fulcrum on the end plate boss. Then carefully remove the shaft from the plate on the atmosphere side.

4. Remove the O-Rings and discard.

5. Clean the O-Ring grooves and bearing surfaces with acetone.

6. Lubricate new O-Rings and actuator shaft with a very thin film of Dow Corning High Vacuum Grease.

7. Reassemble in reverse order.

NOTE: Method of obtaining proper valve closure: After screwing the shaft into the valve plate and yoke assembly to its approximate former position, proper final positioning can be obtained by turning the shaft one or two complete revolutions clockwise or counterclockwise.

8. Lubricate the end of the shaft bushing on the atmosphere side with a few drops of light oil.

9. Fill the grease fitting with Dow Corning #55 Pneumatic Grease.

6.3.3 For 2", 4" and 6" Pneumatic Valves (Type VCS-23A, 43A, 63A) as follows:

1. Remove compressed air supply line from the solenoid valve. (See Figure 1).

2. Remove the screws which fasten the end plate to the valve body. Separate the end plate with the attached cylinder together with the valve plate and yoke assembly from the valve body.

3. Loosen set screws which prevents the shaft from loosening in the valve plate and yoke assembly.

4. Unscrew the valve plate and yoke assembly from the shaft. (NOTE approximate location of the plate assembly on the shaft threads to help in reassembly).

5. Remove the four screws holding the air cylinder to the valve end plate.

6. Carefully remove the shaft from the end plate on the atmosphere side.

7. Remove O-Rings and discard.

8. Clean the O-Ring grooves and bearing surfaces with acetone.

9. Lubricate the new O-Rings with a very thin film of Dow Corning High Vacuum Grease.

10. Reassemble in reverse order.

11. Fill the grease fitting with Dow Corning #55 Pneumatic Grease.

## 7.0 REPLACEMENT OF VALVE OPERATOR

The VCS valves have interchangeable operators. A pneumatic operator can be replaced by a manual throttling operator, for example, without removing the valve body from the vacuum line. The procedure for changing operators follows:

1. Remove the screws which fasten the operator and end plate to the valve body.

2. Remove the operator, end plate and valve plate assembly from the valve body.

3. Make certain the gasket plate is in position on the new operator end plate.

4. Insert the new operator Conversion Kit in the valve casing. Make certain the valve plate is properly oriented with the valve body.

5. Fasten the new operator and gasket in place with the screw removed in step 1.

CONSOLIDATED VACUUM CORPORATION
Rochester, New York 14603
10-21-F/R4-66/EHF/tb Printed in U.S.A.

## 8.0 REPLACEMENT PARTS LIST FOR THE 2-INCH VCS VALVES, TYPES VCS-21A, -22A, -23A

MINIMUM ORDER BILLING OF $10.00 PER ORDER. PLEASE INCLUDE PART NUMBER AND DESCRIPTION OF EACH PART ORDERED.

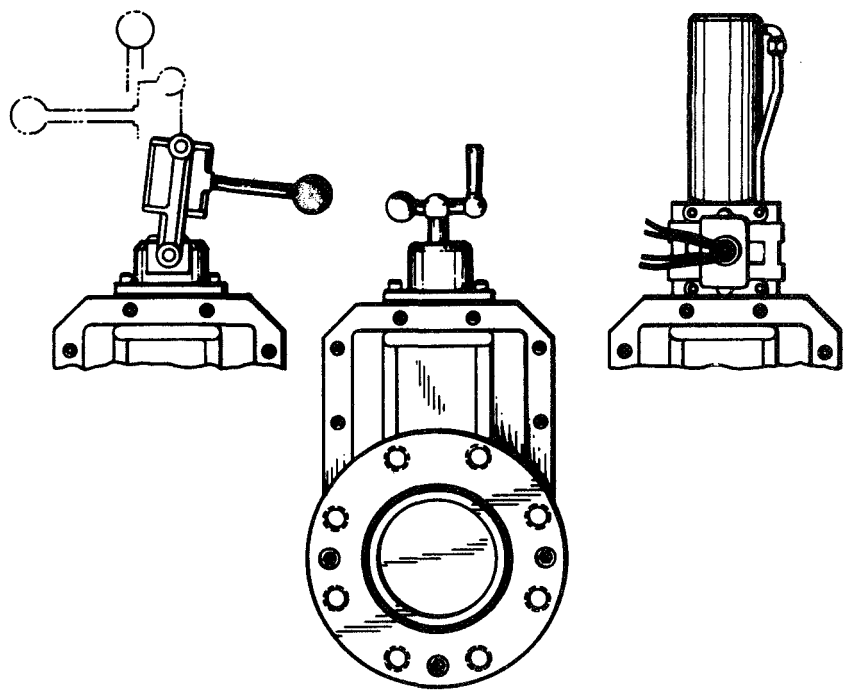
| Description | Part No. |
|---|---|
| Flange Gasket, Viton-A, Con-O-Ring, 2" | 265617-2 |
| O-Ring, Viton-A | 264091-15 |
| Flange Gasket, Buna-N, Con-O-Ring, 2" | 265056-2 |
| O-Ring, Buna-N | 70011-8 |
| Plate Gasket, Viton-A, O-Ring | 264091-31 |
| Plate Gasket, Buna-N, O-Ring | 70011-7 |
| Rectangular End Gasket, Buna-N | 67019 |
| Rectangular End Gasket, Viton-A (21A, 22A) | 67019-1 |
| Shaft Seal Gasket, Buna-N (Types 21A, 22A) 2 Req. | 70010-7 |
| Shaft Seal Gasket, Viton-A (21A, 22A) 2 Req. | 264091-8 |
| Air Operated Shaft Seal O-Ring, Buna-N, 2 Req. by Pneumatic Valve (Type -23A ONLY) | 70010-10 |
| Air Cylinder with Solenoid | 263536 |
| 4-Way Solenoid for above | 262102 |
| Solenoid Coil for 115 V. (50/60 Cycle) | 267846-1 |
| Solenoid Coil for 230 V. (50/60 Cycle) | 267846-2 |
| Shaft Seal Gasket, Viton-A (for 23A) | 264091-14 |

CVC
R4-66/EHF/tb

# APPENDIX F

# FORELINE VALVE

CVC Instruction Manual
No. 10-20-A
Revision No. 1



# GATE VALVES TYPE VST--M2 SERIES

Consolidated Vacuum Corporation

ROCHESTER NEW YORK

# Consolidated Vacuum Corporation

ROCHESTER 3, NEW YORK

## STANDARD WARRANTY

The following warranty will apply only upon condition that Buyer has utilized or operated the goods in strict conformance with operating instructions and manuals appropriate for the goods and any other instructions provided by Seller.

Seller warrants that all goods will be as specified on this order and will be free from defects. No warranty as to fitness, nor suitability to the Buyer's process, nor any other warranty, except of title, shall be implied. Minor deviations from specifications, which do not affect performance of the products covered hereby, shall not be deemed to constitute defects of materials or workmanship or a failure to comply with the specifications referred to herein.

Notice of any claim that the products are in any way defective shall be given the Seller immediately on discovery and the Seller shall thereupon correct the defects by repair or replacement without charge F.O.B. Shipping Point. The liability of the Seller arising out of the supplying of said products, whether based on warranty or otherwise, shall in no case exceed the cost of the parts or products, and all liability shall terminate within one year after shipment from the Seller's plant. The foregoing warranty does not apply to vacuum tubes, diodes, transistors, batteries, lamps or other items which are expendable by nature. No warranty whatever is made with respect to these items and Seller does not agree to repair or replace them. All vacuum gauge sensing elements, such as, thermocouple tubes, Pirani tubes, Philips tubes, etc., are warranted against defects in manufacture in normal use, as determined by Seller's inspection, for a period of 90 days from date of shipment, provided the defective gauge tube is returned to Seller at Rochester, New York for inspection.

## STANDARD ACCEPTANCE

The products covered by the order shall be deemed finally inspected and accepted within ten (10) days after delivery thereof, unless notice of rejection or notice of any claim, express or implied, is given in writing to the Seller within said period. Acceptance as aforesaid shall be deemed full performance of the Seller's obligations hereunder save for its obligation under the above warranty.

TABLE OF CONTENTS

# INSTALLATION AND OPERATING INSTRUCTIONS FOR THE GATE VALVE, TYPE VST-M2

## 1.0 GENERAL INFORMATION

These instructions contain the information required to successfully install and operate the type VST high-vacuum valve.

The 2-inch, 3-inch, 4-inch and 6-inch sizes of the type VST valve are available with manual throttling, manual quick-acting, or pneumatic operators. The 8-inch and 10-inch sizes are available with pneumatic operators only.

## 2.0 INSTALLATION

### 2.1 Unpacking

Inspect the shipping carton and the valve for damage. All equipment is normally shipped F. O. B. Rochester, New York. Damage in transit is the normal responsibility of the transportation company and should be reported to them. Remove all wrappings from the valve.

All gaskets for a normal installation are packed with the valve. These are Buna-N gaskets. The plate gasket should be replaced with a Convaseal gasket if the valve is to be installed near a vapor pump which uses Butyl Phthalate pump fluid.

### 2.2 Vacuum Line Connections

The valve is suitable for use as a high-vacuum valve between a processing chamber and a diffusion pump or as a roughing or backing valve between a chamber or a diffusion pump and a mechanical pump.

1. Wipe each of the connecting faces to remove any particles which might cause leaks.

2. Wipe each O-Ring gasket to remove any foreign particles, spread a thin layer of Celvacene vacuum grease on each gasket and seat each gasket in its respective groove on the connecting face of the valve casing.

3. The valve operates successfully with the plate in either the vertical or the horizontal position and seals tightly against atmospheric pressure in either direction. However, if one side of the valve plate is regularly exposed to atmospheric pressure while the pressure on the other side of the plate is very low, position the valve so that atmospheric pressure reinforces the operating mechanism to close the valve more tightly.

4. Connect each face of the VST valve to a mating connector attached to the system. The 3-, 4-, 6-, 8-, and 10-inch valves are designed to connect directly with the ASA 150-pound fittings. Adapter flanges (drilled and tapped plates with gasket grooves) are available for connecting these valves directly to CVC pumps.

   The 2-inch valves do not have ASA standard connections. These valves are designed to connect with CVC pumps. Adapter plates must be used when the valves are connected directly to a pump because both the valve connector and pump flange have gasket grooves.

## 2.3 Service Connections for Pneumatically-Operated Valves

After completing the installation requirements described in Section 2.2 for a manually-operated valve, connect a compressed air supply to both inlets of the solenoid valve as stamped on the valve body. The recommended air pressure for optimum valve operation is 50 psig except for operating and holding against atmospheric pressure, in which case 70 psig is required. The 115-volt, 60-cycle solenoid valve requires approximately 20 watts. Make electrical connections to the solenoid as shown in Figure 1. Install a toggle switch (or the equivalent) in the solenoid power supply line for operating the valve.

## 2.4 Conversion of Normally-Closed Valve to Normally-Open Valve

All pneumatically-operated type VST valves are supplied for operation as normally-closed valves (that is, the vacuum valve is closed when the solenoid valve is not energized). To convert a normally-closed valve to a normally-open valve, follow this procedure:

1. Disconnect the compressed air supply from the solenoid valve.

2. Remove the two machine screws which hold the solenoid valve to the pneumatic cyclinder of the VST valve.

3. Remove the solenoid valve from the VST valve.

4. Remove the air inlet fitting from the solenoid valve.

5. Remove the cylinder air connection (right-angle fitting) from the solenoid valve and re-install it in the inlet connection mentioned in step 4.

6. Install the inlet fitting in the cyclinder air connection.

7. Orient the solenoid valve so the cylinder air connection mates properly with the pneumtaic cyclinder of the VST valve, position the solenoid valve and fasten it in place with the two machine screws.

8. Both the inlet and bleed ports of the solenoid valve have alternate connections. One connections, in each case, is closed by a Allen-screw type plug. Use the connections most convenient for your specific application. Relocate the air plug as required.

9. Reconnect the compressed air supply to the solenoid valve.

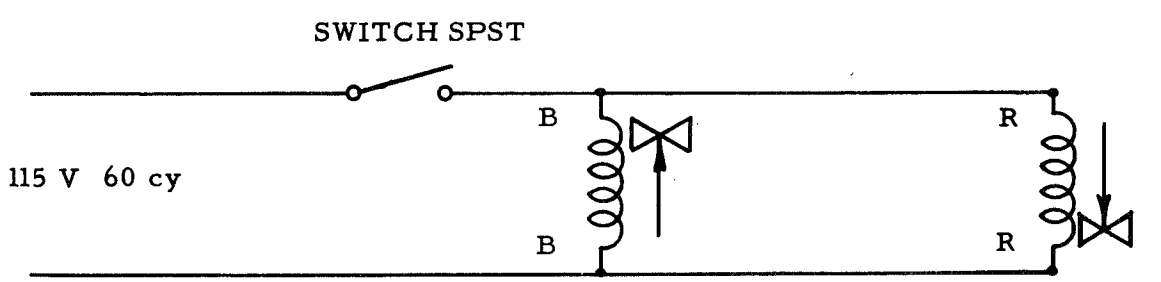



FIG. 1 STANDARD ELECTRICAL SCHEMATIC FOR VST VALVES

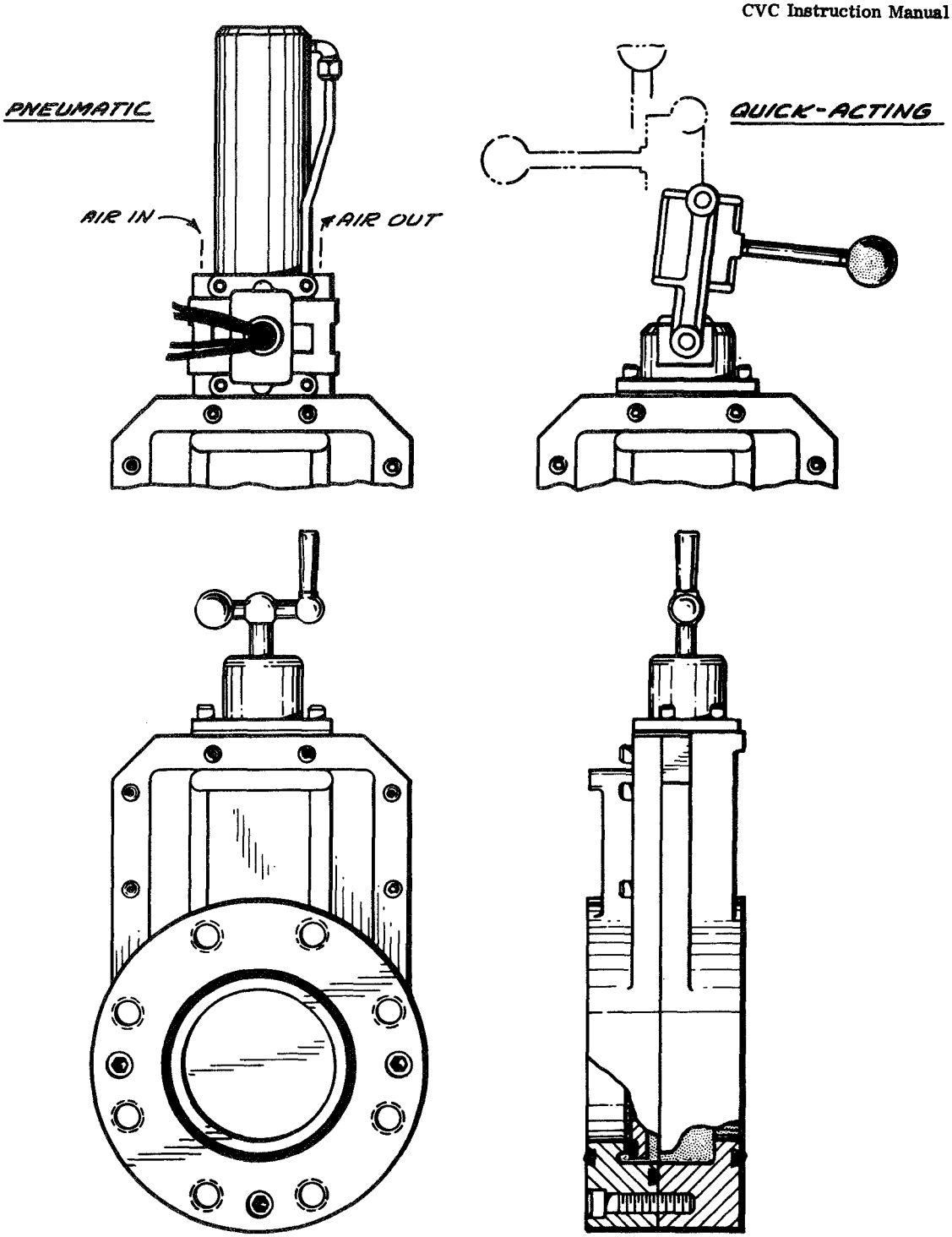



FIG. 2 PNEUMATIC, QUICK ACTING & THROTTLING GATE VALVES TYPE VST (TYPICAL)

## 3.0 OPERATION

Open the manual throttling valve by turning the handwheel in a counterclockwise direction until the free action ceases. Open the manual quick-acting valve by moving the operating handle as shown in Figure 2. The pneumatically-operated valves are opened and closed by means of the toggle switch (furnished by customer) described in Section 2.3 of these instructions.

## 4.0 MAINTENANCE

### 4.1 Cleanliness

Type VST valves will generally perform satisfactorily for long periods of time if they are clean. Failure to seal can be caused by foreign matter on the gate seating surface, the body gasket surfaces or the surfaces of the actuating shaft and seals. The quad-ring seal in the valve system will keep the actuating shaft clean under normal conditions.

### 4.2 Gasket Replacement

After periods of use, the O-Ring gaskets used to seal the valve plate and the valve casing will have to be replaced. The need for new gaskets is indicated by leaks or by a loss or elasticity in the gaskets.

1. Remove the socket head screws which hold the two parts of the valve casing together.

2. Lift off the smaller part of the casing. The plate gasket and the casing gasket, as well as the valve plate mechanism, are now easily accessible.

3. Clean all sealing surfaces and rubber items with acetone or some similar solvent.

4. Lubricate all O-Ring gaskets and square gaskets with a light coat of Celvacene vacuum grease before assembling the valve.

5. After performing the required maintenance, assemble the valve by reversing the procedure of steps 1 and 2.

4.3 Shaft Seal

The seal assembly which prevents leakage along the actuating shaft between the valve operator and the valve plate is made accessible for required lubrication, replacement, etc., by performing the following operations. The components of the seal assembly are packed with a silicone grease. *Do not use Celvacene to repack this assembly because it will dry out and require frequent cleaning and replacement.*

1. Loosen and remove the socket head screws which hold the rectangular metal plate below the operator to the valve casing.

2. The plate can now be lifted to gain access to the seal.

3. When assembling the shaft seal on a threaded actuating shaft, be careful that the threads do not cut the rubber parts.

CONSOLIDATED VACUUM CORPORATION
Rochester, New York 14603
10-20-A/R1-67-EHF/tb Printed in U.S.A.

## REPLACEMENT PARTS LIST FOR THE 3-INCH VST VALVES, TYPES VST-31, -32, AND -33 $M_2$ SERIES

MINIMUM ORDER BILLING OF $20.00 PER ORDER. PLEASE INCLUDE PART NUMBER AND DESCRIPTION OF EACH PART ORDERED.

| Description | No. Req'd. | Part No. |
|---|---|---|
| Flange Gasket, O-Ring, Buna-N | 2 | 70010-49 |
| Plate Gasket, O-Ring, Buna-N | 1 | 70010-39 |
| Body Gasket, O-Ring, Buna-N | 1 | 70010-73 |
| Stuffing Box Seal, O-Ring, Buna-N | 1 | 70010-16 |
| Quad Ring Shaft Gaskets, Buna-N | 2 | 260203-2 |
| Air Operator O-Ring, Buna-N Required by pneumatic valve (type VST-33) only | 2 | 70010-29 |
| Solenoid Connector O-Ring, Buna-N | 1 | 70010-8 |
| Shaft O-Ring Required by pneumatic valve (type VST-33) only | 1 | 70010-12 |
| *Solenoid Air Control Valve Skinner V9HSA13D | 1 | -------- |

*Not immediately available from Rochester Stock (2 or 3 weeks delivery)

CONSOLIDATED VACUUM CORPORATION
Rochester, New York 14603
10-20-A/R1-67/EHF/tb

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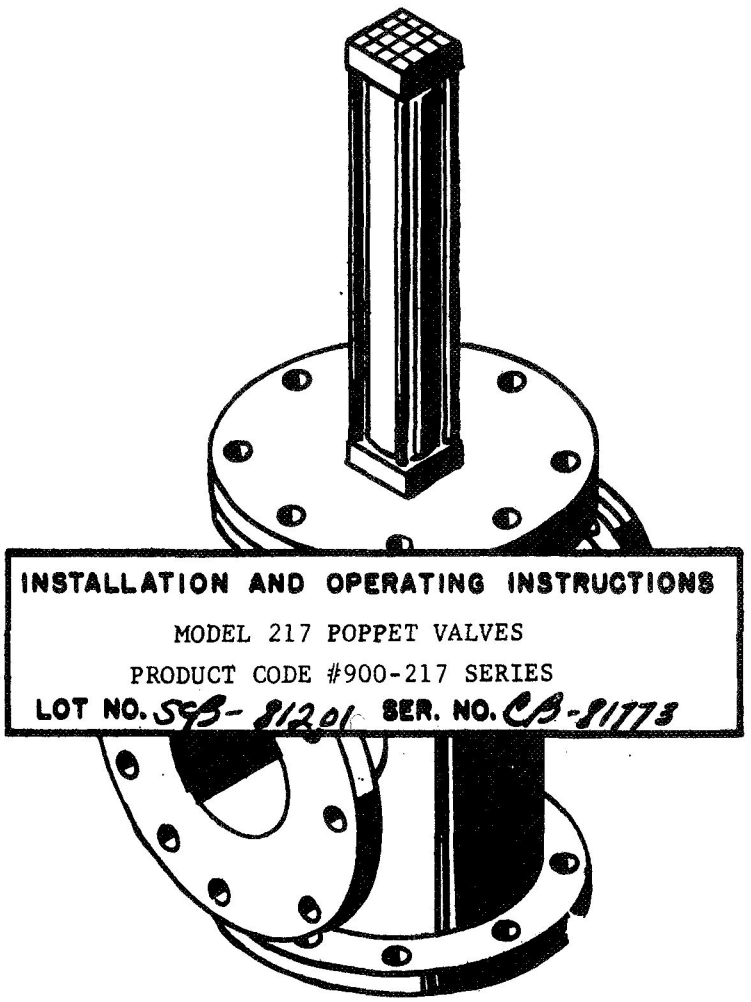
# APPENDIX G

# MAIN VALVE

STOKES



# INSTALLATION AND OPERATING INSTRUCTIONS

MODEL 217 POPPET VALVES

PRODUCT CODE #900-217 SERIES

LOT NO. SCB-81201 SER. NO. CB-81773

F. J. STOKES CORPORATION
5500 TABOR ROAD, PHILA. 20, PA.

# TABLE OF CONTENTS



# ILLUSTRATION

## Section 1

## GENERAL DESCRIPTION

(a) The Stokes Model #217 Poppet Valves are air operated high vacuum valves of the disc type. The 4" and 6" valves will withstand vacuum from either side of the disc and can be opened against high vacuum, while the 10" and 16" valves cannot be opened against a vacuum of better than 200 microns. The Stokes 217-12 10" valve is specially constructed to open at a 15# pressure differential, and the 16" valve can be so furnished on special order.

(b) The disc within the valve is moved up and down by means of an air cylinder located on top of the valve. Operating air pressure if 65-120 psi and clean lubricated air above 65# must be provided at all times in order to keep valves positively sealed against high vacuum. The roughing port is provided for easy connection of a roughing line so that rough pumping can be accomplished through the roughing port above the valve disc while the poppet valve is in the closed position.

## Section 2

## INSTALLATION

The valves are usually shipped completely assembled. However, in case the operating parts are removed for shipping convenience, they should be reassembled according to match marks stamped on the flanges.

(a) Installing Valve

1. Before installing valve, clean and check the flange surfaces of the pipe line for burrs and other obstructions, since the "O" ring gasket requires a metal to metal joint to seal properly. Any burr around the tapped holes in the pipe line flange may result in vacuum leakage. A slight nick in the "O" ring flange gasket may cause leakage; therefore be careful not to damage flange gaskets, and be sure sealing surfaces of flanges are free of scratches and have a finish of better than 125.

2. The valve must be installed in the vertical position with cylinder up, if installed horizontally or at an angle the disc will not seat properly. Ordinarily the disc should face the low pressure area. The 4", 6", 10" and 16" heavy duty valves can be installed in the reverse direction.

NEVER apply any gasket compound to the "O" ring or flange, but a very light coating of light vacuum grease facilitates sealing.

3. Tighten flange bolts alternately and securely.

(b) Service Connections

An air supply of at least 65 psi must be provided to operate the valve. Air supply piping should be no smaller than 1/2" ips. Install an air regulating valve with filter and lubricator as close as possible to the valve. The NORGREN "lubro-Control" Unit #745B-4R, 1/2" ips is recommended.

(c) Valve Controls

To control the opening and closing strokes, a solenoid operated 4-way air valve is supplied. This control valve is to be operated by a selector switch or other means supplied by customer. Controls are normally 110 volts, 60 cycle, 1 phase.

Note: The Air Regulating Valve with filter and lubricator, selector switch, and all piping to be furnished by customer unless specified otherwise.

## Section 3

## LUBRICATION

The lubricator (Section 2-b) must be filled with a low vapor pressure lubricant. Use a highly refined petroleum fraction with a vapor pressure of less than $10^{-5}$mm at 100°F and a viscosity of approximately SAE 20. See Attached parts list.

CAUTION: Ordinary lubricants will seriously off-set degree of vacuum obtainable in the system.

## Section 4

## OPERATION

(a) Fill lubricator with proper oil.

(b) Set air pressure regulator for minimum and then, turn air on. Adjust Regulator for approximately 80#, if available. In any case do not set below 65#. If air lines are long set Regulator for 100#. The valve is shipped with disc in the closed position. Air pressure normally keeps the valve closed.

(c) Connect solenoid to the selector switch. With selector switch in "OFF" position, the valve is closed. When selector switch is in the "ON" position, the solenoid is energized and air is admitted below the piston of the cylinder to open the valve, while the area above the piston is vented. Return selector switch to "OFF" position to close valve.

(d) To test operation of the valve, a manual override is built into the 4-way solenoid valve. This manual override can also be used to open the valve in the event of a power failure.

## Section 5

## MAINTENANCE

The valves are designed to give maximum trouble-free service with a minimum of maintenance. It is only necessary to keep the air lubricator reservoir filled with oil (as specified under Section 3) in order to keep these valves in good operating condition.

NOTE: Adjust amount of oil supplied by the Lubricator to a minimum, as only a small amount of oil is needed for lubricating the working parts of these valves.

(a) To Renew the "O" Ring on Valve Disc

After the valve has been in service over an extended period of time, it may be necessary to replace the "O" rings.

1. Remove bolts in top flange (bearing plate #4) of valve.

2. Lift up cylinder together with poppet valve disc #8.

3. Examine "O" ring #9 and its seating surface carefully for nicks or cuts across face, before removing "O" ring from groove.

NOTE: "O" ring must be sufficiently elastic to sustain its round shape when in the open or unloaded position. It should extend approximately 3/64" above the edge of the groove.

4. Remove faulty "O" ring by carefully slipping the tip of a knife between ring and groove. Take care not to scratch groove.

5. Carefully clean groove with a piece of hard wood.

6. Lubricate groove and new "O" ring slightly with a vacuum grease suitable for high vacuum systems in the range of $1 \times 10^{-6}$ minimum pressure with a melting point of approximately $50^{\circ}C$. See attached parts list.

7. Comparing the valve disc with the face of a clock, press new "O" ring into groove starting at 12 o'clock; then press in at 6 o'clock and at 3 o'clock. Make sure "O" ring is not twisted or stretched. Keep working "around the dial" until "O" ring is seated equally. Use thumbs to start ring; a piece of round wood, rolled back and forth over the entire "O" ring surface, will insure final seating.

8. After re-assembly, open and close the valve approximately 20 to 30 times to give the "O" ring a short "break-in" before resuming operation.

(b) Back Seat Seal and Stem Seal

1. As shown on the parts drawing furnished, the valve is sealed in the open position by means of an "O" ring gasket #7, located in the back seat of bearing plate #4.

2. The air cylinder piston stem is sealed by means of an "O" ring gasket #5 which is located beneath the cylinder spacer #2.

NOTE: In case of leakage, these two "O" ring gaskets should be inspected and if necessary, renewed. However, when leakage occurs, first check flange connections in pipe line before disassembling the valve.

3. To renew "O" rings on back seat and around stem, proceed as described under Section 5 (a), steps 1 and 2. Then remove valve disc #8 by removing the square head plug and loosening the set screw that holds the disc to the stem. Seal #7 can now be removed and the stem seal #5 removed by taking off the spacer plate between the air cylinder and bearing plate #4.

(c) Air Cylinder

The air cylinder is constantly being lubricated and needs little attention. If after an extended period of operation, it becomes necessary to renew its packings, a drawing showing the parts is included in these instructions.

## Section 6

## TROUBLE AND REMEDY CHART

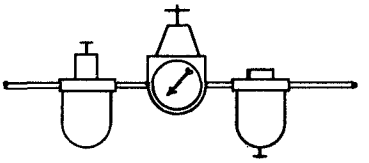
This chart will be helpful in locating and correcting the trouble if difficulties should occur.

| TROUBLES | REMEDIES |
|---|---|
| (a) Valve leaking, due to - | |
| 1. Loose flange connections, or damaged flange "O" ring gaskets. | 1. Tighten flange connections in pipe line and at valve. Replace "O" rings if necessary. |

| | | |
|---|---|---|
| 2. Faulty "O" ring gaskets. | 1. | Inspect "O" ring at valve disc. (Section 5 (a).) |
| | 2. | Inspect "O" ring gaskets at back seat and stem (Section 5(d).) Replace if necessary. |

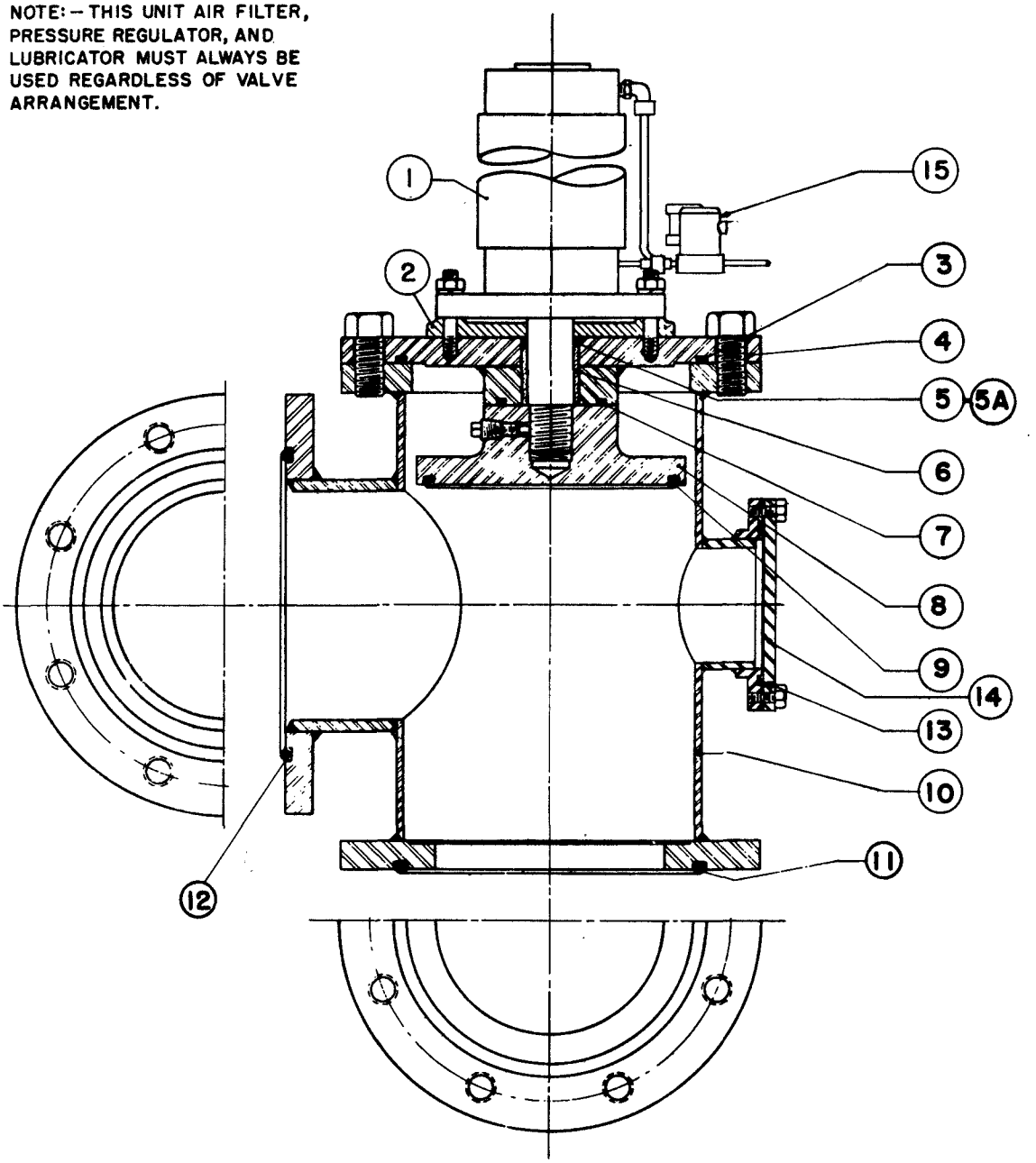
(b) Valve does not seal properly, due to -

| | | |
|---|---|---|
| 1. Improper air pressure. | 1. | Check air supply - must be above 65#. |
| 2. Inoperative control valve. | 1. | Check for faulty coil or power supply, replace if necessary. |
| | 2. | Disassemble, clean, and replace any worn or damaged parts. |
| 3. Excessive air leakage at air cylinder. | 1. | Make sure cylinder packings are lubricated. (Check by squirting oil in at air connections.) |
| | 2. | Replace cylinder packings according to manufacturer's recommendations enclosed, if necessary. |



AIR SUPPLY
65 P.S.I. MIN

NOTE:—THIS UNIT AIR FILTER, PRESSURE REGULATOR, AND LUBRICATOR MUST ALWAYS BE USED REGARDLESS OF VALVE ARRANGEMENT.




# STOKES MODEL 217 HIGH VACUUM POPPET VALVE

Fig 1

**Model** 900-217-25 (6" POPPET VALVE)

**Lot no.** SCA-84490 **to**

| Sym. | Qty. | Part no. | Description |
|---|---|---|---|
| 1 | 1 | C-085-23-446 | Air Cylinder 3-5/8" Bore, 9-7/16" Stroke (H) |
| 2 | 1 | B-279-813-1 | Cylinder Spacer |
| 3 | 1* | 022-2-57 | "O" Ring, 7-1/2" I.D. x 8" O.D. x .275" Section |
| 4 | 1 | C-279-814-1 | Cylinder Bearing Plate |
| 5 | 1* | 022-2-50 | "O" Ring, 1" I.D. x 1-1/4" O.D. x .139" Section |
| 5A | 2* | 022-2-323 | Leather Piston Packing, 1-1/4" O.D. x .062" Thick x .123 Section |
| 6 | 1 | A-279-817-1 | Bushing for Piston 31/32" I.D. x 1-5/8" Long |
| 7 | 1* | 022-2-311 | "O" Ring, 2" I.D. x 2-3/8" O.D. x .210 Section |
| 8 | 1 | C-279-815-1 | Valve Disc |
| 9 | 1 | 022-2-52 | "O" Ring, 6" I.D. x 6-1/2" O.D. x .275" Section |
| 10 | 1 | D-279-811-1 | Valve Body |
| 12 | 1* | 022-2-57 | "O" Ring, 7-1/2" I.D. x 8" O.D. x .275" Section |

*Recommended spare part (stocked)

Re-typed 1/25/67 WRC/AJ PR WRC

# APPENDIX H

# IONIZATION GAUGE/THERMOCOUPLE GAUGE CONTROL UNIT

TABLE OF CONTENTS

# Consolidated Vacuum Corporation

ROCHESTER NEW YORK

## FIVE YEAR GAUGE WARRANTY

The following warranty will apply only upon condition that Buyer has utilized or operated the goods in strict conformance with operating instructions and manuals appropriate for the goods and any other instructions provided by Seller. Warranty is valid only as long as the Seller's sensing tubes are utilized.

Seller warrants that all goods will be as specified on this order and will be free from defects. No warranty as to fitness, nor suitability to the Buyer's process, nor any other warranty, except of title, shall be implied. Minor deviations from specifications, which do not affect performance of the products covered hereby, shall not be deemed to constitute defects of materials or workmanship or a failure to comply with the specifications referred to herein.

Notice of any claim that the products are in any way defective shall be given the Seller immediately on discovery and the Seller shall thereupon correct the defects by repair or replacement without charge F.O.B. Shipping Point. The liability of the Seller arising out of the supplying of said products, whether based on warranty or otherwise, shall in no case exceed the cost of the parts or products, and all liability shall terminate within three years after shipment from the Seller's plant. The foregoing warranty does not apply to vacuum tubes, diodes, transistors, batteries, lamps or other items which are expendable by nature. No warranty whatever is made with respect to these items and Seller does not agree to repair or replace them. All vacuum gauge sensing elements, such as, thermocouple tubes, Pirani tubes, Philips tubes, etc., are warranted against defects in manufacture in normal use, as determined by Seller's inspection, for a period of 90 days from date of shipment, provided the defective gauge tube is returned to Seller at Rochester, New York for inspection.

***ATTENTION PLEASE! The above FIVE YEAR GAUGE WARRANTY is not in effect until the WARRANTY REGISTRATION reply card attached to the gauge power cord has been returned to CVC.***

***All correspondence concerning WARRANTY repairs should be addressed to Consolidated Vacuum Corporation, 1775 Mt. Read Blvd., Rochester, New York 14603, ATTENTION: Quality Assurance Dept. Be sure to include your WARRANTY REGISTRATION NO.***

# 1.0 GENERAL DESCRIPTION

## 1.1 Purpose of Manual

This instruction manual is designed to aid you not only in setting up this equipment but throughout its working life. How well it does this depends upon how thoroughly you read and make reference to this manual. Since your warranty does not cover damage resulting from abuse and from errors in installation, it is to your advantage to read this manual as comprehensively as possible. Further assistance is available if necessary (See Assistance from CVC, Section 6.0.)

A careful reading of the table of contents will reveal the plan and scope of this manual.

## 1.2 General Features of the Gauge Controls

The GIC-200 is an ionization gauge of the hot filament type and operates on 115/230 volts, 50/60 cycle. The gauge reads from $1 \times 10^{-3}$ to $2 \times 10^{-12}$ mm Hg; the ion tube used with this gauge has a range of $1 \times 10^{-3}$ to $2 \times 10^{-10}$ mm Hg. A plug-in thermocouple gauge accessory with either a one or two station option is available to extend the gauge pressure range to 2mm Hg.

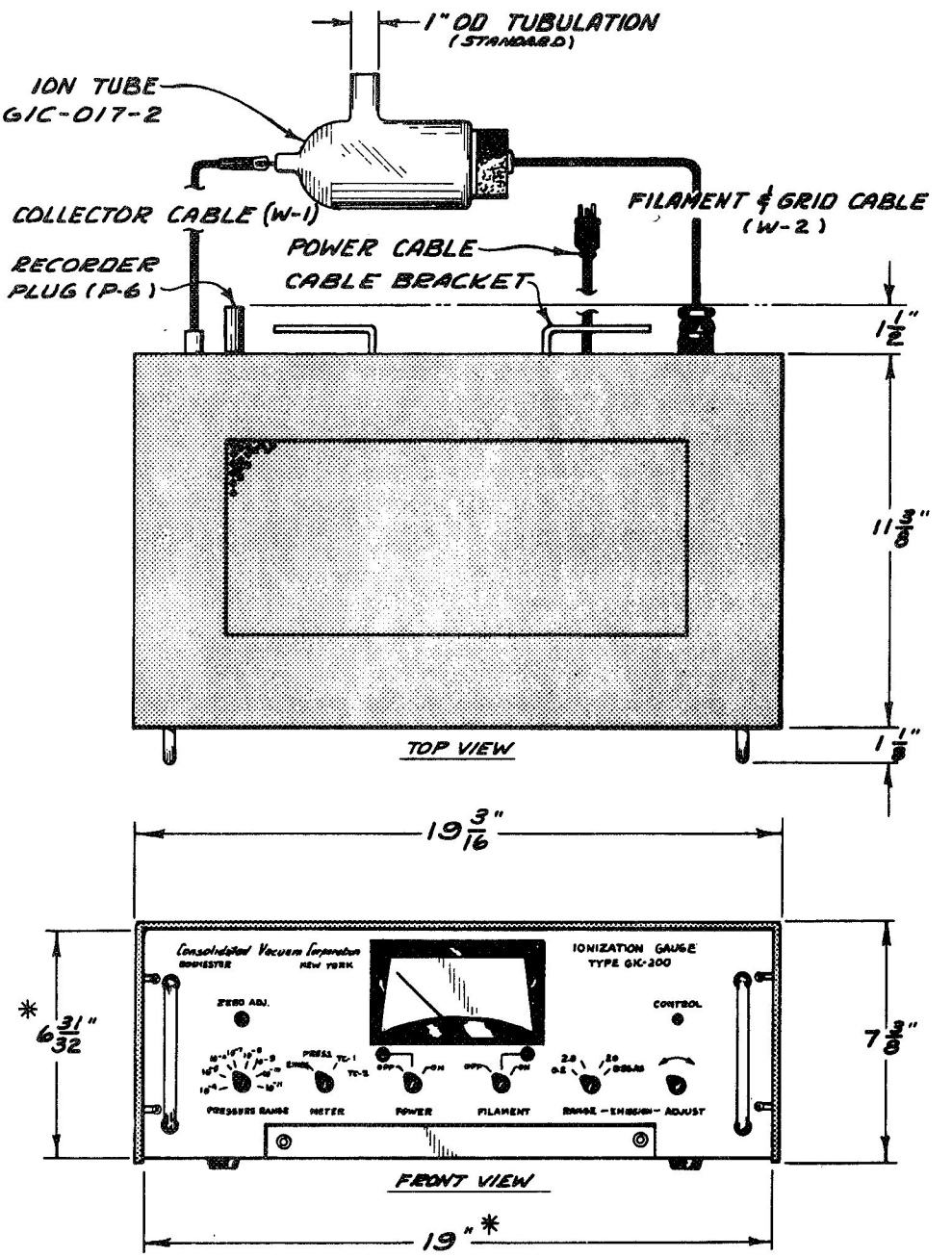
The GIC-200 Gauge has a control relay which the customer may utilize for automating, safety, etc. The gauge also has provisions for recorder connection. The gauge circuit has an adjustable control for automatic filament protection and also includes an external filament activation feature. An external control circuit is connected to and activated by the filament protection circuit. Provisions for extending ion tube life is also included in the gauge design.

## 1.3 Detailed Specifications

Physical

| | |
|---|---|
| Cabinet Width | 19-3/16" |
| Cabinet Height | 7-3/8" |
| Cabinet Depth | 13-3/4" |
| Weight | 45 lbs. |

Gauge panel can be mounted directly into a 19" relay rack by removing the cabinet cover. See Figure 1.




* DIMENSIONS FOR PANEL MOUNTING (STD. RELAY RACK)

## IONIZATION GAUGE
## TYPE GIC-200

FIG. 1

| | |
|---|---|
| Tube Cords, Minimum length | 10 ft. |
| Line Cords, Minimum length | 9 ft. |
| Standard Sensing Tube | GIC-017-2 (1" Tubulation) |
| Absolute Max. Glass Temp. | 450° C. |
| Max. Tube Baking Temp. | 400° C when connector cable is removed from ion tube. |

Electrical

| | |
|---|---|
| Input Line Voltage | 115/230 V. @ 50/60 cycles |
| Max. Power Input | 230 watts |
| Max. Ambient Temp. | 110° F. |
| Amplifier Range | $1 \times 10^{-3}$ to $2 \times 10^{-12}$ mm Hg. |
| Range Multiplier based on tube sensitivity of: | $10\mu a/10^{-4}$ mm Hg. at Calibration emission |
| Time required for Amplifier zero to stabilize to $\pm 1/2\%$ of final value: | 3 minutes |
| Amplifier zero drift with Time: | $\pm 1/2\%$ of Full Scale for 24 hours after warmup. |
| Grounding type of electrical plug (Parallel Blades) | Satisfactory gauge operation and safety reasons require gauge be connected to a grounded power system. |
| Amplifier zero drift for line voltage variation of $\pm$ 10% from 117 V. | 1% of Full Scale. |
| Emission Ranges | 4 - 20 ma<br>0.4 - 2.0 ma<br>0.050 - 0.175 ma |
| Emission drift for line voltage variation of 105 V. - 130 V. from 115 V. | @ 7 ma is less than $\pm$ 1% of full scale.<br>@ .7 ma is less than $\pm$ 1% of full scale.<br>@ .07 ma is less than $\pm$ 1% of full scale. |

| | |
|---|---|
| Emission drift for change in pressure from $10^{-6}$ to $10^{-3}$ torr. | @ 7 ma is less than $\pm$ 2% of full scale. |
| | @ .7 ma is less than $\pm$ 2% of full scale. |
| | @ .07 ma is less than $\pm$ 2% of full scale. |
| Nominal collector voltage | -50 volts |
| Nominal grid voltage | +200 volts |
| Nominal degas power available at transformer | 8 volts @ 12 amps |
| Meter Output | 11 mv full scale. |
| Recorder Output | 10 mv full scale (may be converted to 1 ma full scale.) |
| Filament protection operates at: | 200% of full scale (approx.) |
| Process control (adjustable) | 15-100% of full scale. |
| Tube sensitivity for air (nominal) | 10 $\mu$a per $10^{-4}$ mm Hg per 10 ma emission. |
| Usable tube range: | $1 \times 10^{-3}$ to $2 \times 10^{-10}$ mm Hg, to extend tube linearity to $10^{-3}$, emission must be reduced by a factor of 10. |

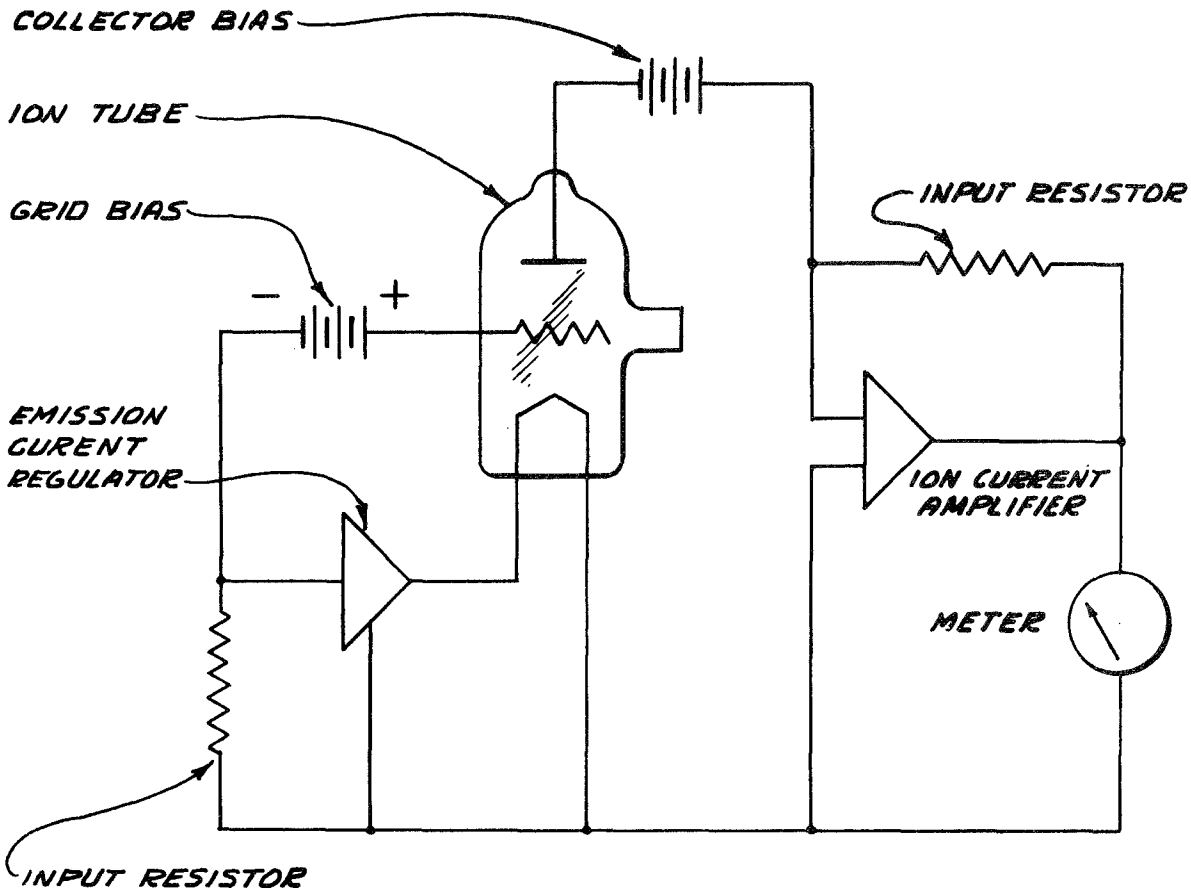
Accessories:

| | |
|---|---|
| Thermocouple Accessory GIC-007, Single Station | 0-2000 microns |
| Thermocouple Accessory GIC-002, Two Station | 0-2000 microns |

## 1.4 General Description of Circuit Operation - See Figure 2.

### 1.4.1 Principles of Operation

The GIC-200 Ionization Gauge consists of two basic circuits: (1) The ion current amplifier with power supply, and (2) The emission current regulator with its power supply as shown in Figure 2.




## SIMPLIFIED SCHEMATIC
## OF GIC-200 GAUGE

FIG-2

The function of the Ion Current Amplifier is to increase the ion current to a level sufficiently high for driving an output indicator such as a pressure meter, recorder, etc.

The Ion Current Amplifier is a three stage, direct coupled, electrometer. A differential amplifier with 100% negative feedback. The high negative feedback results in fast response, good linearity, excellent stability and a circuit essentially unaffected by tube aging. The differential input is excellent for maximum noise rejection and stability.

The Emission Current Regulator has the task of maintaining a constant reference ionizing current against variations in system pressure and line voltage. This circuit utilizes a saturable reactor in a feedback loop to control the emission current at a pre-set level.

1.4.2 Degas

With the EMISSION-RANGE switch in the DEGAS position, the ion-tube elements are degassed by direct resistance heating of the accelerating grid. The emission range in the DEGAS position is the same as the 20 ma range. Pressure is indicated during degas by the same factor as in the 20 ma emission range. If desired, the filament may be de-energized during the degassing procedure with the FILAMENT switch; this switch is located on the front panel of the gauge.

# 2.0 INSTALLATION

## 2.1 Unpacking

Examine the shipping carton for damage or shortages. Damage in transit is the normal responsibility of the transportation company and should be reported to them. The carton contains the following items:

A GIC-200 Control Circuit
An Ion Tube
A Filament-Grid Cord
A Collector Cord
An Instruction Manual

## 2.2 Installation Instructions

1. (a) The GIC-017-2 ion tube, which has a 1-inch 7052 glass tubulation, is supplied as standard and may be attached directly to a glass system. The ion tube is normally mounted vertically but can be mounted in any position. WARNING: The tube is fragile, do not drop.

   (b) When the tube is connected to a metal system a type CGB Connector (CVC No. 265638) may be utilized. It is not recommended however where ultra high vacuum pressures are desired.

   (c) Should the customer need an ionization tube other than the one supplied with the GIC-200, CVC can supply the following:

   GIC-017, has 1" diameter pyrex tubulation and may be sealed directly to pyrex glass systems.

   GIC-017-2, (the standard supplied with this gauge) has hard glass 7052 tubulation with a 1" diameter. It is intended to be used with various elastomer type seals including CVC's connector (see parts list).

   GIC-017-3, has a 1" diameter Kovar metal seal and may be soldered directly to metal systems.

NOTE: Six succeeding tubes differ from the previous three in tubulation diameter and are installed according to the previous corresponding tubulation material.

GIC-016, 3/4" Pyrex Tubulation
GIC-016-2, 3/4" 7052 Tubulation
GIC-016-3, 3/4" Kovar Tubulation
GIC-015, 1/2" Pyrex Tubulation
GIC-015-2, 1/2" 7052 Tubulation
GIC-015-3, 1/2" Kovar Tubulation

In addition to the glass envelope GIC-015, 016, 017, ionization tubes, CVC can also supply the GIC-018 Series of "hot filament" tubes. These ionization tubes have bakeable and replaceable elements and are readily adaptable to different methods of mounting either through or from within the feedthrough ring.

CVC also has an inexpensive exposed element ion gauge tube for use with the GIC-200 when a bakeout is not required. Also available are various other accessories such as adapters, adapter cables of various lengths, and special connectors. For further information regarding the GIC-018 and GIC-019 tubes and accessories, refer to CVC Bulletin 9-80 in the Accessories Section of this manual.

2. Connect the filament and collector cables to the ionization tube and gauge. NOTE: The ionization tube has two calibrated filaments, but in operation uses only one filament. The choice of the filament to be used is made by the installation of the tube plug. When the tube plug is in one position, the first filament is used. When the tube plug is removed from the ionization tube and rotated 180° and replaced, the second filament is used. Each has its own emission value, and this value should correspond to the gauge emission setting of the filament being used.

(a) Avoid exposing the tube filament to oil vapor concentrations. Methods would include the use of effective baffles and installation of the tube such that the tube aperature is not directed toward oil contaminated atmosphere or toward hot surfaces from which re-evaporation of oil concentrations can occur.

(b) Turn off the filament and grid power while traps or chamber walls are heated or when operating near forepressure breakdown point. Apply external heat to minimize tube contamination.

(c) The following is a list of materials considered undesirable for introduction into a vacuum system.

Neoprene
Micarta
Epoxy Resin
Potting Compounds of any type
Identifications made by wax marking crayon
Wax impregnated lacing cord
Plastic coated fiber glass sleeving or tape
Pressure sensitive tape of any type
Insulated wire except Teflon or uncoated fiber glass
Unnecessary paint where other means of coloring or protection is available
Cadmium plating or flashing

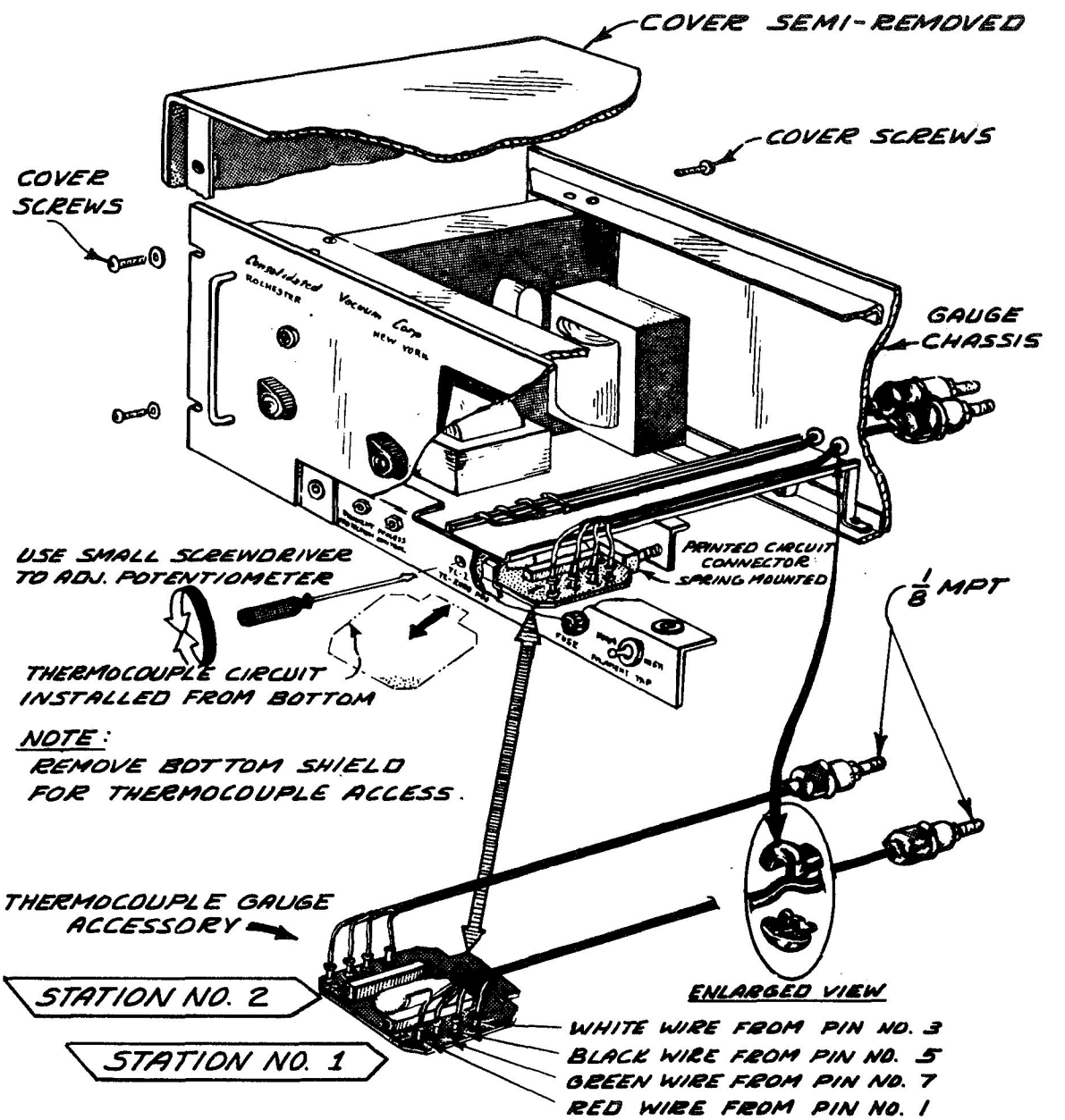
The ideal materials to use are metals, glasses, and ceramics. Acceptable polymerics are Viton-A and Teflon if not subjected to more than 300° F. Apiezon-T grease may be used to increase mechanical joint thermal conduction on test objects.

## 2.3 Installation of Thermocouple Accessory

1. Thermocouple tube type GTC-004 (CVC Part No. 64797) may be installed in a metal system using a CGB type connector (CVC Part No. 61083 with a 61081-2 bushing).

2. To install the thermocouple tube in a glass system, use a glass-to-metal seal (CVC Part No. 72635).

The thermocouple accessory, when installed in the gauge, is located at the bottom of the gauge directly behind the front panel, see Figure 3. If it is to be installed by the customer, use the following procedure.




## THERMOCOUPLE ACCESSORY INSTALLATION

TYPE GIC-200 GAUGE

FIG. 3

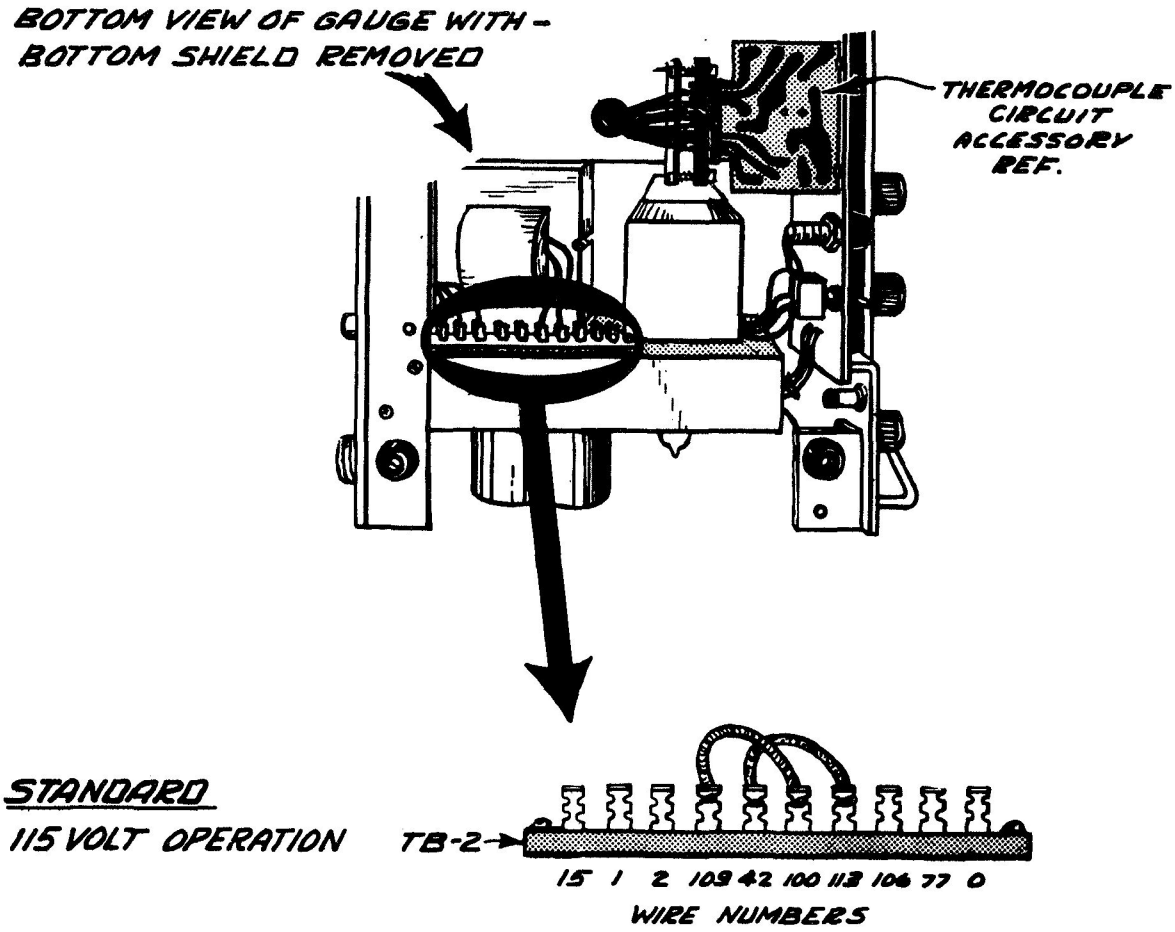
Remove top and bottom covers of the gauge control. Install the thermocouple circuit into the spring-loaded pre-wired, printed circuit receptacle with the taper pin receptacles facing the top of the gauge.

Remove the two snap-in plugs from middle of back panel; install the tube cords and connect the thermocouple accessory to the thermocouple tube(s) as shown in Figure 3 . Be sure that taper pins are tight.

Calibrate the thermocouple accessory as outlined in section 4.1.2.

2.4 Conversion from 115 to 230 Volts.

The GIC-200 gauge is normally wired for 115 Volts AC operation. The gauge can be easily converted for 230 volt operation simply by removing two red/yellow jumpers between terminals 113-42 and 100-109 located on the inside of the emission chassis. Add one jumper between terminals 42 and 100. See Figure 4.




## WIRING CONNECTIONS FOR 115 OR 230 V. 50/60 CYCLE OPERATION

GIC-200 GAUGE

FIG. 4

# 3.0 OPERATING INSTRUCTIONS

## 3.1 Explanation of External Controls

The controls are described in order of their location from left to right across the front of the cabinet. See Figure 5.

### 3.1.1 Zero Adjust

This control is used to balance the ion current amplifier for zero meter reading when there is no input signal.

### 3.1.2 Pressure Range Selector Switch

This switch selects the proper input resistor to provide full-scale pressure readings of $1 \times 10^{-3}$ to $1 \times 10^{-10}$ mm Hg depending on the specific position of the range selector switch.

### 3.1.3 Meter Function Selector Switch

This four-position switch provides a means of selecting the function which is indicated on the gauge meter as described in the following steps.

a. EMISSION - The meter indicates emission current between the grid and filament of the ionization tube. Full scale meter deflection equals 0.2, 2, and 20 ma depending on the position of the EMISSION-RANGE switch.

b. PRESSURE - The meter is connected to the amplifier output. The output is calibrated in terms of pressure and the indicated pressure is equal to the numerical value shown on the top meter scale (1 to 10) multiplied by the power of ten shown by the PRESSURE-RANGE selector switch. See Section 3.1.6.

c. TC-1 and TC-2 - If the gauge has a plug-in thermocouple accessory, the meter shows thermocouple pressure on the T.C. MICRON scale (red) when the switch is in one of these positions.

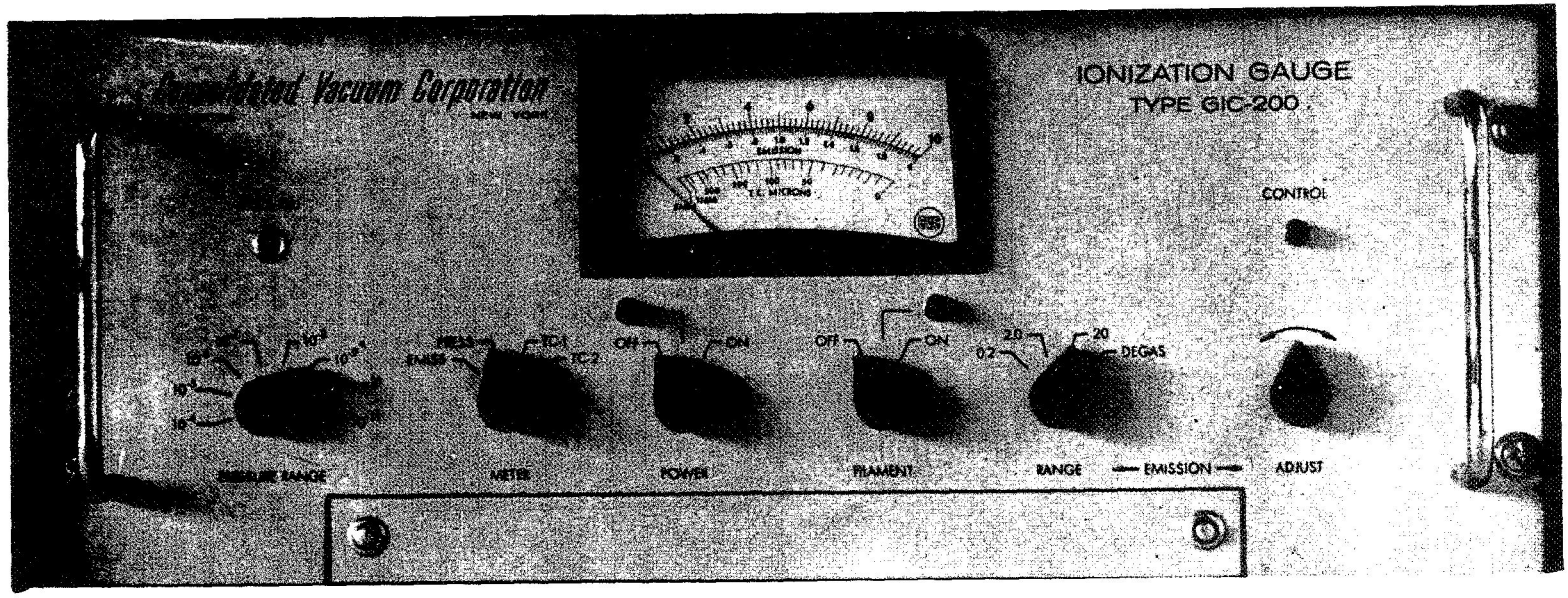



FIG-5 FRONT PANEL ON GIC-200 GAUGE

3.1.4 Power Control Switch

This switch controls the AC supply power input to the gauge.

3.1.5 Filament

This switch performs three functions: It controls the ion tube filament power, resets the filament protection and external protection circuits.

3.1.6 Emission Range Selector Switch

The emission is read on the lower black scale (0-2). This four position switch selects the ionization tube power inputs as described in the following positions.

a. 0.2 - The meter indicates a full scale emission current of 0-2 milliamps.

b. 2.0 - The meter indicates a full scale emission current of 2.0 milliamps.

c. 20 - The meter indicates a full scale emission current of 20 milliamps.

d. Degas - This position selects the 20 ma full scale emission range and in addition it energizes the grid to degas the ion tube.

The 0.2 and the 2.0 positions of the EMISSION-RANGE switch are used to operate the gauge at reduced emission. The following table gives positions for the EMISSION-RANGE and the PRESSURE RANGE switches when reading the system pressure.

| System Pressure | Switch Positions | |
|---|---|---|
| | EMISSION-RANGE | PRESSURE-RANGE |
| $10^{-3}$ | 2.0 | $10^{-4}$ |
| $10^{-4}$ | 2.0 | $10^{-5}$ |
| $10^{-5}$ | 2.0 | $10^{-6}$ |
| $10^{-6}$ | 2.0 | $10^{-7}$ |
| etc. | etc. | etc. |
| $10^{-10}$ | 2.0 | $10^{-11}$ |

| System Pressure | Switch Position | |
|---|---|---|
| | EMISSION-RANGE | PRESSURE-RANGE |
| $10^{-3}$ | 0.2 | $10^{-5}$ |
| $10^{-4}$ | 0.2 | $10^{-6}$ |
| $10^{-5}$ | 0.2 | $10^{-7}$ |
| $10^{-6}$ | 0.2 | $10^{-8}$ |
| etc. | etc. | etc. |
| $10^{-9}$ | 0.2 | $10^{-11}$ |

The advantages of operating the ion tube at reduced emission are: extended tube filament life, reduced tube pumping and extended linearity in the upper pressure range.

3.1.7 Emission Adjust

This control sets the emission current as indicated by the lower black scale (0-2) on the meter.

3.2 Sub-Panel Calibration Controls

See Figure 6 for the arrangement of these controls.

3.2.1 Filament Protection

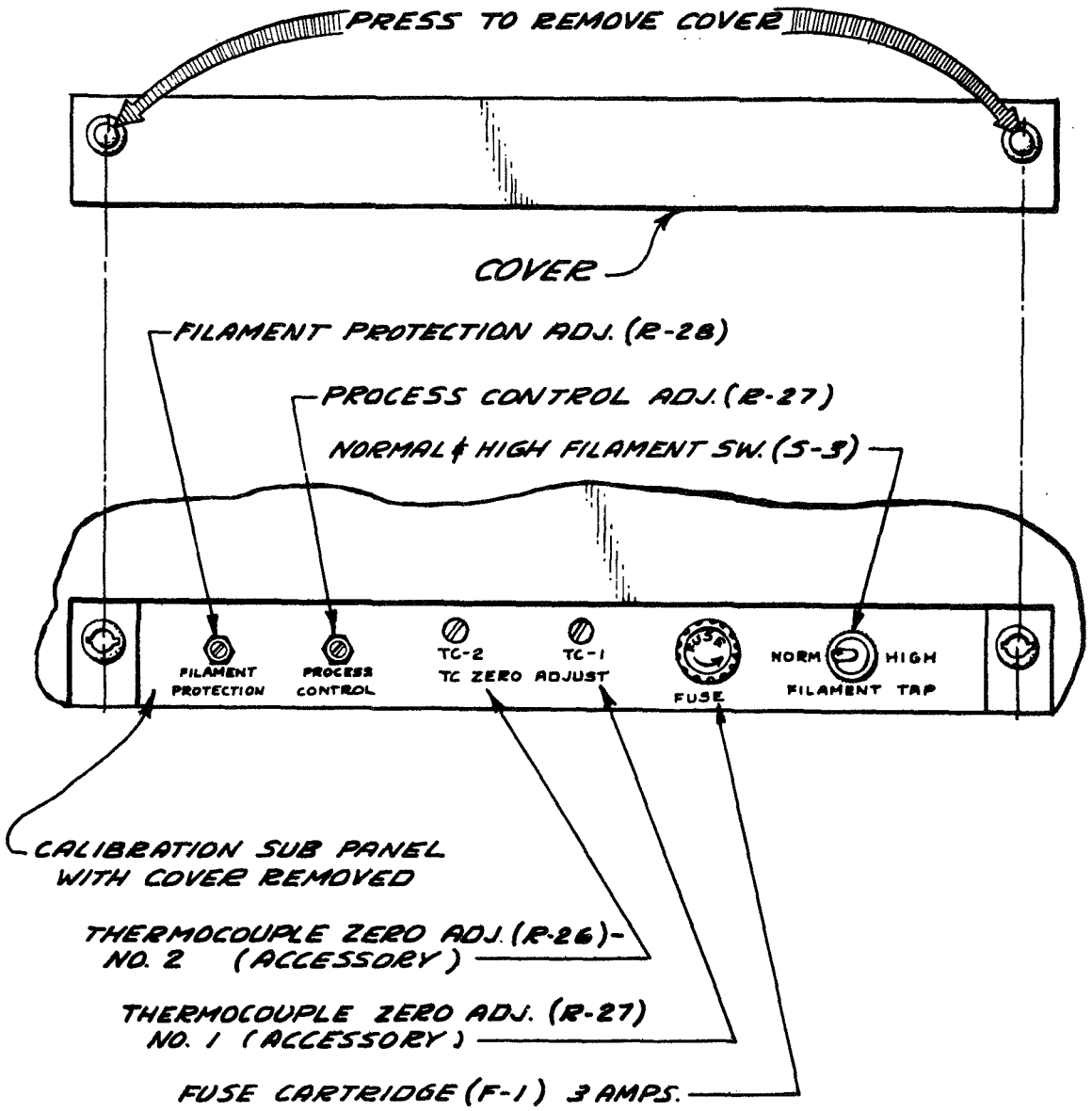
This control determines the pressure at which the ionization tube filament is automatically turned off.

3.2.2 Process Control

This control determines the pressure at which an external process can be controlled.

3.2.3 TC-2 Zero Adjust

This control is used to set the TC-2 thermocouple station to zero when the pressure at the thermocouple tube is less than a micron.




## CALIBRATION SUB-PANEL

TYPE GIC-200

FIG. 6

3.2.4 TC-1 Zero Adjust

This control is used to set the TC-1 thermocouple station to zero when the pressure at the thermocouple tube is less than a micron.

3.2.5 Fuse

The AC supply power input to the gauge is interrupted by the action of this fuse if an overload occurs.

3.2.6 Filament Tap Switch

Power available to the ion tube filament is increased by switching the FILAMENT TAP switch from the normal to the high position.

3.3 Explanation of Internal Controls

The internal controls are preset at the factory and may require re-adjustment only after prolonged gauge operation due to components aging or tube replacement.

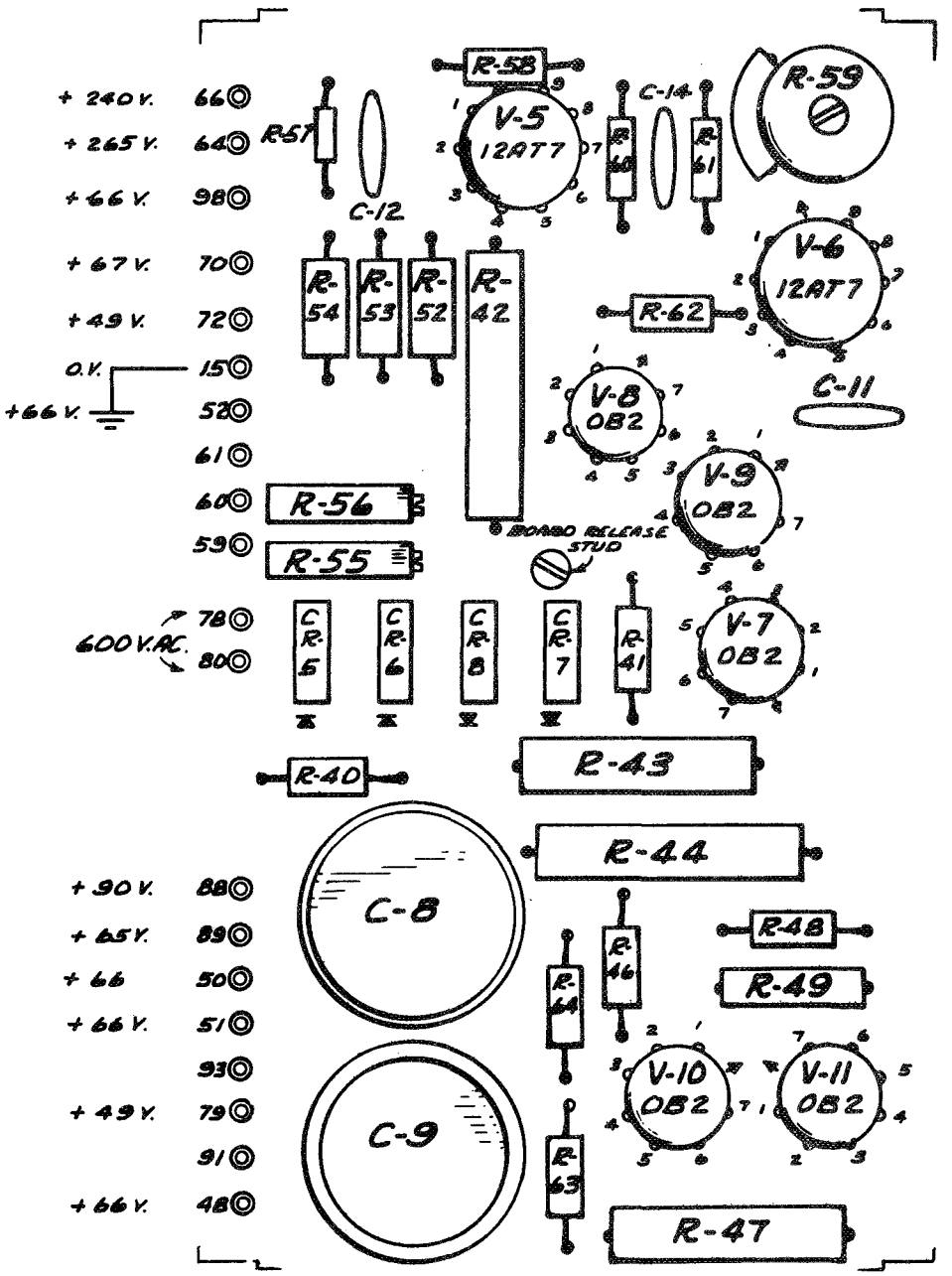
Controls R-55, R-56, and R-59 are located on the emission printed board (Figure 7) on the right side of the gauge. R-18 located on the ion amplifier printed board (Figure 8) on the left side, under the pre-amplifier cover.

3.3.1 Gain Control (R-59)

The gain control adjusts the operating point of the emission current regulator. If either of the 12AT7 tubes are replaced, the gain control may require re-adjustment. Refer to Section 4.1.1.

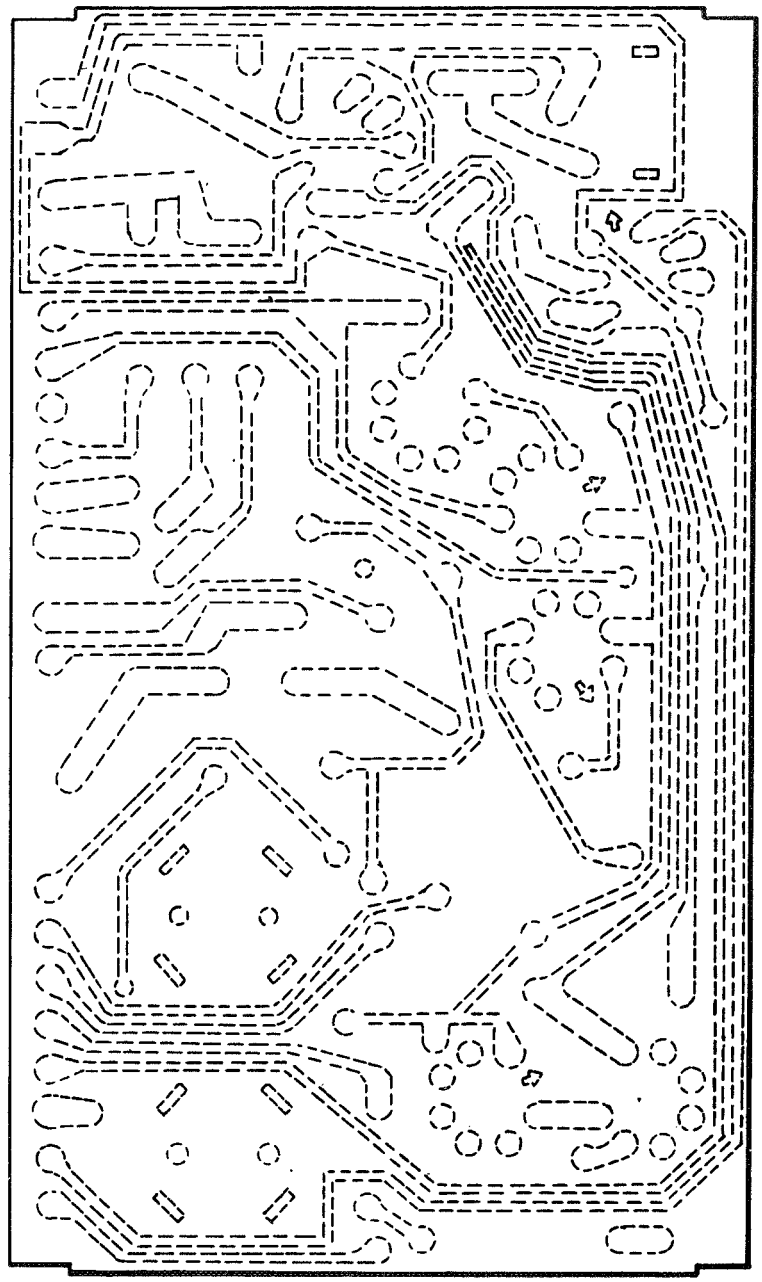
3.3.2 Emission Calibrate Control

a. 2 ma range (R-56) - The emission calibrate control is adjusted to reduce the emission current by a factor of ten as the EMISSION-RANGE switch is rotated from the twenty (20) ma range to the 2 ma range position.




## EMISSION CONTROL BOARD

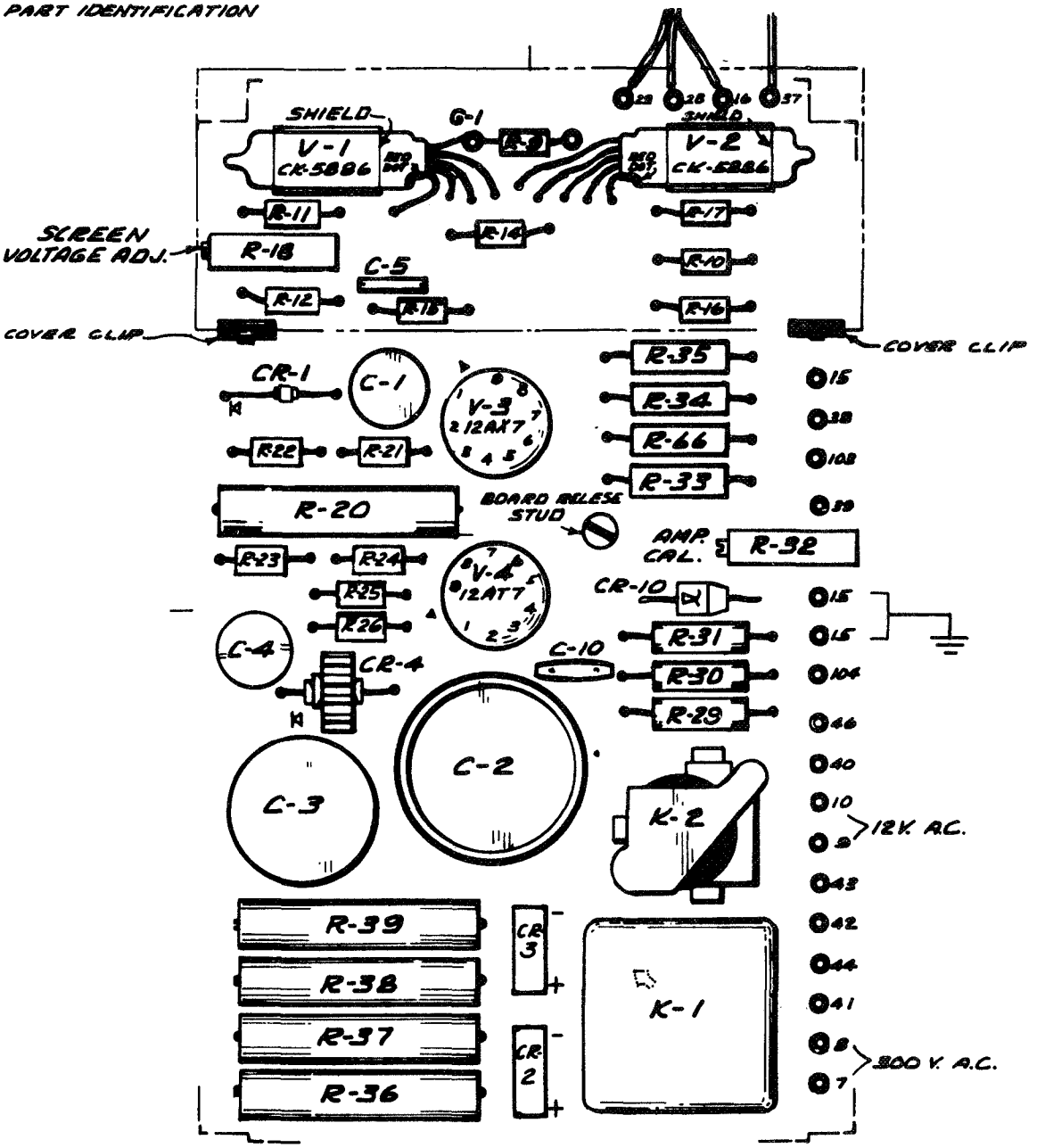
FIG. 7



**BOARD LESS COMPONENTS**

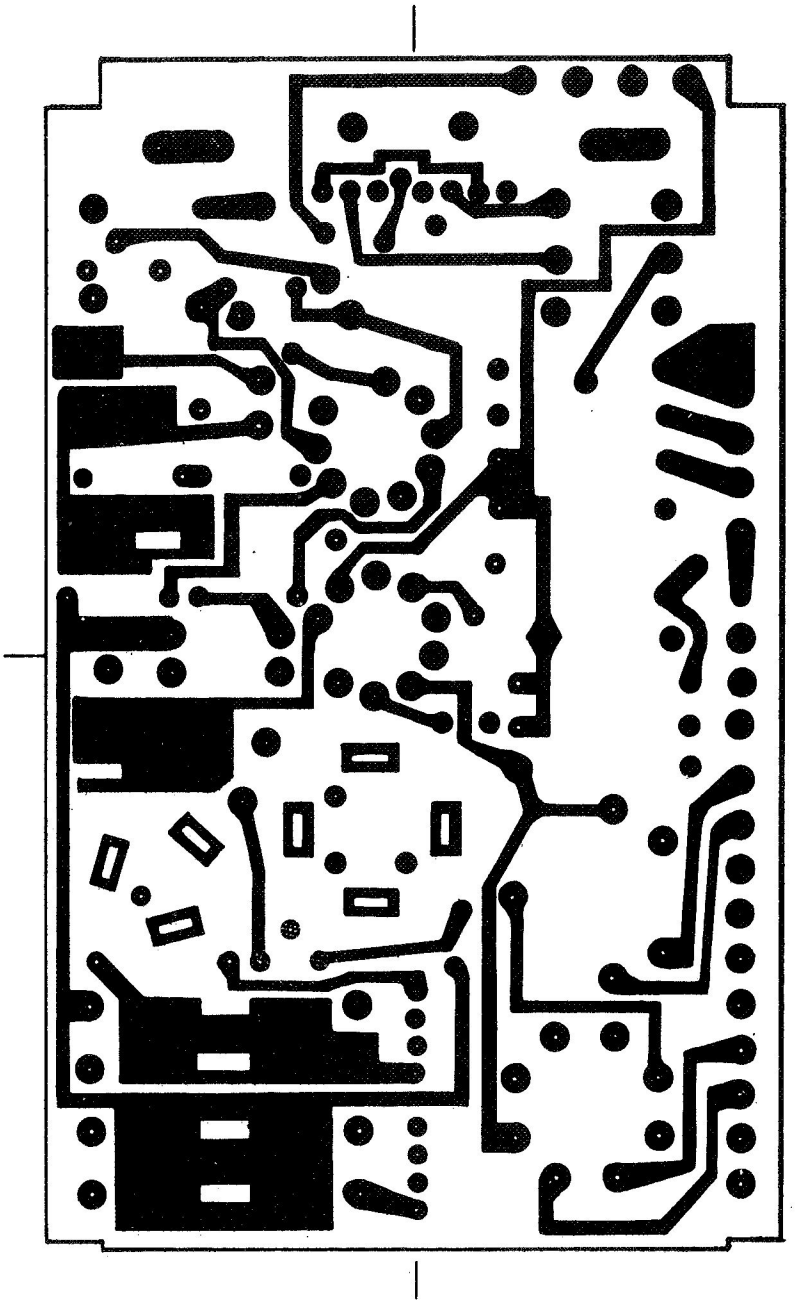
FIG. 7 A

SEE SCHEMATIC FOR PART IDENTIFICATION




## ION CURRENT AMPLIFIER BOARD

FIG. 8



BOARD LESS COMPONENTS

FIG 8A

b. .2 ma range(R-55) - The emission calibrate control is adjusted to reduce the emission current by a factor of ten as the EMISSION-RANGE switch is rotated from the 2 ma range to the .2 ma range position.

3.3.3 Screen Voltage Control (R-18)

This control sets the screen grid bias on V-1 and V-2 and therefore affects the amplifier zero, linearity and gain. (See Figure 8 & 8A).

This amplifier linearity may be checked with a suitable electrometer current source such as "Grya Electronics Corp. Current Source", Model #CS-57.

3.4 Normal Operation

1. Turn the POWER switch OFF and plug in the gauge to a suitable power outlet.

2. PRESSURE RANGE SWITCH TO THE $10^{-4}$ POSITION.

3. METER selector switch to PRESS (Pressure).

4. FILAMENT switch to OFF.

5. EMISSION-RANGE switch to 20 ma range.

6. EMISSION-ADJUST control fully counterclockwise. Check mechanical zero on pressure meter.

7. Turn POWER switch to ON and allow gauge to warm up. After approximately 5 minutes, make a preliminary zero adjustment (if required) with the ZERO ADJUST control on the front panel. The final zero adjustment should be made with the PRESSURE-RANGE switch in the $10^{-11}$ position after the instrument has been sufficiently stabilized. However, if the system pressure is not expected to reach this range, the final zero adjustment may be made easily in the $10^{-10}$ range because it is less susceptible to transients. Recheck zero at other range positions as it is returned to $10^{-4}$ position.

NOTE: The high sensitivity and high input resistance of the Ion Current Amplifier particularly on the $10^{-11}$ pressure range make it also sensitive to unwanted electrostatic charges, and capacitive changes in the input circuit. Both effects will cause disturbances in the amplifier output (pressure meter or recorder). These effects are completely normal with very sensitive instruments and can be either completely eliminated or minimized to an insignificant level by using a grounded shield around the Ion tube and the unshielded end of the collector lead.

8. If the PRESSURE IN THE SYSTEM IS LESS THAN ONE MICRON Hg, turn the METER selector switch to EMISSION.

9. Turn FILAMENT switch to ON. With the EMISSION-ADJUST CONTROL, set the emission (middle scale on meter) for the filament being used to the value marked on the ion tube tag. See Section 3.1.6.

10. Place METER switch in PRESS (Pressure) position. Advance PRESSURE RANGE switch clockwise until a suitable meter reading is obtained. (Pressure in mm Hg = Meter reading on the top scale times the multiplying factor indicated by the PRESSURE RANGE switch).

11. To degas the ion tube, first place the pressure range switch in the $10^{-4}$ position and then turn the EMISSION-RANGE switch to the DEGAS position. After the initial gas burst has been reduced, advance the range switch to read pressure in the lower ranges ($10^{-5}$, $10^{-6}$ etc.).

12. Zero Check of the Ion Current Amplifier

To check the amplifier zero while reading pressure, simply turn the FILAMENT switch to OFF, rotate PRESSURE-RANGE switch from $10^{-4}$ to $10^{-11}$ position, stopping briefly in each position to observe the meter reading. If any adjustment is required, it should be made on the $10^{-11}$ range. To read pressure, simply turn the FILAMENT switch to ON. No additional adjustment of the EMISSION-ADJUST control switch should be necessary.

If the zero reading is to be checked on one range only, (while reading pressure) simply turn the FILAMENT switch to OFF and check the zero. If the zero adjustment is required, repeat the zero check procedure; if no zero adjustment is required, turn the FILAMENT switch back to ON and continue reading pressure.

## 3.5 Operation of Auxiliary Features

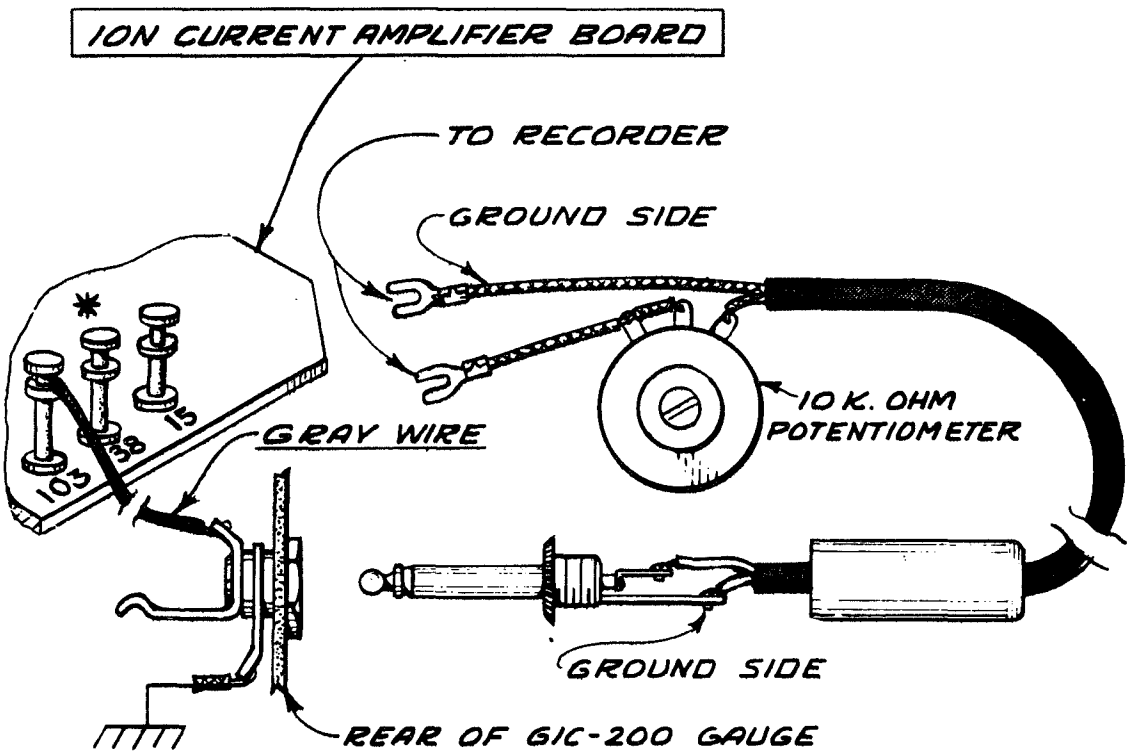
### 3.5.1 Pressure Recording

A phone jack is provided on the back panel of the gauge for a direct connection to a 10 mv high impedance recorder. The recorder output reads ion tube pressure regardless of the METER selector switch position. The recorder pressure reading is equal to recorder reading multiplied by the factor indicated by the position of the PRESSURE-RANGE switch if the EMISSION-RANGE switch is in the 20 ma position and a 0-10 scale is used on the recorder. The GIC-200 gauge can be adapted to operate a one milliampere recorder by changing the gray wire from the #38 to #103 terminal located on the printed wiring board on the left side of the gauge. In addition, a 10, 000 ohm potentiometer must be added in series with the ungrounded, recorder input terminal external to the gauge. The potentiometer is adjusted for full scale reading on the recorder when the gauge meter is reading full scale; METER selector switch is in the PRESS (pressure) position. (See Figure 9)

### 3.5.2 Filament External Protection, and Process Control Circuits

Figure 10 presents a table and a simplified schematic of contact action of the external protection and process control circuits.

Both circuits are brought out of a common connector (J-2). Pins 1, 4 and 5 are for the external protection circuit which is activated when the ion tube filament is automatically turned off by a pressure increase (off scale). Pins 1, 2 and 3 provide the output from the process control circuit which is activated by a pressure change (on scale) the action of which is indicated by illumination of the control pilot light.




(1) REMOVE GRAY WIRE FROM TERMINAL NO. 38 & SOLDER TO TERMINAL NO. 103.

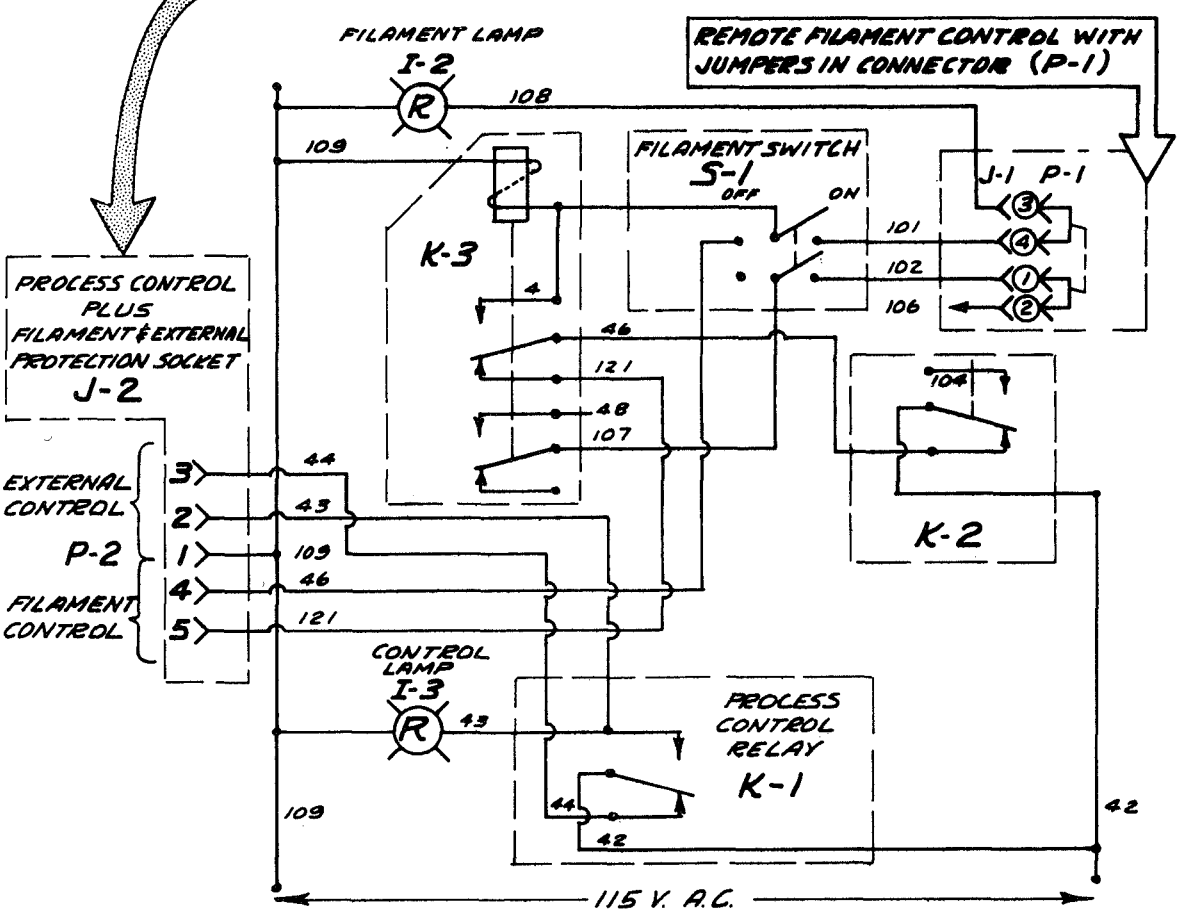
(2) WIRE & 10K. POTENTIOMETER SUPPLIED BY CUSTOMER.

## CONNECTION FOR 1 MA. RECORDER

CONVERSION BY CUSTOMER

FIG. 9

| Filament Switch (S-1) | Filament & External Protection Circuits (K-2) | | Process Control Circuit (K-1) | |
|---|---|---|---|---|
| Position | Ion Tube Filament | 115V AC @ 1.5A At Pin Nos.(J-2) | Control Light | 115V AC @ 0.25A At Pin Nos.(J-2) |
| OFF | OFF | 1 and 4 | OFF | 1 and 3 |
| ON | ON | 1 and 4 | OFF | 1 and 3 |
| ON | ON | 1 and 4 | ON | 1 and 2 |
| ON | OFF | 1 and 5 | OFF | 1 and 3 |




NOTE: Relays K-1 and K-2 will momentarily energize during gauge warmup; however, the ion tube will not go on regardless of the position of the filament switch.

## SIMPLIFIED SCHEMATIC OF PROCESS CONTROL CIRCUIT PLUS FILAMENT & EXTERNAL PROTECTION CIRCUIT

FIG. 10

3.5.3 Filament Protection Circuit

The purpose of the filament protection circuit is to shut off the filament if the pressure increases to approximately 200% of full scale; this is the factory setting. The filament protection circuit can be re-adjusted to operate in the range of 150 to 200% of full scale pressure reading by adjusting the FILAMENT PROTECTION control (R-28) on the calibrated sub panel. See Figure 6.

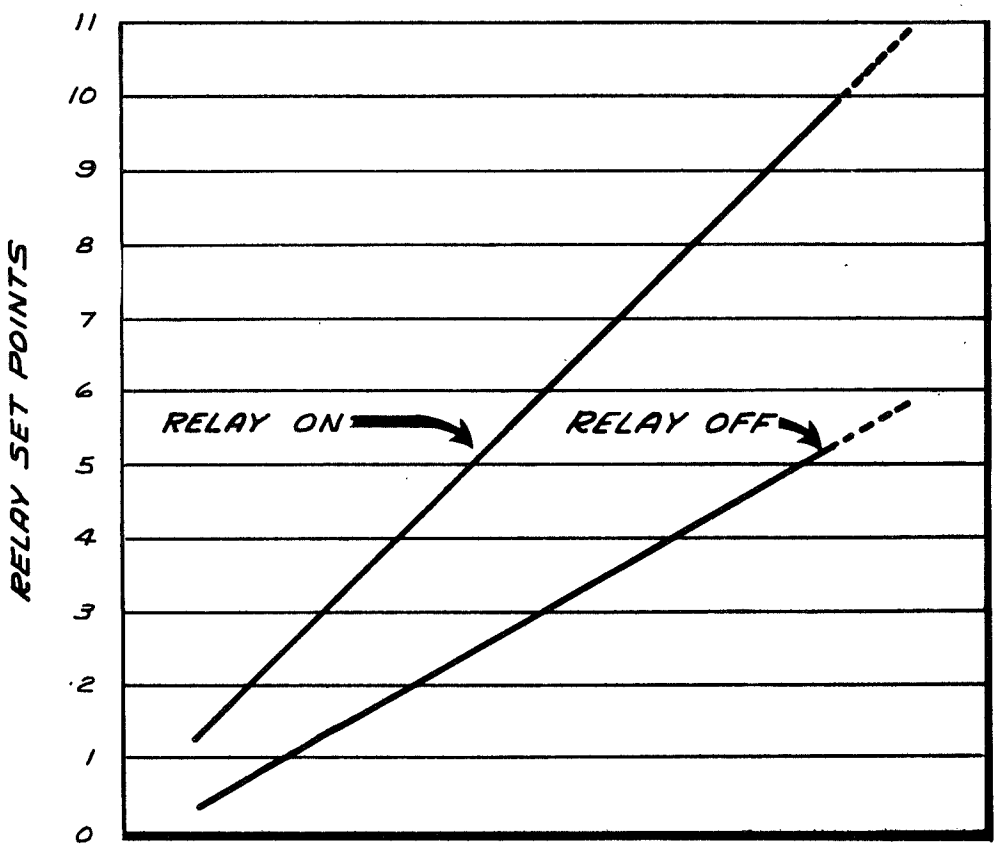
To provide this feature, two relays are used: (1) a pressure sensitive relay (K-2) located on the amplifier printed wiring board and (2) an interlocking relay (K-3) located on the amplifier chassis. When the pressure increases beyond the trip point setting, the pressure sensitive relay (K-2) is energized; this causes the interlocking relay (K-3) to become de-energized; and thereby interrupts the power to the ion tube filament.

In order to re-apply power to the ion tube filament, it is necessary to momentarily place the FILAMENT switch in the OFF position to reset the interlocking relay. This procedure is necessary regardless of the reason for the interlocking relay becoming de-energized, namely, operation of pressure sensitive relay (K-2), gauge turned off, power failure, etc. Turning the FILAMENT PROTECTION control (R-28) clockwise increase the sensitivity of the filament protection circuit.

3.5.4 Process Control

The PROCESS CONTROL operates in any range of the ionization gauge. Within its operating range, this circuit is entirely independent of the filament protection circuit. The process control point can be set anywhere from approximately 15% to approximately 100% of full scale. The relay differential varies from approximately 10% of full scale at the low setting to 50% of full scale at the high setting. See Figure 11.

To adjust the PROCESS CONTROL to operate with increasing pressure, set the system pressure to the desired operating point and adjust the PROCESS CONTROL (R-27) located on the calibration sub-panel (See Figure 6 ) until the pilot light




**APPROXIMATE PROCESS CONTROL**
**RELAY DIFFERENTIAL**
FOR GIC-200 GAUGE
FIG.- 11

marked CONTROL goes on. Turning the control clockwise trips the relay at a lower pressure point. Next, reduce the system pressure until the control light goes off. The difference between the two pressure readings is the differential. A graph showing the approximate differential for all control settings is shown in Figure 11.

The control light will operate independent of the position of the METER selector switch. Alternating current of 115 volts at .25 amperes is provided by the gauge at the process control plug for the control function.

3.5.5 Remote Filament Control

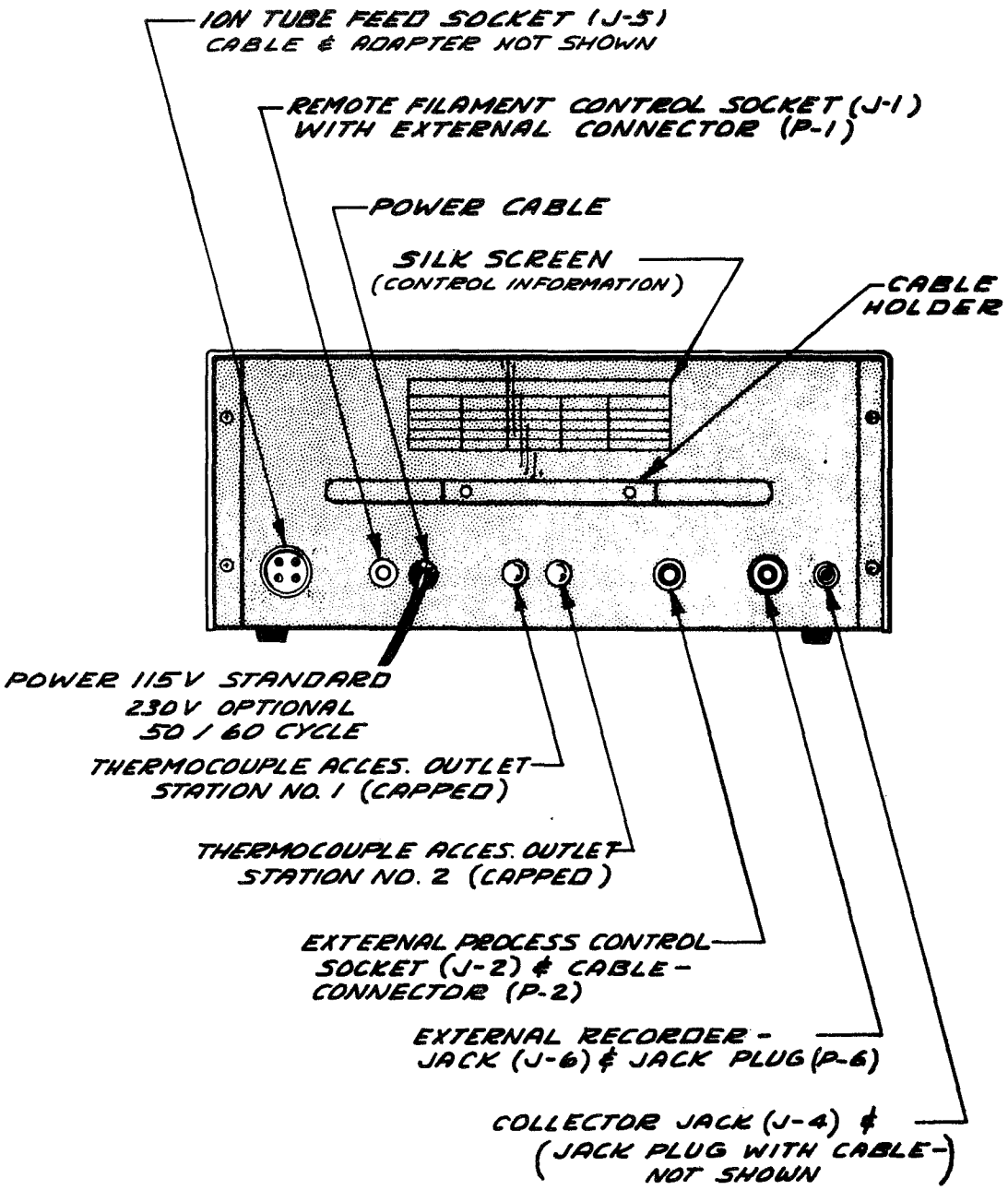
Located on the back panel of the gauge is a four-contact receptacle labeled REMOTE FILAMENT CONTROL, See Figure 12 . Its purpose is to allow the filament to be turned ON and OFF by some external means which the customer provides such as a vacuum switch, thermocouple, Pirani gauge, etc. This external switch is wired in series with the ion tube filament circuit, and operates independent of the filament protection circuit. The switch can be independently operated, repeatedly, if this switching takes place at the pressure level below the filament protection trip point.

For normal gauge operation without external filament control, a jumper plug is installed in the REMOTE FILAMENT CONTROL receptacle on the back panel. The filament can be energized only if the jumper plug is in place.

3.5.6 Thermocouple Accessory

The GIC-200 gauge can accept either a single station (GIC-007) or a two station (GIC-002) thermocouple accessory in the range of zero to 2 mm Hg pressure. Pressure is indicated by the red scale marked T.C. MICRONS. Note that this scale reads from right to left.

Station 1 is read with METER selector switch on TC-1; Station2 is read with the METER selector switch on TC-2. The thermocouple accessories are factory installed and calibrated if ordered with the GIC-200 ionization gauge control circuit. Should future recalibration become necessary, See Section 4.1.2.




## REAR VIEW OF GAUGE

TYPE GIC - 200

FIG. 12

When a two station thermocouple accessory is used, both tubes are operated from a common power supply. Operation of the two tubes is slightly inter-related with variation in pressure of one tube causing a small shift in reading of the other.

# 4.0 MAINTENANCE

## 4.1 Readjustment and Recalibrations

### 4.1.1 Emission Circuit

EMISSION-RANGE selector switch changes the emission current by a factor of 10 for each of the three positions. In the event readjustment is required, proceed as follows:

1. Connect a 1/2 per cent 10 ma. meter in series with the ion tube and the grid lead. ( A modified grid-filament cable should be used for this purpose). Connect only 1 grid lead (Wire #64).

2. Meter selector switch to "Emission" position and EMISSION-RANGE selector to 20 ma. position.

3. Connect grid lead to gauge and collector lead to the tube.

4. With the line voltage set at 115 volts and the gain control (R-59) full CCW, set the Emission control (R-45) to full CW.

5. With (R-45) full CW, turn the gain control (R-59) clockwise until the gauge meter reads just beyond 20 ma. (20.5).

6. Set the emission current to 7 ma. on the gauge meter with the Emission Control (R-45). Compare readings of the test meter with the gauge meter at the 7 ma. point. The gauge meter should read within $\pm$ 2% F.S. of the test meter.

7. Vary the line voltage from 115 to 105 volts and note emission change. Next change voltage to 130 volts and note emission change. Total emission deviation is to be $\pm$ 2% of full scale or less.

NOTE: If deviation is more than ± 2% readjust the gain control for a slightly lower emission (6.9 ma). Reset the emission to 7.0 ma. with the Emission Control and repeat the above line voltage stability test.

Repeat the above steps until good line voltage stability is obtained.

4.1.2 Recalibration of Thermocouple Accessories GIC-002 & GIC-007.

1. Calibrate the thermocuple tube(s) against a standard such as a McLeod gauge, or against another reference gauge. When the two tube accessory is calibrated, both tubes must be pumped down and calibrated simultaneously.

2. When comparing the thermocouple gauge to a McLeod gauge, both gauges should be preceded by a cold trap so that both gauges are reading only non-condensable gases in the system. This procedure is necessary for an accurate calibration.

NOTE: Accessories purchased not installed must be calibrated after installation into the gauge circuit. Replacement thermocouple tubes for the accessory must be calibrated also.

3. Pump the system down until the reference gauge pressure is less than $1 \times 10^{-5}$ mm Hg. With the pressure stabilized at this point, set the zero of the thermocouple accessory. This zero set is done by placing the METER selector switch at the TC-1 position and adjusting the TC-1 potentiometer on the calibrating sub-panel until the meter reads zero on the TC MICRONS scale. Rotate the METER selector switch to the TC-2 position and follow the same procedure for the number two station.

4. Raise the system pressure to atmosphere. The meter should now read at least 2 mm Hg on the TC MICRON scale for both the TC-1 and TC-2 positions. Recheck zero if necessary.

4.1.3 Filament, External Protection, and Process Control Circuits - See Section 3.5.2.

4.2 Cleaning Procedure for the Ion Tube

1. Use a hydrocarbon solvent such as trichlorethylene.

2. Gently fill the tube with the cleaning solvent. CAUTION: DO NOT FORCE FLUIDS INTO THE ION TUBE.

3. Tip the tube gently back and forth several times keeping the cleaning solvent in the tube.

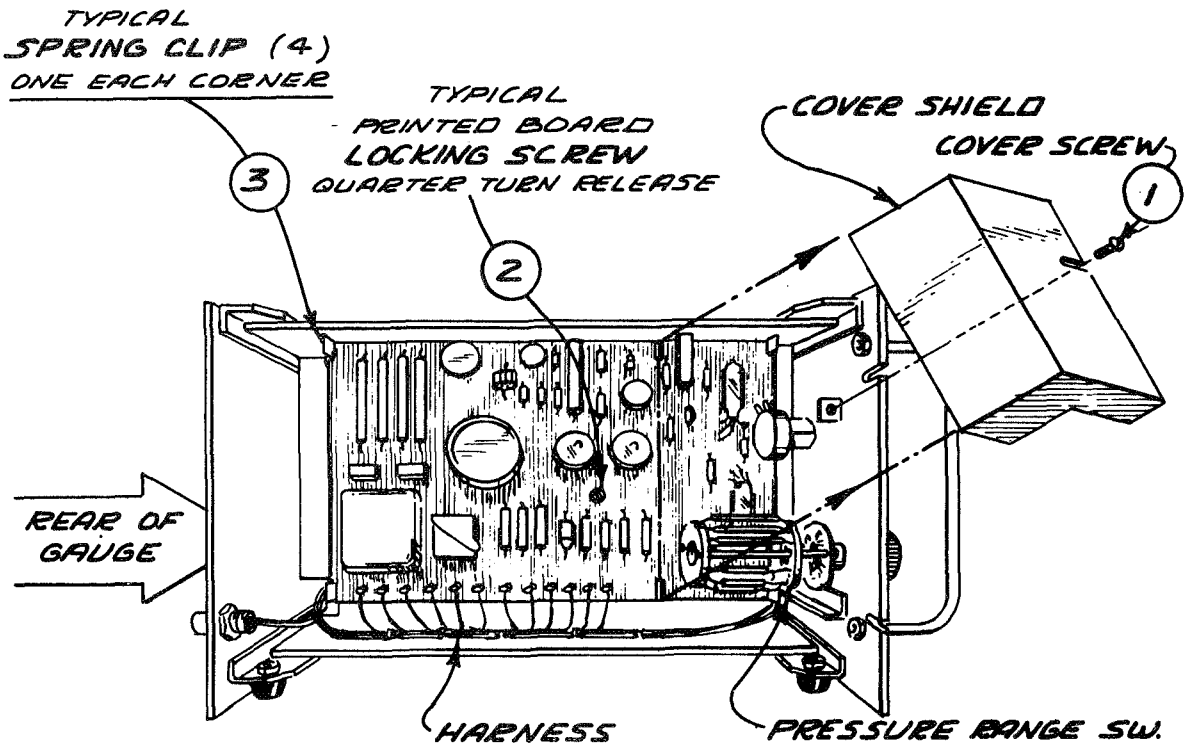
4. Empty the tube of cleaning solvent.

5. Refill the tube with ALCONOX, LAKESEAL, or other detergent, allowing to soak if necessary.

6. Empty the tube of detergent and rinse several times with distilled water.

7. Dry the tube.

8. Re-install the tube in the vacuum system and degas the tube for thirty minutes after the pressure has been reduced to less than one micron.




GAUGE WITH COVER REMOVED

NOTE:

(1) REMOVE COVER SCREW & SHIELD FROM SPRING CLIPS.

(2) TURN BOARD LOCKING SCREW $\frac{1}{4}$ TURN COUNTERCLOCKWISE.

(3) SPREAD SPRING CLIPS AWAY FROM BOARD & PULL BOARD, REAR FIRST, DIAGONALLY AWAY FROM GAUGE.
AVOID CONTACT WITH PRESSURE RANGE SWITCH.

## AMPLIFIER BOARD REMOVAL
## GIC-200 GAUGE
## FIG. 13

# 5.0 TROUBLE SHOOTING

## 5.1 Ion Current Amplifier

The ion current amplifier will provide long and reliable operation. Normally, it will not require servicing. However, if a failure does occur, the servicing should be done only by personnel familiar with electrometer circuits. If this is not possible, the GIC-200 gauge should be sent back to CVC for reconditioning.

Extreme care should be taken to prevent fingerprints, pencil marks, or other conducting material from being placed on the first stage of the ion current amplifier which includes the electrometer tubes, standoff insulators, Hi-meg glass resistors, the insulator on the PRESSURE RANGE switch assembly, and the inner insulation on the coaxial cables. Any leakage path introduced in this printed wiring board may cause lower output and noise in the output signal. For these reasons, the amplifier cover should never be removed except for repairs or for trouble shooting. See Figure 13.

If the amplifier reads upscale and cannot be zeroed and the emission is off, the cause may be leakage in the collector circuit. By disconnecting the collector lead from the gauge, the problem is isolated, either to the gauge or to some external condition. If the reading returns to zero with the collector lead removed, the cause may be low leakage resistance in the collector lead or the ion tube. Both problems can usually be remedied by cleaning.

A low noise co-axial cable is used for the collector lead. This material has a graphite coating over the center insulation. If the cable is shortened or replaced, the stripped ends must be washed with alcohol to prevent surface leakage from the shield to the center conductor.

## 5.2 Amplifier Calibration

5.2.1 If an electrometer tube is replaced, readjust the amplifier as follows:

1. Rotate front panel zero control full clockwise.

2. Turn gauge on and allow it to warm up for a few minutes.

3. With the meter selector on PRESSURE, rotate the screen voltage control (R-18) for lowest meter reading.

4. Zero the amplifier with front panel zero control. The amplifier is now in calibration within a few percent.

5.2.2 If a more accurate calibration is required, the amplifier can be checked with an electrometer current source (See Section 3.3.3) as follows:

1. With the gauge range switch on the $10^{-4}$ position, set current source range switch to $10 \times 10^{-5}$ position. Turn current source to "ON" and set the amplifier calibration control (R-32) for full scale meter deflection.

2. Turn current source to "OFF" and check zero.

   a. If an adjustment is required, use the fine zero on the front panel.

   b. If zero re-adjustment has been made, turn current source to "ON" and reset to full scale with amplifier calibrate control (R-32).

   c. Repeat steps 1 and 2 if necessary.

3. With the current source turned "OFF", rotate the gauge switch and the current source range switch stopping at each position to check the zero. The zero should not vary more than 1/2% of full scale from zero to any range. Allow sufficient time for reading to stabilize in the $10^{-10}$ and $10^{-11}$ ranges.

4. With the current source "ON" and set at $10 \times 10^{-5}$ and the gauge range switch set at $10^{-4}$, the gauge should read full scale.

   All other ranges are checked by first switching the current source to the next lower range. The gauge meter should now read $\pm$ 2% F.S. Next, switch the gauge to the next lower range. The meter should now read full scale $\pm$ 3% F.S. (All the ranges are to have $\pm$3% F.S. tolerance except the $10^{-11}$ range which is $\pm$ 4% F.S.).

## ION CURRENT AMPLIFIER VOLTAGE CHART (See Figure 8)

All voltages measured to ground with a high impedance vacuum tube voltmeter except as noted in the remarks. Range switch to $10^{-4}$ position Collector lead removed.

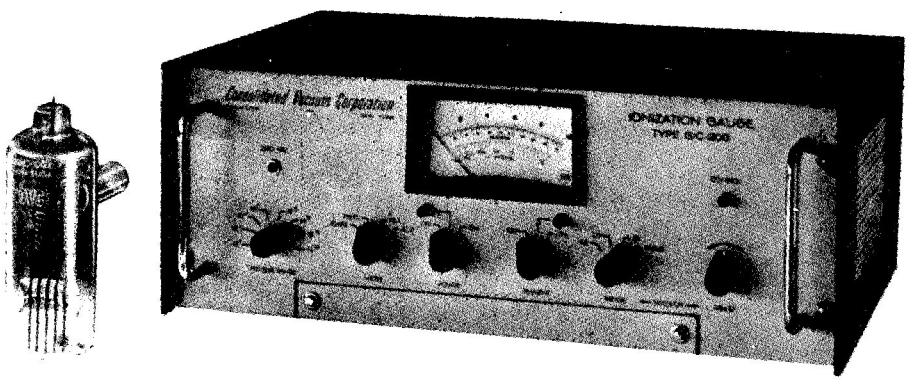
| TUBE | TUBE TYPE | PIN # | NOMINAL VOLTS | REMARKS |
|---|---|---|---|---|
| V-1 | 5886 | +F | +2.7 | |
| | | -F | +1.8 | |
| | | G1 | ---- | |
| | | G2 | +5.8 | |
| | | P | +5 to 20 | |
| V-2 | 5886 | +F | +2.7 | |
| | | -F | +1.8 | |
| | | G1 | 0 | |
| | | G2 | +5.8 | |
| | | P | +5 to 20 | |
| V-3 | 12AX7 | 1 | +86 | Variable |
| | | 2 | +4.7 | " |
| | | 3 | +5.8 | " |
| | | 4 & 5 | -6.2v | To pin 9 |
| | | 6 | +83 | " |
| | | 7 | +3.0 | " |
| | | 8 | +5.8 | " |
| | | 9 | +6.2 | To pins 4 & 5 |
| V-4 | 12AT7 | 1 | +110 | |
| | | 2 | -1.5 | |
| | | 3 | 0 | |
| | | 4 & 5 | -6.2 | To pin 9 |
| | | 6 | +175 | |
| | | 7 | -1.5 | |
| | | 8 | 0 | |
| | | 9 | +6.2 | To pins 4 & 5 |

## EMISSION VOLTAGE CHART (See Figure 7)

All voltages measured to ground with a high impedance vacuum tube voltmeter except as noted in the remarks. Emission current set at 7 ma.

| TUBE NO. | TUBE TYPE | PIN # | NOMINAL VOLTS | REMARKS |
|---|---|---|---|---|
| V-5 | 12AT7 | 1 | +144 | |
| | | 2 | +66 | |
| | | 3 | +67 | |
| | | 4 & 5 | 6.3 v. AC | To Pin 9 |
| | | 6 | +144 | |
| | | 7 | +66 | |
| | | 8 | +67 | |
| | | 9 | 6.3 v. AC | To pins 4 & 5 |
| V-6 | 12AT7 | 1 | +240 | |
| | | 2 | +67 | |
| | | 3 | +76 | |
| | | 4 & 5 | 6.3 v. AC | To pin 9 |
| | | 6 | +240 | |
| | | 7 | +67 | |
| | | 8 | +76 | |
| | | 9 | 6.3 v. AC | To pins 4 & 5 |
| V-7 | OB2 | 1 | +155 | |
| | | 2 | +49 | |
| | | 3 | no connection | |
| | | 4 | +49 | |
| | | 5 | +155 | |
| | | 6 | no connection | |
| | | 7 | +49 | |
| V-8 | OB2 | 1 | +265 | |
| | | 2 | + 58 | |
| | | 3 | no connection | |
| | | 4 | +58 | |
| | | 5 | +265 | |
| | | 6 | no connection | |
| | | 7 | +58 | |

CVC Instruction Manual
No. 9-81-N
Revision No. 3 Lot 3




# IONIZATION GAUGE
# TYPE, GIC-200

EMISSION VOLTAGE CHART (Cont'd.)

| TUBE NO. | TUBE TYPE | PIN # | NOMINAL VOLTS | REMARKS |
|---|---|---|---|---|
| V-9 | OB2 | 1 | +155 | |
| | | 2 | +49 | |
| | | 3 | no connection | |
| | | 4 | +49 | |
| | | 5 | +155 | |
| | | 6 | no connection | |
| | | 7 | +49 | |
| V-10 | OB2 | 1 | +49 | |
| | | 2 | -58 | |
| | | 3 | no connection | |
| | | 4 | -58 | |
| | | 5 | +49 | |
| | | 6 | no connection | |
| | | 7 | -58 | |
| V-11 | OB2 | 1 | -58 | |
| | | 2 | -170 | |
| | | 3 | no connection | |
| | | 4 | -170 | |
| | | 5 | -58 | |
| | | 6 | no connection | |
| | | 7 | -170 | |

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Rochester, New York 14603
9-81-N/R5-66/EHF/tb

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## 6.0 REPLACEMENT PARTS LIST FOR THE IONIZATION GAUGE, TYPE GIC-200

MINIMUM ORDER BILLING OF $10.00 PER ORDER. PLEASE INCLUDE PART NUMBER AND DESCRIPTION OF EACH PART ORDERED.

NOTE: Refer to the Electrical Schematic attached to this manual for description and numbers of gauge circuit electrical components.

### ACCESSORIES AND REFERENCE GAUGES

| Description | Electrical Schematic No. | Part No. |
|---|---|---|
| Connector, 1/2" CGB (Metal Systems) | Mounting for GIC | 61079 |
| Connector, 3/4" CGB (Metal Systems) | Ionization Series | 52237 |
| Connector, 1" CGB (Metal Systems) | Tubes for Quick Disconnect | 265638 |
| Connector, 1/4" to 1/2" (Quick Disconnect-Metal Systems) | Mounting of GTC-004 Thermocouple Tube | 61083 with 61081-2 bushing |
| Seal, glass-to-metal 1/2" | | 72635 |
| Thermocouple Acc., Single Station Plug-In, includes GTC-004 tubes & cables (not installed) GIC-007 | | 67429-1 |
| Thermocouple Acc., Two-Station Plug-In, includes GTC-004 tubes and cables (not installed) GIC-002 | | 67429-2 |
| Tube, Thermocouple, GTC-004 | | 64797 |
| Tube, Ionization 1/2" Pyrex tubulation, GIC-015 | | 260857 |
| Tube, 3/4" Ionization, Pyrex tubulation, GIC-016 | | 260858 |
| Tube, 1" Ionization, Pyrex tubulation, GIC-017 | | 260859 |
| Tubulation, #7052 Hard Glass, GIC-015-2 | | 260857-2 |
| Tubulation, Kovar, GIC-015-3 | | 260857-3 |
| Tubulation, Hard Glass #7052, GIC-016-2 | | 260858-2 |
| Tubulation, Kovar, GIC-016-3 | | 260858-3 |
| Tubulation, #7052 Hard Glass, GIC-017-2 | | 260859-2 |
| Tubulation, Kovar, GIC-017-3 | | 260859-3 |
| Grid Filament Cable (std.), 10' 6" length | | 268785-1 |
| 15' | | 268785-2 |
| 25' | | 268786-3 |
| 50' | | 268786-4 |
| 100' | | 268786-5 |

| Description | Part No. |
|---|---|
| Collector Cable (std), 10' 6" length | 265570-1 |
| 15' | 265570-2 |
| 25' | 265570-3 |
| 50' | 265570-4 |
| 100' | 265570-5 |
| McLeod Gauge (triple scale) GM-100A | 67857 |
| McLeod Gauge (extended range) GM-110 | 64581 |

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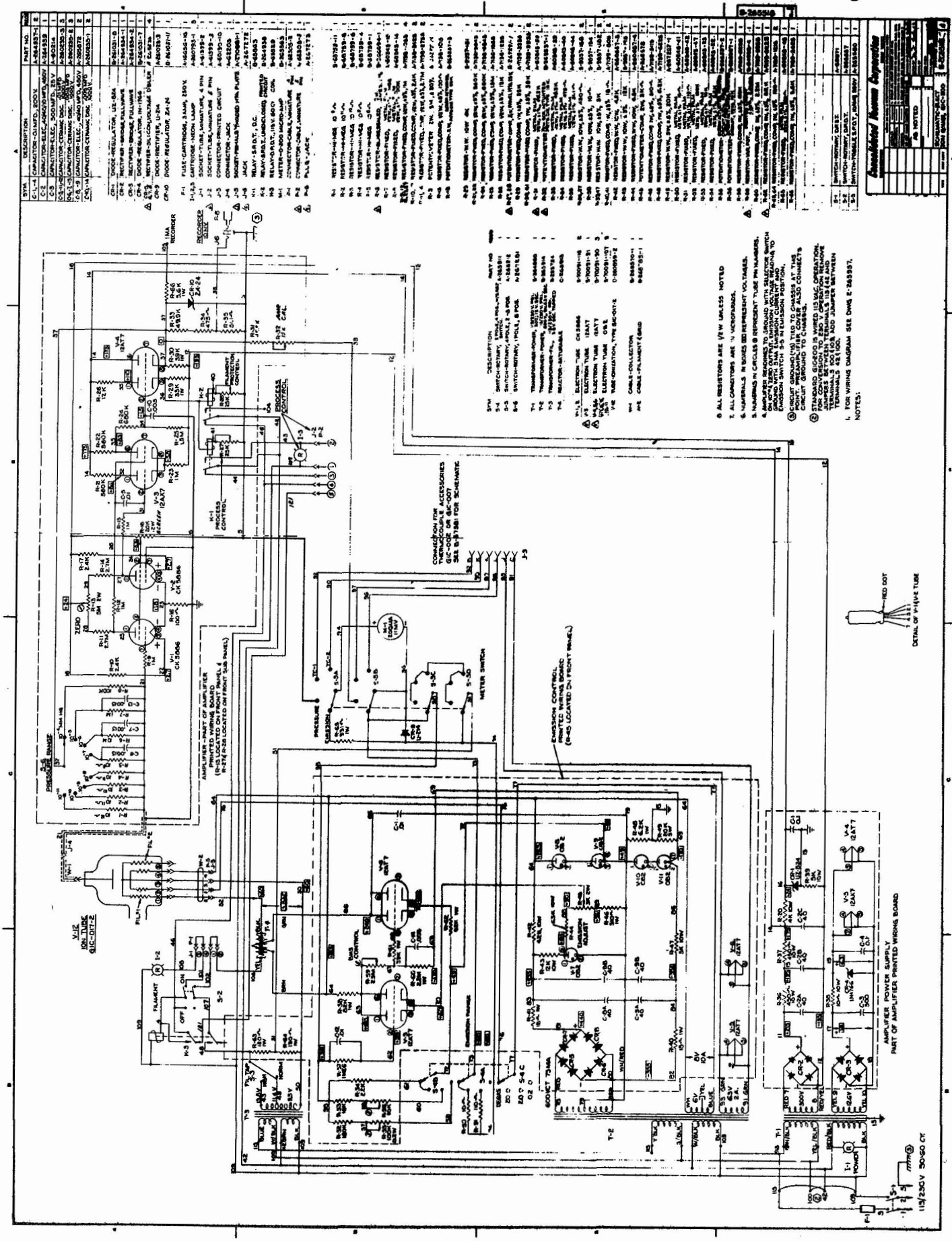

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