Conversion of Refrigerator Compressors into Vacuum Pumps

F. B. Lee

MORRIS and LEE
Buffalo, N. Y. 14207

VACUUM PUMPS FROM REFRIGERATOR COMPRESSORS

Methods for converting rotary compressors from refrigerators into vacuum pumps for systems operating below 1 mm. mercury.

Many appliance dealers are junking old refrigerators received in trade which have useable compressors. If such a box can be located, the compressor may be obtained for little more than the time required to remove it. Some dealers salvage useable parts for service replacement and sell tested useable compressors at prices ranging from $5.00 to $10.00. Directions for the conversion of inoperable (as well as operable) compressors have been included herein for the benefit of those unable to obtain a working unit. Inoperable units are currently selling at $1.00 in this area.

Only three major appliance manufacturers utilize a type of compressor suitable for a good vacuum pump: Frigidiare, Norge and Cold Spot. Of these, the Norge rollator belt driven unit rates best for vacuum produced and ease of compression. Frigidaire rates best for availability and second best for two stage service below 20 microns, and Cold Spot, though unsuitable for pressures below .5mm, is superior to Frigidaire as a single stage unit.

FRIGIDAIRE COMPRESSOR

A suitable unit for conversion is the Frigidaire "Meter Miser", the unit which has been standard equipment on all that company's domestic refrigerators since 1936. The smaller refrigerators contain split phase motors rated at less than 1/7 H. P. The Imperial or Cold Wall series and all those over 13 1/2 Cubic feet contain capacitor motors and the purchaser is advised to secure the capacitor as well as the compressor. Since the motor is not self starting, it is advisable to obtain the starting relay for the motor, but if this in not available one may improvise a starter from a push button or tap key.

The motor may be started by applying power to terminals 1 and 3 (see Fig. 1), and by momentarily short-circuiting terminals 2 and 3 for a period of 4 seconds. Once started, the motor will continue to run. Do not apply power for any length of time to terminal 2 as the motor will burn out.

Three important changes are necessary to secure a good vacuum. The bypass line B (Fig. 1) which serves a useful purpose in a refrigerator, defeats the attainment of a good vacuum. This line must be cut off and the ends sealed. Upon completing this operation, a vacumm of 1 mm. hg. may be obtained, providing the check valve C is open and providing the strainer N is not wet with oil. The check valve will open if the pressure in the system is over 3 mm. hg., but will remain closed if the pressure is already lower than this. The strainer, when wet with oil, will not allow gas to flow through it if the pressure is less than 10 mm. hg. The strainer may be rendered oil free and the check valve opened by passing air through the pump for a few minutes immediately before using the pump for producing a vacuum. The screen used as a strainer may also be completely removed from the pump. Once the strainer is removed, great care must be exercised to prevent the entry of dirt or foreign material into the pump.

To remove the strainer, cut the intake line D about 1" away from the case using a tubing cutter. A hack saw would produce chips which could find their way into the pump and stall it. Make a hook by bending back the point of a nail or 1/16" steel wire 120 to 150 degrees. Insert the hook into the intake and well into the strainer, press the point into the screen and pull out sharply. With one or more attempts the strainer will be pulled out. After removal of the strainer, inspect the opening with a small flashlight and remove any remaining wires with a tweezers. Cap the opening to prevent the re-entrance of dirt. A temporary cap can be made from rubber tubing and a pinch clamp.

The pump is best installed at a 10 or 15 degree angle as shown in Fig. 6, 7, and 8 and the line to the oil trap should be pitched upward away from the pump. This will assure that no oil pockets form in the line which would require pressure to move. The oil trap is made from a 1 quart milk bottle. Since the pump contains less than a quart of oil, this trap will completely prevent oil from flowing back into the system. A compressor operating for 3 hours under vacuum and with good ventilation showed a temperature rise of 30 degrees Centigrade internally. This rise is satisfactorily low.

Inoperable Frigidaire Units

A compressor which will not start may have a jammed pump and useable motor windings. Repairs can often be made quite simply once the case is opened. To open the case:

1. Cut off intake line D flush with the case with a hack saw.
2. Cut through the 1/8" thich steel case just below the cooling fins. (F)
3. When the case is cut all around, the lower section will fall off or can be pushed off easily. It is fastened only to the intake line D.
4. Saw a vertical slot about 3" long through the case but no more than necessary into the pump block. (L) This will release the pump block.
5. If the motor winding is in good condition, carefully wash away chips with kerosene and dismantle pump as follows:
   a. Remove strainer.
   b. Remove 3 small screws holding valve cover U to end Plate V; remove cover.
   c. Remove 4 machine screws holding end plate V to pump stator O. Remove end plate and support assembly in an upright position on blocks placed near the outside edges of block I.
   d. Manipulate motor rotor J to right and left with fingers. All moving parts except eccentric T will fall out onto table.
   e. Examine interior of pump for foreign material and scrape off.
   f. Clean and reassemble. If pump turns freely, apply power to test.

If the moving parts are jammed too tightly to respond to step d, proceed as follows:

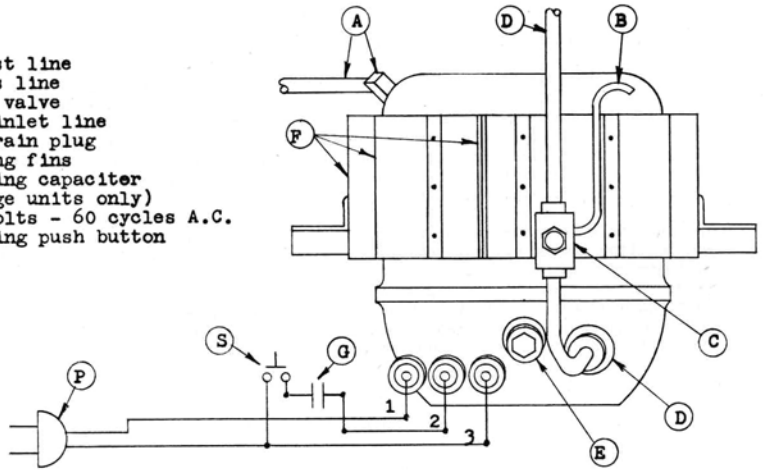
   g. Mark the shaft and hub with a file or pumch to assist in returning these parts to their correct position. If the counterweights on J are not aligned with eccentric, the pump will vibrate when run.
   h. Place a 1/2" dia. steel bar against shaft K and hammer end of bar. When shaft is driven out, all moving parts will come out with it. Do not apply the hammer to the shaft itself.

Two such cut open pumps were used as a two stage vacuum pump to produce pressures as low as 5 microns. The second stage pump was altered as follows:

FRIDGIDAIRE COMPRESSOR

Fig 1

A- Exhaust line
B- Bypass line
C- Check valve
D- Pump inlet line
E- Oil drain plug
F- Cooling fins
G- Starting capaciter
(large units only)
P- 110 volts - 60 cycles A.C.
S- Starting push button



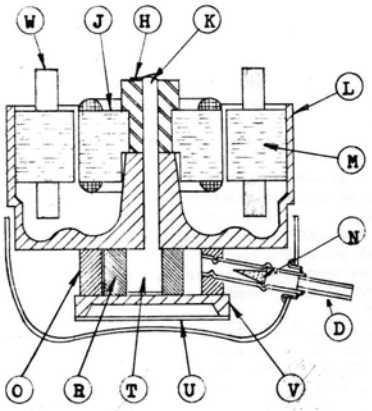


Fig 2

H- Motor rotor hub
J- Motor rotor
K- Drive shaft
L- Pump block
M- Motor stator
N- Strainer (fine wire screen)
O- Pump stator
R- Pump Rotor
T- Eccentric
U- Valve cover plate
V- Pump end plate
W- Motor winding

NORGE ROLLATOR

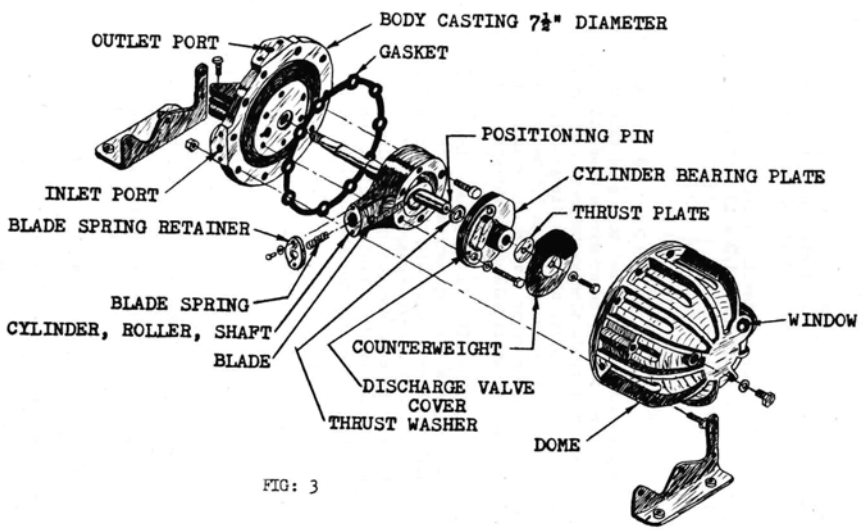


FIG: 3

1. Remove valve cover U and end plate V.
2. Carefully drill a 1/8" hole from edge of end plate into exhaust port. This requires care, as the metal is only 1/4" thick.
3. Salvage a length of 1/8" copper tubing from the compressor by-pass line and press snugly into the 1/8" hole. For best results, the tubing should be soldered (not brazed) to the end plate.
4. Remove any burrs.
5. Connect 1/8" tubing to intake of roughing stage with oil resistant rubber tubing. Line from first to second pump will give best results if it is down hill, as no pressure will be required to drive along the slight oil leakage.

A pair of pumps operated in this manner has developed pressures as low as 5 microns. These pumps were mounted in a common oil bath 6 1/2 x 13 x 6" deep in which was maintained a 3" depth of #40 motor oil.

NORGE COMPRESSORS

The only Norge unit which may readily be converted to a good vacuum pump is the Norge Rollator. This unit is belt driven and any motor may be used with it. Used units of this type are available and although production was discontinued on this model several years ago, new units are still available from distributors for about $30. Tests on these models have resulted in pressures below 0.5 mm Hg with no alteration. However, by removing the cover from the exhaust valve and raising the oil level, pressures of 20 microns were achieved while exhausting the pump to the atmosphere.

To open, lay the compressor on its back with the shaft up. Loosen the bolts in the rim of the compressor case and pry the cover up, spreading the joint no more than 1/16". Run a thin blade under the gasket so it will adhere to one side of the case or the other. Failure to do this will tear the gasket and necessitate replacement. Lift the compressor assembly from the case and remove the valve cover. (See Fig. 3.) Reassemble and add sufficient oil to cover the exhaust valve. Norge sealed units are not suitable for vacuum pumps as the strainer and check valve are inside and cannot be removed.

COLD SPOT (SEARS) COMPRESSOR

The Cold Spot is a rotary compressor of the Vane type (See Fig. 5) and only one model was available for tests; Model K 1858. The screen is readily removable, but the check valve cannot be removed without cutting away the case. It is possible but difficult to prop open the check valve with a wire forced into the intake. The check valve opens at pressures above 3mm Hg and remains open until the pressure drops to about 50 microns whereupon the valve closes again and will not reopen until the untake pressure rises to 3mm Hg again. This fact precludes its use as a second stage in either a reservoir staged unit or a two-stage pump assembly.

Unlike the Frigidaire, the Cold Spot compressor exhausts through a separate opening (B) in the case. A connection must be provided from line B to line C to return to the pump the oil that slowly emerges through line B. Except for the location of the terminal (Fig. 4) the starting procedure is similar to Frigidaire. Temperature rise in the windings is a safe 30 degrees C on continuous use.

COLD SPOT COMPRESSOR (SEARS)

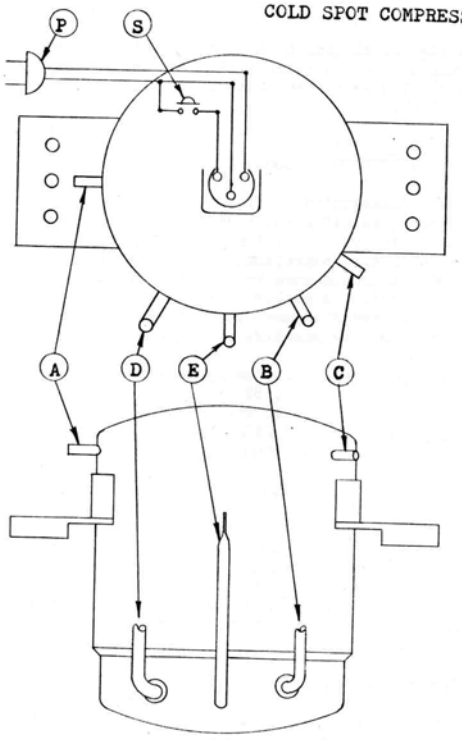


Fig 4

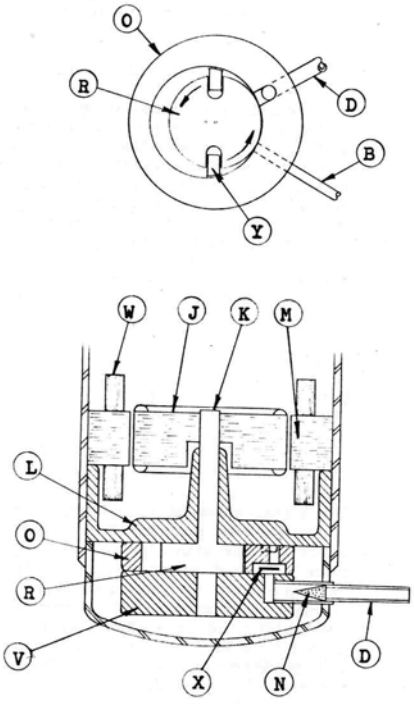


Fig 5

A- Exhaust
B- Oil line connect to C
C- connect to B
D- Pump intake line
E- Filling connection
J- Motor rotor
K- Drive shaft
L- Pump block
M- Motor stator

N- Strainer
O- Pump stator
P- 110 volts 60 cycles A.C.
R- Pump rotor
S- Starting push button
V- Pump end plate
X- Check valve
Y- Vanes

The procedure for opening a Cold Spot pump is similar to that for Frigidaire with two exceptions. 1) The bolts inside the unit are a special 12 point type which will fit no common wrenches, and 2) a 3" wide metal band must be provided to reattach the motor stator to the pump block.

APPLICATIONS OF CONVERTED COMPRESSORS

Three easily constructed pump systems are illustrated in Fig. 6,7, and 8. Each system incorporates a Frigidaire compressor, an oil trap, a dirt trap and a valve to insolate the pump from the remainder of the vacuum system. The simplest system (Fig. 6) produced a vacuum of 1.1 mm Hg with one compressor and .5 mm Hg with another. The pressures were determined with a McLeod gage reading from 1 to 1200 microns after about 5 minutes of pump operation. A number of tests were then undertaken to determine the vacuum available when the pumps were operated at exhaust pressures less than atmospheric with the following results.

Unit A	750 mm exhaust pressure	.5 mm Hg at intake
	50	.035
	20	.020
	3	.010
	.1	.005
Unit B	750	1.1
	50	.20
	20	.15
	3	.08
	.1	.010

The system shown in Fig. 7 uses a reservoir to provide an exhaust pressure of about 50 mm Hg. The pump first evacuates the system and reservoirs to a pressure of about 1 mm Hg with clamp #5 closed, all others open. Clamp 1 is then closed, clamp 5 opened and operation continued for a few minutes. This results in an exhaust pressure of about 150 mm Hg. Clamps 2 and 3 are now closed and clamp 1 opened. This exhausts the compressor case to about 30 mm Hg. The pump can operate a whole day on a closed system without increasing the reservoir pressure more than 1 or 2 millimeters of mercury. The reservoirs may be re-exhausted periodically without disturbing the rest of the system by closing clamp 4 during the process. NOTE: ENCLOSE RESERVOIRS IN WOOD BOX TO RESTRAIN BROKEN GLASS IN EVENT OF BREAKAGE.

A similar reservoir system was reported in Scientific American Magazine, Jan., 1959, page 158, using two compressors and a reservoir stage.

TWO-STAGE PUMP

Another way to reach a lower pressure than that achieved by a pump working against a back pressure of 1 atmosphere is to introduce an independent stage. This is more desirable than reservoir staging because a larger volume of gas can be handled. In effect, the two stage system is simply a reservoir which is constantly being evacuated.

Because of its nature, the two stage system can use any unit as the first stage. Using a unit evacuating to 10 mm as the first stage and an altered Frigidaire or Norge as the second stage, pressures of 0.1 mm or better can be easily achieved and maintained even under conditions which are introducing small quantities of gas into the system.

Additional Techniques

Most of the gas produced by a tightly closed system is either water vapor desorbed from surfaces or organic vapors evolved from gasket material, pump fluids of solvent materials used in samples. Water vapor is one of the most difficult materials to pump, because it liquifies under compression and hence cannot be completely expelled from the pump. Of course, as the pump warms up, the water problem diminishes, but probably does not disappear without assistance from desicants if water vapor is expected to be troublesome. Such drying agents should be put in the reservoirs which do not contain liquid. Among desicants that can be used are clacium oxide, calcium sulfate 1/2 H_2O dehydrated at 400 degrees C (sold under the trade name "Drierite") and silica gel. The last is probably best because it offers a dust free drying agent and is not corrosive. Moisture from the air can be kept from entering the pump exhaust by installing a bunsen valve which will allow flow in only one direction. This simple check velve is made by cutting a 1" longitudinal slot in rubber tubing with a razor blade. A little grease on the cut will make it completely tight.

Lubricant

For pressures lower than 1mm Hg, it may be necessary to use a vacuum pump oil in the compressors to get satisfactorily low pressures. Whether this is necessary depends on pump wear and can only be determined by experiment. If the lubricant in the pump is found to be unsatisfactory, i.e., a pressure below 1mm Hg can not be obtained after following the above procedures, the lubricant should be replaced with vacuum pump oil. About 7 oz. of oil is required. Automobile motor oil often contains excessive amounts of volatile material, and is inferior to vacuum pump oil and refrigerator lubricant.

Removal of Organic Vapors

Since the oil in the compressor (even vacuum pump oil) contains vapors of low boiling substances derived from the refrigerant or the cracking of oil under heat and use, it may be desirable to provide traps for those substances. In addition, the system to be evacuated may exude low boiling vapors.

There are two ways by which these materials can be kept out of the evacuated system. Dust free coconut or bone charcoal, previously heated to drive off moisture, may be added to the dirt trap or a low temperature trap is introduced into the system. This trap may be cooled by a mixture such as alcohol and dry ice. A cold trap is expensive and can be hazardous, therefore it should be used only if a quantity of material is expected.

Operation

Tests of several hours have indicated that with proper ventilation, any of the afore-mentioned units may be used without over heating. However, for operating economy it is desirable to turn the unit off periodically if the dirt trap or reservoir can take the exhaust from the system without undue pressure rise.

MATERIAL LIST

	System 1(Fig.6)	System 2(Fig.7)	System 3(Fig.8)
Compressor	1	1	2 *
1/16 to 1/4" Neoprene tubing	2"	2"	4"
1/4" copper tubing	2'	4'	3'
Vacuum rubber tubing	1'	2'	1'
Milk bottle	1	1	1
1/2 gal jug in wood box	1	1	1
1 gal. jug in wood box		2	
Pinch clamps	1	5	1
#7 Neoprene stoppers 2 hole	1	1	1
#6 Neoprene stoppers 2 hole	1	3	1

Optional Items:
Vacuum pump oil, about 1 quart, if need is shown by experiment
Vacuum grease, 1/2 oz.

The compressors listed below will produce vacuums of about 10 or 20 mm Hg. They are piston type units and cannot be altered for vacuum pump service, but they can be used as the first stage for the system in Fig. 8.

Copeland
Frigidaire belt driven models
General Electric
Hotpoint (G. E. and Westinghouse compressors)
Kelvinator
Philco
Spartan
Stewart-Warner
Westinghouse
All large commercial units except Norge.

Note: Not all bottle and jugs are of strength high enough for safe use. Milk bottles are safest, wine bottles and pop bottles are very good, 1/2 gallon wine jugs are good, and 1 gallon wine jugs are fair. Failure usually occurs at the bottom of the jug and is least likely in bottles and jugs where the corners are generously rounded so as to provide a minimum of flat bottom area. Flying glass from 1 quart bottles generally will not penetrate two thicknesses of corrugated cardboard. 1 gallon jugs should be enclosed in no less that 1/4" of plywood.

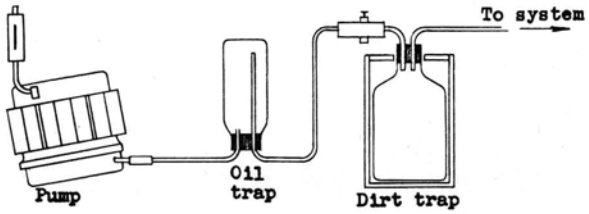


Fig. 6

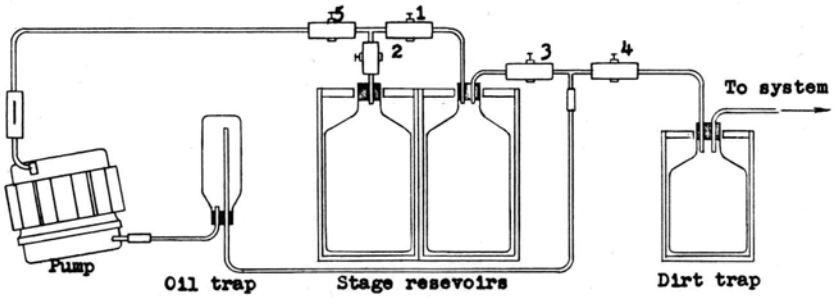


Fig. 7