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Nagao et al.

[11] **3,737,608**

[45] **June 5, 1973**

[54] **METHOD AND APPARATUS FOR STERILIZING THE INTERIOR OF A VESSEL CONTAINING A FLUID WITH SOME VOID SPACE ALLOWED THEREIN**

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

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[52] **U.S. Cl.** ..... **219/10.55,** 21/80, 21/102 R, 99/249, 99/253

[51] **Int. Cl.** **H05b 9/06,** A611 3/00

[58] **Field of Search** ..... 219/10.55; 21/80, 21/102 R; 99/217, 249, 252

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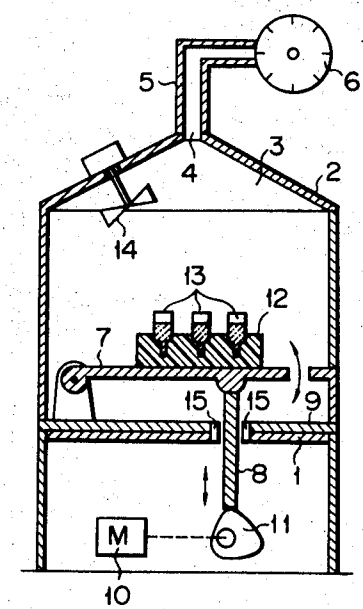
Assistant Examiner—Hugh D. Jaeger
Attorney—Kemon, Palmer & Estabrook

[57] **ABSTRACT**

A method for thermally sterilizing the interior of a vessel containing a fluid with some void space allowed therein comprises moving the vessel so as to cause the fluid contained therein to flow over its entire inner walls and irradiating microwave energy to the vessel while it is moved.

2 Claims, 13 Drawing Figures



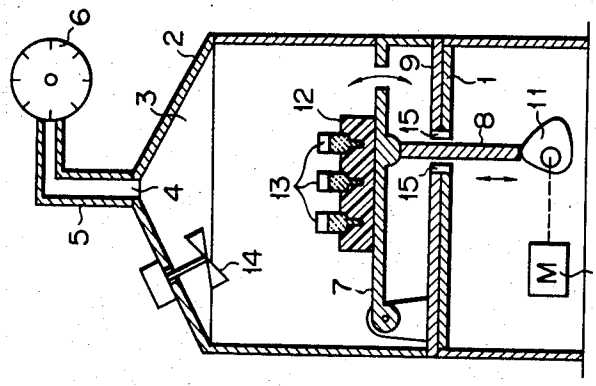


FIG. 1

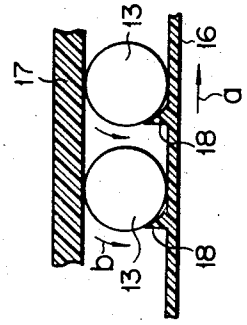


FIG. 2B

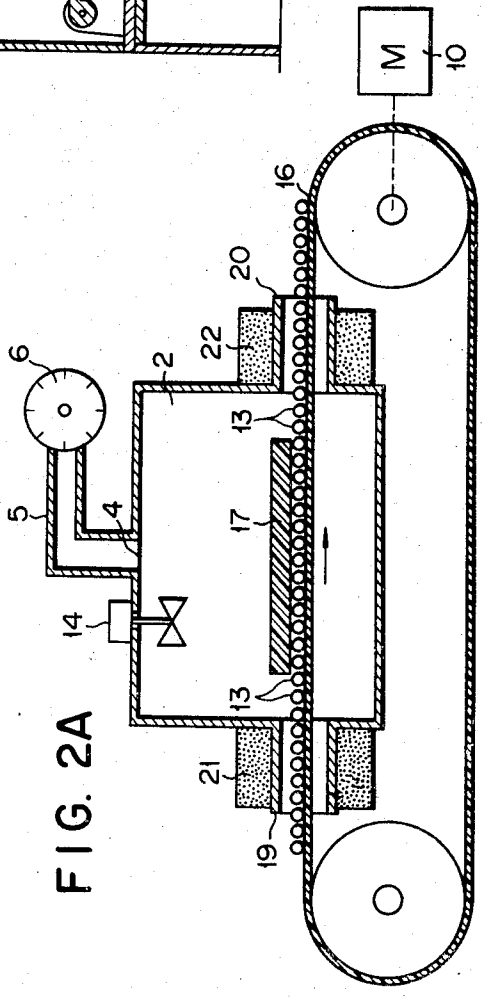


FIG. 2A

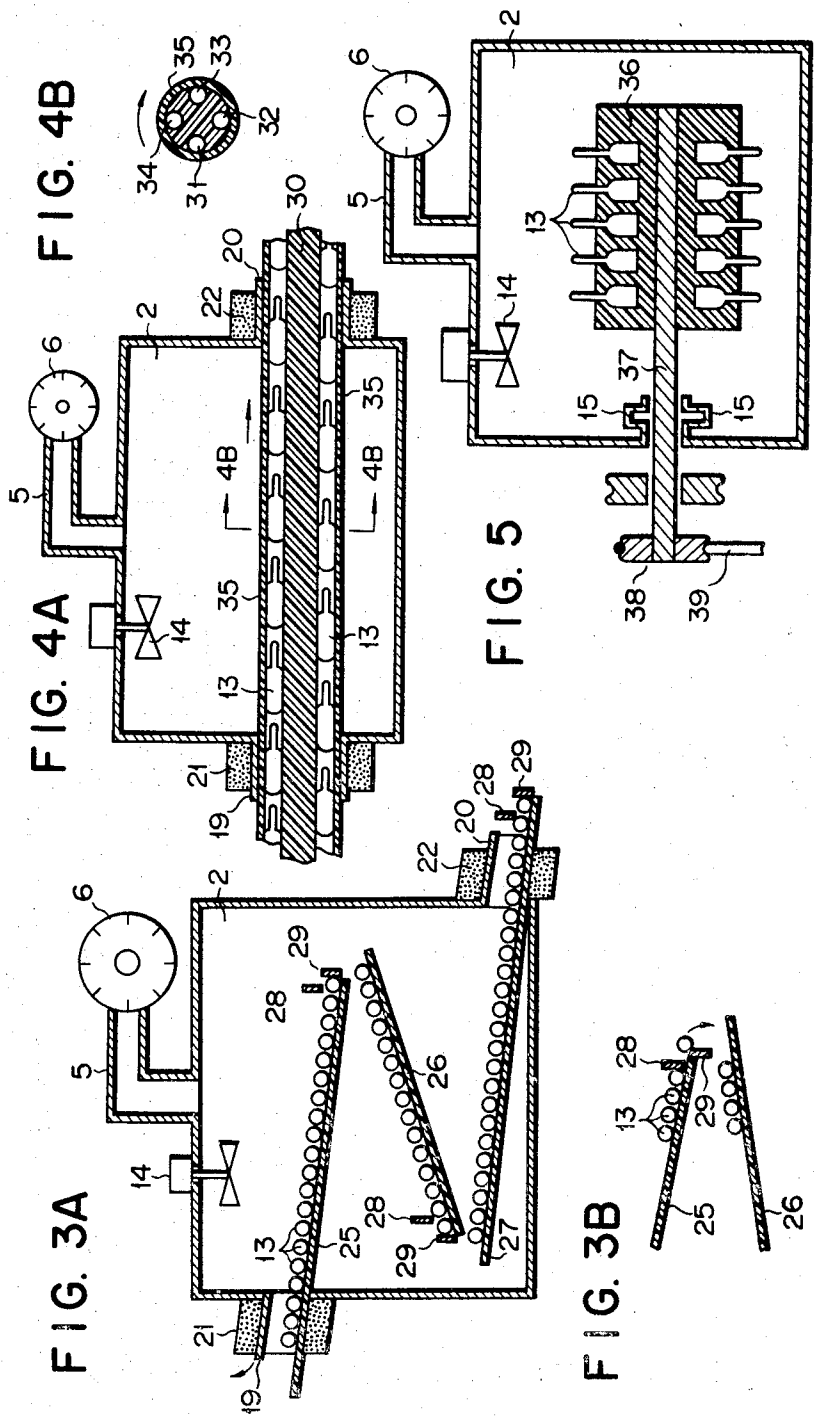


FIG. 4B
FIG. 4A
FIG. 5
FIG. 3A
FIG. 3B

FIG. 7A

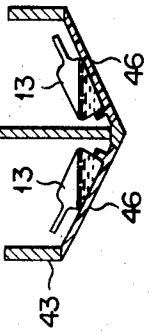


FIG. 7B

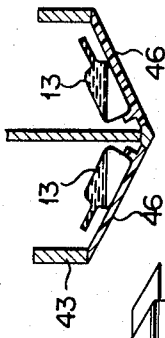
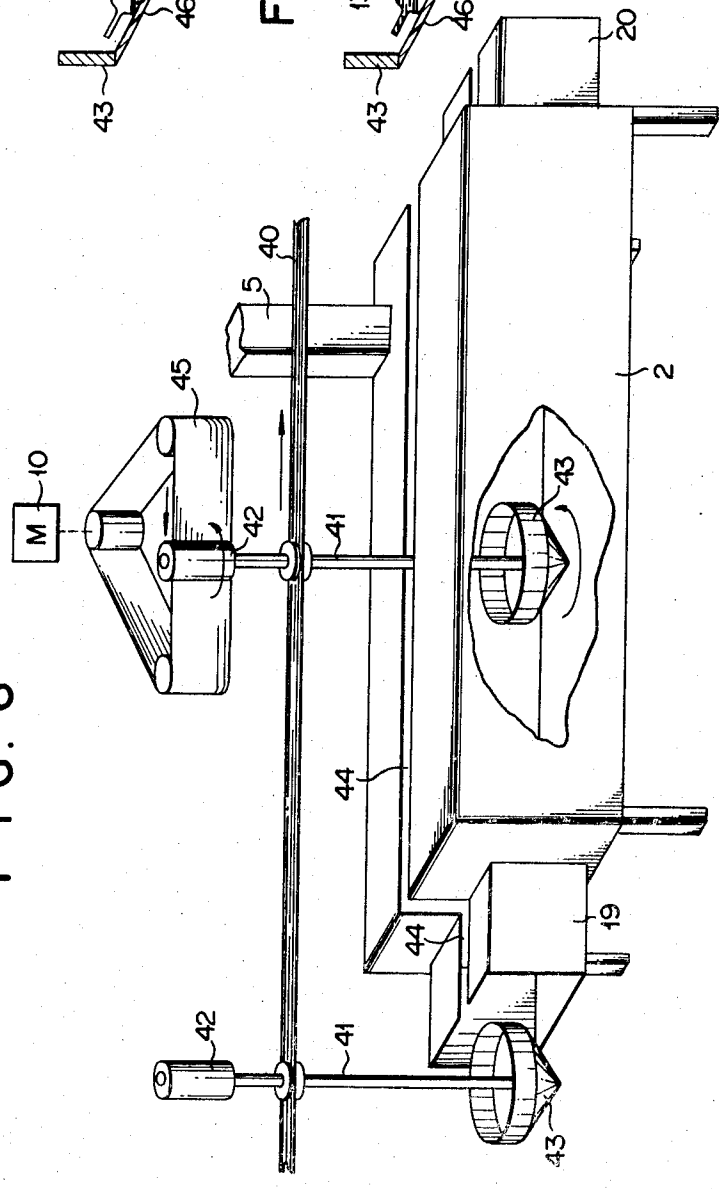
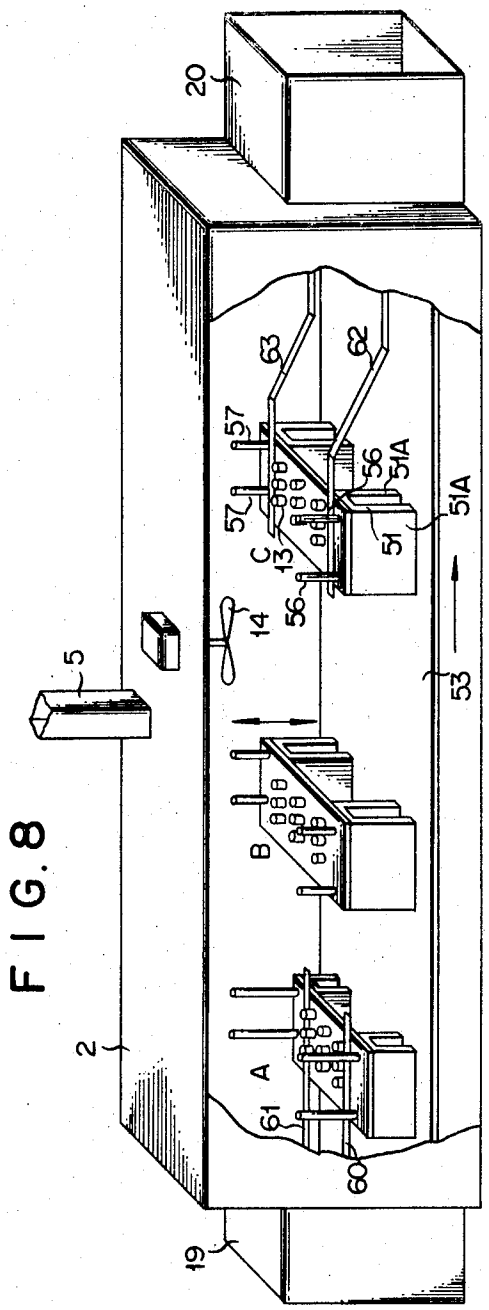


FIG. 6




20
63
62
57
56
51A
51
57
C
13
56
14
5
53
51A
B
2
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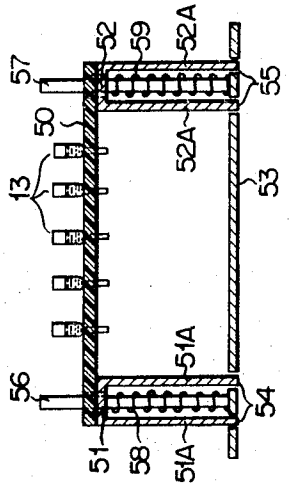
61
60
19

FIG. 8


57
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51A

FIG. 9

METHOD AND APPARATUS FOR STERILIZING THE INTERIOR OF A VESSEL CONTAINING A FLUID WITH SOME VOID SPACE ALLOWED THEREIN

This invention relates to a method and apparatus for sterilizing the interior of a fluid-containing vessel by applying microwave energy to the fluid.

Fluid materials are generally handled as contents of a vessel. Among these fluid materials, certain kinds of liquid medicine and beverage should be preserved in a vessel in a sterilized state free from harmful germs. However, it often happens that miscellaneous germs are carried into a vessel due to the imperfect washing of its interior or while it is filled with a fluid material. Therefore, it is general practice to apply low or high temperature sterilization to the vessel after it is sealed. Thermal sterilization is generally effected by, for example, application of infrared rays or boiling. These processes only heat the outer surface of a vessel, so that there is required unduly long time for the interior of a substance contained therein to be heated up to a prescribed temperature for sterilization. Moreover, heating is conducted ununiformly. There has been proposed another thermal sterilization method using microwaves. However, this method is accompanied with the following drawback. Generally, liquid medicine is received in an ampule in a manner to occupy half or one-third of its inner volume, with the remaining space filled with a gas compressed with a higher pressure than the atmospheric. When microwaves are applied to such ampule, the portion mainly heated is only the medicine contained therein. Those inner walls of the ampule which are not contacted by the medicine but exposed to the gas are not practically heated. This is due to the fact that the ampule made of glass or plastics material does not absorb high frequency waves and causes heat to be unduly radiated due to its thin walls. Therefore, even when the medicine in the ampule is heated to a sufficiently high temperature to obstruct the growth of miscellaneous germs, residual germs settled on the inner walls do not perish. Moreover, if microwaves continue to be applied, the medicine will eventually boil, causing the ampule to be damaged due to the resulting excessive vapour pressure.

It is accordingly the object of this invention to provide a method and apparatus for fully sterilizing the interior of a fluid-containing vessel by irradiation of microwaves.

According to an aspect of this invention, there is provided a method for sterilizing the interior of a vessel containing a fluid containing void space which comprises moving the vessel in such a manner as to cause the fluid contained therein to flow over its entire inner walls and applying microwave energy to the vessel while it is being moved.

According to another aspect of the invention, there is provided an apparatus for sterilizing the interior of a vessel containing a fluid with some void space allowed therein, which comprises a microwave power source; a microwave oven; a waveguide for conducting microwaves from the microwave generator to the microwave oven; and a support member provided in the microwave oven for moving the vessel so as to cause the fluid contained therein to flow over its entire inner walls.

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

FIG. 1 is a schematic sectional view of a microwave sterilizer according to an embodiment of this invention;

FIG. 2A represents another embodiment of the invention;

FIG. 2B illustrates the manner in which the sterilizer of FIG. 2A is operated;

FIG. 3A shows another embodiment of the invention;

FIG. 3B indicates the manner in which the sterilizer of FIG. 3A is operated;

FIG. 4A is a schematic illustration of still another embodiment of the invention;

FIG. 4B is a sectional view on line 4B—4B of FIG. 4A;

FIG. 5 indicates a further embodiment of the invention;

FIG. 6 is a schematic perspective view of a still further embodiment of the invention;

FIG. 7A shows the condition of vessels when the vessel support of FIG. 6 is not rotated;

FIG. 7B indicates the condition of vessels when the vessel support of FIG. 6 is rotated;

FIG. 8 is a schematic perspective view of a still further embodiment of the invention; and

FIG. 9 shows the construction of the vessel support of FIG. 8.

There will now be described specific embodiments of this invention by reference to the appended drawings. Throughout the figures, the same parts are denoted by the same numerals. Referring to FIG. 1, there is formed a microwave irradiation window 4 at the top 3 of a metal microwave oven 2 mounted on a base 1. To the microwave irradiation window 4 is connected through a waveguide 5 a microwave power source 6, for example, a magnetron. In the microwave oven 2 is disposed a vessle support member 7 permissibly made of metal and rockably supported at one end. A drive rod 8 for rocking the support member 7 penetrates the base 1 and the bottom 9 of the microwave oven 2 to abut at the inner end on the underside of the support member 7 near its free end and contact a cam 11 driven by a motor 10 at the other end. On the support member 7 is mounted a holder 12 of vessels, for example, ampules which consist of a material minimizing the loss of high frequency waves such as polytetrafluoroethylene, polypropylene or silicone rubber. To the holder 12 are attached ampules 13 with the pointed end directed downward. Reference numeral 14 represents a known stirrer fan for distributing microwaves in all directions within the oven 2, and 15 denotes a known choke portion for preventing the outward leakage of microwaves.

When the support member 7 is repeatedly rocked by motor drive, the liquid medicine in the ampule 13 is distributed throughout its interior. When, under such condition, the microwave power source 6 is actuated, the whole of the ampule is fully heated by microwave energy. For example, where there was applied one minute microwave enerby of 2450 MHz and 2 Kw to one hundred glass ampules each of 5 c.c. containing 2 c.c. water to which there were purposely added hay bacilli, the ampules, as well as the content, were heated to 100°C, presenting a full sterilizing effect.

FIG. 2A shows another embodiment of this invention, wherein microwaves are irradiated on ampules while they are rolled in a microwave oven. To this end,

there is provided a belt conveyor **16** for carrying ampules thereon which are to be forwarded by the motor **10** through the oven **2** in the direction of the arrow. The belt conveyor is formed of the same material as described above which minimizes loss of high frequency waves. There is also provided a cover plate **17** made of the same material as the belt conveyor **16** and fixed in the oven by proper means (not shown) so as to allow ampules placed on the belt conveyor **16** to be rolled.

The belt conveyor **16** has pawls **18** formed on its upper surface as illustrated in FIG. **2B** which engage ampules **13.** As apparent from this figure, the ampules **13** whose top contacts the cover plate **17** are sent forward in the direction of the arrow "*a*" through the oven **2** while rolling counterclockwise in the direction of the arrows "*b*," thus causing the liquid medicine in the ampule **13** to be distributed over its entire inner walls. When, under such condition, there are irradiated microwaves, the interior of the ampule **13,** as well as its content, are fully sterilized.

The reference numerals **21** and **22** in FIG. **2A** are known lossy portions provided around the inlet **19** and outlet **20** of the oven **2,** which consist of a vessel made of, for example, polypropylene and filled with water or sand so as to prevent the outward leakage of microwaves.

FIG. **3A** is a modification of FIG. **2A,** which is designed to cause ampules **13** to roll by gravitational fall. To this end, there are provided in the oven **2** inclined chutes **25, 26** and **27.** When ampules **13** are placed on the first chute **25** at the upper inlet **19** of the oven **2,** they roll down the first, second and third chutes **25, 26** and **27** in turn to be taken out of the lower outlet **20** of the oven **2.** In this case, there is produced the same sterilizing effect as in the preceding case. The lower end portions of the chutes may be provided with shutter means **28** and **29** driven by proper device (not shown) so as to allow the ampules **13** to fall one by one on to the succeeding chutes. In FIG. **3A,** the ampules on the chutes are prevented from falling on to the succeeding ones by the shutter means **28** and **29,** while in FIG. **3B,** the lowest ampule **13** alone is allowed to fall on to the following chutes due to the movement of the shutters **28** and **29.**

Referring to FIG. **4A,** the reference numeral **30** shows a cylindrical ampule guide penetrating the microwave oven **2.** This guide is made of the same material as in the preceding cases which minimizes loss of high frequency waves and has four guide grooves **31, 32, 33** and **34** formed lengthwise along the outer periphery as shown in FIG. **4B.** Ampules **13** are fitted into the guides **31, 32, 33** and **34** as illustrated in FIG. **4A.** After the ampules **13** are placed in the grooves, the cylindrical ampule guide **30** is covered with sleeves **35** formed of the material which similarly reduces loss of high frequency waves. The cylindrical ampule guide **30** is made to travel from the inlet **19** to the outlet **20** of the oven **2,** and at the same time rotate clockwise as indicated in FIG. **4B.** Therefore, the embodiment of FIG. **4A** has the same full sterilizing effect as the preceding embodiments.

Referring to FIG. **5,** the reference numeral **36** is an ampule-holding chuck portion fitted to a shaft **37,** one end of which extends into the oven **2.** This chuck portion **36** is formed of the same material as in the preceding embodiments which minimizes loss of high frequency waves. To the outer end of the shaft **37** is fitted a pulley **38** which is coupled with a motor (not shown) by a belt **39.** According to the embodiment of FIG. **5,** there are irradiated microwaves while the motor is stopped. When the chuck portion **36** is rotated upon the drive of the motor, the ampules are fully sterilized in the same manner as in he foregoing cases.

Referring to FIG. **6,** the reference numeral **40** denotes a rail disposed above the oven **2.** To this rail **40** is rotatably fitted a shaft **41,** to the upper end of which there is fixed a pulley **42,** and to the lower end of which there is attached an ampule holder **43.** The rail **40** is made to travel in the direction of the arrow. To this end, there is formed in the upper surface of the oven **2** a slit **44** extending throughout the surface so as to guide the shaft **41** through the oven **2.** When the shaft **41** enters the slit **44** by the movement of the rail **40,** the ampule holder **43** is introduced into the oven **2** through the inlet **19.** Under this condition, the ampule holder **43** is carried forward in the travelling direction of the rail **40.** When the ampule holder **43** is brought near the center of the oven **2,** the pulley **42** fitted to the top of the shaft **41** rotates by contact with a belt **45** driven by a motor **10,** causing the ampule holder **43** to rotate substantially at the center of the oven **2.** When the pulley **42** is released from the belt **45,** the ampule holder **43** stops its rotation and is brought to the outlet **20** of the oven **2** by the movement of the rail **40.** FIG. **7A** represents the condition of the ampules **13** when the ampule holder **43** does not rotate. At this time, the liquid medicine contained the ampule **13** remains at the bottom. Upon rotation of the ampule holder **43,** the medicine is brought upward by the centrifugal force applied thereto as shown in FIG. **7B.** Therefore, the alternate rotating and non-rotating operation of the ampule holder **43** in the oven **2** enables the ampule **13** to be fully sterilized. Those parts of the ampule holder **43** which are brought into contact with ampules **13** are made of the same material as in the preceding embodiments which minimizes loss of high frequency waves.

The embodiment of FIG. **6** is provided with a lossy or choke portion (not shown) as in the preceding embodiments to prevent microwaves from leaking out of the openings of the oven **2.**

According to the embodiment of FIG. **8,** the ampule holder **50** is shaken by the action of a spring. The holder **50** is mounted, as shown in FIG. **9,** on metal supports **51** and **52** having leg portions **51A** and **52A,** the lower ends of which are fitted into two pairs of slits **54** and **55** respectively formed in a metal belt **53.** The ampule holder **50** and supports **51** and **52** are penetrated by rods **56** and **57,** the lower ends of which contact those portions of the belt **53** defined between the respective pairs of slits **54** and **55.** The ampule holder **50** is normally urged upward by springs **58** and **59** stretched between the metal supports **51** and **52** and the belt **53.**

The belt **53** moves in the direction of the arrow of FIG. **8.** When the ampule holder **50** is brought to a section A near the inlet **19** of the oven **2,** it is forced downward by metal rails **60** and **61.** When the ampule holder **50** leaves the rails **60** and **61** by further movement of the belt **53,** it is vertically shaken at a section B, as shown by the arrows, by the action of the springs **58** and **59.** When the ampule holder **50** further advances to a section C, it is gradually forced downward by downwardly bent rails **62** and **63** to stop its shaking. The ampule holder **50** consists of the same material as

in the preceding embodiments which minimizes loss of high frequency waves. The metal supports **51** and **52** well serve to prevent discharges of microwave energy from the springs **58** and **59.**

This invention is adapted to sterilize the interior of capped bottles or other vessels in addition to ampules. And the materials to be sterilized include not only liquid medicine, but also other fluid materials requiring sterilization such as milk, juice or other beverage.

What we claim is:

1. An apparatus for sterilizing the interior of ampuls each having a neck portion and a body portion and containing a liquid medicine with some void space therein comprising:

a microwave power source;

a microwave oven;

a waveguide for conducting microwaves from said microwave power source to said microwave oven;

an ampul holder for supporting ampuls with their neck portions directed downward; and

means for moving said ampul holder up and down within said microwave oven.

2. An apparatus for sterilizing the interior of ampuls each having a neck portion and body portion and containing a liquid medicine with some void space therein comprising:

a microwave power source;

a microwave oven;

a waveguide for conducting microwaves from said microwave power source to said microwave oven;

an ampul holder for supporting ampuls with their neck portions directed downward;

conveyor means for moving said ampul holder horizontally in said microwave oven;

spring means for urging upward said ampul holder on said conveyor means; and

means provided in said microwave oven for forcing downwardly said ampul holder against the force of said spring means until said ampul holder further moves and disengages therefrom, thereby to permit said spring means to move said ampul holder up and down.

* * * * *