United States Patent

Mole

[15] **3,663,307**

[45] **May 16, 1972**

[54] THERMOELECTRIC DEVICE

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[73] Assignee: **Westinghouse Electric Corporation**, Pittsburgh, Pa.

[22] Filed: **Feb. 14, 1968**

[21] Appl. No.: **705,507**

[52] **U.S. Cl.** **136/204**, 136/212

[51] **Int. Cl.** **H01v 1/32**

[58] **Field of Search** 136/203, 204, 205, 211, 212, 136/230

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Assistant Examiner—Harvey E. Behrend
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[57] **ABSTRACT**

A thermoelectric pellet is disposed between and attached to two metal plates by suitable means, such as metallurgical bonding. A structural member, such as an annulus composed of an epoxy resin having a characteristic of shrinking when cured, surrounds the pellet and is bonded to the metal plates, thereby sealing it from the atmosphere. The structural member is so arranged that the pellet is maintained under a substantial compression load at all times and the complete structure is both rigid and strong.

13 Claims, 12 Drawing Figures

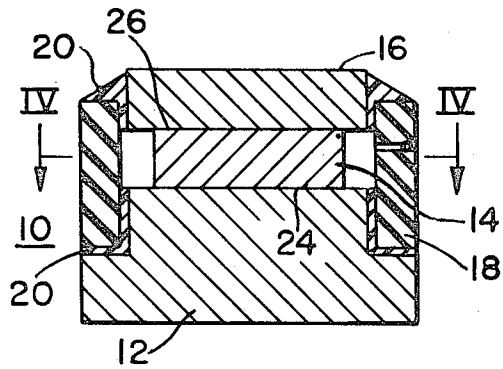


FIG. 1

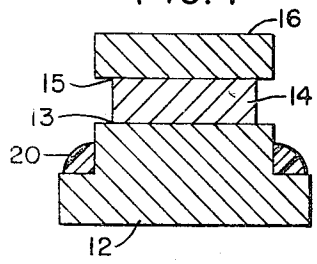


FIG. 2

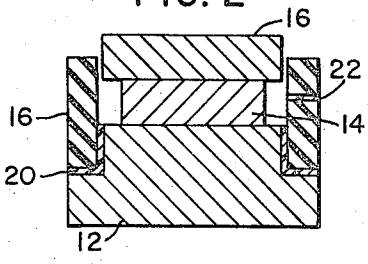
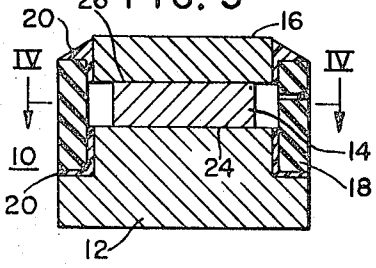


FIG. 3



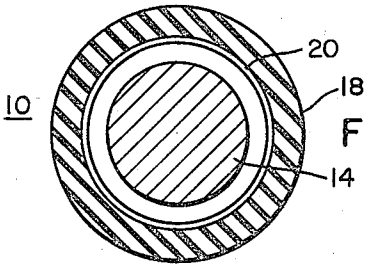


FIG. 4

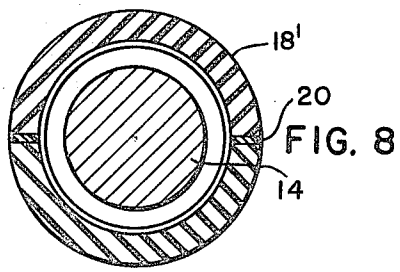
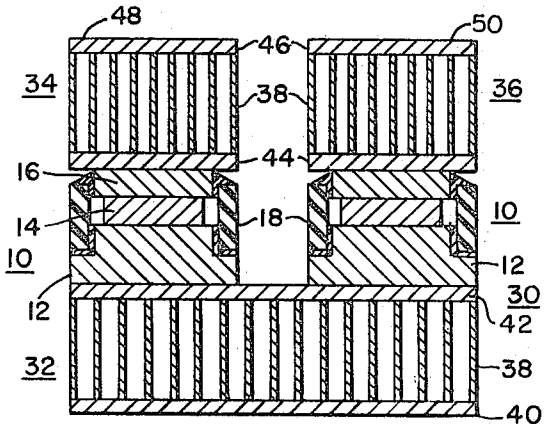


FIG. 8

FIG. 5



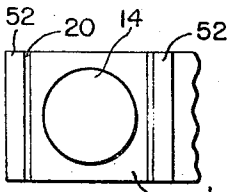


FIG. 7

FIG. 6

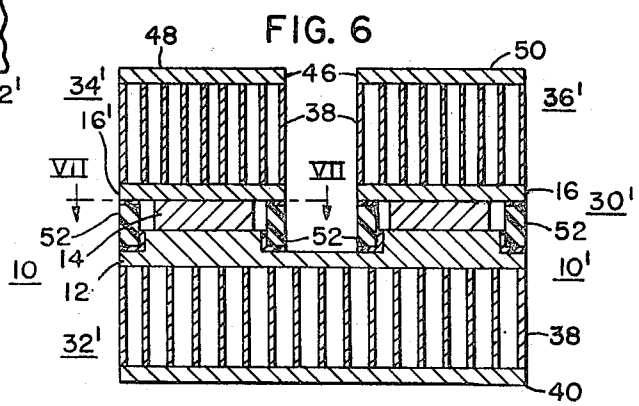


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FIG. 9

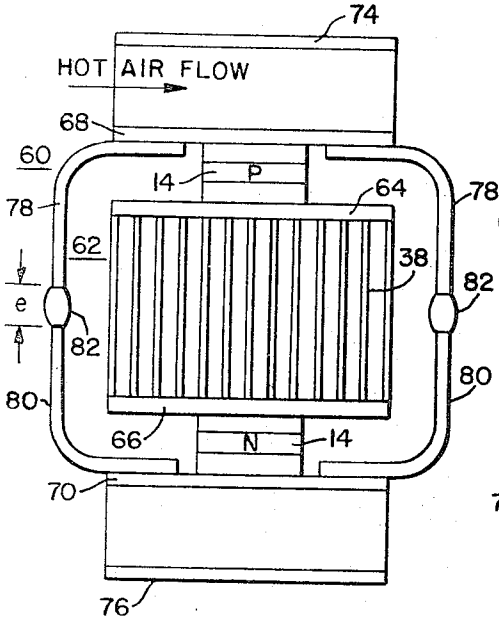


FIG. 10

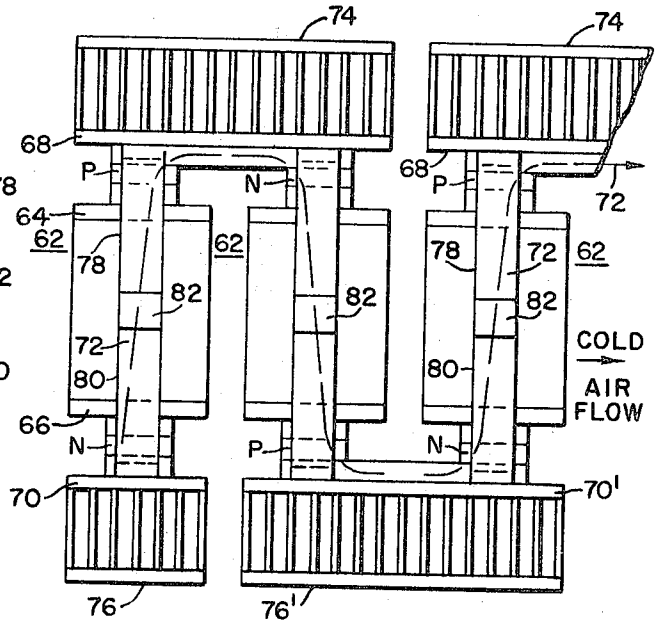


FIG. 11

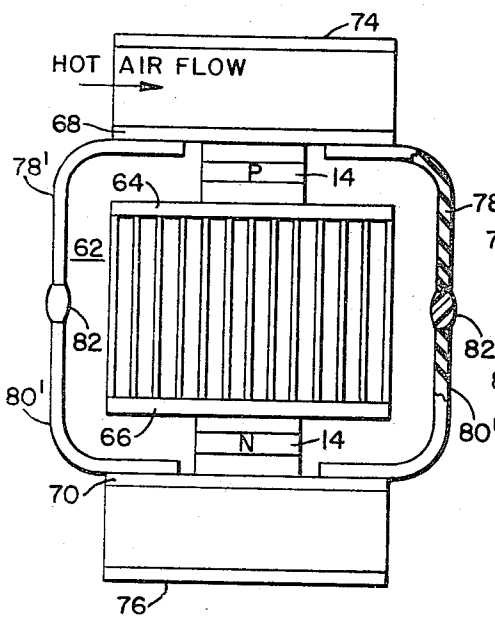
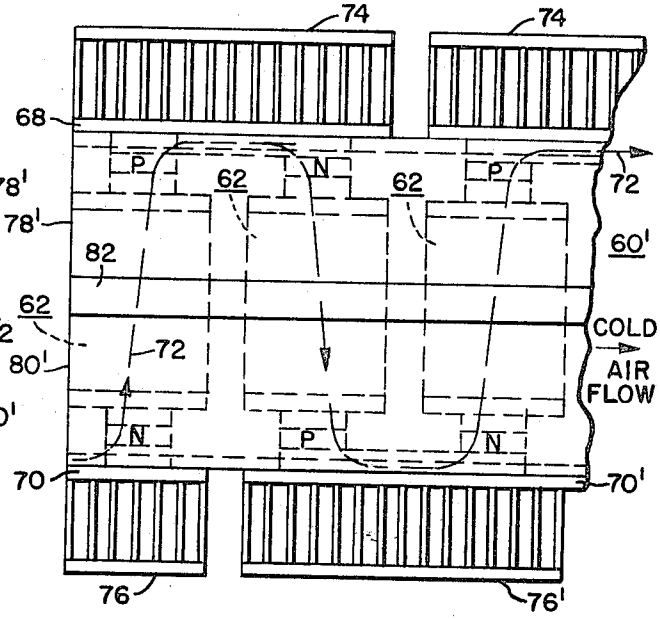


FIG. 12



THERMOELECTRIC DEVICE

BACKGROUND OF THE INVENTION

This invention relates, generally, to thermoelectric devices and, more particularly, to encapsulated thermoelectric pellets for use in thermoelectric heat exchangers.

The physical weakness of thermoelectric materials results in inherent problems in heat exchanger module construction. The thermoelectric pellets and related joints should be kept in compression at all times and protected from appreciable tensile, shear and bending loads. Since different alloys are used at each joint between pellets and adjacent parts, good sealing is necessary to prevent the entrance of moisture at the joints with resulting corrosion problems. The problems of maintaining an array of thermoelectric pellets and connections in heat exchangers in compression with handling, assembly, shock and vibration are difficult and heretofore have required heavy and expensive structures with complex sealing arrangements.

An object of this invention is to provide a capsule in which a thermoelectric pellet is maintained under a compression load at all times.

Another object of the invention is to provide an encapsulated thermoelectric assembly which can be used as a structural member is thermoelectric apparatus.

Other objects of the invention will be explained fully hereinafter or will be apparent to those skilled in the art.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the invention, a thermoelectric heat exchanger includes a pair of spaced metal support members with at least one thermoelectric pellet extending between and secured to opposed surfaces of the support members. An epoxy resin annulus surrounds the pellet and is bonded to the support members in a manner to exert forces on the members tending to move the surfaces toward each other, thereby sealing the pellet and maintaining it under a compression load at all times.

BRIEF DESCRIPTION OF THE DRAWING

For a better understanding of the nature and objects of the invention, reference may be had to the following detailed description, taken in conjunction with the accompanying drawing, in which:

FIGS. 1, 2 and 3 are views, in section, showing successive steps in the procedure for providing an encapsulated thermoelectric pellet embodying principal features of the invention;

FIG. 4 is a view, in section, taken along the line IV—IV in FIG. 3;

FIG. 5 is a view, in section, of a heat exchange apparatus in which encapsulated thermoelectric pellets of the type shown in FIG. 3 are utilized;

FIG. 6 is a view, similar to FIG. 5, of a modified thermoelectric heat exchange apparatus;

FIG. 7 is a view taken along the line VII—VII in FIG. 6;

FIG. 8 is a view, similar to FIG. 4, of another modification of an encapsulated thermoelectric pellet;

FIGS. 9 and 10 are views, in end and side elevation, respectively, of a modified thermoelectric heat exchanger; and

FIGS. 11 and 12 are views, similar to FIGS. 9 and 10, of another modification of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, particularly to FIGS. 1 to 4 inclusive, the thermoelectric device or capsule 10 shown therein is an improvement over prior devices, such as the one described in U.S. Pat. No. 3,303,058, issued Feb. 7, 1967 to George Sonnenschein, in which a metal bellows is utilized to enclose a thermoelectric pellet. As shown in FIG. 3 the thermoelectric device 10 comprises a lower support member 12, a thermoelectric pellet 14, an upper support member 16, an annulus 18 and bonding material 20. The support members 12 and 16 are composed of a material, such as copper, having good heat and electrical conductivity. The pellet 14 may be formed from either thermoelectrically positive or thermoelectrically negative materials which are well known in the art. The annulus 18 may be composed of an epoxy resin of a thermosetting type having a relatively high coefficient of expansion and a characteristic of shrinking when cured. A suitable epoxy resin for this application is diglycidyl ether of bisphenol-A and epichlorohydrin with two hardeners, meta-phenylenediamine and methyl nodic anhydride with catalytic curing agents BF_3 monoethylamine. The bonding material 20 is available on the market under the trade name "Delta Bond". Numerous other suitable bonding materials are also available on the market.

As shown in FIGS. 1, 2 and 3, the device 10 may be constructed by attaching the pellet 14 to opposed surfaces 13 and 15 of the support members 12 and 16, respectively, by soldering or other methods of metallurgical bonding. A fillet of bonding material 20 is applied around the step of the pedestal type support member 12. The epoxy ring 18 is then placed over the upper support member 16 and seated firmly on the step of the lower support member 12 so that the complete circumference is sealed by the bonding material 20. Note that a small hole 22 is provided in the epoxy annulus or ring 18. A fillet of bonding material 20 is then applied around the top of the epoxy ring 18 to completely seal it to the upper support member 16. The encapsulated pellet is then placed in an oven at a relatively high temperature, for example 400° F. for curing. During the curing process the ring 18 is bonded to the support members 12 and 16.

As previously explained, the annulus 18 has the characteristic of shrinking when cured. Thus, forces are exerted on the support members 12 and 16 tending to move their opposed surfaces 24 and 16 toward each other to exert a compression force on the pellet 14. After the capsule has been cured completely, removed from the oven, and cooled to room temperature the small hole 22 is sealed with a dab of the bonding material 20.

The epoxy annulus 18 functions as an insulating member to avoid electrically shunting the pellet 14. The ring or annulus 18 also functions as a structural member to make the capsule strong and rigid, thereby making it suitable for utilization in thermoelectric heat exchangers. Since the pellet 14 is maintained under compression at all times by the force exerted by the annulus 18, the pellet is protected from tensile, shear and bending loads. Furthermore, the pellet 14 is completely sealed, thereby preventing moisture from entering the capsule which could result in corrosion at the joints between the different metals utilized in the capsule or device 10.

As explained hereinbefore, the strength and rigidity of the capsule 10 makes it suitable for use in thermoelectric heat exchangers, such as the exchanger 30 shown in FIG. 5. The exchanger 30 includes two capsules or devices 10, one having positive characteristics and the other negative characteristics, connected in series-circuit relation, and heating or cooling fin structures 32, 34 and 36 which are electrically and thermally conductive. The fin structure 32 comprises a plurality of metal fins 38 spaced between and attached to metal plates 40 and 42. The fins 38 may be attached to the plates by brazing, or other suitable means. The plate 42 is attached to the lower support members 12 of the capsules 10 opposite the pellets 14, as by brazing. Each one of the fin structures 34 and 36 comprises a plurality of fins 38 spaced between and attached to metal plates 44 and 46. Each plate 44 is attached to the upper support member 16 of one of the capsules or devices 10. Air, or other fluid, may be circulated through the fin structures by any suitable means. The exchanger 30 may be utilized to create temperature differences in the circulated fluid by applying suitable electric power to the exchanger through conductors 48 and 50. If desired, the exchanger may be utilized to generate an electric current in a manner well known in the art by circulating a fluid of different temperatures through the fin structure 32, 34 and 36.

In the modified exchanger 30' shown in FIG. 6, a generally rectangular member 12' functions as the lower support member for two capsules 10'. The fins 38 for the fin structure 32' are attached directly to the support member 12'. Likewise, the fins 38 for each of the fin structures 34' and 36' are attached to one of the upper support members 16' for one of the capsules 10'. In this manner the height of the exchanger 30' is reduced by omitting the plates 42 and 44 from the structure.

As shown more clearly in FIG. 7, two generally rectangular epoxy resin bars 52 are disposed at opposite sides of each thermoelectric pellet 14 between the support members 12' and 16'. The epoxy bars 52 are bonded to the members 12' and 16' in the manner hereinbefore described. Therefore, they maintain a compressive force on the pellet 14 as previously explained. The exchanger 30' is suitable for use where it will not be subjected to moisture and dirt, thereby not requiring the capsules 10' to be completely sealed. The bars 52 add rigidity and strength to the structure as previously explained.

If it is desired to seal the pellet 14 in the structure 30', this may be done by utilizing an annulus or ring 18' which is divided into two sections with the sections being bonded together by bonding material 20 as shown in FIG. 8. The ring 18' or the bars 52 are installed and cured in the manner hereinbefore described. Therefore, they function to maintain a compressive load on the thermoelectric pellet 14.

Instead of using a thermosetting epoxy resin as hereinbefore described, a cold curing epoxy resin having a characteristic of shrinking when cured may be utilized in the thermoelectric device. Thus, a pellet may be encapsulated by placing an open end container around or adjacent to the pellet between opposed surfaces of the support members for the pellet and pouring in the epoxy in a fluid state before it has hardened after the resin material has been mixed with a suitable hardener. During curing the epoxy bonds to the support members, but not to the container which may be composed of a material to which the epoxy will not adhere, such as Polytetrafluoroethylene which is available under the trade name "Teflon". The epoxy will shrink during curing, thereby placing a compressive load on the pellet in the manner previously described.

In a modified heat exchanger 60 shown in FIGS. 9 and 10, the thermoelectric pellets 14 are arranged in pairs with one pellet of each pair having positive characteristics and the other having negative characteristics. An electrically and thermally conductive unit 62 is disposed between and secured to the pellets of each pair of pellets and the polarities of successive pairs are reversed as shown in FIG. 10.

Each unit 62 comprises a plurality of metal fins 38 welded or brazed to an upper metal plate 64 and to a lower metal plate 66. The plate 64 is secured to the upper pellet 14 and the plate 66 is secured to the lower pellet 14 of one pair of pellets by soldering or other means of metallurgical bonding. The upper pellet 14 is secured to the lower face of an upper metal support member 68. The lower pellet 14 is secured to the upper face of a lower metal support member 70. Each support member 68 bridges two pellets, thereby connecting a P and N pellet in series. The member 70 is connected only to an N pellet, but each of the members 70' connects a P and an N pellet in series. Accordingly, current will flow through the units 62 as indicated by the line 72 in FIG. 10.

An additional thermally and electrically conductive unit 74 is attached to each upper support member 68. Likewise, conductive units 76 and 76' are attached to the lower support members 70 and 70', respectively. The units 74, 76 and 76' are similar in construction to the units 62. Thus, when direct current is caused to flow through the exchanger in the direction indicated by the line 72, the units 62 become cold fins and the units 74, 76 and 76' become hot fins. As shown by the arrows, air may be circulated through the fin structures by any suitable means to obtain the desired cooling or heating effect.

In order to strengthen the structure and to apply a compressive load on the pellets 14, upper arms 78 on each support member 68 extend toward corresponding lower arms 80 on the support members 70 and 70'. In the structure shown in FIGS. 9 and 10, two arms 78 and two arms 80 are provided for each unit 62. The arms may be formed integrally with the support members 68, 70 and 70' or they may be secured to the support members by welding or brazing. If the arms are composed of a plastic material, they may be bonded to the support members.

The lower end of each arm 78 is spaced from the upper end of its corresponding arm 80 a predetermined distance to permit the ends to be bonded together by means of an insulating epoxy resin 82 which has a characteristic of shrinking when cured. A cold curing resin may be utilized by providing a suitable retainer or mold at each pair of ends to be joined and pouring the resin into the mold while in a fluid state. The resin is bonded to the ends of the arms and shrinks during curing, thereby drawing the arms toward each other to exert a compressive force on the pellets 14 and on the conductive unit 62. The compressive load on the pellets is determined by the distance "*e*" (FIG. 9) and the characteristics of the bonding resin. Thus, the load can be changed by changing the distance "*e*" which changes the cross section of the bonding material.

The heat exchanger 60' shown in FIGS. 11 and 12 is similar to the exchanger 60 with the exception that the arms 78' and 80' extend the full length of the structure and are common to all of the electrically and thermally conductive units 62. The arms must be composed of insulating material bonded to the support members. This arrangement simplifies the operation of bonding the ends of the arms together with a suitable epoxy resin.

From the foregoing description it is apparent that the present invention provides a thermoelectric capsule or device which has numerous advantages over devices of the prior art. Some of the advantages are:

1. The structural system for a thermoelectric module is simplified and substantial cost savings are obtained.
2. The capsule may be used as a structural member.
3. The pellet is sealed from the atmosphere.
4. Greater reliability is obtained.
5. Special provision for terminal connections for electrical power and fluid are not required, thereby resulting in reduced weight and volume in the construction of thermoelectric heat exchangers.

Since numerous changes may be made in the above described construction and different embodiments of the invention may be made without departing from the spirit and scope thereof, it is intended that all subject matter contained in the foregoing description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In a thermoelectric heat exchanger, in combination, a plurality of electrically conductive spaced support members each having a surface thereon, said surfaces of adjacent support members being respectively opposed to one another, a plurality of pellets secured directly to said surfaces of adjacent support members, respectively, and tubular means formed at least in part from insulating material extending between and adherently bonded directly to said support members, the insulating material being composed at least in part of a material having a characteristic of shrinking when cured to exert forces on said adjacent members tending to move said surfaces toward each other to exert a compressive force on said pellets, respectively.

2. The combination defined in claim 1, wherein the means is in an elastic condition after being bonded to the support members.

3. The combination defined in claim 1, wherein the material is a thermosetting resin.

4. The combination defined in claim 1, wherein the material is a cold curing resin.

5. The combination defined in claim 1, wherein the means is an annulus surrounding each pellet.

6. The combination defined in claim 5, wherein the annulus is divided into a plurality of sections.

7. The combination defined in claim 6, wherein the sections of the annulus are adherently bonded together.

8. The combination defined in claim 1, including electrically and thermally conductive heat exchange means supported by said support members.

9. The combination defined in claim 8, wherein said heat exchange means are respectively attached directly to surfaces of the support members opposite the pellet.

10. A thermoelectric heat exchanger comprising a plurality of spaced electrically conductive support members each having a surface thereon, said surfaces being opposed to one another, thermoelectric pellets secured directly to said surfaces, said pellets being arranged in pairs with one pellet of each pair having positive thermoelectric characteristics and the other having negative thermoelectric characteristics, an electrically and thermally conductive heat exchange unit disposed between and secured to the pellets of each pair of said pellets formed at least in part from insulating material, and means extending between and adherently bonded directly to said support members, said insulating material being composed at least in part of a material having a characteristic of shrinking when cured to exert forces on said members tending to move said surface toward each other to exert a compressive force on said pellets and on said heat exchange unit.

11. The thermoelectric heat exchanger defined in claim 10, including additional thermally and electrically conductive heat exchange units attached directly to said support members.

12. The thermoelectric heat exchanger defined in claim 10, wherein the support members on opposite sides of the electrically and thermally conductive unit have arms extending toward each other and the insulating means is bonded to said arms.

13. The thermoelectric heat exchanger defined in claim 11, wherein the support members on opposite sides of the electrically and thermally conductive units have arms extending toward each other and the insulating means is bonded to said arms and wherein said arms are composed of insulating material and are common to a plurality of said units.

* * * * *