THE WELCH SCIENTIFIC COMPANY

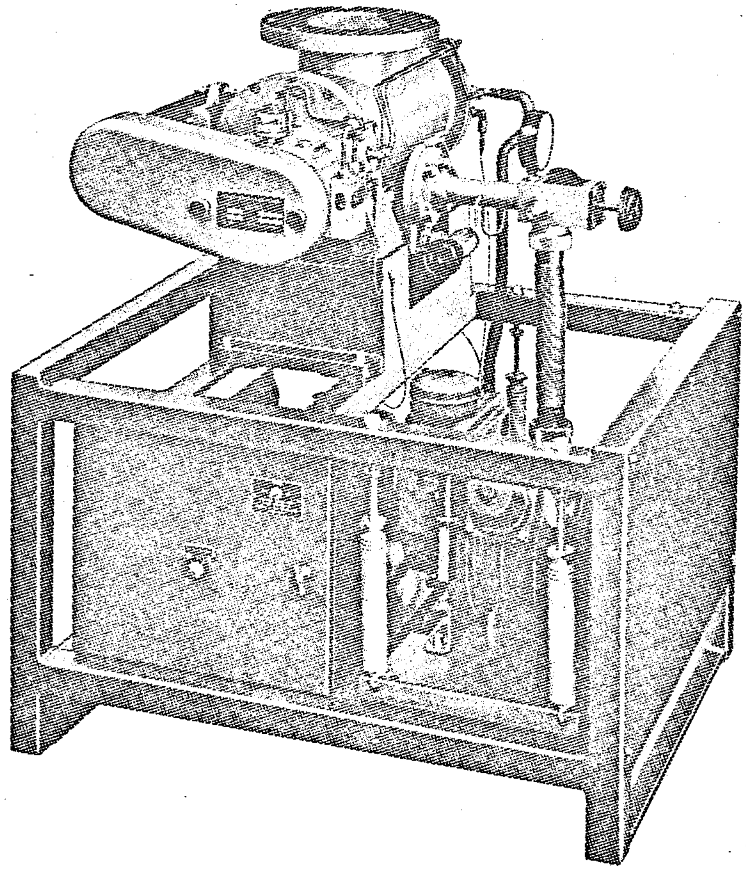
TURBO MOLECULAR PUMP

MODELS 3102A, 3102B, & 3102C

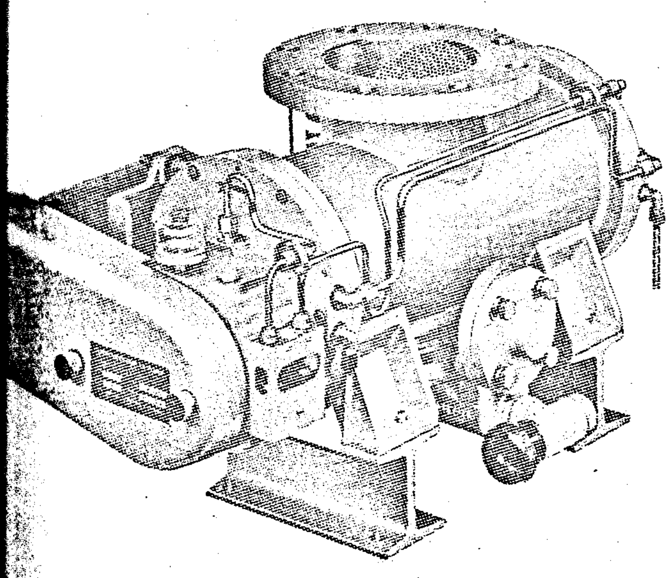
OPERATOR'S MANUAL

Vault

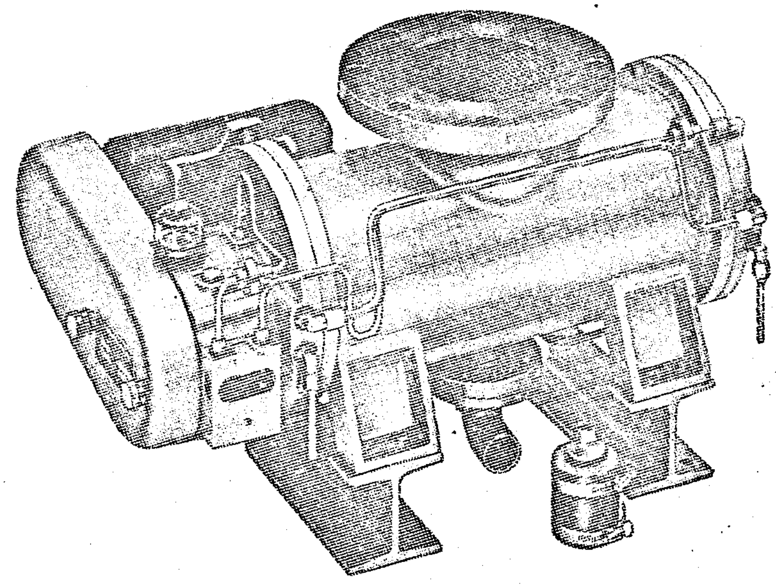
ISSUED APRIL 23, 1965



MODEL 3102A



MODEL 3102B



MODEL 3102C

TABLE OF CONTENTS

General Information

Operating Instructions

CONTENTS (continued)

LIST OF ILLUSTRATIONS

GENERAL INFORMATION

HISTORY

The Turbo-Molecular Pump, although relatively new as a useful tool for research and production, has a history of several decades. The first design of a mechanical device capable of pumping in the high vacuum range is generally attributed to Gaede, because of his "molecular drag" pump of 1913. This pump "dragged" molecules from the inlet to the outlet of the pump by imparting a velocity to the molecules, due to frictional contact with a rapidly spinning cylindrical rotor.

By constructing ridges on the cylindrical rotor of a molecular drag pump which spiralled from the center toward each end, Holweck increased the drag path. A disc with radial spirals was developed by Siegbahn. The pumps of Gaede, Holweck and Siegbahn were of necessity built with clearances which were so close as to cause damage if exposed to sudden pressure bursts.

A major design improvement was made in 1958 by Becker of Arthur Pfeiffer in Wetzlar, Germany. This design incorporates a series of inclined rotor and stator discs, or rings of blades, similar to a turbo-compressor. Due to the high rotational speed of these blades, molecules are given a directional velocity upon impact with the inclined surfaces of the blades. This is the design used in the Welch Scientific Company's current Turbo-Molecular Pumps. It allows the use of clearances ten times as large as previously possible. The standard

Pfeiffer pump and the first Welch pump were very similar in design, and both had a pumping speed of 140 liters/second. Improvements in the blade design by Welch increased the pumping speed to 260 l/sec in the present models, without sacrificing the pump's immunity to sudden gas bursts.

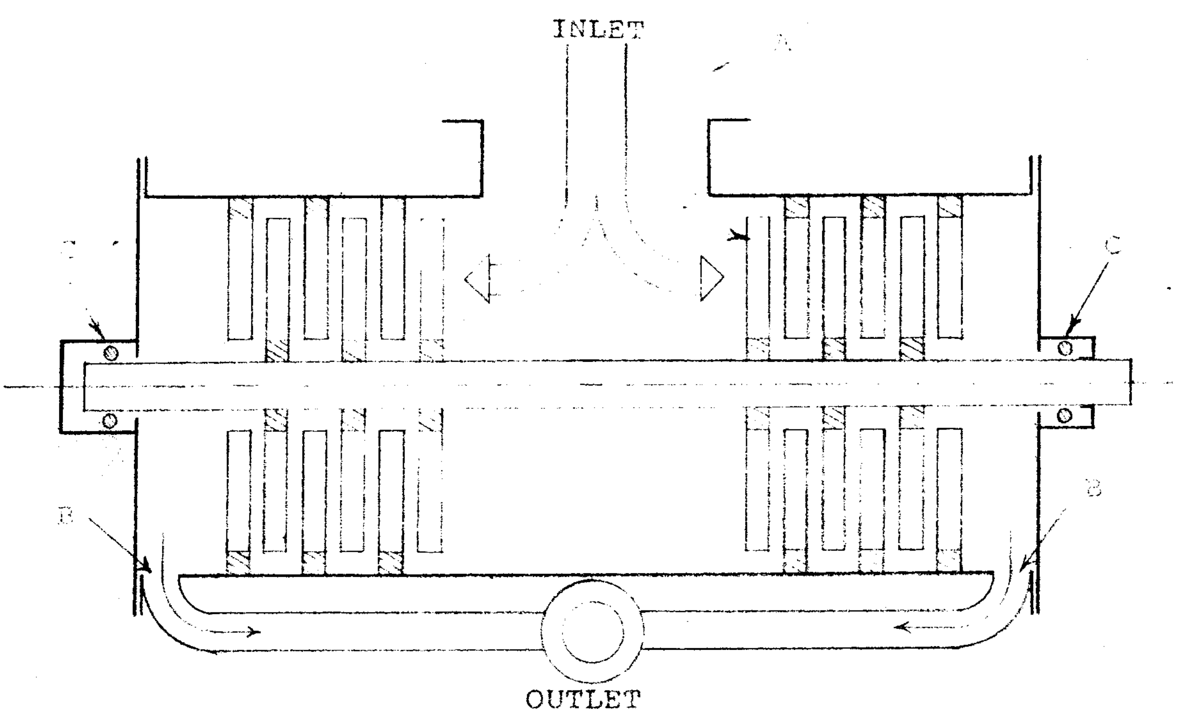


Fig. 1. Schematic Cross-Section of Turbo-Molecular Pump

PRINCIPLES OF OPERATION

Refer to Figure 1 for illustration. The turbo-molecular pump and its attached vacuum system, if any, are rough pumped to the low torr range by a forepump which must be connected to the OUTLET. The turbo-molecular pump is then started and within a few minutes the rotor, with attached blades, (see A) is rotating at 16,000 RPM. Molecules of air, water vapor, or other gases enter the pump at the INLET, which is the high vacuum side of the pump. These molecules collide with all the interior surfaces of the INLET portion of the pump, and some of them are accelerated axially toward the ends of the pump when the first disc of rotor blades strikes them. The molecules are then guided in a favorable direction by impinging upon the first disc of stationary stator blades, which are oriented in such a fashion as to increase the probability of molecules being struck by the second disc of rotor blades. This process is repeated through nineteen stages on each end of the pump, resulting in what is commonly referred to as a compression pressure ratio. This action depends on the relative motion of blades and molecules. The faster the blades move in comparison to the speed of the free molecules, the greater the compression ratio of the pump becomes. Thus heavy molecules, such as oil vapor, have compression ratios several orders of magnitude higher than gases such as nitrogen or hydrogen.

The compression of gases toward the ends of the pump result in a forepressure which extends into the foreline at B and is pumped by the forepump connected to the OUTLET. The refrigerant- or water-cooled, high speed ball bearings which support the rotor are located at each end of the pump, at C. The oil used to lubricate the bearings is thus in the forepressure. This oil is more volatile than normal vacuum pump oil, and any spattering which might accidentally cause oil to reach the blades cannot migrate any significant distance toward the high vacuum area at the center of the pump before it is vaporized and pumped back to the foreline.

Since the turbo-molecular pump operates on a definite compression ratio principle, the forepump (frequently referred to as a backing pump) becomes important. The blank-off pressure rating of the turbo-molecular pump is based on a forepressure of 1×10^{-4} torr (McLeod), which is readily attained by Welch Duo-Seal two-stage vane type mechanical pumps.

GENERAL CHARACTERISTICS

Some of the important characteristics of the turbo-molecular pump are discussed in the following paragraphs to enable the operator to use the pump to its best advantage.

The Turbo-Molecular Pump:

is free of hydrocarbon contamination during operation. There is no backstreaming of oil vapors, and therefore no need for liquid nitrogen traps. Hydrcarbons may be pumped through the pump indefinitely without damage.

can pump noble gases as easily as the common gases. Leak detection poses no problem regardless of the tracer gas used.

does not store or re-eject previously pumped gases. Any gas pumped by the pump is completely removed by the forepump.

can pump indefinitely at any pressure without damage. Even under the extremely unusual condition of operating at atmospheric pressure the worst that could happen is that the drive motor would become overheated and a thermal overload would trip.

has immediate recovery. If the pump should be subjected to pressure in the upper limit of molecular flow for hours or days, as when a gas is bled through a system, the pump will recover immediately upon closure of the bleed. Of course, water vapor or corrosive gases will require bake-out to remove completely, as in any vacuum system.

has a reliable pumping action. As long as the rotor is spinning, the pump is pumping.

is insensitive to sudden air inrush. Accidental venting or implosion of system components does not cause pump damage unless debris is allowed to fall directly into the rotor blades. A screen is provided to prevent such occurance. A burst of gas cannot harm the pump, even sudden venting from ultimate blank-off to atmosphere.

has easily attained starting pressures. There is no delay from the time the forepump nears its ultimate until the time the turbo-molecular pump begins pumping efficiently. In fact, the effective pumping ranges of the two pumps overlap, and the sudden drop in pressure from the millitorr (micron) range is impressive.

need not be bypassed by roughing lines. It is so simple to cycle that roughing can be done directly thru the pump by the forepump.

does not decompose pumped gases. Whatever goes in, must come out.

APPLICATION

Description of Models:

3102A-

The 3102A is a complete pumping set. It includes the 3102 Turbo-Molecular Pump, a Welch 1397 Duo-Seal forepump, a closed refrigeration system, a pre-wired control panel, and a foreline manifold containing a foreline valve and a leak detection valve with coupling, all mounted on a sturdy framework.

3102B-

The 3102B Turbo-Molecular Pump is shipped on an "H" beam base and includes a foreline trap with a leak detection valve with coupling.

3102C-

The 3102C Turbo-Molecular Pump is the same basic pump as the 3102B, but the foreline terminates at a choice of two vacuum hose connections (both supplied).

A choice of three models is offered to accomodate all possible applications. The 3102A model is complete and ready to receive a vacuum chamber or to use in conjunction with other pumping systems. Turbo-Molecular pumps have, for example, been used with both ion pumps and sublimation pumps with excellent results. The inherent durability and cleanliness of the turbo-molecular pump qualify it as an ideal component in large systems where backstreaming is to be avoided. For example, a turbo-molecular pump which evacuates a chamber in conjunction with an ion pump can increase the useful life of the ion pump by a thousand-fold if it pumps the chamber to 10^3 torr lower than the pressure at which the ion pump is usually started. The 3102A is a very convenient pump-set upon which to build space simulation chambers, surface physics apparatus, mass spectrometry systems, and any application where cleanliness is of paramount importance.

The 3102B & C turbo-molecular pumps have essentially the same characteristics, but are not built into a complete self-sufficient set. These models are for use in applications where space is of primary concern, or where existing facilities eliminate the need for a refrigerator, forepump, control panel, etc. They are readily adapted to custom applications and are easily incorporated into complex apparatus.

Selection of Fore Pump:

In order to obtain maximum usefullness from a turbo-molecular pump, it is essential to use an adequate forepump. However, from the standpoint of economy, it is wasteful to over-design a system. The following information is included to serve as a guide in selecting a proper forepump for the 3102B or 3102C model.

The Turbo-Molecular Pump begins pumping efficiently

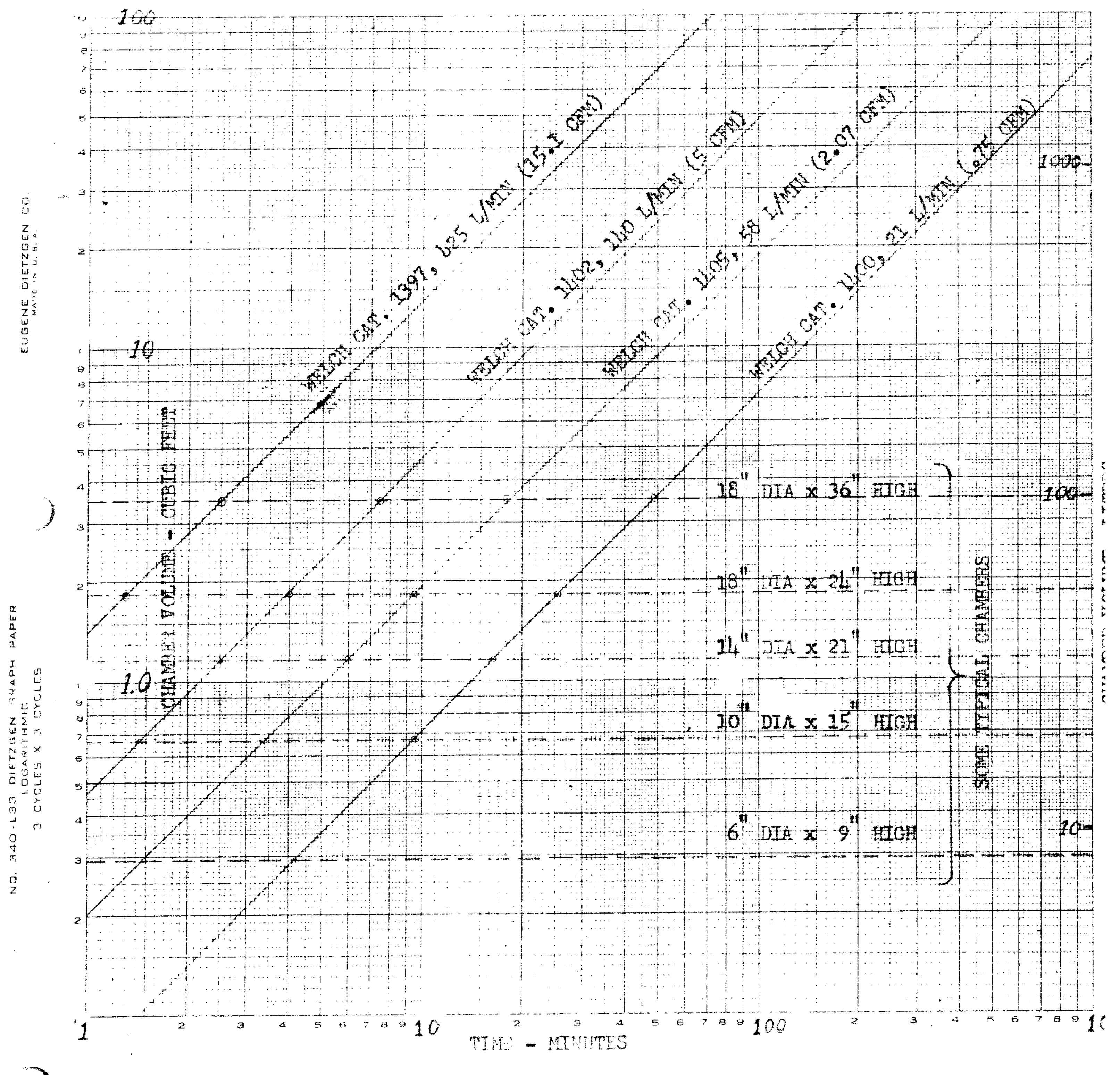


FIG. 2. EVACUATION TIME TO 200 MILLITORR

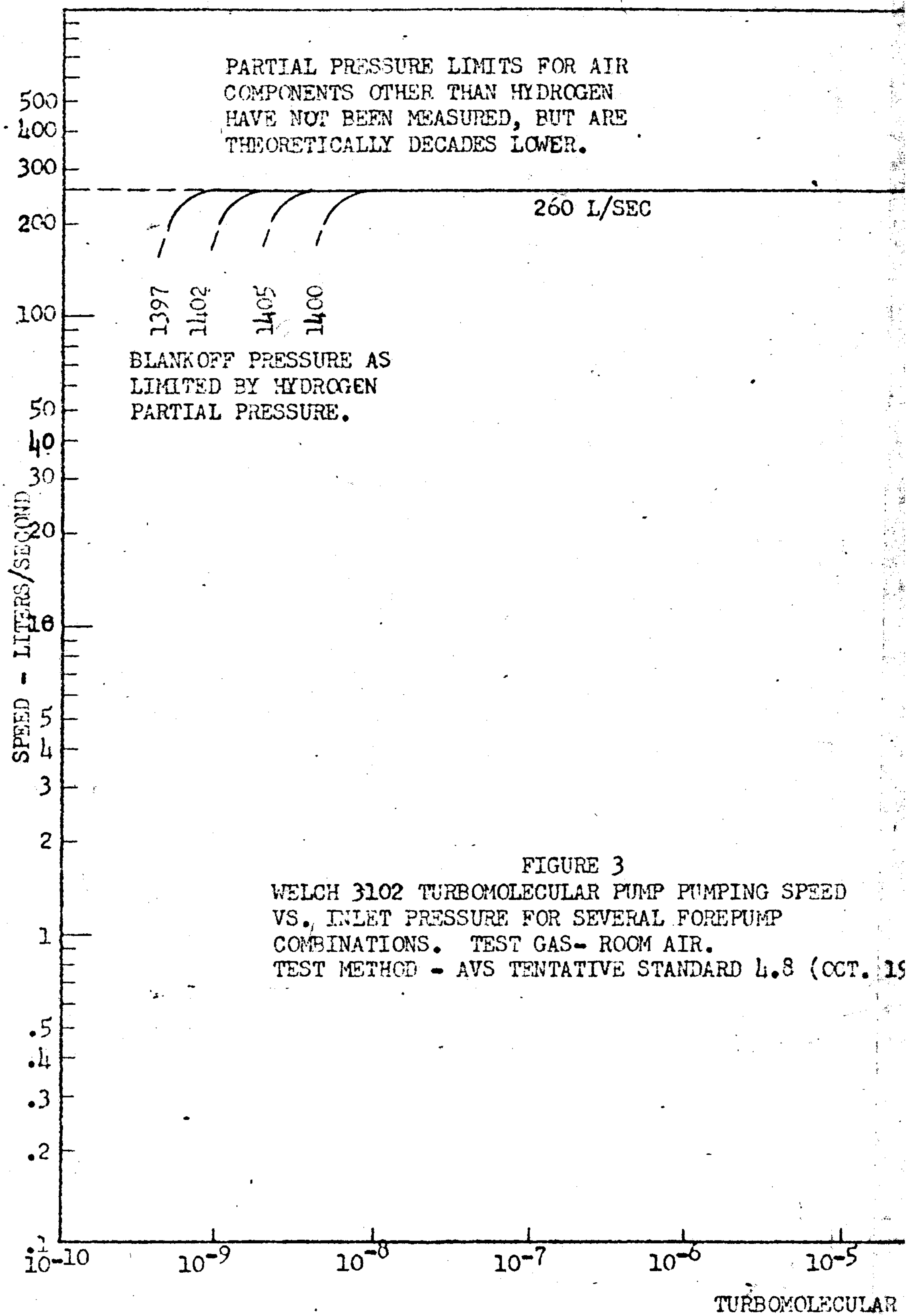
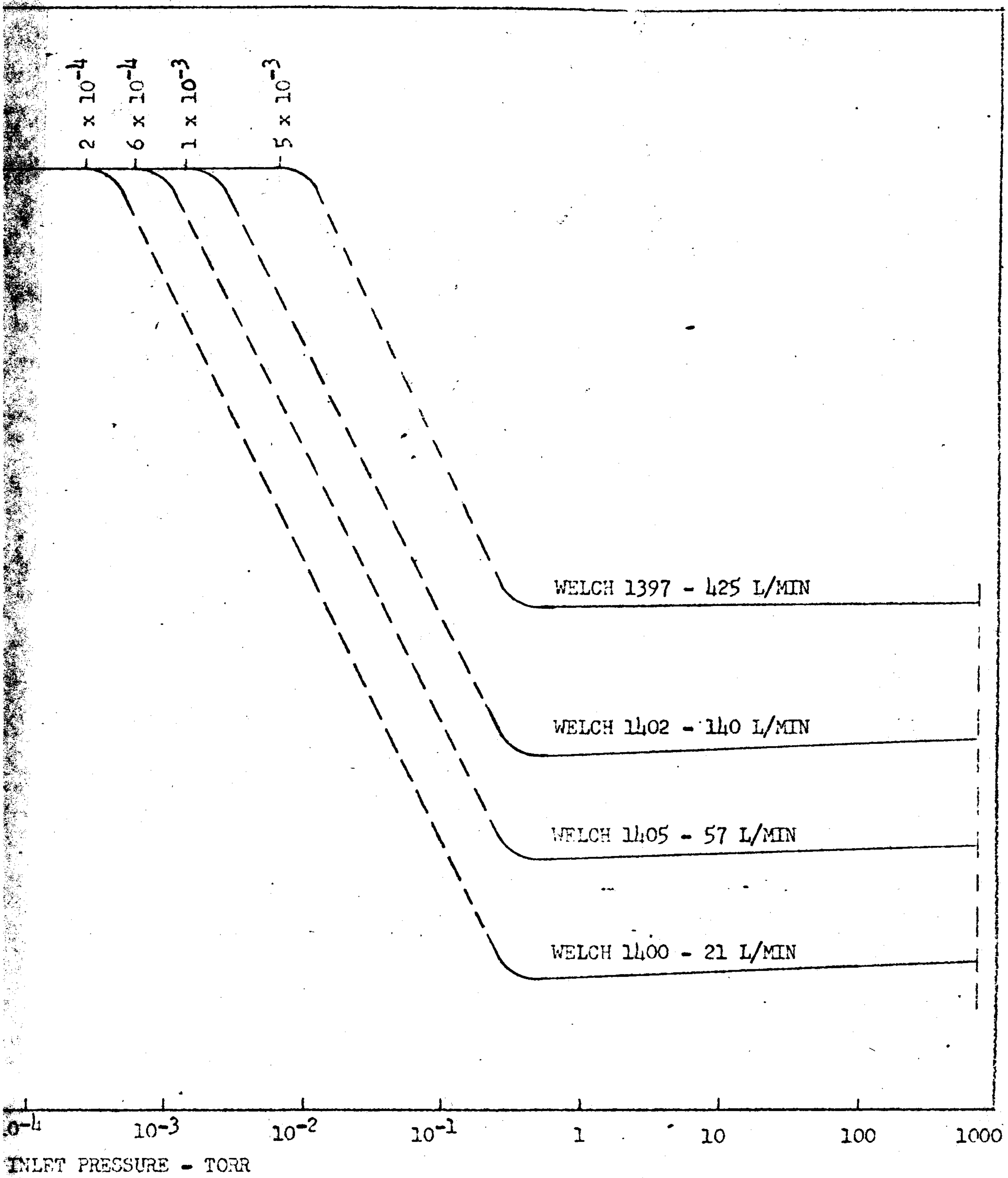


FIGURE 3
WELCH 3102 TURBOMOLECULAR PUMP PUMPING SPEED VS. INLET PRESSURE FOR SEVERAL FOREPUMP COMBINATIONS. TEST GAS- ROOM AIR.
TEST METHOD - AVS TENTATIVE STANDARD 4.8 (OCT. 19



2 x 10-4
6 x 10-4
1 x 10-3
5 x 10-3
WELCH 1397 - 425 L/MIN
WELCH 1402 - 140 L/MIN
WELCH 1405 - 57 L/MIN
WELCH 1400 - 21 L/MIN
10-4
10-3
10-2
10-1
1
10
100
1000
INLET PRESSURE - TORR

when the inlet pressure has reached the mid-millitorr (micron) region. The time required to reach this pressure is, of course, dependent on the forepump. Also, because of the finite compression ratio developed by the Turbo-Molecular Pump (see Principles of Operation), the ultimate vacuum reached is dependent on the ultimate fore vacuum. Fig. 2 shows the evacuation times required for several Welch Duo-Seal pumps to reach 200 millitorr, when pumping various chambers, which is the highest forepressure at which the Turbo-Molecular pump can operate at full pumping speed. It can be seen that whereas a Welch 1397 pump will evacuate an 18" x 36" bell jar to 200 millitorr in approximately 2.5 minutes, a Welch 1400 pump will require approximately 50 minutes. However, with a 6" x 9" bell jar the saving in time with different forepumps is not nearly as significant.

A different type of plot, showing pumping speed in liters per second versus inlet pressure in torr, is shown in Fig. 3 for a Turbo-Molecular Pump using various forepump combinations. For the region from 10^{-4} to 10^{-8} torr, the pumping speeds are quite similar. In the 10^{-9} torr region, the type of forepump used is seen to affect the ultimate vacuum. In the 10^{-3} torr region to atmosphere, the forepump is very important. It is in this region that much time is frequently wasted. It can readily be seen that the Welch 1397 gives the best performance over the entire operating range, but if the vacuum chamber is small and only minimal outgassing loads are anticipated, a small Welch 1400 could serve equally well as a forepump with only a small loss of time during roughing to 200 millitorr, and a slight decrease in ultimate vacuum.

Vacuum Techniques:

Because of the rapidly increasing frequency of the use of vacuum apparatus in research and manufacturing, personnel who are not intimately connected with vacuum procedures are often called upon to quickly become familiar with vacuum techniques. A brief, and by no means complete, list of some of the standard vacuum practices is included to aid those unfamiliar with this type of endeavor.

High vacuum systems are typified by pumping passages as short as possible and of the same diameter as the pump inlet, to avoid reducing the conductance of the pumping paths. These systems are usually constructed of stainless steel and connections are sealed with metal gaskets. A high vacuum system is usually capable of withstanding a bakeout of 400 or 450° C. Small internal crevices are strictly avoided, because they act as pockets for gases which are difficult to remove. It is generally advisable to use solvents for cleaning which do not contain corrosive chemicals such as chlorine. An accepted procedure is to clean with benzene and

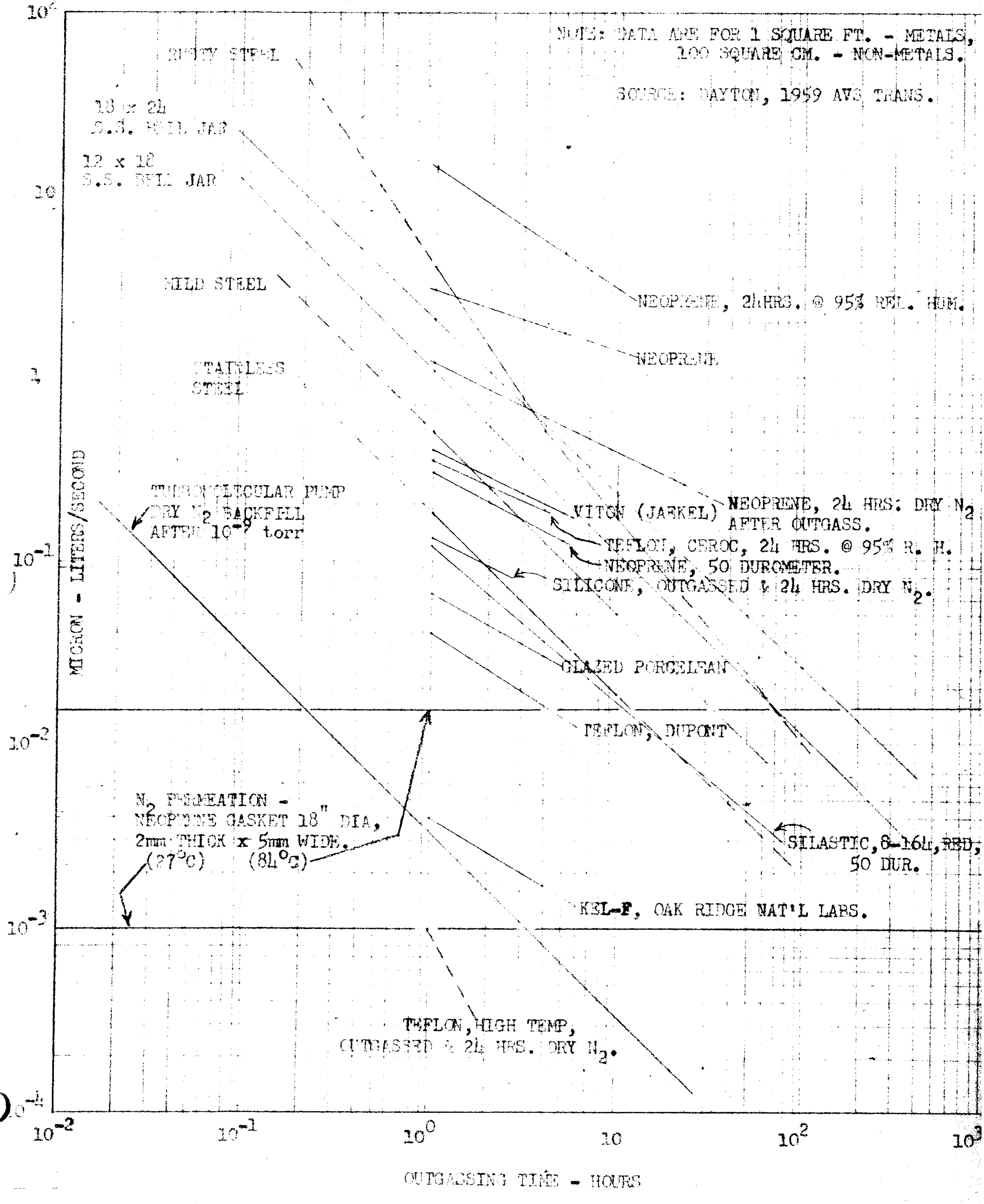


FIG. 4. OUTGASSING RATES OF VARIOUS MATERIALS.

rinse with acetone, using care, of course, because both solvents are flammable. Smooth, polished internal surfaces are necessary to reduce the actual outgassing area. Valves, electrical feed-throughs, and various fittings are often responsible for considerable outgassing in an otherwise ideal system, because of improper selection of these items. Any hardware containing elastomers should be avoided if possible.

Outgassing and permeation are usually responsible for limiting ultimate vacuums and deserve special consideration. Fig. 4 is an outgassing chart which clearly illustrates the importance of this problem. It shows the outgassing rates of various materials as a function of the time they have been outgassing. The two horizontal lines represent the constant permeability of neoprene, in order to illustrate that permeability is inherent in elastomers over and above normal outgassing. There are available many excellent books on vacuum techniques which should be consulted on methods for improving the efficiency of vacuum systems.

Gauges are important components in any vacuum system. It is generally recommended that high vacuum gauges be inserted directly into the vacuum chamber without an envelope, that is, "nude" gauges should be used. Recent developments in gauges show much promise, and hopefully many present-day problems will soon be resolved. Since forepressure is associated with ultimate pressure of a pump, it should be recognized that some gauges used in fore lines can decompose oil vapors and introduce hydrogen into the fore line. Increasing the partial pressure of hydrogen in the fore line can increase the partial pressure of hydrogen in the vacuum chamber.

The practice of back-filling a vacuum system with an inert gas or a dry gas when it is necessary to vent, prevents atmospheric moisture from being absorbed or adsorbed on the internal surfaces of the system. Water vapor is probably the most common cause of slow pump-down. A good bake-out is the only quick method of removing water vapor once it has been introduced (see section on bakeout). The prime requisite in high vacuum work is ultra-cleanliness.

SPECIFICATIONS

	3102A	3102B	3102C
Power connection	208-220V, 60 cycle, 3 phase	208-220V, 60 cycle, 3 phase	208-220V, 60 cycle, 3 phase
Maximum starting current	10 amps.	10 amps.	10 amps.
Normal running current	2.0 amps	1.5 amps.	1.5 amps.
Range of operation	atm. to -10^{-9} torr	10^{-2} to 10^{-9} torr	10^{-2} to 10^{-9} torr
Pumping Speed (air)	260 l/sec.	260 l/sec.	260 l/sec.
Dimensions	see Fig.5	see Fig.6	see Fig.7
Weight	804 lbs	302	302
Coolant	self contained	external supply	external supply
Lubricating oil	1377K turbo molecular pump oil and Duo-Seal pump oil	1377K turbo molecular pump oil	1377K turbo molecular pump oil
External Connections	see Fig.5	see Fig.6	see Fig.7
Guaranteed bearing life	10,000 Hrs.	10,000 Hrs.	10,000 Hrs.

INSTALLATION

Moving-

The Turbo Molecular Pump is drained of lubricating oil before it is shipped, and should not be refilled until permanently located. The pump should never be stood on end, even though drained. A filled pump may be moved a short distance without draining if it is not tipped more than 5° nor jarred severely. In the case of the 3102A, if the set is to be shipped outside the immediate building the hold-down bolts should be replaced in the fore pump base plate and tightened. (See Fig. 5).

Mounting

3102A

Turbo molecular pump oil should not be added nor should the forepump hold-down bolts be removed until the pump set is placed in its permanent position. The 3102A should be placed on a solid, level floor. If necessary, place shims under the legs of the frame to eliminate any possible wobble. The refrigerator condenser should not be obstructed to the degree that it does not have free air circulation. The control panel door requires a 16" radius for opening. The back side of the pump set (opposite the control panel) should not be permanently inaccessible. Since the pump set is sturdily built, vacuum system components may be supported directly on the inlet flange unless they are quite massive or off-center.

3102B - 3102C

These pumps can be placed on any flat surface without necessity of attaching them to the surface. However, if the apparatus which is to constitute the vacuum system will displace the center of gravity so as to cause the entire assembly to be unstable, the pump should be secured to the floor or table. In all cases, the pump should be level and solidly supported. There must be access to fill and drain the lubricating oil and to connect power and coolant lines.

Vibration Isolation

In cases where even the slightest vibration would disturb the processes being performed, it may become necessary to isolate the turbo molecular pump from the vacuum system. For these applications, the Welch Scientific Company can supply a 6" double flanged, stainless steel bellows which attaches directly to the pump inlet. The upper flange is then supported directly from the floor on independent supports. In this manner, the turbo molecular pump is completely isolated from the system. In the case of either the 3102B or the 3102C models, the weight of the pump is not sufficient to prevent it from being lifted and collapsing the bellows, therefore they <u>must</u> be screwed to the floor when using vibration isolation apparatus.

Wiring

3102A

Power requirement is 220 volt, 60 cycle, 3 phase sufficiently fused to accomodate a maximum starting current of 10 amperes. The grounded, 4-conductor power supply cable is brought into the control panel through an opening in the back of the panel. Connections are made at L1, L2, and L3 on the terminal strip for power, and a ground connection is made at G.

3102B - 3102C

Power requirement is 220 volt, 60 cycle, 3 phase, sufficiently fused to accomodate a maximum starting current of 10 amperes. Power connection is made at the drive motor. For purposes of safety, the turbomolecular pump should be grounded.

Coolant

3102A

The 3102A is supplied with a self-contained refrigeration system which operates automatically.

3102B - 3102C

The coolant connections are seen on the outline drawing for each pump (Fig. 6 or Fig. 7). The direction of flow of the coolant is not important. Any non-corrosive coolant may be used. During normal operation a very small amount of coolant is required, since it is only necessary to maintain the ends of the turbo molecular pump at a temperature slightly below room temperature.

IMPORTANT

> During periods when the pump is being baked-out, heat transfer to the coolant will increase, and unless the coolant is controlled by a temperature sensitive device, the coolant flow rate must be increased manually.

Where water is used as the coolant, the supply should be reasonably dependable. Where an already-available refrigeration system is used, it is not only unnecessary to cool the ends of the pump below 50° F, but it will also cause condensation during humid weather which will drip onto the floor.

Blank-Off Test

If it is desired to test the Turbo Molecular Pump to gaurantee that it is functioning properly, a blank-off test should be arranged before the pump is installed in a vacuum system. The shipping cover which is on the pump inlet when received can be utilized for this purpose. By boring a hole in the cover, and welding one half of a metal gasket sealing flange to the cover, an efficient blank-off plate is produced. To this flange can be attached an ionization gauge. A thermocouple gauge (zeroed) should be inserted in the foreline. Normal startup and bakeout procedures can then be followed.

STARTUP

Lubricating Oil

The turbo-molecular pump must not be operated without a flow of oil being directed to the high speed ball bearings. The oil is pumped by a screw-type pump which is an integral part of the transmission drive shaft. The transmission housing acts as a reservoir for the oil. The transparent oil cup immediately above the transmission supplies oil to the rotating seals of the drive shaft. (See "Oil Fill" on Fig.5, 6, or 7, Outline Drawing).

To fill the transparent cup, lift the lid and fill the cup, being careful not to pour oil in the small air-escape tube visible in the opening. Turbo-molecular pump oil (catalog no. 1377K) should be used.

If it has not been verified that the turbo-molecular pump transmission has been completely drained of oil (as in moving from one location to another), remove the red drain plug under the transmission and the red tubing elbow immediately behind the plug (see outline drawing). The red elbow must be <u>completely removed</u> for proper drainage, since it contains a ball check valve. Replace the drain plug and elbow and after cleaning the area surrounding it, remove the red fill plug on top of the transmission. Using only very clean vessels, pour 680cc of turbo-molecular pump oil into the transmission and replace the plug. NOTE: It is important to carefully clean the area around the fill plug before removing the plug, and to use clean vessels. Small metallic chips or dirt particles can shorten bearing life drastically. The Welch Scientific Company will not guarantee the pump unless turbo-molecular pump oil is used.

In the case of the 3102A, the fore pump is shipped filled.

Coolant

With the 3102B or 3102C, it will be necessary to start the coolant flow when the pump is started. With the 3102A, this is automatic.

Roughing and Starting

When rough pumping the turbo-molecular pump, or rough pumping a system directly through the pump, adjust the roughing speed to allow at least a full minute to reduce the pressure in the pump to the low millimeter range. This can easily be done on the 3102A by using the small bypass valve on the foreline. The purpose of this is to avoid creating a pressure differential between the pump housing and the transmission housing, which might cause a small loss of turbo-molecular pump oil into the foreline.

On the 3102A, the forepump and refrigerator both are started when the switch in the center of the control panel is turned to START. On other systems, where the 3102B or 3102C is used, other means of operation will be used.

Close foreline valves.

Start forepump.

Slowly open foreline (or bypass) valve.

When forepressure reaches approximately 10 or 20 millimeters, (74cm of vacuum on the foreline dial gauge of the 3102A) turn the turbo-molecular pump on and fully open foreline valves. Before the turbo-molecular pump rotor reaches full speed, the balls in the oil flow indicators on the side of the transmission will rise (see outline drawing). This indicates that oil is being pumped to the high speed bearings. The pump should reach full speed in two or three minutes. The drive motor will generate a considerable amount of heat during startup, and is no cause for alarm. If the pump is to be shut down and started again immediately afterward, it should first be allowed to operate at least 6 or 7 minutes at full speed before shutting down to allow the motor sufficient cooling time.

Bake-Out

In order to attain the ultra-high vacuum of which the turbo-molecular pump is capable, it will be necessary to degas the pump by baking at no more than 150° C. This can be accomplished with any heaters available, or heaters designed for this purpose can be ordered from the Welch Scientific Company. On the back of the control panel of the 3102A are 220V outlets to accomodate heater plugs. These outlets are controlled by a switch inside the control panel door.

It is only necessary to bake the pump inlet and the center of the pump immediately below the inlet, since the ends of the pump operate at fore pressure. Unless the pump being baked is on the 3102A set or has some other type of automatic cooling system, it must be remembered to increase coolant flow during bakeout, otherwise damage may result.

If it is desired to reach the ultimate vacuum of the pump, bakeout should be continued until the inlet pressure (barring leaks) reaches approximately 2 or 3×10^{-8} torr. The occurance of leaks at metal-to-metal seals during cool-down should be recognized as a possible source of trouble.

SHUTDOWN

On all models, the foreline valve should be closed, and then the turbo-molecular pump should be turned off. On the 3102A, also turn off the switch in the center of the control panel. This will stop the forepump and the refrigerator. Allow the pump rotor to slow considerably before venting the system. This will prevent aerating the lubricating oil which is being agitated in the transmission while the rotor is turning.

In applications where the coolant is not interlocked with the pump, turn off the coolant. This will prevent condensation inside the pump if the venting gas contains condensibles such as water vapor.

SAFETY PRECAUTIONS

Aside from the usual care exercised when operating 220 volt equipment, the only other precaution necessary is to avoid catching fingers or clothing, <u>especially neckties</u>, in the external drive belt.

CONTAMINATION

Symptoms

When the inlet pressure of the blanked-off turbo molecular pump remains at approximately 5×10^{-5} torr, and forepressure, rotating speed, and leak situation all appear normal, then the probability is that lubricating oil has been introduced into the high vacuum area of the pump. This could be caused by tipping the pump, over-filling with oil, or excessively rapid initial pumpdown.

Decontaminating

To decontaminate the pump, access must be provided to the inlet and to the outlet. On the 3102A and 3102B models, remove the plug in the outlet tap under the pump (see outline drawing) and close the foreline valve. On the 31020 model, remove the vacuum hose from the outlet connection under the pump. Drain the lubricating oil as described under "Startup". Place a drain pan under the pump outlet and remove the belt guard and belt. If adequate ventilation and safety conditions are present, use a fine jet of benzene to wash down the inlet of the pump while rotating the pump rotor by hand in the normal drive direction. If an inlet screen is used, wash this also. Use at least a pint of benzene and rotate the rotor rapidly. Repeat with acetone, and continue turning the rotor until after the sound of the liquid disappears. If safety considerations require it, Welch Turbo-Flush (catalog no. 3101F) may be used for non-flammability and low toxicity, or trichloroethylene or carbon tetrachloride may be used. Chlorinated solvents require extra pumping time to remove all traces of chlorine from the pump.

Reassemble the pump, refill with lubricating oil, and start the forepump. NOTE: If an auxiliary mechenical pump is available which can be used as a roughing pump to remove the solvent vapors, this will avoid the necessity of changing forepump oil two or three times. After the auxiliary roughing pump and the turbomolecular pump have been in operation about 20 minutes, the original forepump can be reconnected and the remaining solvent vapors will be minute. The oil in the auxiliary roughing pump can then be changed to eliminate solvent contamination when time permits. On the 3102A and 3102B, the auxiliary pump can be connected to the foreline valved outlet tap. Slowly open the foreline valve, so that at least one minute is required to evacuate to the low torr range. Turn on the turbo-molecular pump when the fore-pressure is less than 10 torr. After the turbo-molecular pump has run for approximately 20 minutes, drain the forepump oil while the pump is operating, and refill with clean oil. It will not damage Welch Duo-Seal pumps to change oil while operating. If time is available, the forepump (or the auxiliary roughing pump), if it is a Welch Duo-Seal pump with vented exhaust, can be allowed to operate overnight with the vented exhaust open to remove condensible vapors from the oil. When the fore pressure reaches a McLeod pressure of 0.1 millitorr (microns) or a thermal gauge pressure of 15 millitorr, the forepump oil can be considered sufficiently clean and no further oil change necessary.

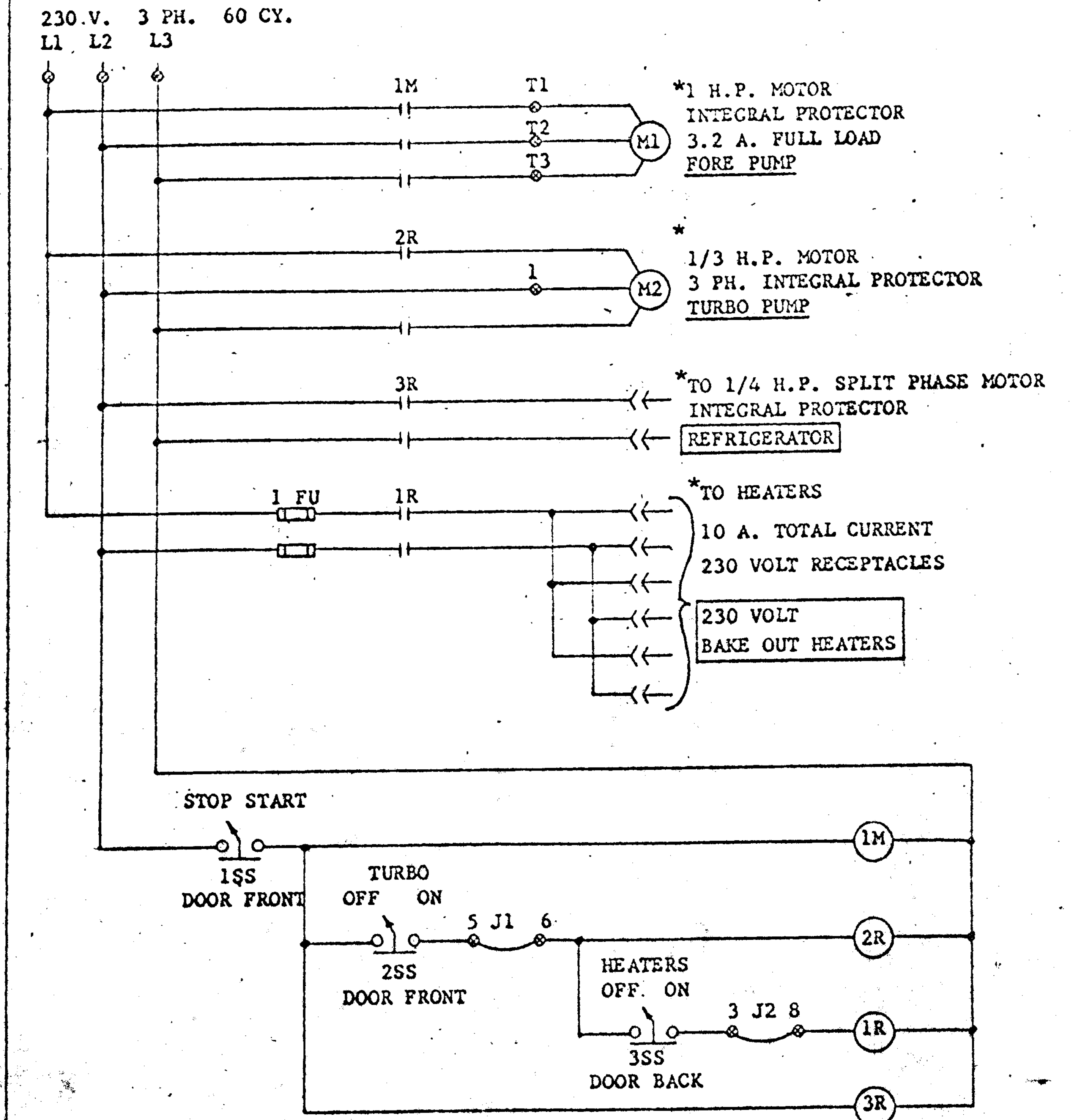
LEAK DETECTION

When leak checking a system pumped by a turbomolecular pump, the leak detector should be connected to the foreline of the pump. The turbo-molecular pump captures the helium and compresses it into the foreline, where it can be quickly detected by the leak detector. (On the 3102C model, a valved tap must be installed in the foreline). For highest sensitivity, the foreline valve should be closed. Except for large leaks, the leak detector is usually capable of acting as a holding pump. A leak detector of a sensitivity of 10^{-10} cc/second or better is recommended for systems to be pumped below 1×10^{-8} torr.

EMERGENCY CONDITIONS

Power Failure

In the event of an unexpected loss of electrical power the normal procedure is to close the foreline valve of the turbo-molecular pump immediately. All mechanical pumps which are used as fore-pumps have a specific leak-back rate which means that air will leak through a stopped forepump into the vacuum system. Even though the path which oil molecules must follow through the turbo-molecular pump is a very tortuous one, eventually some oil vapor will find its way to the inlet. Ordinarily this can be pumped out as soon as the turbo-molecular pump is restarted. In applications where even a minute amount of oil vapor will cause serious difficulty, it may be necessary to provide safeguards against power failure when the pump is unattended. There are two effective methods of preventing this problem. One is to install a solenoid-operated vent valve upstream of the turbo-molecular pump which



NOMENCLATURE

1M	SIZE 00 CONTACTOR
1R, 2R, 3R	CR 120E RELAY
1SS	CR 2940 SEL. SWITCH
2SS, 3SS	TOGGLE SWITCH
—●—	TERMINAL BOARD POINT
J1, J2	JUMPER WIRE
1 FU	10 A. FUSE
*	EXTERNAL DEVICE

FIG. 8

THE WELCH SCIENTIFIC COMPANY
SKOKIE, ILLINOIS U.S.A.

CONTROL SYSTEM
3101A & 3102A TURBO PUMP

DRAWN 222 APP'D A.M. DATE 11/19/64

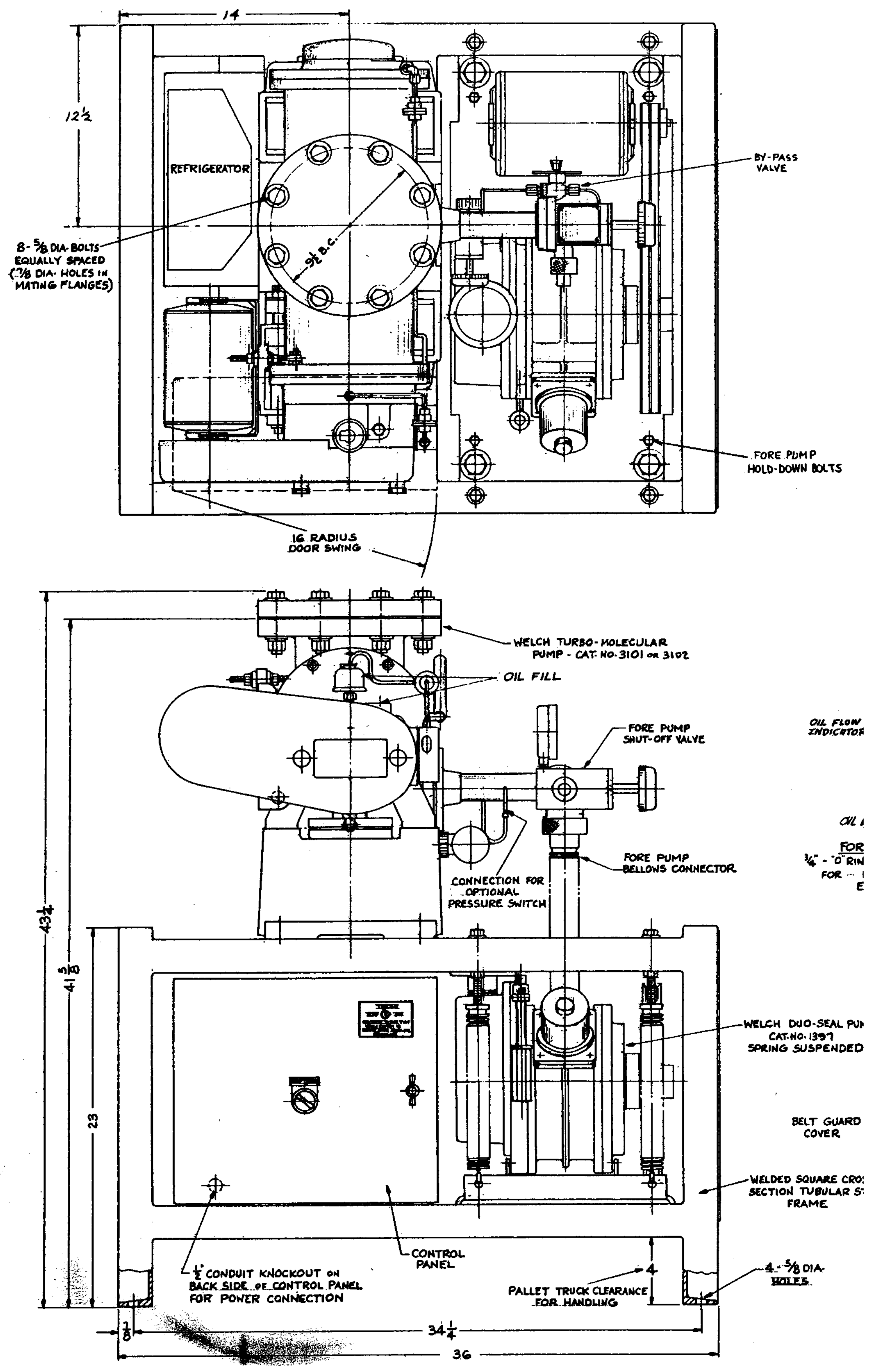
41-4221

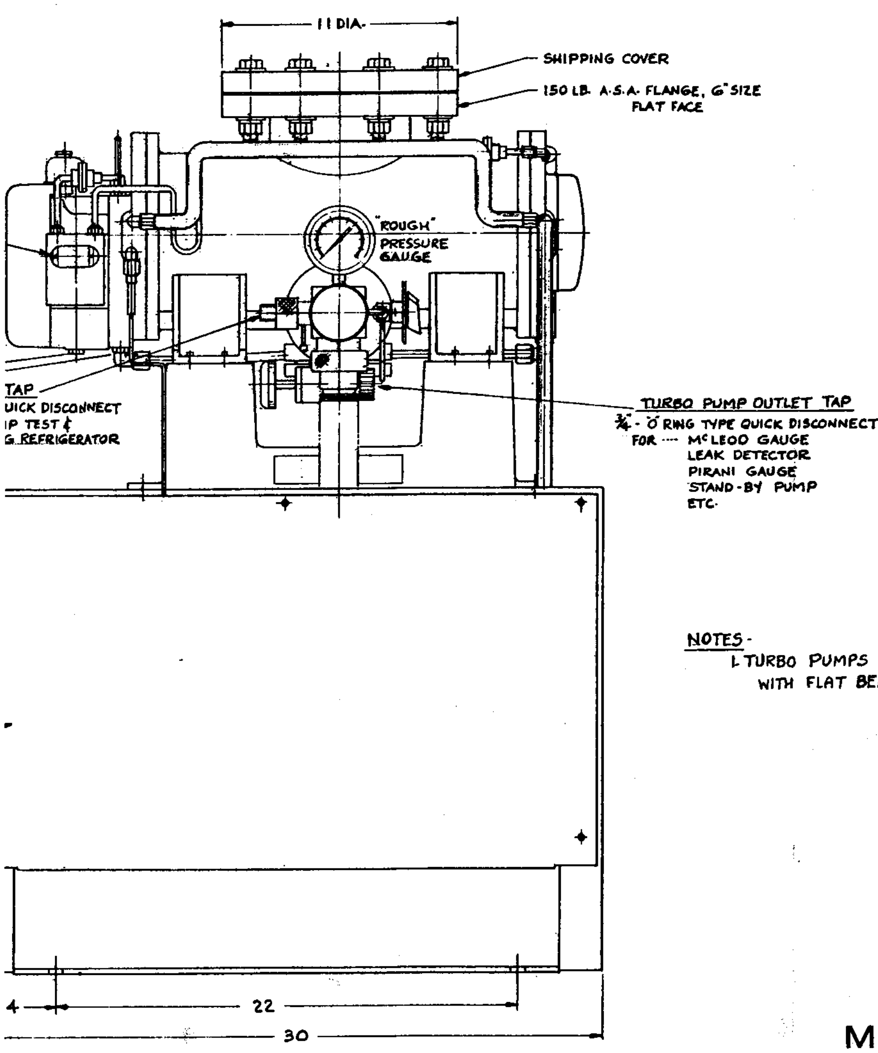
41-4221

will open in the event of a power failure and admit a dry gas into the system at a pressure between 10 torr and atmosphere. A second method is to install an automatically closing gate valve at the pump inlet. An important fact to remember is that on the 3102A pump set and probably on many custom-built systems, the pumps will restart with the restoration of power. In this case, if an automatic vent valve is used, it should close again when power is restored. As will be noted later in the section on the electrical system of the 3102A, the turbo-molecular pump motor will overheat and cut off if pumping at high pressures for too long a time. A device which starts the pump only after the forepressure is low (10 torr) can be obtained from The Welch Scientific Company if power failures seem probable.

Implosions - Particles

It is necessary to avoid introducing any foreign objects into the inlet of the turbo-molecular pump. This could occur during a bell jar or window implosion or as a result of physical failure of internal components in a system. When there is any possibility of nuts, bolts, wires, glass, or other objects falling directly into the pump inlet during operation, the inlet screen which is shipped with each pump must be used. Fine particles such as carbon dust will not damage the pump.


14
12½
REFRIGERATOR
BY-PASS VALVE
8-⅝ DIA. BOLTS EQUALLY SPACED (⅞ DIA. HOLES IN MATING FLANGES)
9½ B.C.
FORE PUMP HOLD-DOWN BOLTS
16 RADIUS DOOR SWING
WELCH TURBO-MOLECULAR PUMP - CAT. NO. 3101 OR 3102
OIL FILL
FORE PUMP SHUT-OFF VALVE
FORE PUMP BELLOWS CONNECTOR
CONNECTION FOR OPTIONAL PRESSURE SWITCH
43¼
41⅝
23
WELCH DUO-SEAL PU
CAT. NO. 1397
SPRING SUSPENDED
BELT GUARD COVER
WELDED SQUARE CRO
SECTION TUBULAR S
FRAME
CONTROL PANEL
½" CONDUIT KNOCKOUT ON BACK SIDE OF CONTROL PANEL FOR POWER CONNECTION
PALLET TRUCK CLEARANCE FOR HANDLING
4
4-⅝ DIA. HOLES
⅞
34¼
36

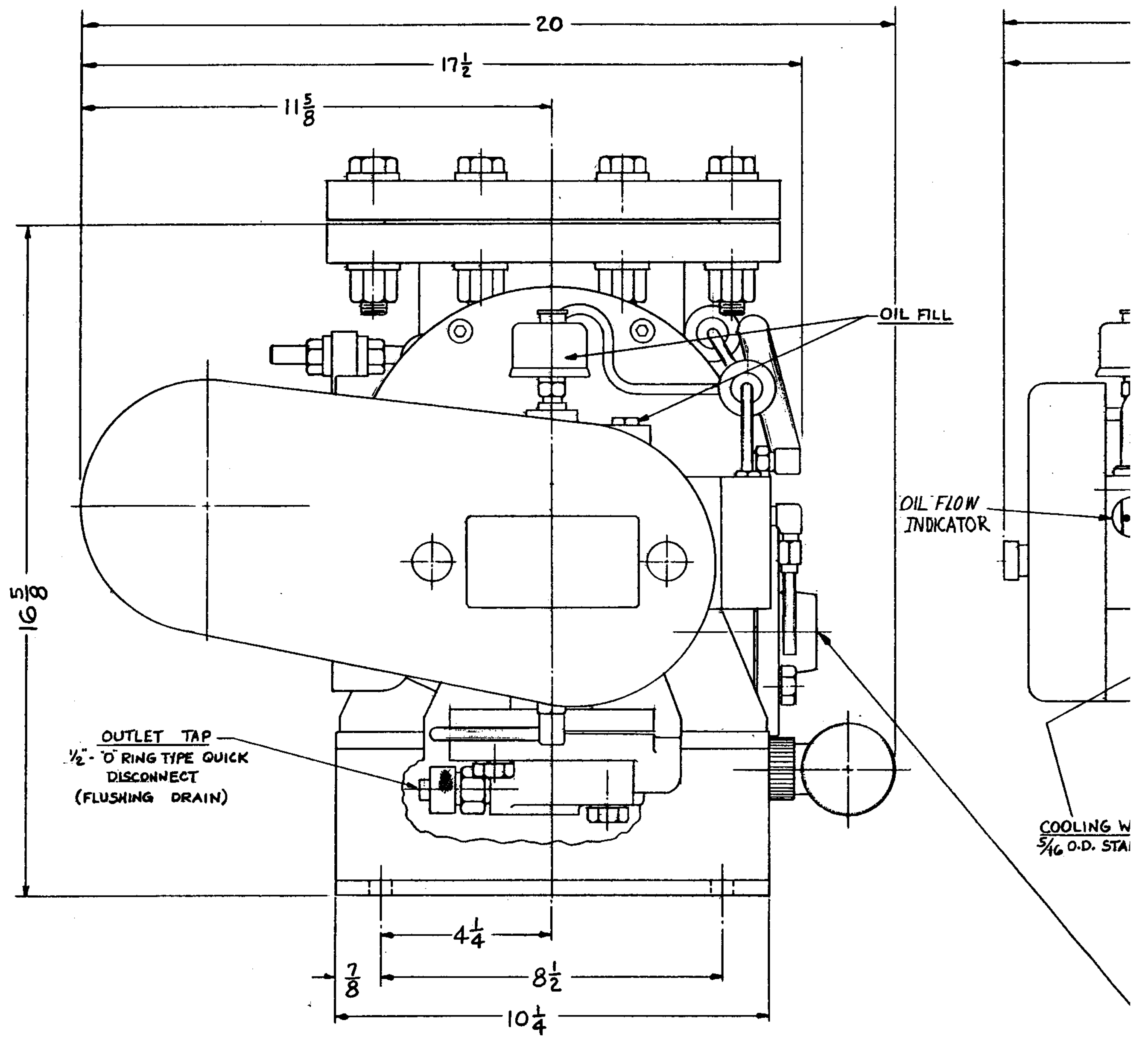


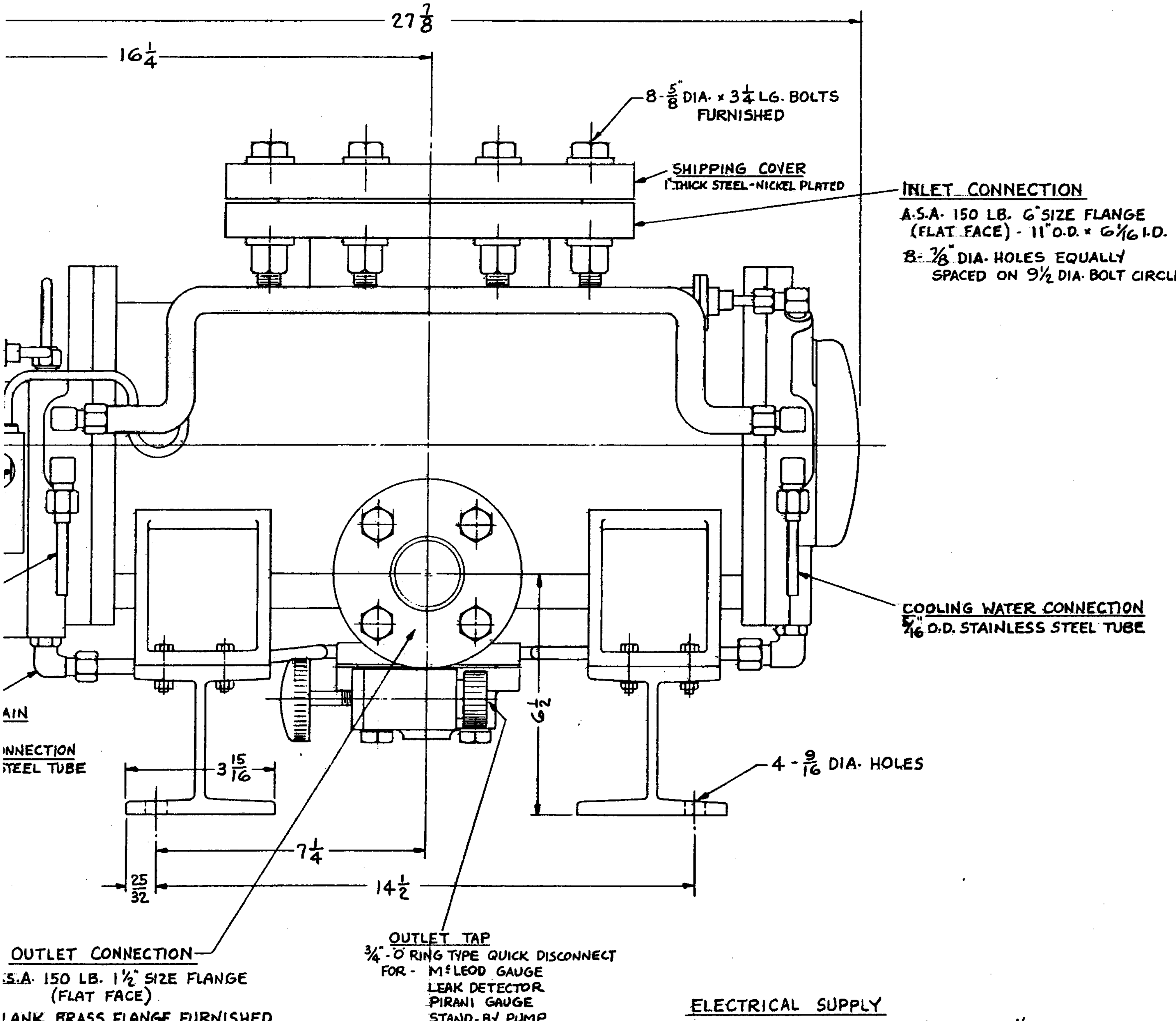
NOTES -

1. TURBO PUMPS SERIAL #101 THRU #160 SUPPLIED WITH FLAT BELT & CLUTCH DRIVE

FIGURE 5

MODEL 3102A


20
17 1/2
11 5/8
OIL FILL
OIL FLOW INDICATOR
16 5/8
OUTLET TAP
1/2" - "O" RING TYPE QUICK DISCONNECT
(FLUSHING DRAIN)
4 1/4
7/8
8 1/2
10 1/4
COOLING W
5/16 O.D. STA



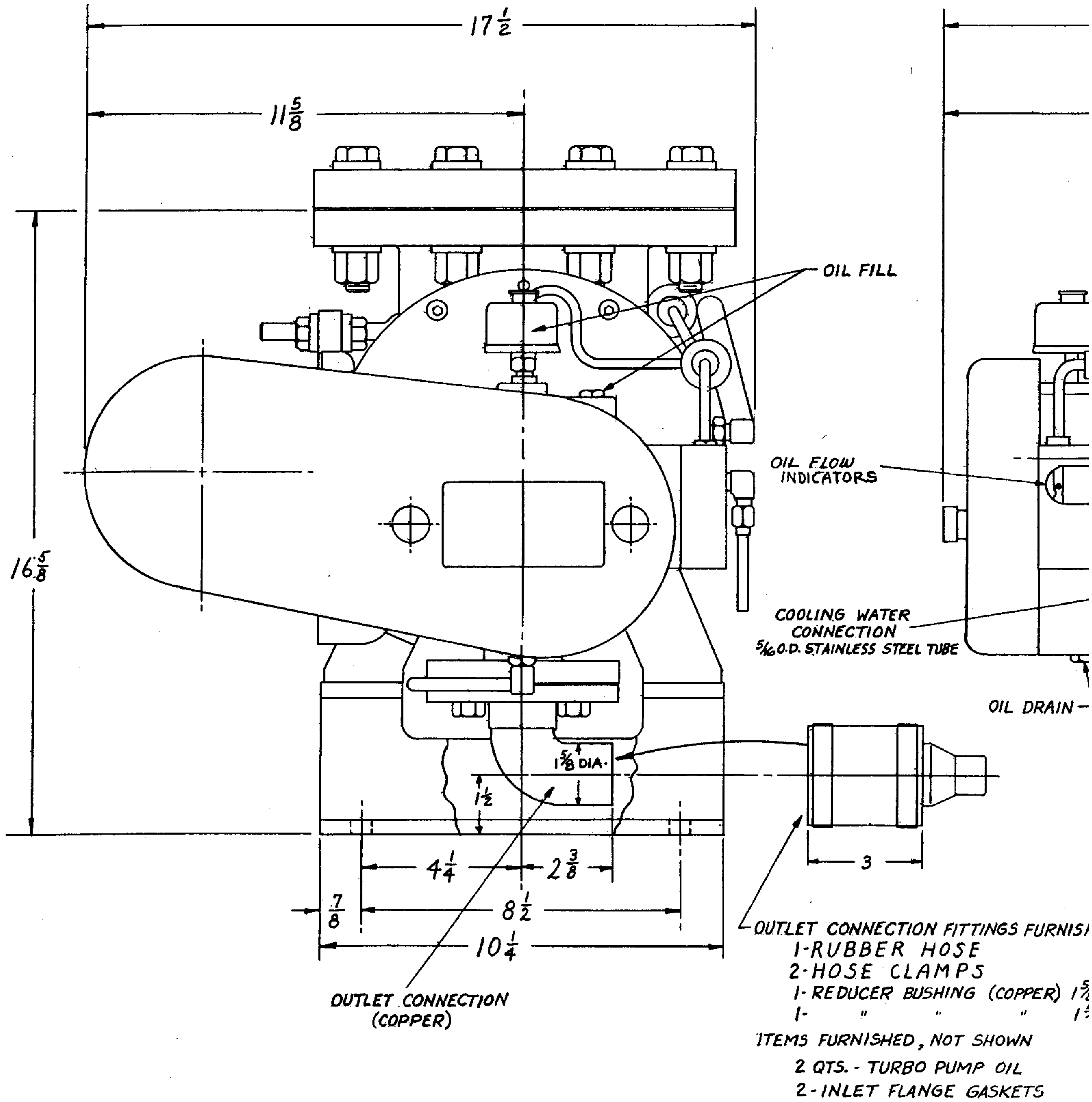
ELECTRICAL SUPPLY

220 VOLT - 3 PHASE - 60 CYCLE FOR 1/3 H.P. MOTOR
9 AMPS. LOCKED ROTOR CURRENT
1 1/2 AMPS. RUNNING CURRENT

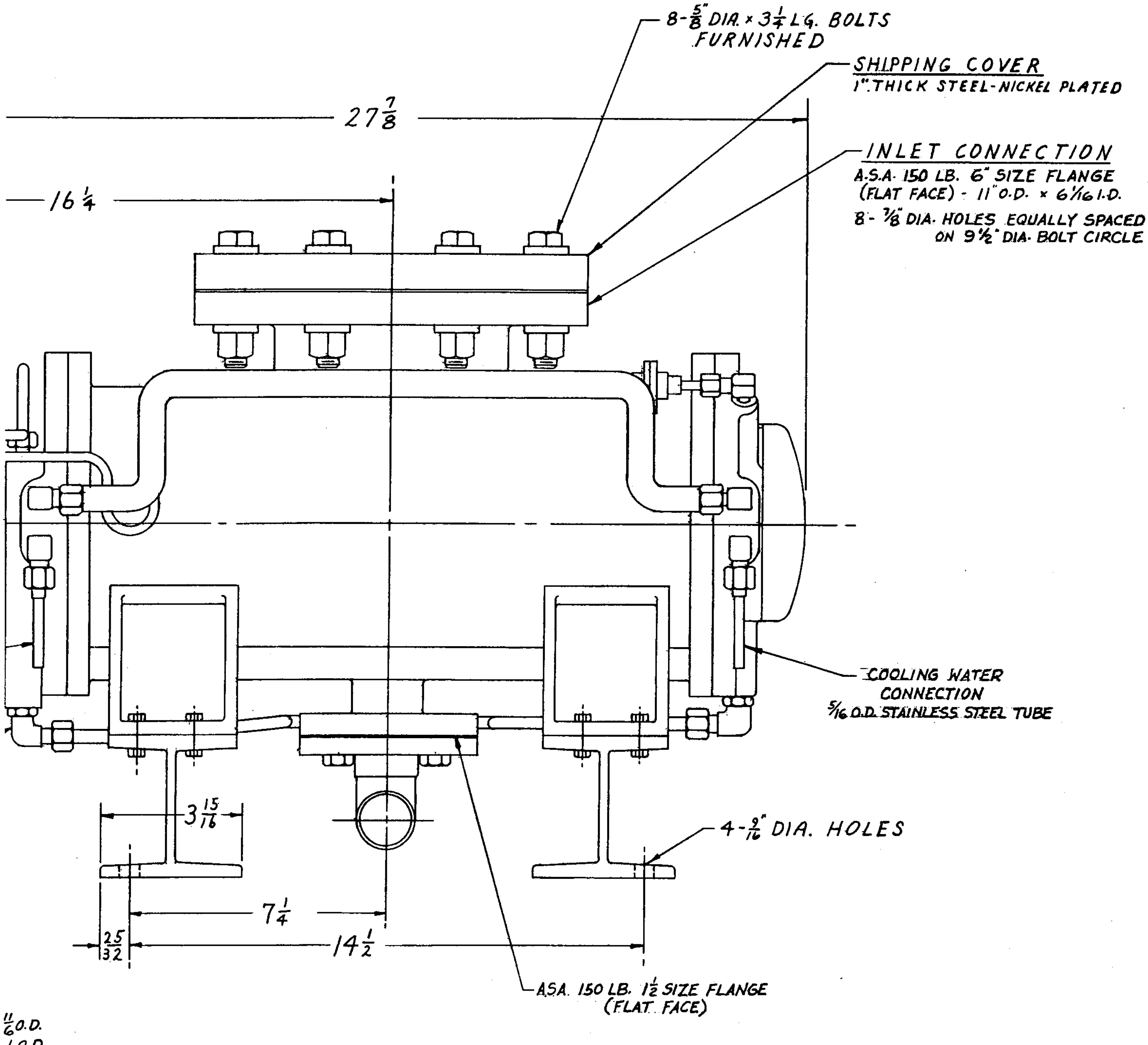
TOTAL WEIGHT - 300 LBS.

FIGURE 6

MODEL 3102B



17 1/2
11 5/8
16 5/8
OIL FILL
OIL FLOW INDICATORS
COOLING WATER CONNECTION
5/16 O.D. STAINLESS STEEL TUBE
OIL DRAIN
1 5/8 DIA.
1 1/2
4 1/4
2 3/8
3
7/8
8 1/2
10 1/4
OUTLET CONNECTION (COPPER)
OUTLET CONNECTION FITTINGS FURNIS
1-RUBBER HOSE
2-HOSE CLAMPS
1-REDUCER BUSHING (COPPER)
ITEMS FURNISHED, NOT SHOWN
2 QTS. - TURBO PUMP OIL
2-INLET FLANGE GASKETS



ELECTRICAL SUPPLY
220 VOLT-3 PHASE-60 CYCLE FOR 1/3 H.P. MOTOR
9 AMPS LOCKED ROTOR CURRENT
1 1/2 AMPS RUNNING CURRENT

TOTAL WEIGHT - 300 LBS.

FIGURE 7

MODEL 3102C

Explanation of Wiring

Refer to Figure 8. When the STOP-START switch in the center of the control box door is turned to START, contactors 1M and 3R are energized, supplying power to the forepump motor and refrigerator motor, respectively. When the system has been rough pumped, the TURBO switch on the control box door is turned ON energizing contactor 2R which powers the turbo-molecular pump drive motor.

When 2R is energized, the bakeout heater receptacles on the back of the control box can be powered by turning the HEATER switch inside the control box door to ON, thus energizing contactor 1R. Heaters will lose power if either the TURBO switch or the main STOP-START switch is turned off.

If a power interruption occurs, all motors and heaters will of course stop. Upon restoration of power, the motors and heaters will start simultaneously. If the system pressure has risen during shutdown and the system volume is large, the air friction on the turbo molecular pump rotor might cause the overload protector to cut out on the drive motor. This must be manually reset when the motor cools (about 45 minutes). The forepump and refrigerator will continue to operate, and massive contamination of the system will be retarded by the cold ends of the turbo-molecular pump until such time as the pump can be restarted.

Interlocking devices can be installed in the TURBO or HEATER circuits by removing the jumper at J1 or J2 and installing the device at that point. An automatic starting device is also available that will start the turbo-molecular pump when the forepressure reaches a pre-determined value (usually 10 torr).

Explanation of Refrigeration

The primary purpose of the refrigerator system is to maintain the end walls of the turbo-molecular pump at a lower temperature than the adjacent stator and warm rotor blading. The thermal gradient thus established assures that there will be no continuous condensation of oil films anywhere but on the internal ends of the housing where they can drain away harmlessly. A secondary purpose is to maintain a constant cool temperature under all conditions.

The temperature of the turbo-molecular pump ends is set by automatic control to 50° F. minimum. By restriction of the temperature to 50°, condensation of atmospheric water on the pump is avoided on all but the most humid days. Such condensation does no immediate harm; but in time it will rust parts and make puddles on the floor.

Non-corrosive, sediment free, cool water from 50° to 70° F. is quite satisfactory as an alternative to the mechanical refrigerator system provided. However, experience has shown us that satisfactory cooling water is seldom continuously available.

Should the mechanical refrigerator system fail, the turbo-molecular pump can continue to run indefinitely without harm to moving parts. The longer such operation is continued, particularly if the pump is stopped and started, the greater the probability of oil vapor contamination becomes. However, if the pump is being heated, the heaters should be turned off immediately if the cooling is interrupted in order to avoid damagingly high temperatures in the bearings.

Operation of Mechanical Refrigeration System

(Refer to Fig. 9) Liquid Freon 12 refrigerant at about 150 psi collects in the bottom of the condenser (A) and flows through service valve (B), drier (C), and strainer (D). The liquid flow then divides approximately equally through the capillary restrictions (E and F), flowing thence into evaporating passages in the pump ends (G and H), wherein the pressure is automatically maintained by evaporator pressure regulating valve (I) in such a way that boiling occurs at a constant 50° F. The heat flowing into ends (G and H) is normally insufficient to convert all the liquid refrigerant to gas except when turbo-molecular pump is being heated. The boiling liquid streams from ends (G and H) join and pass through pressure regulating valve (I). Between valve (I) and service valve (J) to the compressor (K) (not visible in Fig. 9), the pressure usually is such that the remaining liquid boils at lower than 32° F. Thus frost forms on the tubes and valves. Only a small amount of liquid remains in the stream passing into the compressor. The hot, high pressure gas discharged from the compressor gives up its latent heat in condenser (A) and liquifies; thus completing the cycle.

Refrigerator System Maintenance

Wipe the dust from the condenser from time to time so that air flow is not blocked. Check refrigerant charge annually to maintain compressor inlet pressure at 15 psig. If desired this can be done by a local refrigerator serviceman.

Refrigerant leak check, Refrigerant addition

The system has been checked for leaks by methods sufficiently sensitive to insure operation for at least a year without refrigerant addition. Should serious charge loss occur, the turbo-molecular pump ends will no longer feel cool and the top top condenser coils on the refrigerator unit will not feel as warm as usual. The usual frost downstream from the regulating valve disappears (although low winter humidity may also cause temporary frost disappearance). If the leak is slow, the simplest thing to do is add gas while the system is running until the compressor inlet pressure returns to 15 psig. (Anyone familiar with refrigerator systems will know how to do this even without the following instructions). Use a refrigerator charging and testing gauge and hose set (see Fig. 10). Connect a Freon-12 can to charging connection (L) (Fig. 9) after purging the hose with refrigerant. Remove valve cap (M) and turn valve stem 3 turns clock-wise. Open valve on refrigerant can slowly (until can cools) to keep compressor inlet pressure below 20 psig. Do not turn can upside down. Allow refrigerant gas to enter system until compressor inlet pressure is 20 psig. Close can valve. Turn valve stem counter-clockwise until valve closes tight. Remove hoses, wipe condensate water from fitting, replace stem and connection caps quickly.

A simple alcohol flame type Freon leak detector, available at small cost, is sufficiently sensitive to make possible leak reduction sufficient for many months of operation without refrigerant addition. A serviceman equipped with a good portable electronic refrigerant leak detector can extend this period to years.

Opening Refrigerant System

If the refrigerant system must be opened, first close off compressor-condenser unit by turning stems of valves B and J clockwise to end of stroke. Release system refrigerant by removing caps L and O.

Drying, Evacuating, and Charging System

Refer to Fig. 9. After tubing is reconnected, using new copper gaskets, and drier C, open regulator I by turning the adjusting screw under Q all the way counterclockwise. With system tubing joints open at valves J and B, pass dry nitrogen through system for 1/2 hour to dehydrate walls. Flush nitrogen out with Freon gas and quickly connect tubing to service valves J and B. Release refrigerant in compressor unit by unscrewing caps L and O of valves J and B. Connect charging and testing set to service valves at L and O as shown in Figure 5. Connect set to forepump at T (Fig. 11) with 3/4" tube vacuum connector. Install 30" suction to 300 psi gauge at port S of regulator I and open gauge valve at R. Cut refrigerator power by pulling refrigerator plug from back of control box. Set valving of charging and test set to permit evacuation of refrigerator system at J and B simultaneously. Screw stems of J and B to mid-position. Close forepump valve to turbo-molecular pump and turn on forepump.

Evacuate system to 29" vacuum through both valves J and B. Do not pump to lower pressures or excessive foaming of compressor oil may occur. Close off forepump at charging and test set. Connect refrigerant can, then purge hoses, and valve can into system to pressurize for leak test. Purge room of Freon and leak test all joints with flame or better still, electronic halogen detector. When system is tight, re-connect wiring and start compressor. Admit refrigerant carefully until can cools so that compressor inlet pressure does not exceed 20 psi. After can is cold, compressor inlet pressure will fall below atmospheric pressure and then slowly rise. Stop charging when compressor inlet pressure rises to 15 psig. Re-adjust regulator I to 46 psig (50° F. on Freon 12 scale). Leave gauges in place and when turbo-molecular pump is started re-check 15 psig charge pressure and 46 psig regulator setting. Then valve J and B can be screwed all the way counter-clockwise and regulator gauge port valve at S can be screwed closed. Remove regulator gauge and charging and test hoses. Blow Freon out of openings of J and B, cap, and leak test at caps. Blow Freon out of gauge port S and valve port R. Using sealer such as "Leak Lock", cap R and plug S. Leak check at this cap and plug.

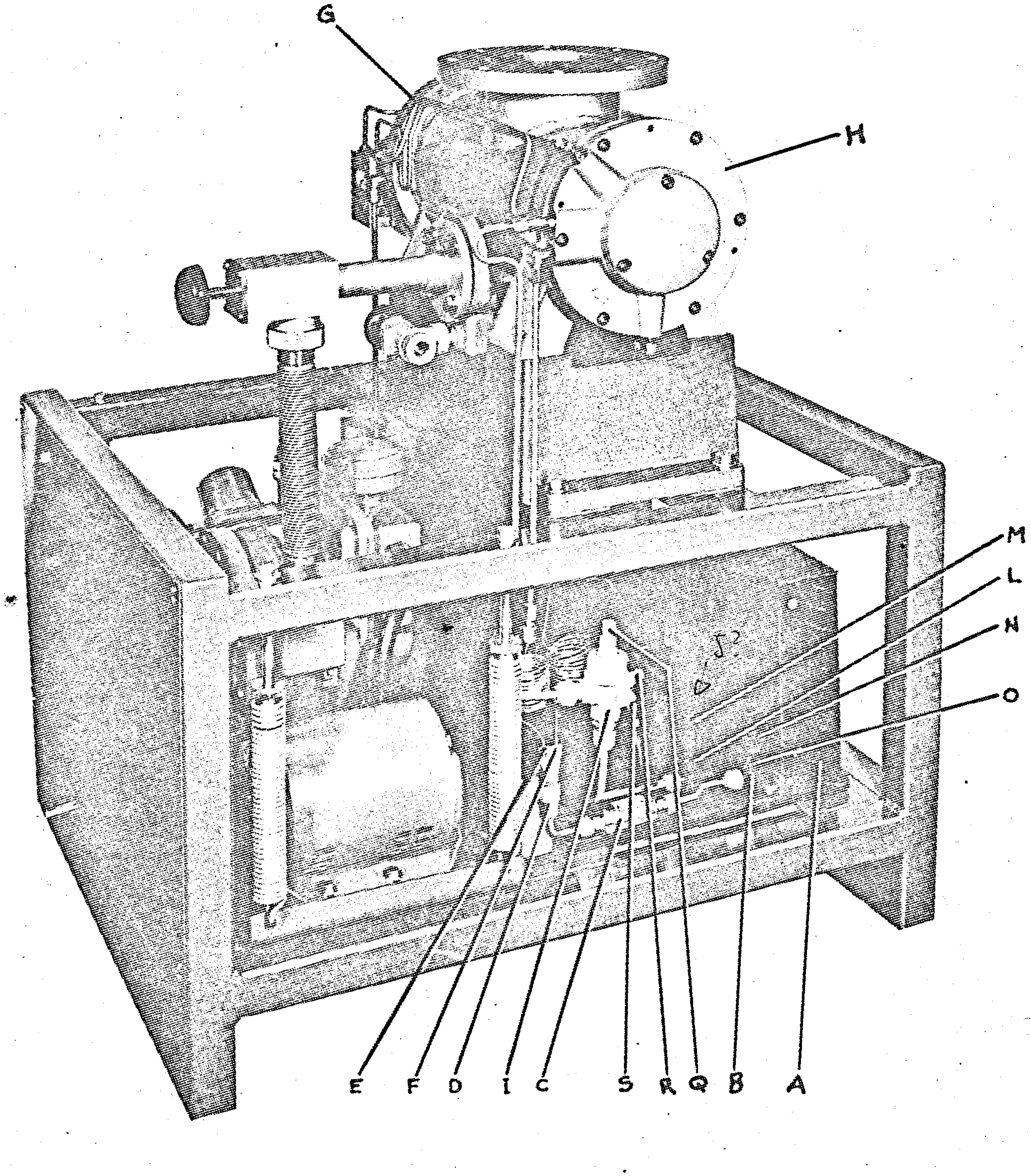


FIG. 9

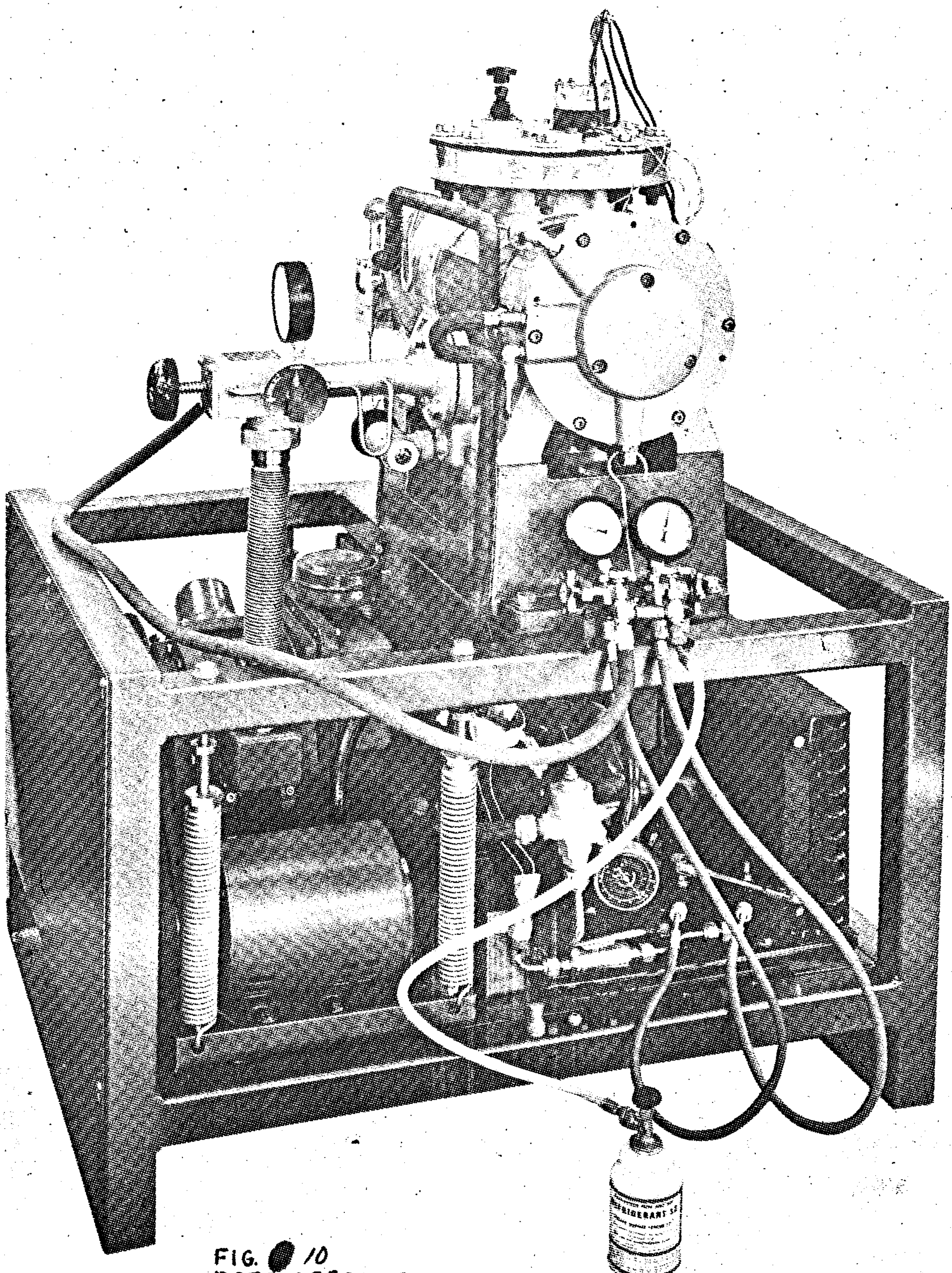


FIG. 10
REFRIGERATOR CHARGING
AND TESTING EQUIPMENT CONNECTED

C-2085

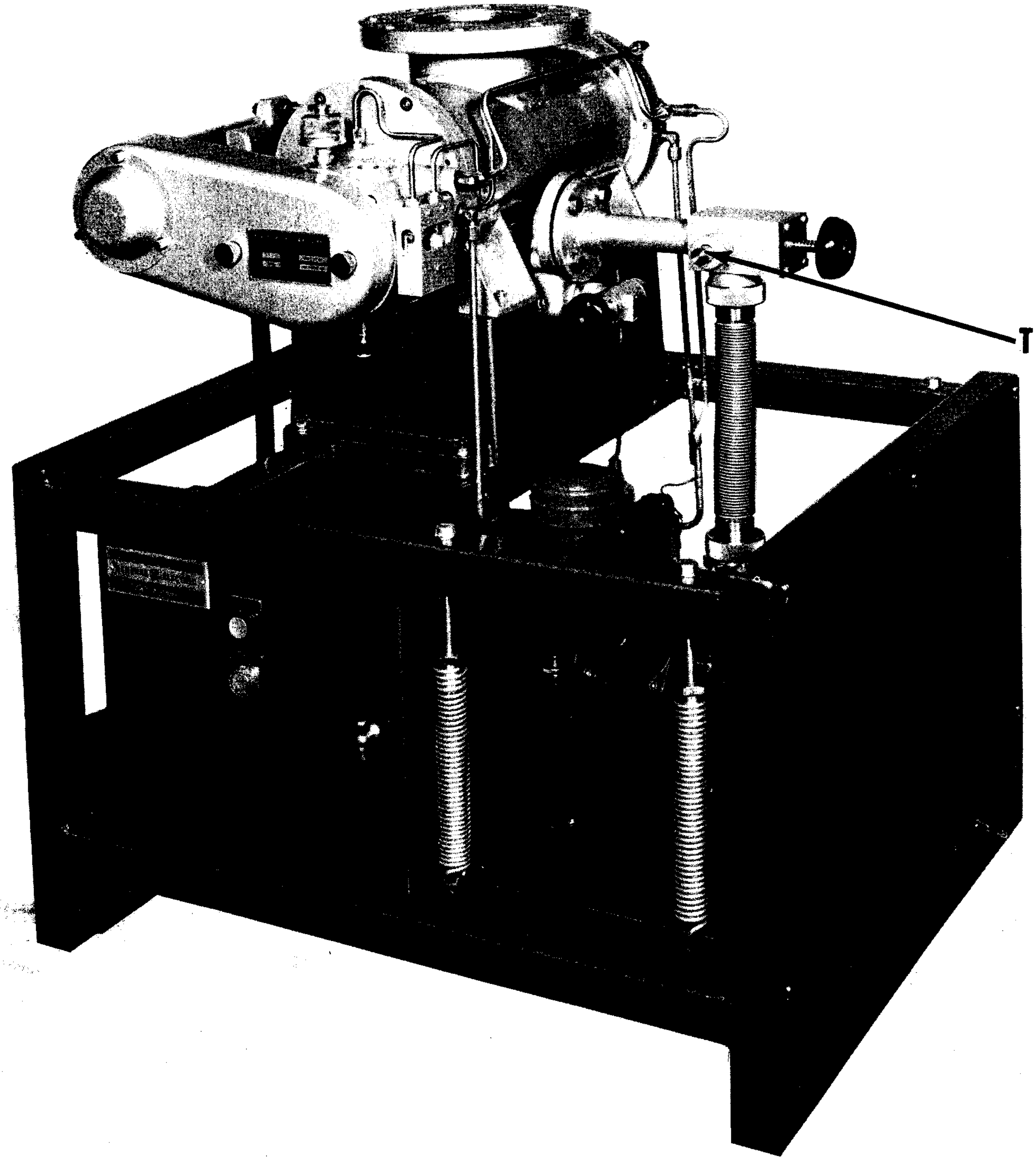


FIG. 11