(57) Abstract: A compressor (2) for a refrigeration unit having a stator (16), a rotor (40) orbiting in engagement with the stator to cyclically open, fill with refrigerant gas from at least one inlet port (56), compress and discharge compressed refrigerant gas through at least one discharge port (54), a rotary drive (18, 48, 52) for orbiting the rotor, a driven element of a magnetic coupling in driving connection with the rotary drive, a casing (4) sealed save for the ports and enclosing all of the foregoing components, a driving element (36) of the magnetic coupling outside of the casing in close proximity to the driven element (26), and a motor (34) to rotate the driving element. Preferably the rotor is a multilobed rotor orbiting within a trochoidal chamber defined by the stator. Most preferably, a three lobed rotor is journaled on an eccentric (42) carried by a shaft (18) of the rotary drive and has a ring gear (50) driven by a gear (46) of the rotary drive having the same eccentricity as the eccentric and rotated in synchronism therewith, the gear ratio of the ring gear to the eccentric being three to one.
European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for all designations

— as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations

**Published:**

— with international search report

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
FIELD OF THE INVENTION
This invention relates to refrigeration compressor units especially but not exclusively units for small refrigeration units such are suitable for use in domestic ice cream makers, small refrigerators and similar appliances. Such units must be compact, quiet, reliable and economical to manufacture and operate.

BACKGROUND OF THE INVENTION
Compressor units for domestic refrigerators are commonly of the sealed unit type in which both the compressor and a motor permanently coupled to the compressor are located within an enclosure which is completely and permanently sealed except for refrigerant connections to the remainder of the refrigeration unit. Such a unit has the disadvantages that failure of either the motor or the compressor requires both to be discarded, different sealed units are required for electrical supplies requiring different motors, even though the compressor is identical, and two devices, both of which generate unwanted heat, are thermally coupled within the same enclosure.

It is known in compressor units for automotive air conditioning systems, which are engine driven, and thus require a clutch mechanism, to utilize an electromagnetic clutch between a belt driven pulley and the compressor.

It is also known to use magnetic couplings in drives for pumps so as to avoid the necessity of sealing a drive shaft entering the pump chamber. Examples of such arrangements are to be found in U.S. Patents Nos. 3,584,975 (Frohbieter); 3,680,984 (Young et al.); 4,065,234 (Yoshiyuki et al.); and 5,334,004 (Lefevre et al.), and in ISOCHEM (Trademark) pumps from Pulsafeeder. Although the first of the patents relates to a circulation pump for an absorption type air conditioning system, the use of a permanent magnet coupling in the drive to the compressor of a compressor type refrigeration unit has not to the best of my knowledge
previously been proposed. Reasons may include the sharply fluctuating torque required by piston type compressors normally used in such systems.

In the interests of smoother and more silent compression, there has been some adoption of scroll type compressors in compression type refrigeration units, available for example from Lennox, Copeland and EDPAC International.

An alternative form of piston compressor which has been proposed, although not to the best of my knowledge for refrigeration applications, is the rotary piston compressor using a lobed rotor in a trochoidal chamber and having some superficial resemblance to rotary piston engines such as the Wankel engine although the operating cycle is substantially different and the shaft is driven by an external power source rather than being driven by the rotary piston. Such compressors are exemplified in U.S. Patents Nos. 3,656,875 (Luck); 4,018,548 (Berkowitz); and 4,487,561 (Eiermann).

U.S. Patent 5,310,325 (Gulyash) discloses a rotary engine using a symmetrical lobed piston moving in a trochoidal chamber on an eccentric mounted on a rotary shaft and driven through a ring gear by a similarly eccentric planet gear rotated at the same rate as the eccentric, the gear ratio of the ring gear to the planet gear being equal to the number of lobes on the rotor, typically three. The apices of the lobes trace trochoidal paths tangent to the trochoidal chamber wall thus simplifying sealing. There is no suggestion that similar principles of construction could be used in a compressor.

**SUMMARY OF THE INVENTION**

In its broadest aspect, the invention provides a compressor for a refrigeration unit having a stator, a rotor orbiting in engagement with the stator to cyclically open, fill with refrigerant gas from at least one inlet port, compress and discharge compressed refrigerant gas through at least one discharge port, a rotary drive for orbiting the rotor, a driven element of a magnetic coupling in driving connection
with the rotary drive, a casing sealed save for the ports and enclosing all of the
foregoing components, a driving element of the magnetic coupling outside of the
casing in close proximity to the driven element, and means to rotate the driving
element.

Preferably the rotor is a multilobed rotor orbiting within a trochoidal chamber
defined by the stator, although a scroll type compressor with stationary and
orbiting scrolls may also be utilized. Most preferably, a three lobed rotor is
journalled on an eccentric carried by a shaft of the rotary drive and has a ring
gear driven by a gear of the rotary drive having the same eccentricity as the
eccentric and rotated in synchronism therewith, the gear ratio of the ring gear to
the eccentric being three to one.

Further features of the invention will be apparent from the following description of
a presently preferred embodiment thereof.

**SHORT DESCRIPTION OF THE DRAWINGS**

Figures 1 - 4 are cross-sectional views through a compressor in accordance with
the invention, showing different phases of its operation, Figure 1 being a section
on the line 1 - 1 in Figure 5; and

Figure 5 is a longitudinal section of the unit on the line 5 - 5 in Figure 1, with the
compressor and drive separated for clarity.

**DESCRIPTION OF THE PREFERRED EMBODIMENT**

Referring to Figure 5, a compressor 2 comprises a casing 4 which is completely
sealed apart from input and output pipes 6 and 8 which connect the compressor 2
respectively to the evaporator and the condenser (not shown) of a refrigeration
unit. A third pipe 10 is used only to charge the unit with refrigerant and is then
permanently sealed. Internally the pipes 6 and 8 are connected to chambers 12
and 14 respectively (see Figs. 1 - 4) formed between the casing 4 and a stator 16
of the compressor, the chambers being separated by walls 38. A compressor
drive shaft 18 is journalled in bearings 20 in end walls 22, 24 of the stator, and carries at one end a driven element 26 of a magnetic coupling which may for example consist of concentric rings of ceramic disc magnets 28 having alternating polarities at their faces adjacent an end plate 30 of the casing 4.

The end plate 30 is secured to a motor casing 32 which mounts a motor 34 coupled to a driving element 36 of the magnetic clutch, which is similar to the driven element 26 and supports faces of its magnets 28 adjacent the end plate 30. The coupling may advantageously be designed so that the torque it can transmit is insufficient to apply damaging overloads to the compressor or the motor. The motor may be selected to suit the application. For example alternating or direct current motors for operation at any desired voltage may be utilized, or higher or lower speed motors, or variable speed motors to provide to provide high, low or variable compressor output. The motor need not be electric; for example an internal combustion engine or even a clockwork or manually powered drive could be used. Since the motor is not within the sealed unit, it is simpler to arrange for its cooling, any heat produced can be kept away from the compressor, and the motor can be of cheaper construction, as well as being replaceable.

The compressor 2 utilizes features of construction which resemble features of the motor described in U.S. Patent No. 5,310,325, the text and drawings of which are incorporated herein by reference. A trilobar rotor 40 is supported by a bearing 41 on an eccentric 42 mounted on the shaft 18 for orbital movement along a path within a trochoidal chamber 44 defined within the stator 16, through which path it is driven by an eccentric gear 46 fast on a shaft 48 journalled in the stator 16 by a bearing 49, which gear engages a ring gear 50 within the rotor 40. The rotor is sealed to the end walls 22, 24 by ring seals 51. The shaft 48 is driven by a belt 52 from the shaft 18, and together with the shaft 18 constitutes a rotary drive to the rotor 40 such that the eccentric 42 and eccentric gear 46 rotate synchronously. The ratio of the ring gear to the eccentric gear is equal to the number of lobes, in
this case three, of the rotor, and the eccentricities of the eccentric 40 and the
gear 46 are the same. The stator 16 is formed with ports 54 and 56
communicating with the chambers 12 and 14 respectively. The ports 54 may be
equipped with spring valves such as reed valves 58 to prevent unwanted reverse
flow.

Figure 1 shows the position of the rotor 40 when the maximum eccentricities of
the eccentric 40 and gear 46 are directed upwardly (as seen in the drawing). The
direction of rotation in this example is clockwise, and the apices of the lobes of
the rotor are labeled A, B and C for convenient reference. The geometry of the
rotor and stator and of the drive are such that the apices remain in contact with
the wall of trochoidal chamber 44. Apex B contacts the wall between the lower
ports 54 and 56, while the surface of the rotor between apices A and C lies
against the chamber wall, obturating the upper ports 54 and 56. As the rotor
moves clockwise, gas is drawn through the lower port 56 into the chamber
labeled D, while gas in chamber E is compressed and forced out of the chamber
through lower port 54 past valve 58 if its pressure exceeds that in chamber 14.

As the rotor reaches the position shown in Figure 2, apex B moves past lower
port 56 cutting off the induction of gas into chamber D and then apex A moves
past upper port 54 so that gas compressed in chamber D on further motion of the
rotor can pass through that port once its pressure exceeds that in chamber 14. At
the same time, that portion of the rotor between apices A and C moves away from
the stator forming chamber F into which gas is induced through upper port 56,
and pressurized gas continues to be expelled through lower port 54 from
chamber E.

In Figure 3, the position is analogous to that in Figure 1, except that apex A lies
between upper ports 54 and 56, and lower ports 54 and 56 are obturated by the
surface of the rotor between apices B and C. In Figure 4 the position is
analogous to that in Figure 2, with chamber F filled, chamber E refilling, and
compressed gas being expelled from chamber D. When the eccentric again
reaches the position shown in Figure 1, the rotor has turned through 120 degrees
and a similar sequence is then repeated. After three sequences, the rotor has
turned through 360 degrees. In effect, three compression cycles are occurring
simultaneously, 120 degrees out of phase, providing high volumetric efficiency
and a very smooth action.

Particularly if at least one of the rotor and the stator is molded from synthetic
plastic, it may be possible to dispense with apex seals, thus further simplifying
construction. The use of an external motor means that the latter may also power
other functions of apparatus including a refrigeration unit incorporating the
compressor, for example mixing paddles in an ice cream maker. The compactness
of the equipment suits it for use in portable applications such as refrigerated
protective clothing.

Although a particularly preferred embodiment of compressor has been described,
other forms of compressor using rotors orbiting in trochoidal chambers may be
utilized, as may scroll compressors.
Claims:

1. A compressor for a refrigeration unit having a stator, a rotor orbiting in engagement with the stator to cyclically open, fill with refrigerant gas from at least one inlet port, compress and discharge compressed refrigerant gas through at least one discharge port; a rotary drive for orbiting the rotor, a driven element of a magnetic coupling in driving connection with the rotary drive, a casing sealed save for the ports and enclosing all of the foregoing components, a driving element of the magnetic coupling outside of the casing in close proximity to the driven element, and means to rotate the driving element.

2. A compressor according to claim 1, wherein the rotor is a multilobed rotor orbiting within a trochoidal chamber.

3. A compressor according to claim 2, wherein the rotor is a three lobed rotor journalled on an eccentric carried by a shaft of the rotary drive and has a ring gear driven by a gear of the rotary drive, the latter gear having the same eccentricity as the eccentric and being constrained to rotate in synchronism therewith, the gear ratio of the ring gear to the eccentric being three to one.

4. A compressor according to claim 1, wherein the means to rotate the driving element is an electric motor.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

| IPC | F04C18/22 | F04C23/00 |

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

| IPC | F04C | F01C |

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

**Date of the actual completion of the international search**

7 May 2002

**Date of mailing of the international search report**

04/06/2002

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