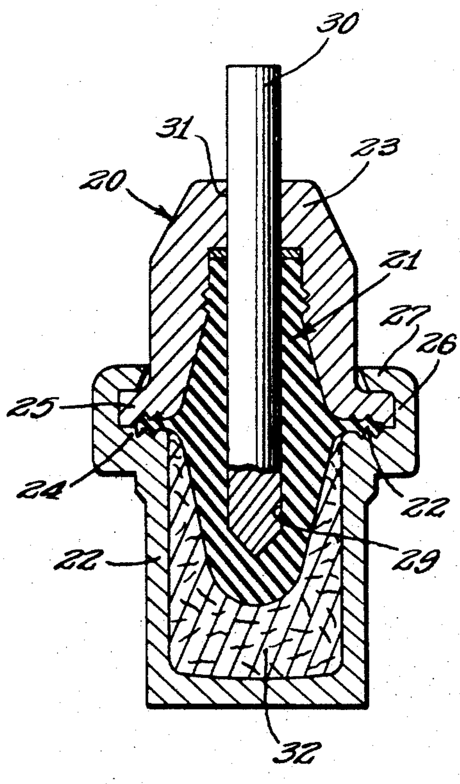
THERMAL SENSITIVE ELEMENT

Filed June 8, 1966



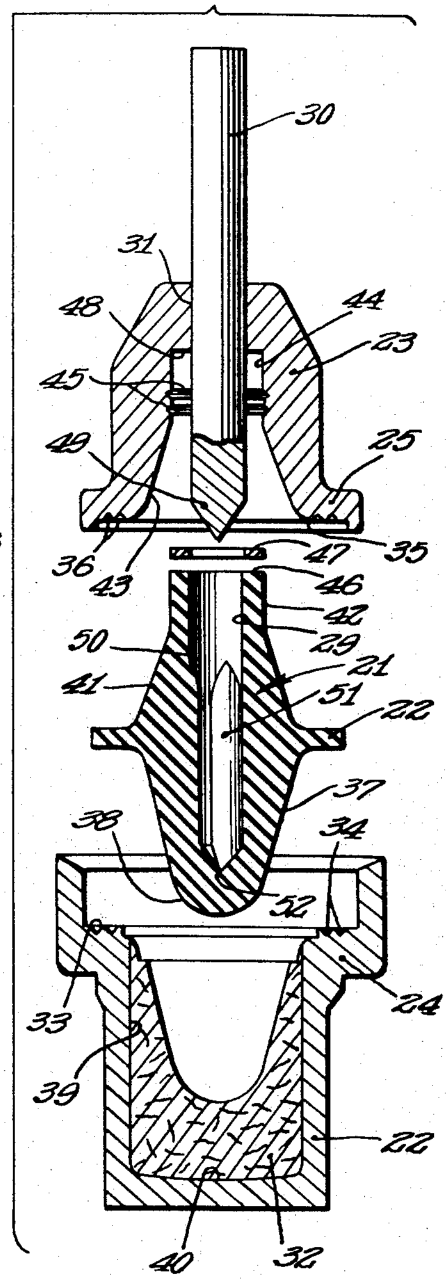


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Fig. 3

PRIOR ART

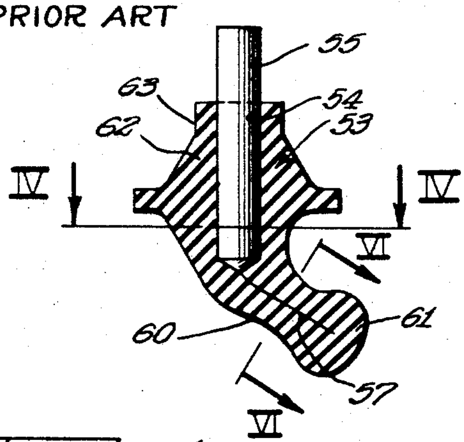


Fig. 7

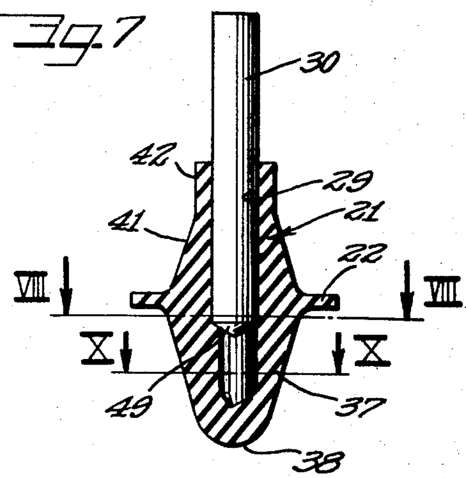


Fig. 4

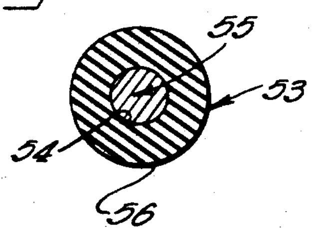


Fig. 8

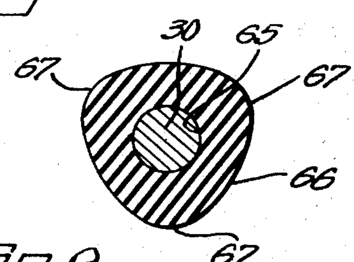


Fig. 5

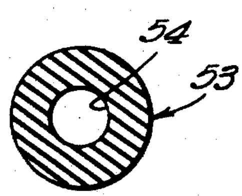


Fig. 9

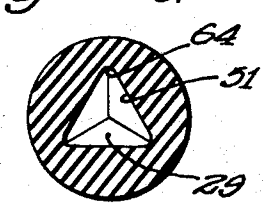


Fig. 10

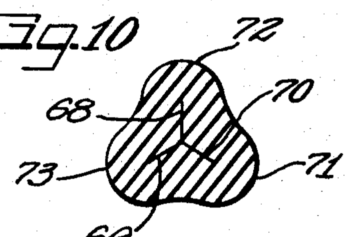
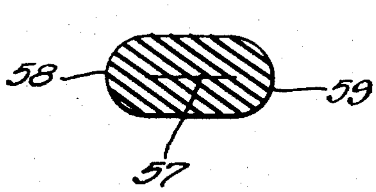


Fig. 6



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3,420,105
THERMAL SENSITIVE ELEMENT

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U.S. Cl. 73—368.3 19 Claims
Int. Cl. G01k *5/32;* F01b *19/00;* F16j *3/00*

This invention relates to a thermal power unit and in particular relates to a thermal power unit of the squeeze-push type wherein the well for holding the power piston has a novel shape for resisting bending of the squeeze boot after extension of the power piston.

Squeeze-push type thermal power units generally employ a casing for holding a thermally expansible wax or the like and a resilient boot for being operably mounted in the casing to coact with the thermally expansible wax for squeezing a power piston out from a well formed within the boot. The boot may have a peripheral bead for mounting the boot within the casing and a base portion extending beneath the bead for being immersed in the thermally expansible wax. The base portion is held in spaced relation with the sides of the casing, and the thermally expansible wax acts at the outside of the base portion for compressing the boot to extend the piston upon a temperature rise ambient the casing.

To assure that the pressure exerted by the thermally expansible wax is directed for squeezing the piston out from the associated well, the base of the well is generally formed to have a spade-shaped configuration for converting the squeezing action into a continuous upward pressure on the piston. However, the well may also be formed with a conical or hemispherical shaped base.

It has been found that the use of the spade-shaped or conical configuration at the base of the well causes the boot to collapse about a single plane which tends to weaken the lateral strength of the boot. The result is that with the boot collapsed along a single plane, slight variations in pressure developed by the thermally expansible wax causes the boot to bend within the casing such that the axis of the well is substantially misaligned after the extension of the piston.

With the axis of the well misaligned within the casing after extension of the power member, retraction of the power member becomes more difficult and less predictable than would be possible if the axis of the well were maintained in a substantially aligned condition.

Also, the twisting or bending of the base portion of the resilient boot causes a bulb to be formed at the lower portion of the boot which is pushed ahead of the retracting power member and which, therefore, causes stretching of the upper portions of the boot to accommodate the retraction of the power piston. Since the upper portion of the boot is generally used to seal the interior of the casing from outside dust, water and the like, the stretching of the upper portion of the boot tends to disturb the seal and permit the entry of foreign matter into the casing which further aggravates the operation of the thermal power unit.

In addition to the unpredictability of operation and to the disturbance or destruction of the sealing effect of the boot, the bending or misalignment of the base portion of the boot causes the retraction of the power member to produce unnecessary wear at the inner surface of the well. This is because the bent portion of the boot tends to remain misaligned, and the retraction of the power member is directed into the side wall of the boot rather than into the well. In fact, extreme bending of the lower portion of the boot can cause the side wall to be punctured, hence, destroying the operation of the thermal power unit.

In addition to the several disadvantages associated with

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the misalignment of the base portion of the boot after the extension of the power member, the folding of the boot about a single plane, as induced by the spade-shaped configuration of the base of the well, generates undesirable stresses at the outside corners of the fold. Essentially, the pressure applied to the boot due to a rise in temperature ambient the thermally expansible material causes the normally cylindrical boot to be substantially flattened with the result that cracks and breaks may occur at high-stress regions developed at the folded edges.

Accordingly, it is a principal object of this invention to provide a resilient boot for a squeeze-type thermal power unit which has a novel boot structure for decreasing the operation stresses of the power unit.

It is also an object of this invention to provide a resilient boot for a squeeze-push thermal power unit wherein the boot is provided with a well having flat sides and fold angles for causing the boot to collapse in a predetermined stress pattern.

It is another object of this invention to provide a resilient boot for a squeeze-push type thermal power unit wherein the well for holding the thermal power piston has a triangular cross-sectional profile for causing the boot to collapse along three distinct planes to improve the predictability of the operation of the power unit and to increase the longevity of the resilient boot.

It is a further object of this invention to provide a resilient boot for a squeeze-push type thermal power unit wherein the boot has a polygonal well, the sides of which converge to form a common vertex at the base of the well for causing the boot to collapse in such a manner as to develop longitudinal ribs on the exterior surface of the boot for resisting bending or twisting thereof in response to pressures applied by a thermally actuating substance.

It is an additional object of this invention to provide a resilient boot for a thermal power unit having a well with a polygonal cross-section and having a power piston for being received internally of the well which piston has a cylindrical diameter greater than the diameter of the largest circle circumscribed by the polygonal cross-section of the well.

It is also an object of this invention to provide a thermal power unit employing a resilient boot having a well formed therein for receiving a power piston wherein the well has a polygonal cross-section at the base portion of the boot and a cylindrical cross-section at the upper portion of the boot and wherein the power piston has a cylindrical configuration for being fitted snugly within the entire length of the well.

These and other objects, features and advantages of the present invention will be understood in greater detail from the following description and the associated drawings wherein reference numerals are utilized in designating an illustrative embodiment and wherein:

FIGURE 1 is a sectional view of a thermal power unit showing the workable relationship of a resilient boot and an associated power piston according to this invention;

FIGURE 2 is an exploded view of the thermal power unit of FIGURE 1;

FIGURE 3 is a sectional view of a resilient boot and an associated power member of a prior art structure wherein the power member or piston has been extended from the boot and wherein the pressure applied at the outside of the base portion of the boot has caused misalignment or bending of the boot;

FIGURE 4 is a sectional view of the prior art form as taken along the line IV—IV of FIGURE 3;

FIGURE 5 is a cross-sectional view similar to the view of FIGURE 4 with the power piston removed from the boot and with the boot maintained in an unstressed condition;

FIGURE 6 is a sectional view of the base portion of the prior art form shown in FIGURE 3 after the power piston has been substantially extended from the boot and under conditions of maximum compression of the thermally expansible substance associated with the thermal power unit; this view is taken along the line VI—VI of FIGURE 3;

FIGURE 7 is a sectional view of a resilient boot according to this invention as would appear in a thermal power unit after expansion of the associated thermally expansible substance and after compression of a portion of the boot for extending the power piston therefrom;

FIGURE 8 is a sectional view of the resilient boot and power member structure as taken along the lines VIII—VIII of FIGURE 7;

FIGURE 9 is a sectional view of the resilient boot of FIGURE 7 when the boot is in an unstressed condition and when the power member is removed from the associated well. Under such circumstances, the sectional view of FIGURE 9 would be taken along lines similar to the sectional view of FIGURE 8; and

FIGURE 10 is a sectional view of the resilient boot of this invention as taken along the lines X—X of FIGURE 7 showing the collapsed nature of the base portion of the resilient boot in response to forces applied at the outside of the boot by the thermally expansible substance of FIGURE 1.

This invention concerns generally a resilient boot for being employed in a squeeze-push thermal power unit wherein the boot is provided with means for causing the folding or collapsing of the boot to take place in a predetermined pattern for reducing the operation stresses of the thermal power unit. By providing the well of the resilient boot, for instance, with a triangular configuration as viewed in cross section, the boot can be caused to collapse along three planes rather than a single plane, with longitudinal ribs or protuberances formed along the outside of the boot for resisting bending or misalignment of the boot in response to pressures exerted thereon by an associated thermally expansible substance.

A thermal power unit **20** has a resilient boot **21** embodying the features and advantages of the present invention.

The thermal power unit **20** has a lower casing **22** and an upper casing **23** which are securely mounted together at flanges **24** and **25**, respectively. The flange **24** has an upwardly extending rim **26** which may be folded about the flange **25** as at **27** for securing the upper and lower casings together.

The resilient boot **21** has an annular bead **22** which is sandwiched between the flanges **24** and **25** of the casings **22** and **23**, and, accordingly, the boot **21** is rigidly positioned within the cavity formed by the respective casings.

The boot **21** has a well **29** for receiving a power piston **30**. The power piston **30** extends into the well **29** through a guide opening **31** formed centrally of the upper casing **23**. The piston **30** is preferably of a larger diameter than the well **29**, however, the piston may have a smaller diameter without interferring with the novel folding action of the boot **21**. The interior of the lower casing **22** is filled with a thermally expansible substance **32** such as a thermally expansible wax or the like which, upon rises in temperature, will exert a pressure at the outside surface of the boot for squeezing the piston outwardly from the well **29** and pushing the boot and piston ahead of the expanding wax.

The detailed structure of the components forming the thermal power unit of FIGURE 1 may be seen more clearly in the exploded view of FIGURE 2. In particular, the flange **24** of the lower casing **22** has a grip surface **33** consisting of a pair of V-shaped concentric grooves **34**. Similarly, the flange **25** of the upper casing **23** has a grip surface **35** consisting of a pair of concentric V-shaped grooves **36**. When the bead **22** of the resilient boot **21** is sandwiched between the flanges **24** and **25** of the lower and upper casings as shown in FIGURE 1, the resilient material extrudes within the V-shaped grooves **34** and **36** for forming a pressure seal between the respective casings as well as for rigidly positioning the resilient boot **21** within the interior of the casings.

The resilient boot **22** has a base portion **37** depending from the lower surface of the bead **22** and tapering to a rounded end **38**. As shown in FIGURE 1, the tapered sides of the base portion **37** maintain the boot in spaced relationship with the inner surface **39** of the lower casing **22**. Also, the rounded end **38** of the boot **21** is maintained in spaced relationship with the lower surface **40** of the casing **22**. In this way, the thermally expansible substance **32** is disposed about the entire base **37** of the boot for exerting transverse pressures thereon to squeeze the piston **30** from the well **29**.

The resilient boot **21** has a truncated conical upper portion **41** and an integral cylindrical neck portion **42**. Similarly, the inside of the upper casing **23** has a truncated conical surface **43** and a cylindrical surface **44** for conforming with the surfaces **41** and **42** of the boot **21**. In addition, the cylindrical surface **44** of the interior of the casing **23** has a pair of V-shaped grooves **45** formed similarly to the V-shaped grooves **34** and **36** for causing the neck portion **42** of the boot **21** to extrude therein in order to form a pressure seal between the casing **23**, the boot **21**, and the power piston **30**. In this way, the guide opening **31** associated with the piston **30** can be closed from external dust, fluids and the like.

The neck portion **42** of the boot **21** terminates in a flat end wall **46**, and an anti-chafe ring **47** is disposed between the end wall **46** and a similar end wall **48** associated with the interior of the upper casing **23**.

The power piston **30** is cylindrical in configuration and has a conical end portion **49** which is received within the well **29** of the boot **21**. Unlike the configuration of the power piston **30**, the configuration of the inner surface of the well **29** is irregular and has been shaped to produce a predetermined folding action for the base portion **37** of the boot in response to rises in temperature ambient the thermally expansible material **32**.

The well **29** has a cylindrical cross-sectional profile from the end face **46** of the boot **21** to a point **50**. From the point **50** to the base of the well, the cross-sectional profile is triangular as is evident by the plane side walls **51**. The walls **51** converge at a common vertex as at **52** such that a cavity is formed at the base of the well having an inverted pyramidal configuration. The effect of the triangular cross-sectional profile of the well **29** can be understood from a comparison of the prior art FIGURES 3 through 6 with the corresponding FIGURES 7 through 10 showing a resilient boot according to this invention.

In FIGURE 3, a resilient boot **53** has a well **54** for holding a realtively extensible power piston **55**. When the boot is in a non-stressed condition, such as when the boot is removed from the thermal power unit, the well **54** is substantially cylindrical in form as shown in FIGURE 5. When the power member **55** is inserted within the well **54**, the resilient boot **53** retains its cylindrical configuration both at the external surface **56** and at the inner surface defining the well **54**.

However, when the prior art boot **53** is disposed in an operational thermal power unit, extension of the power member **55** will cause the well **54** to fold or collapse along a single plane as at **57**. The particular plane about which the boot folds is determined by the spade-shape or chisel-shape of the lower end of the well. In the prior art structure, the spade-shape at the lower end of the well was provided to enable the transverse pressures of the thermally expansible substance within the power unit casing to exert a pressure on the boot which would gradually urge the piston **55** outwardly from the well **54**.

The folding of the prior art boot about the plane **57**, as shown in FIGURE 6, has not been entirely satisfactory in that such a folding may produce high stress regions as at **58** and **59**. After repeated use the areas **58** and **59** may tend to crack or split thereby defeating the proper operation of the power unit. Also, the fact that the resilient boot folds along the plane **57** weakens the resistance of the boot to pressure supplied transversely of the base portion **60**. The result is that the base portion **60** may be bent or misaligned from the remainder of the boot after the piston **55** has withdrawn as shown in FIGURE 3.

When the power unit cools permitting a return spring or the like to cause the power member **55** to retract within the well **54**, the bent or misaligned portion **60** of the boot **53** may resist the retraction motion of the piston. As the piston forces its way into the misaligned well **57**, a bulb **61** forms at the lower end of the boot, and the entire misaligned section tends to be pushed ahead of the retracting piston. The result is that the upper portion of the boot, as at **62**, begins to stretch downwardly within the associated casing, and the neck portion **63**, accordingly, breaks its seal with the casing and with the power member **55**.

Once the seal at the neck portion **63** is broken, dust, water and the like can enter the power unit for further aggravating the operation thereof. In addition, the retraction of the power member **55** with the lower portion of the boot **60** misaligned, as in FIGURE 3, causes the power member to develop excessive wear at the inner surface of the well **54** in the region of the misaligned portion **60**. If, in fact, the base portion **60** is sufficiently misaligned, the power member **55** in retracting into the well **54** could puncture the wall of the boot and destroy the operation of the power unit. In conditions of less serious misalignment, the retraction of the power member **55** tends to make the operation of the power unit less predictable and less reliable.

In contrast with the resilient boot **53** of the prior art structure as shown in FIGURES 3 through 6, the resilient boot **21** of FIGURES 1 and 2 as illustrated in FIGURES 7 through 10 maintains substantial alignment after extension of the power member **30** from the well **29**.

The cross-sectional profile of the base portion of the well **29** is triangular in shape, as shown in FIGURE 9, and has plane walls **51** and fold angles **64**. As shown in FIGURE 2, the plane walls **51** converge along the fold angles **64** to a common vertex **52**. When the power member **30** is fitted within the well **29**, the cross-sectional profile of the base portion **37** of the boot **21** takes the form shown in FIGURE 8, and in particular, the cross-sectional profile is substantially cylindrical at the inner surface of the well **29** as at **65** and is substantially triangular in shape at the outer surface as shown at **66**. The outer surface of the base portion **37** of the boot **21**, as shown in FIGURE 8, may be said to have longitudinal ribs **67** formed due to the stressing of the boot material by the presence of the cylindrical power piston **30**.

When the power piston **30** is extended from the well **29** due to a rise in temperature ambient the casing **22**, the base portion **37** of the boot **21** folds or collapses along three planes as at **68**, **69** and **70** of FIGURE 10. As will be observed, the folded boot of FIGURE 10 does not have the regions of high stress as at **58** and **59** of FIGURE 6. Essentially, the fold is more uniform around the periphery of the base portion **37**.

The result of the triangular fold as shown in FIGURE 10 is that longitudinal ribs or protuberances **71**, **72** and **73** are formed along the length of the base portion **37** for resisting bending of the boot or misalignment of the well as was described in connection with FIGURE 3. In FIGURE 10, it will be noted that one of the protuberances **71**, **72** or **73** is formed on one side of all planes which contain the axis of the boot **21**. Therefore, regardless of the orientation of bending action attempted to be impressed upon the base portion **37** of the boot **21**, at least one of the curved protuberances **71** through **73** will be orientated for resisting that bending action.

Accordingly, when the power member **30** is extended from the well **29** as shown in FIGURE 7, the lower portion of the boot collapses due to the pressure of the thermally expansible substance within the casing **22**, however, the collapse is preorientated in such a manner as indicated by the cross-section of FIGURE 10 to cause the well **29** to maintain substantial alignment under all available pressures experienced by the thermally expansible substance. Accordingly, not only are high stress regions avoided during the folding of the base portion **37** of the boot, but the boot is maintained in a position for receiving the retracting power member **30** in such a manner as to avoid undue stretching of the neck portion **42** and as to avoid undue wear of the inner surface of the well **29** and as to avoid unpredictable operation of the power unit due to increasing the force required to retract the power member **30**.

It will be understood that various modifications and combinations of the features of this invention may be accomplished by those versed in the art, but I desire to claim all such modifications and combinations as properly come within the scope and spirit of my invention.

I claim as my invention:

1. A thermal power unit comprising:
- a casing containing a thermally expansible material,
- a resilient boot fitted within the casing in operable contact with the thermally expansible material,
- a well formed within the boot for receiving a relatively extensible power piston therein,
  - said well having an inner cross-sectional profile substantially triangular in configuration, and
- a power piston operably disposed within said well and being extended relative to said casing in response to an increase in temperature ambient said thermally expansible material.

2. A thermal power unit in accordance with claim **1** wherein the inner side walls forming said substantially triangular cross-sectional profile of said well converge at a common vertex at the base of the well and wherein said thermally expansible material is confined about said boot to compress said boot in response to a temperature rise ambient said casing, and wherein said boot collapses initially at said common vertex for squeezing the piston from the well.

3. A thermal power unit in accordance with claim **1** wherein said resilient boot has a base portion depending within the casing and spaced from the inner side walls thereof and wherein a portion of said thermally expansible material is maintained about the boot between the depending base portion and the inner side walls of the casing, said well being formed substantially axially within said boot and extending into said base portion, and said thermally expansible substance exerting lateral forces on said base portion for squeezing said piston from said well in response to a rise in temperature ambient said casing.

4. A thermal power unit in accordance with claim **1** wherein said resilient boot has an external bead and a base portion depending from the bead, said bead being mounted within said casing in a manner for providing a sealed cavity between said base portion and said casing, said boot having an opened end formed oppositely of said base portion, said well extending from said opened end into said base portion, and said thermally expansible material filling said cavity for squeezing said piston from said well in response to a rise in temperature ambient said casing.

5. A thermal power unit in accordance with claim **1** wherein said resilient boot has a neck portion and a base portion, said well extending from said neck portion to said base portion, said power piston having a substantially circular cross-sectional profile, said substantially triangular cross-sectional profile of said well being formed within said base portion and said well having a substantially circular cross-sectional profile formed within said neck portion.

6. A thermal power unit in accordance with claim **5** wherein the inner walls of said boot forming said well converge at the base of the well into an inverted substantially pyramidal cavity.

7. A thermal power unit in accordance with claim **5** wherein said well terminates within said base portion of the boot at triangular end surfaces meeting at a common vertex.

8. A thermal power unit in accordance with claim **5** wherein the inner side walls forming said substantially triangular cross-sectional profile of said well converge at a common vertex at the base of said well.

9. A thermal power unit comprising:

a casing containing a thermally expansible material,

a resilient boot fitted within the casing in operable contact with the thermally expansible material,

said boot secured to the casing in a manner for forming a sealed cavity between the boot and the casing,

the thermally expansible material disposed within said cavity in a manner for compressing said boot in response to a temperature rise ambient the casing,

a well formed within the boot for receiving a power piston therein,

a number of strain orientating walls formed longitudinally along the inner surface of the well and causing said well to collapse in a predetermined pattern in response to pressure applied against said boot by said thermally expansible material,

each adjacent pair of said strain orientating walls forming substantially equal angles, and each of said strain orientating walls being of substantially equal length,

said boot forming a convex longitudinal protuberance on one side of all planes passing through the longitudinal axis of the boot when said well is collapsed due to pressure applied by said thermally expansible material, and

a power piston operably disposed within said well.

10. A thermal power unit in accordance with claim **9** wherein said strain orientating walls form a substantially triangular cross-sectional profile and wherein a longitudinal convex protuberance is formed at the junctions of adjacent strain orientating walls when said well is collapsed due to pressure applied to said boot by said thermally expansible substance.

11. A thermal power unit in accordance with claim **10** wherein said strain orientating walls converge at a common vertex at the base of said well, whereby said well collapses into a predetermined configuration for resisting misalignment of the boot after extension of the power piston.

12. A thermal power unit comprising:

a casing,

a resilient boot having an opened end and a base portion,

said resilient boot being secured within said casing in such a manner as to form a sealed cavity between said base portion and the inner surface of the casing,

a thermally expansible material disposed in said cavity to compress said boot upon a rise in temperature ambient said casing,

said boot having a well formed therein, said well extending from said opened end into said base portion,

said well having a substantially triangular cylindrical inner surface within said base portion, and

a power piston operably disposed within said well.

13. A thermal power unit in accordance with claim **12** wherein said base portion of said boot has a substantially circular cross-sectional outer profile.

14. A thermal power unit in accordance with claim **13** wherein said power piston comprises a substantially circular cylinder.

15. A thermal power unit in accordance with claim **12** wherein said power piston comprises a substantially circular cylinder having a conical actuation end disposed within said base portion of said boot and wherein the triangular cylindrical inner surface of said well converges to a common apex at the end of the well for receiving the conical actuation end of the piston.

16. In a squeeze type thermal power unit having a casing and a thermally expansible material disposed within the casing, a resilient boot for receiving a power piston and for being disposed in operable contact with the thermally expansible substance, said boot having an opened end, a base portion, and a well extending from the opened end into said base portion, said well having a substantial polygonal cross section, with each angle of the polygon being substantially equal with each other angle thereof and each wall forming the sides of the polygon being of substantially equal length, said boot folding substantially equally along each of the angles of the polygonal cross section in response to pressure applied to the outside of the boot by said thermally expansible substance.

17. In a squeeze type thermal power unit, the combination of a resilient squeeze boot having a well for receiving a power member, said well having a substantial polygonal cross section, and a cylindrical power piston having a diameter greater than the diameter of the largest circle contained by said polygonal cross section.

18. A thermal power unit in accordance with claim **17** wherein the plane sides forming said polygonal cross section converge at a common vertex at the base of the well.

19. A power unit comprising:

a casing containing an expansion material,

a sealing member mounted on and closing said casing and having an elongated resilient boot depending therefrom,

a piston well formed along the longitudinal axis of said boot,

said well having at least three flat surfaces along at least a portion of its length adjacent the base of the well, and

a cylindrically configurated piston extending from said casing and fitted snugly within said well and having a conically configurated inner end fitted within the base of said well.

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WILLIAM HENRY II, *Assistant Examiner.*

U.S. Cl. X.R.

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