United States Patent

Kubota et al.

[15] **3,645,358**

[45] **Feb. 29, 1972**

[54] MUFFLER FOR HERMETICALLY SEALED MOTOR COMPRESSORS

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[73] Assignee: **Tokyo Shibaura Electric Co., Ltd.,** Kawasaki-shi, Japan

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[21] Appl. No.: **102,453**

[30] **Foreign Application Priority Data**

Oct. 27, 1970 Japan.....45/106249

[52] **U.S. Cl.** .....**181/36 R,** 181/59, 417/312

[51] **Int. Cl.**.....**F01n 1/02**

[58] **Field of Search** .....181/35, 36 R, 36.4, 48, 54, 181/59, 58, 53; 417/312

[56] **References Cited**

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Primary Examiner—Robert S. Ward, Jr.
Attorney—Flynn & Frishauf

[57] **ABSTRACT**

A muffler for hermetically sealed motor compressors comprising a muffler cup constituting a resonance chamber therein, two linearly arranged tubings penetrating the muffler cup and engageably joined in its interior so as to constitute a gas passage and a plurality of openings formed at the joint of said tubings so as to cause their interior to communicate with the resonance chamber whereby noises generated by compressed gases are absorbed in the resonance chamber through said openings for silent operation of a compressor.

4 Claims, 12 Drawing Figures

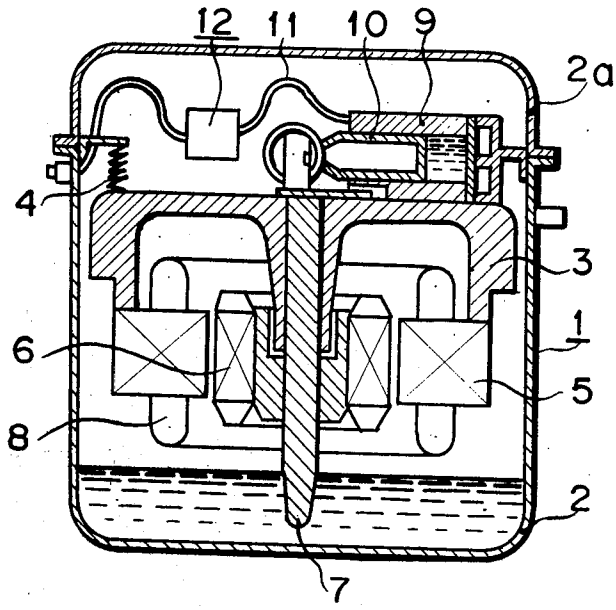


FIG. 1

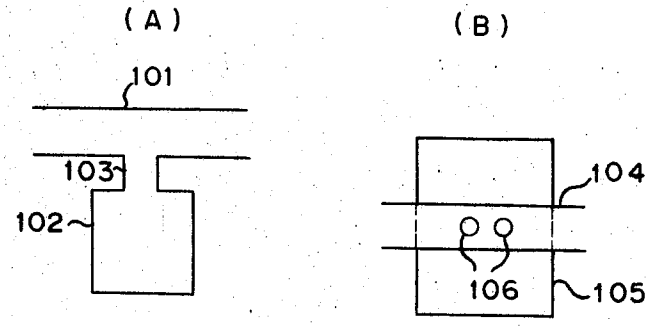

(A)
(B)
101
103
102
104
106
105

FIG. 2

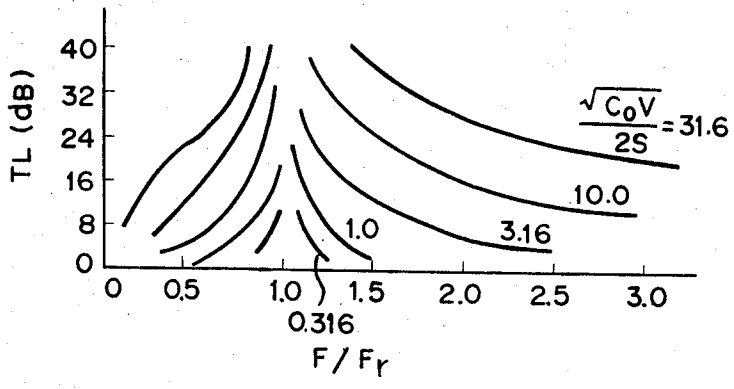

TL (dB)
40
32
24
16
8
0
0
0.5
1.0
1.5
2.0
2.5
3.0
0.316
F / Fr
√C0V / 2S = 31.6
10.0
3.16
1.0

FIG. 3

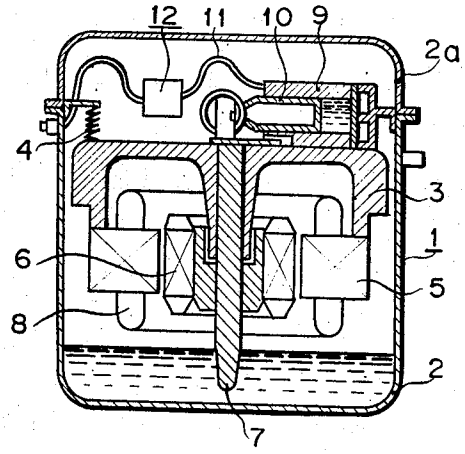


FIG. 4

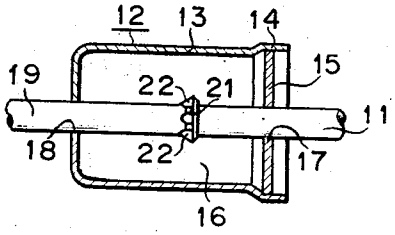


FIG. 5

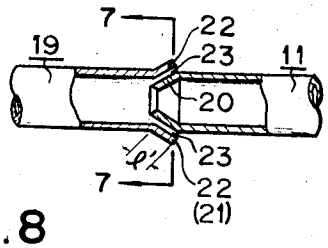


FIG. 6

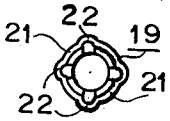


FIG. 7

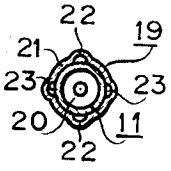


FIG. 8

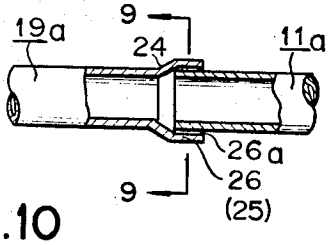


FIG. 9

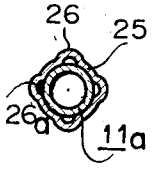


FIG. 10

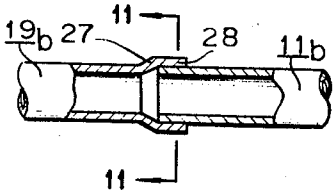
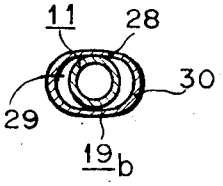


FIG. 11



MUFFLER FOR HERMETICALLY SEALED MOTOR COMPRESSORS

The present invention relates to a muffler used in, for example, a small hermetically sealed motor compressor and more particularly to a muffler of resonance absorption type.

In recent years, there has been growing demand to reduce or suppress noises occurring in a small compressor while it is operated for a cooling system consisting of a compressor, condenser and evaporator. To meet this demand, there have been proposed a method of broadening the wall thickness of a compressor seal casing and a method of fitting a muffler to the compressor. The former results in not only the increased weight but also the high cost of the compressor, failing to be put to practical application, so that the latter has had to be exclusively relied on.

Mufflers heretofore widely accepted for the above purpose are of the resonance type and may be broadly classified into two types, i.e., the one wherein a gas tubing is made to communicate with a resonance chamber through a small duct and the one wherein a resonance chamber is penetrated by a gas tubing, which is perforated with resonance holes in that part enclosed in said chamber. Both types are indeed capable of reducing noises of a particular frequency, but they still have the following drawbacks. Namely, to increase the decibel value of noises, the aforesaid small duct has to be extended for the former type, resulting in the bulkiness of a muffler as a whole. With the latter type, it is necessary to increase the wall thickness of a gas tubing, enlarge the diameter of the resonance holes or provide more resonance holes. Particularly with the latter type of muffler, there are not only presented difficulties in drilling the gas tubing, but also said drilling most likely leads to the occurrence of fins or burrs on the inner walls of the gas tubing which are difficult to remove. If such unnecessary appendage falls off during the compressor operation, it will possibly be carried into a cooling system to cause its failure.

It is accordingly an object of the present invention to provide a muffler for hermetically sealed compressors wherein tubings are engageably joined in a resonance chamber, and part of the tubing joint is perforated with at least one hole so as to cause the interior of the tubings to communicate with that of the resonance chamber, enabling noises of particular frequency to be reduced with great ease by resonance absorption.

Another object of the invention is to provide a compact inexpensive muffler wherein the occurrence of failure is minimized due to elimination of the work of drilling tubings.

Still another object of the invention is to provide a muffler wherein tubings are joined in a resonance chamber, thereby enabling said joint to be accurately positioned and facilitating their assembly.

The present invention can be more fully understood from the following detailed description when taken with reference to the accompanying drawings, in which:

FIGS. 1A A and 1B are schematic illustrations of the prior art mufflers;

FIG. 2 is a curve diagram showing the properties of the mufflers of FIGS. 1A and 1B;

FIG. 3 is a longitudinal sectional view of a hermetically sealed motor compressor using an embodiment of the present invention;

FIG. 4 is a longitudinal sectional view of a muffler according to an embodiment of the invention;

FIG. 5 is a side view, partly in section, of the joint of gas tubings included in the muffler of FIG. 4;

FIG. 6 is a cross-sectional view of the engaged part of the gas tubings;

FIG. 7 is a sectional view on line 7—7 of FIG. 5;

FIG. 8 is a side view, partly in section, of a gas tubing joint according to another embodiment of the invention;

FIG. 9 is a cross-sectional view on line 9—9 of FIG. 8;

FIG. 10 is a side view, partly in section, of a gas tubing joint according to still another embodiment of the invention; and

FIG. 11 is a sectional view on line 11—11 of FIG. 10.

For better understanding of the present invention, there will now be described the operation of the conventional muffler.

FIG. 1 schematically illustrates the prior art muffler. FIG. 1A represents one example of said muffler and FIG. 1B another. Referring to FIG. 1A, numerals **101**, **102** and **103** respectively denote a gas tubing, resonance chamber and small duct connecting the gas tubing **101** with the resonance chamber **102**. In FIG. 1B, numerals **104**, **105** and **106** respectively show a gas tubing, resonance chamber and resonance holes causing the interior of the gas tubing **104** to communicate with that of the resonance chamber **105**.

Throughout both figures, let the following characters represent the items given opposite thereto:

a: radius of the small duct **103** or resonance holes **106**
A: cross-sectional area of the small duct **103** or all the resonance holes put together
V: volume of the resonance chamber **102** or **105**
S: cross-sectional area of the gas tubing **101** or **104**
c: sound velocity
β: correction due to the end effect of tubing
fr: resonance frequency
f: frequency of sounds generated by compressed gas
Co: propagation rate of sounds
T_L: decibel value of transmission loss,

Then,

$$T_L = 10 \log_{10}\left[1+\left(\frac{\sqrt{\frac{CoV}{2S}}}{f/fr-fr/f}\right)^2\right] \quad (1)$$

$$fr=\frac{c}{2\pi}\sqrt{\frac{Co}{V}} \quad (2)$$

Where, in FIG. 1A, the length of the small duct **103** is designated as *l*,

then,

(3)

Where, in FIG. 1B, the number of the resonance holes **106** is designated as *n* and the wall thickness of the gas tubing **104** as *t*,

then,

$$Co=(A/l+2\beta a)$$
$$Co=nA/(t+0.8\sqrt{A}) \quad (4)$$

FIG. 2 presents the properties of a muffler showing the relationship between the decibel value of transmission loss of noises t_L and f/fr, with $\sqrt{CoV/2S}$ taken as a parameter. As seen from this figure, if $\sqrt{CoV/2S}$ and in consequence *Co* (when *V* and *S* have a fixed value) are made to assume a large value, the muffler effect will be elevated.

Where it is desired to reduce high-frequency noises with the volume of the resonance chamber **102** or **105** fixed, it will be seen from the equation (2) that *Co* will have to be increased. To elevate *Co*, it will be necessary, in the case of FIG. 1A, to shorten the length *l* of the small duct **103** and, in the case of FIG. 1B, increase the number *n* of the resonance holes **106** or enlarge their radius *a*.

There will now be described by reference to FIG. 3 a hermetically sealed motor compressor using a muffler according to an embodiment of the present invention. Referring to FIG. 3, the casing **1** of a hermetically sealed motor compressor comprises a lower shell **2** open at the top and an upper shell **2***a* so disposed as to close up said opening. In the casing **1**, a support frame **3** is supported by a spring **4**. To the support frame **3** is fitted an electric motor **8** consisting of a stator **5**, rotor **6** and rotating shaft **7**. The support frame **3** is further provided with a piston **10** which is made to reciprocate through a cylinder **9** by the rotating shaft **7** of the electric motor **8**. Numeral **12** denotes a muffler for reducing noises generated by compressed gas.

There will now be described the muffler **12** by reference to FIGS. 4 to 6. FIG. 4 illustrates the muffler **12** received in the casing **1**. A muffler cup **13** assumes a blind cylindrical form open at one end. To an engaging flange **14** disposed around the opening is brazed a substantially disklike muffler cap **15** to constitute a hermetically sealed resonance chamber **16**. The muffler cap **15** is bored at the center with a hole **17** through

which there is inserted a first gas tubing **11** extending from the compressor outlet in airtight relationship by means of welding or brazing. The bottom plate of the muffler cup **13** is also perforated at the center with a hole **18** through which there is inserted a second gas tubing **19** communicating with the inlet port of a condenser (not shown) similarly in airtight relationship by means of welding or brazing. Both tubings **11** and **19** are engageably joined in the muffler cup **13**. The open end of the first gas tubing **11** constitutes, as shown in FIG. **5**, a conical overlapping part **20** and the open end of the second tubing **19** assumes a flared overlapping part **21** so as to receive the conical overlapping part **20** of the first tubing **11**. On the inner wall of the flared overlapping part **21** are spatially arranged a plurality of outwardly expanding projections **22**, thereby providing gaps **23** between the flared overlapping part **21** and the peripheral surface of the conical overlapping part **20** received therein so as to cause the interior of both gas tubings **11** and **19** to communicate with that of the muffler cup **13**. In this case, the position of their joint is accurately defined by the contact of the outer peripheral surface of the conical overlapping part **20** of the first gas tubing **11** with the inner peripheral surface of the flared overlapping part **21** of the second gas tubing.

There will now be described the operation of a muffler constructed as described above. A compressed fluid drawn out of the compressor or a gaseous refrigerant flows through the resonance chamber **16** from the first tubing **11** to the second tubing **19**. At this time, noises having a frequency corresponding to the overall volume defined by the gaps provided in the joint of both tubings **11** and **19** and the resonance chamber **16** of the muffler cup **13** (said frequency is hereinafter referred to as "resonance frequency") are reduced by resonance absorption. Proper selection of the conditions of said resonance absorption permits the reduction of noises of a certain frequency.

Where the resonance frequency is to be changed, it is only required to vary the propagation rate of sounds *Co* as described in connection with the prior art muffler. In the case of the foregoing embodiment, the propagation rate of sounds *Co* may be expressed as follows:

$$Co=nAs'/(l'+0.8\sqrt{As'}) \quad (5)$$

where

n: number of the gaps **23**

l': engaged length of both tubings **11** and **19**

As': total cross-sectional area of the gaps **23**

As seen from the equation (5) above, the total cross-sectional area of the gaps **23** can be easily adjusted to the resonance frequency of noises which should be reduced.

There will now be described by reference to FIGS. **8** and **9** a muffler according to another embodiment of the present invention. The open end of the second gas tubing **19***a* penetrating the bottom plate of the muffler cup **13** in airtight relationship constitutes a cylindrical overlapping part **25** of enlarged diameter including a funneled-stepped portion **24**. Into said enlarged diameter part is inserted the overlapping part of the first gas tubing **11***a* extending from the compressor. Further on the inner wall of said enlarged diameter part **25** are spatially arranged a plurality of outwardly expanding projections **26**, thereby providing gaps **26***a* so as to cause the interior of both tubings **11***a* and **19***a* to communicate with that of the muffler cup **13**.

There will now be described by reference to FIGS. **10** and **11** a muffler according to still another embodiment of the invention. The open end of the second tubing **19***b* penetrating the bottom plate of the muffler cup **13** in airtight relationship constitutes a cylindrical overlapping part **28** of enlarged diameter including a taper stepped portion **27**. Said enlarged diameter part is slightly flattened, as illustrated in FIG. **11**, so as to form a laterally expanding deformed portion **30** having a substantially elliptic cross section, thereby providing gaps **29** which permit the interior of both tubings **11***b* and **19***b* to communicate with that of the muffler cup **13**.

In the embodiments of FIGS. **8** to **11**, as in those of FIGS. **5** to **7**, the total cross-sectional area of the gaps **26***a* or **29** can be easily adjusted to the resonance frequency of noises which should be reduced, by changing the number of said gaps **26***a* or **29** and the engaged length of both tubings.

What we claim is: claim

1. A muffler for hermetically sealed motor compressors comprising a muffler cup including a resonance chamber; a first gas tubing having an overlapping part formed at its open end disposed in the resonance chamber; a second gas tubing communicating with a condenser and having an overlapping part formed at the open end of said tubing so as to receive the overlapping part of the first gas tubing; and a plurality of gaps provided in the space defined between said overlapping parts so as to cause the interior of both tubings to communicate with that of the resonance chamber.

2. The muffler according to claim **1** wherein the overlapping part of the first gas tubing is formed into a conical shape, the inner wall of the overlapping part of the second gas tubing takes a funneled shape so as to allow the outer peripheral surface of the overlapping part of the first gas tubing to fit in therewith and the gaps are provided in the space defined between the projections formed on the inner wall of the overlapping part of the second tubing and the outer peripheral surface of the overlapping part of the first gas tubing.

3. The muffler according to claim **1** wherein the overlapping part of the second gas tubing takes a tubular form with an enlarged diameter so as to receive the overlapping part of the first gas tubing and the gaps are provided in the space defined between the projections formed on the inner wall of the overlapping part of the second tubing and the outer peripheral surface of the overlapping part of the first gas tubing.

4. The muffler according to claim **1** wherein the outer periphery of the overlapping part of the first gas tubing takes a conical form and the overlapping part of the second gas tubing takes a funneled form having a substantially elliptic cross section, and the gaps are defined by the inner wall of the overlapping part of the second gas tubing and the outer wall of the overlapping part of the first gas tubing.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,645,358 Dated February 29, 1972

Inventor(s) Tadao KUBOTA et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 36 - insert the equation --Co = A/(1+2βa)--

Column 2, line 40 - delete the equation"Co = (A11+2βa)".

Signed and sealed this 15th day of August 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

PO-1050
(5/69)

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