United States Patent

[11] 3,624,836

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[54] **TEMPERATURE GRADIENT BAR SEALER**
9 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** ..... **219/243,** 100/93 P, 156/583
[51] **Int. Cl.** **H05b 1/00**
[50] **Field of Search** ..... 219/243; 156/378, 583; 73/15, 15 D; 100/93 P

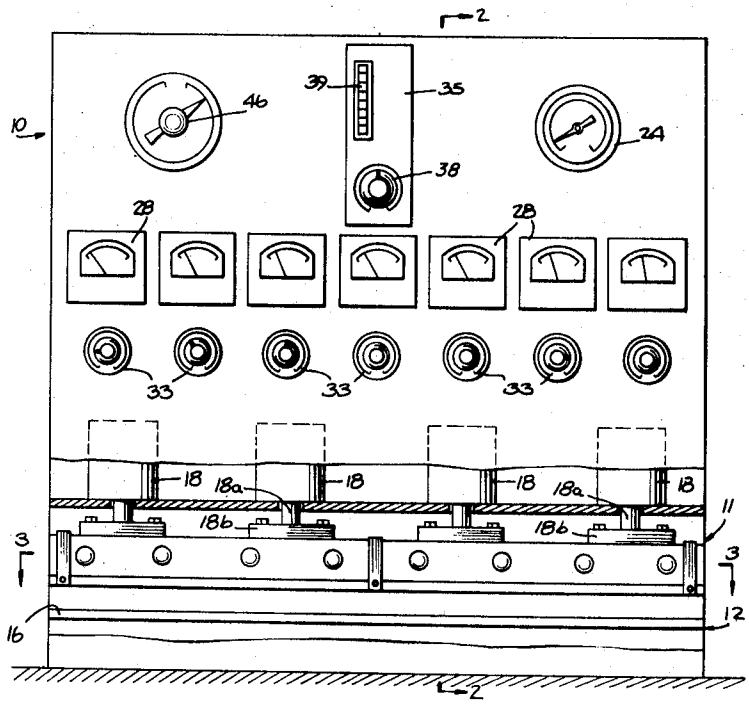
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ABSTRACT: Apparatus for and a process of heat-sealing various materials such as plastics, papers, laminates and coatings. The apparatus can be used for several purposes such as determining the optimum temperature at which a given heat-sealing operation should be conducted under given conditions of pressure and dwell time and to effect increased quality control by maintaining the temperature at which the heat is supplied during the heat-sealing operation under given conditions of pressure and dwell time.

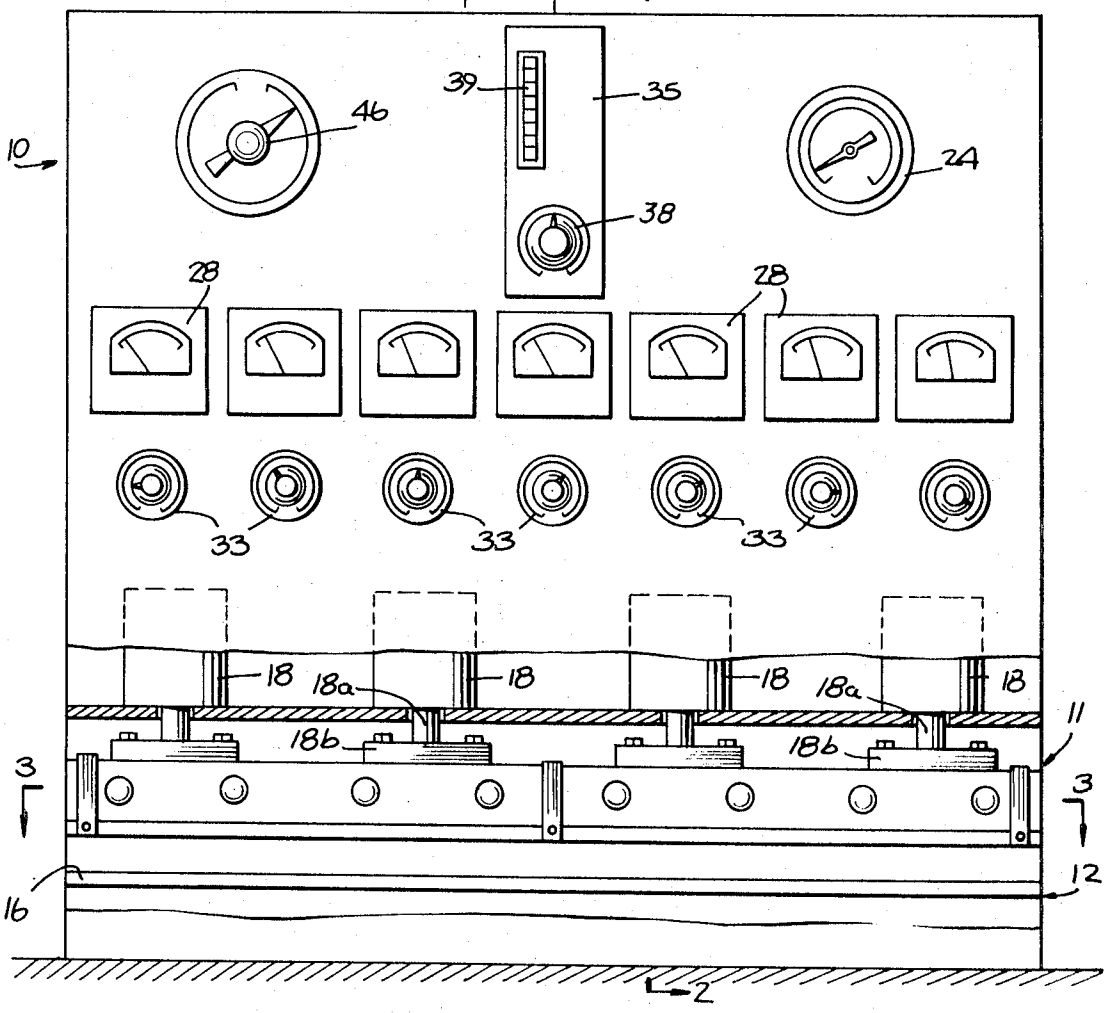


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SHEET 1 OF 3

Fig. 1.



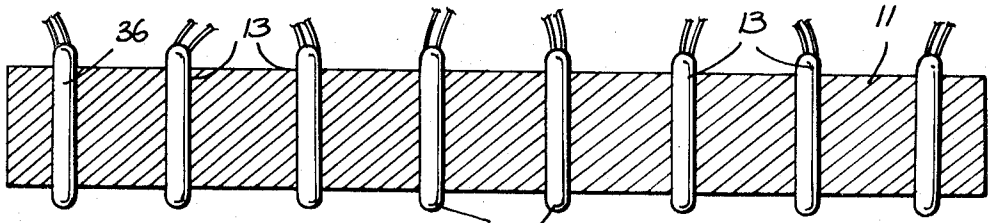


Fig. 3.

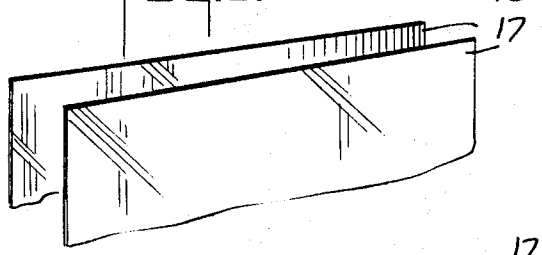
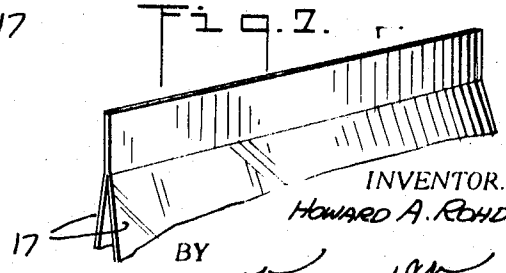


Fig. 6.

Fig. 7.



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Fig. 2.

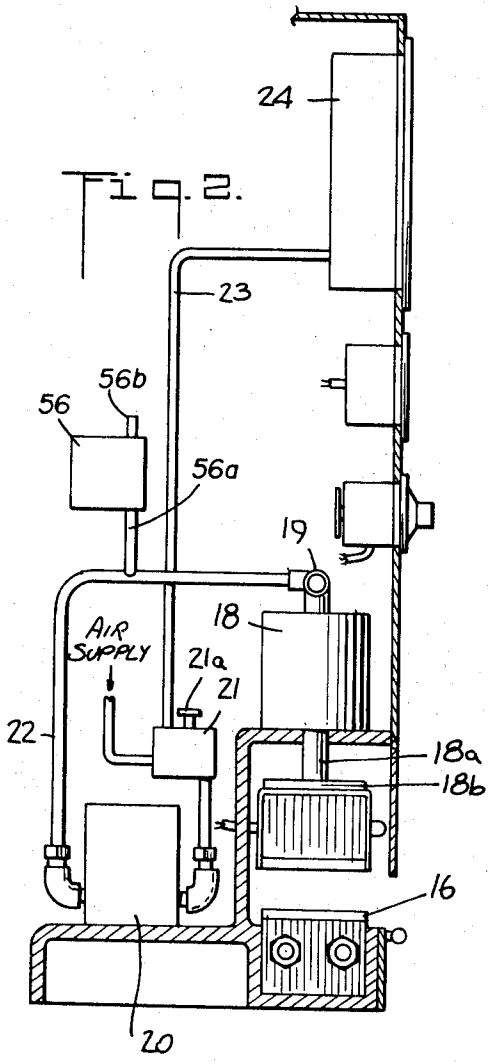


Fig. 4.

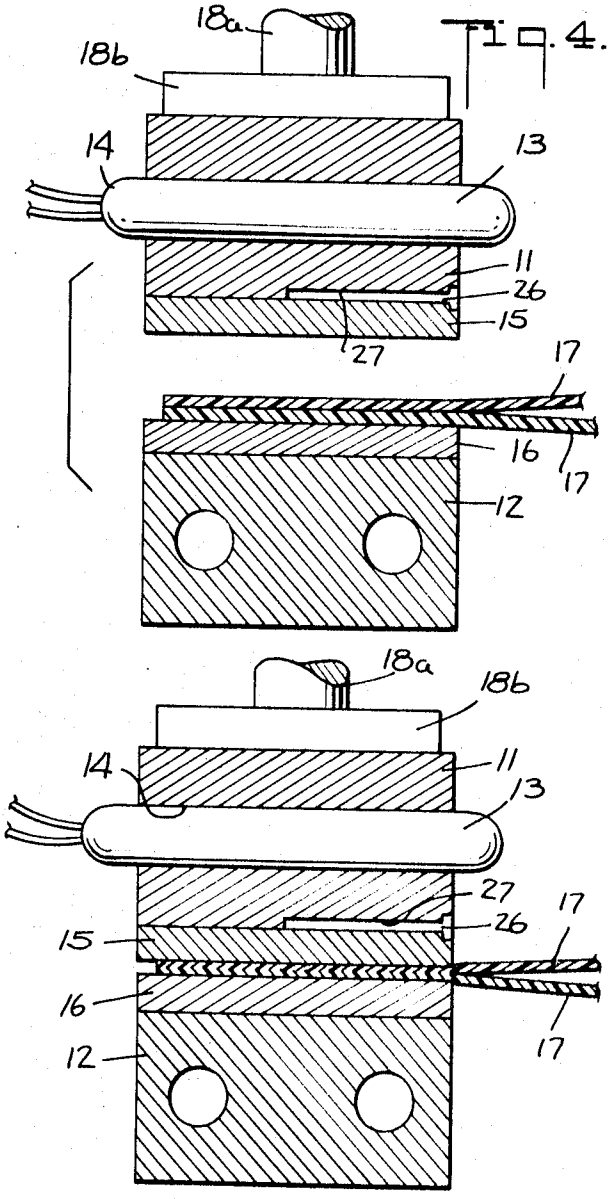


Fig. 5.

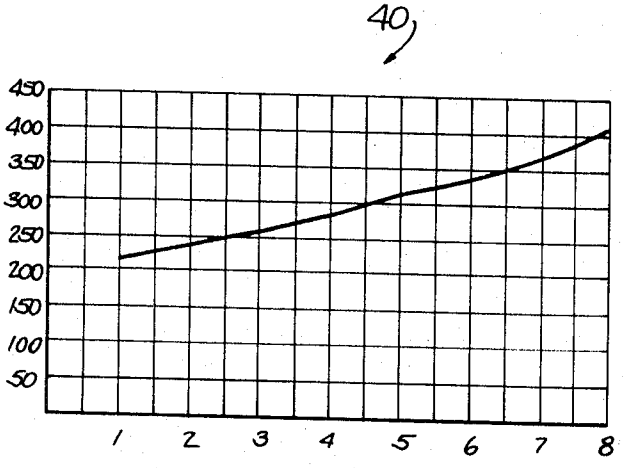


Fig. 8.

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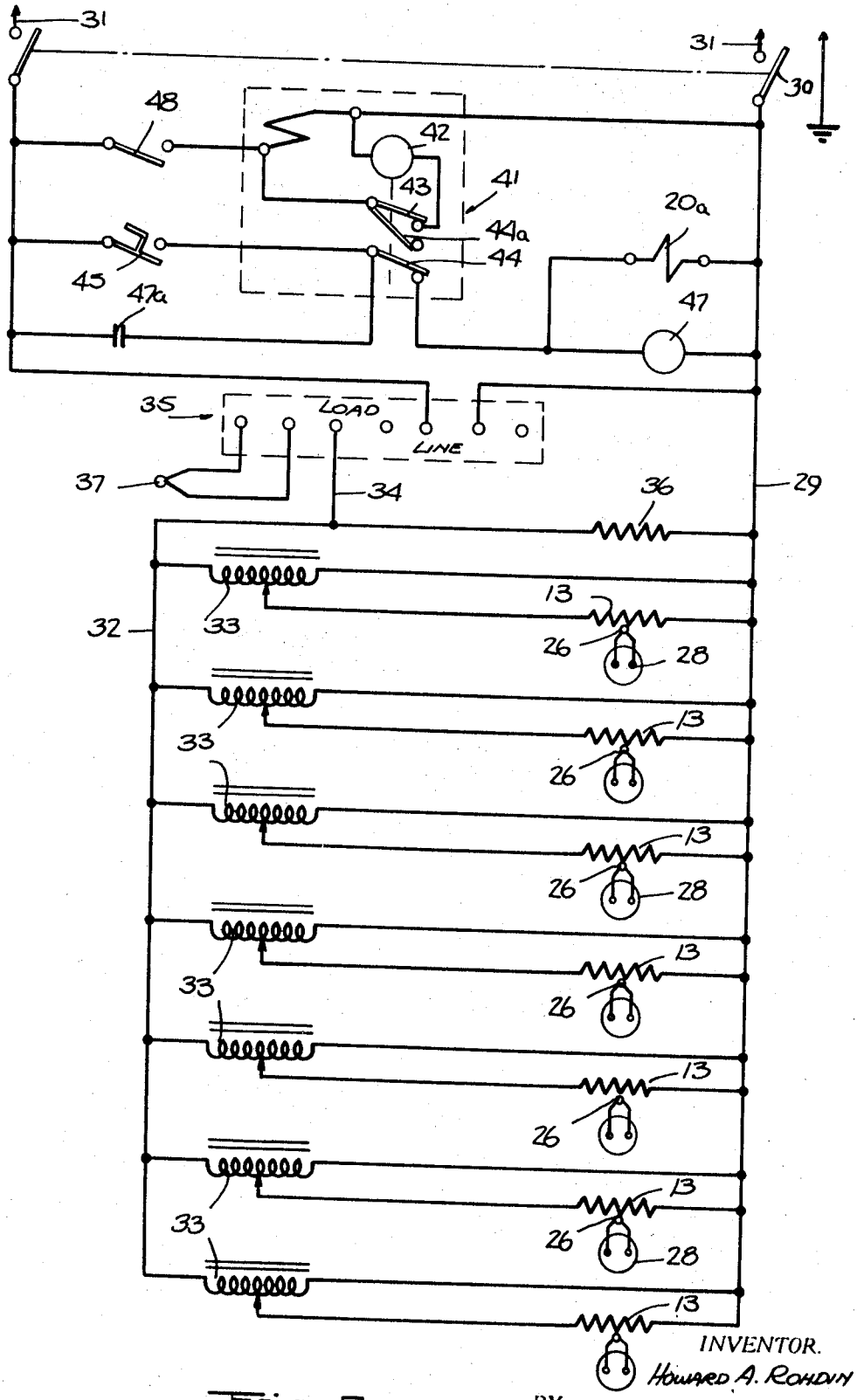


Fig. 8.

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TEMPERATURE GRADIENT BAR SEALER

FIELD OF THE INVENTION

This invention relates to the apparatus and method of heat-sealing various materials which are widely used in the packaging industry. The apparatus can be used as a laboratory test device to determine what is the optimum temperature at which a given material should be heat-sealed. In the alternative the apparatus can be used as production line equipment to seal the packaging of various items and it enables a close control of the temperature being applied during the heat-sealing process.

DESCRIPTION OF THE PRIOR ART

In prior art heat-sealing devices, the temperature of the sealing bar has been controlled by sensing the temperature at one location along the length of the bar. As a result the temperature at other locations along the sealing bar can vary from that of the controlled location.

In prior art gradient bar sealers, special electrical heating windings have been employed to obtain a predetermined temperature gradient. For example the interval between adjacent turns of an electrical heating winding is varied in a cut-and-try manner and the winding is then inserted in a hole extending through the length of the sealing bar. Such an arrangement is very difficult to construct, can only be done on a cut-and-try basis to obtain a desired temperature gradient, and once assembled cannot be varied or otherwise compensated.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a convenient, portable, inexpensive apparatus which can produce various temperatures along the length of a bar used for heat-sealing in order that a technician by means of a single test can heat-seal materials over a range of temperatures. With one or more of such tests the best temperature at which the given material should be heat-sealed can be readily determined by examining the nature of the seal at various points which correspond to a number of different sealing temperatures.

It is another object of this invention to provide close control over the temperature maintained along the length of a heat-sealing bar by enabling the temperature of the bar to be controlled in order that a predetermined temperature is produced at each point along the length of the heat-sealing bar. In this way a controlled amount of heat is applied to the material which is being heat-sealed.

In one embodiment of the invention there is provided a machine for heat-sealing layers of material. A sealing bar applies heat along a portion of the material which has been placed beneath the sealing bar. The heat provided to each different portion of the bar is separately controlled in order to obtain a number of different selected temperatures. In this way, one operation of the sealing bar enables a number of different sealing temperatures to be evaluated at a selected sealing pressure and dwell time.

The machine includes two elongated bars to form a jaw which grips the layers of material. The temperature of the upper movable bar can be held at a constant selected level along the entire length of the bar or the temperature can be varied along the length of the bar from a low temperature such as 100° F. at one end of the bar to a high temperature such as 550° F. at the opposite end of the bar.

A plurality of heating elements are embedded in the heating bar and spaced at substantially equal distances along the bar. These heating elements produce a plurality of different temperature zones along the bar. The heating elements and their corresponding temperature zones can be individually set by separate control mechanisms for different temperatures or for the same temperature.

Other objects and purposes of this invention will become obvious from the following disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevational view of the apparatus of the invention.

FIG. 2 is a vertical section view along the line 2—2 of FIG. 1 and showing the sealing bar and its actuator.

FIG. 3 is a horizontal sectional view along the line 3—3 of FIG. 1 and showing the plurality of controlled heating elements.

FIG. 4 is an enlarged fragmentary vertical section view of a portion of FIG. 2 showing the material to be heat-sealed inserted between the jaws of the apparatus before the jaws of the apparatus are closed upon the material.

FIG. 5 is also an enlarged fragmentary vertical section view of a portion of FIG. 2 showing the material to be sealed inserted between the jaws of the apparatus with the jaws closed upon the material.

FIG. 6 is a perspective view of the edge portion of two sheets of typical materials before they have been heat-sealed, that is, before they have been inserted between the jaws of the apparatus.

FIG. 7 shows the same sheets of material as shown in FIG. 6 after the edge portions of the sheets of the material have been heat-sealed, that is, after they have been removed from the jaws of the apparatus.

FIG. 8 is a graph depicting the temperature gradient along the sealing bar.

FIG. 9 is an electrical schematic diagram of the apparatus shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 is a front elevation view of apparatus 10 of the invention. The apparatus includes upper and lower jaws 11 and 12, respectively. The upper jaw and/or the lower jaw is heated by a plurality of electrical heater elements 13 which are disposed in holes 14 positioned across the jaw and parallel to sole plate 15 (FIGS. 4 and 5). In operation heat flows from each of the heater elements through jaw 11 and into sole plate 15 in order to raise the sole plate to a temperature which is sufficient to heat-seal material clamped between the jaws. Lower jaw 12 is provided with surface plate 16 (FIGS. 1, 4 and 5) upon which the material, such as sheets 17 of thermoplastic material, are disposed prior to the closing of the jaws.

Upper jaw 11 is lowered from the elevated position shown in FIG. 4 to the operative position shown in FIG. 5 by means of a plurality of fluid actuators 18 (FIGS. 1 and 2). Piston rods 18*a* of each of the actuators are coupled by plates 18*b* to the upper surface of jaw 11. The provision of a plurality of actuators spaced at equal intervals along the entire length of upper jaw 11 enables the upper jaw to apply a substantially uniformly distributed force or pressure to the work material disposed upon the lower jaw. The number of actuators is determined by the length of the upper jaw. By way of example when the upper jaw is approximately 24 inches long, four actuators 18 such as shown in FIG. 1 are sufficient for applying the necessary sealing force. Upper jaw 11 is returned from its operative position to its elevated position by means of tension springs (not shown) extending from the upper jaw to a frame member of the apparatus. Thus whenever fluid pressure is released from the actuators the springs raise the upper jaw.

As shown in FIG. 2 each of the actuators 18 is connected to manifold 19. When the upper jaw 11 is to be lowered, solenoid valve 20 is actuated to connect a flow of fluid at regulated pressure from pressure regulator 21 to line 22 leading to manifold 19. The regulated pressure is connected by line 23 to gauge 24 (FIGS. 1 and 2) which can be calibrated to indicate the pressure applied by the jaws to the material being sealed. Thus the regulated pressure is converted to sealing pressure by means of the scale on gauge 24. By means of knob 21*a* the operator of the machine can set the level of the regulated pressure to be applied to the actuators of the upper jaw and thereby set a predetermined jaw pressure which for example can be in the range of 5 p.s.i. to 80 p.s.i.

Whenever solenoid valve **20** is connecting the controlled pressure from regulator **21** to line **22** and thereby the manifold, the controlled pressure causes dump valve **56** to close. When valve **20** closes, the pressure in line **22** is reduced. Valve **56** opens when the pressure in line **22** is reduced and the dump valve **56** then connects line **56***a* and thereby the manifold to the atmosphere through exhaust port **56***b*. The purpose of the dump valve is to speed the evacuation of pressured fluid from the actuators whenever solenoid valve **20** is closed so that the tension springs can immediately raise the upper jaw to its elevated position. But for the dump valve it would be necessary for the tension springs to overcome the fluid pressure resulting from the need to evacuate the actuators through line **22** and solenoid valve **20**.

As shown in FIGS. **4** and **5** the upper jaw **11** is provided with a thermocouple **26** inserted in well **27** adjacent to heater element **13**. Thus each thermocouple is exposed to the temperature of the sole plate **15** adjacent each of the heating elements. Each of thermocouples **26** are connected to a different one of a plurality of pyrometers **28** which are calibrated microvolt meters (FIGS. **1** and **2**). As a result the temperature conditions at various locations along the sole plate are directly indicated by the pyrometers.

Power is supplied to the heater elements by line **29** (FIG. **9**) which is connected through switch **30** to power source **31**. Each of heater elements **13** is connected to the wiper of a different one of a plurality of variable transformers **33**. In turn the winding of the transformer is connected across lines **29** and **32**. Line **32** is connected by line **34** to temperature controller **35** which is adapted to energize line **34**. It can be seen that by adjusting the variable transformers **33** whenever the temperature controller energizes line **34** and thereby the transformers, it is possible to set a predetermined temperature condition for each portion of the sole plate of the upper jaw.

Temperature controller **35** is adapted to control the temperature of electrical heater element **36** which is similar in construction to that of elements **13** and is mounted in a hole similar to hole **14** in the upper jaw. By way of example element **36** can be disposed at one end of the upper jaw as shown in FIG. **3**. Thermocouple **37** is mounted adjacent to heater element **36** in a manner similar to that of the mounting of thermocouples **26**. The temperature control (FIG. **1**) which can be of conventional construction is adapted to energize line **34** whenever the temperature set by means of dial **38** is different from the actual temperature at thermocouple **37**. Thermometer **39** indicates the actual temperature in response to the thermocouple. Thus whenever the temperature of the sole plate of the upper jaw is below the required temperature set at dial **38**, controller **35** energizes line **34** and thereby heater element **36**. At the same time the energizing of line **34** energizes all of variable transformers **33** which in turn energize their respective heater elements **13**.

In accordance with the calibration procedure the operator initially selects the reference temperature to be maintained at the location of thermocouple **37** by setting dial **38**. By means of variable transformers **33** the operator can then adjust the temperature sensed at each of thermocouples **26** to be in a predetermined relationship with the temperature being maintained by the controller. For example the temperature of the sole plate adjacent to element **36** (FIG. **3**) can be that corresponding to number **1** on the graph **40** of FIG. **8**. The temperatures adjacent the remaining elements **13** are those corresponding to numbers **2–8** of the graph. Thus in accordance with the example it can be seen that each of the heater elements **13** can be adjusted in temperature to be elevated with respect to the temperature of heater element **36** in the manner of a straight line as shown by the graph. With such an arrangement it can be seen that a predetermined temperature gradient can be set for the length of the sole plate of the upper jaw. With such a gradient it can be understood that upon forming a heat seal, the sealing temperature at each point of the seal would correspond to a different temperature as shown by the graph. Consequently the forming of a single seal provides test results of a range of sealing temperatures. In effect one test cycle gives the results as far as variable sealing temperatures are concerned of the equivalent of an appreciable number of test cycles. Thus the test procedure is greatly simplified as far as the temperature variable is concerned and the operator is enabled to then concentrate the test investigation as to the sealing pressure and dwell time variables.

It should be noted that the temperature characteristic of the heater elements can be varied in other predetermined manners with respect to the temperature adjacent element **36**. Thus the characteristic need not be an increase in temperature. Instead a uniform temperature could be maintained along the bar. In addition elements **13** can be controlled to heat the sole plate at temperatures extending below that of element **36**. Furthermore elements **13** could be maintained at temperatures both above and below element **36**. With the advantage of being capable of maintaining a wide range of temperature characteristics along the sealing bar it can be understood that the apparatus and method of the invention can be used both for laboratory as well as production purposes.

In order to control the dwell time of the application of the sealing force to the material the apparatus of the invention is provided with timer **41** which is of a conventional construction. The timer includes timing motor **42** which operates switches **43** and **44**. In order to place the apparatus in operation, the operator initially closes main power switches **31**. The operator then sets temperature controller **35** at the required reference temperature. It is then necessary for the operator to adjust variable transformers **33** in order that a predetermined temperature characteristic or gradient be indicated by pyrometers **28**. By means of knob **46**, the operator sets the dwell time of the application of sealing pressure to the workpiece. Knob **46** is coupled in a conventional manner to timer **41**.

When the temperature of the sealing bar of upper jaw **11** has stabilized and the pyrometers indicate that the desired temperature condition is present along the sealing bar, the operator places the material to be sealed between the jaws **11** and **12**. Foot switch **45** is then depressed by the operator. The foot switch completes a circuit to relay **47** through switch **44** which is in its normally closed position. The energization of relay **47** closes contacts **47***a* which furnish a holding circuit for the relay. At the same time solenoid winding **20***a* of solenoid valve **20** is energized and causes fluid pressure to be applied to actuators **18**. In this way the sole plate of the upper jaw is lowered into engagement with the workpiece.

The descent of the upper jaw engages and closes limit switch **48**. The limit switch **48** is positioned with respect to the upper jaw so that the switch can only be closed when the upper jaw has descended into engagement with the material to be sealed. The closing of switch **48** energizes timing motor **42** and begins the timed cycle. At the conclusion of the time period set by knob **46** of timer **41**, the timer causes switch **44** to be opened with respect to relay **47** which thereby deenergizes the relay.

The deenergizing of the relay results in the opening of relay contacts **47***a* which previously had provided the holding current to relay **47** following the release of the foot-operated switch **45**. The opening of switch **44** also causes solenoid winding **20***a* to be deenergized and, as a result, solenoid valve **20** opens and causes dump valve **56** to void the actuators. Consequently the dump valve evacuates fluid pressure from actuators **18** and permits the tension springs to elevate the upper jaw.

When timing motor **42** opens switch **43**, the time cycle has been completed; however the timing motor continues to run in response to the closed limit switch **48** until the timing motor recycles switches **43** and **44** and prepares the system for the next actuation of foot-switch **45**. Limit switch **48** opens as soon as the actuators **18** are voided and the tension springs elevate the upper jaw.

When the nature of the material being sealed should warrant it, lower jaw **12** may be provided with passages through which a coolant such as water can be directed. In this way the

lower jaw can be maintained at a controlled relatively low temperature.

What is claimed is:

1. Apparatus for heat-sealing material comprising:

a. a bar having a surface extending along its length adapted to apply heat to material to be heat-sealed, said bar being formed of heat-conductive material extending continuously from one end to the other thereof and providing thereby a continuous thermal conductive path from one end to the other;

b. a plurality of sources of heat mounted upon said bar spaced apart from one another along the length of said bar;

c. means for controlling each of said plurality of sources of heat to maintain a predetermined temperature at the surface of said bar adjacent to each of said plurality of sources of heat;

d. an additional source of heat mounted on said bar; and

e. means responsive to the relation of the temperature at the surface of said bar adjacent to said additional source to a preselected temperature for activating said additional source of heat to maintain said preselected temperature and for actuating said plurality of sources of heat concurrently therewith while said plurality of heat sources remain subject to said controlling means, whereby a predetermined and continuously varying temperature condition, extending lengthwise along the surface of said bar, can be maintained.

2. A machine for heat-sealing material comprising:

a. a pair of jaws including two bars formed of heat-conductive material extending continuously from one end of each bar to the other and providing thereby a continuous thermal conductive path from one end of each bar to the other, one bar being a stationary bar and the other bar being a movable bar, the bars being disposed in a horizontal position parallel to one another, the movable bar being positioned above the stationary bar in order that material to be sealed can be disposed between said pair of jaws and that said jaws when closed can apply sealing pressure to the material to be heat-sealed;

b. a plurality of electrical heating elements disposed on at least one of said bars along the length thereof;

c. means for varying the circuit resistance of said heating elements, each of said heating elements producing a temperature zone adjacent itself;

d. a different variable transformer connected to each of said heating elements to vary the temperature of each of said heating elements;

e. a different temperature indicator for each of the zones along the length of the bar to indicate the temperature of each such zone, at least a portion of each of said indicators being in thermal communication, respectively, with each related temperature zone;

f. means for predetermining the jaw pressure to be applied to the material to be heat-sealed;

g. means for predetermining the dwell time during which the jaws are closed and the material is being heat-sealed;

h. an additional source of heat mounted on said bar; and

i. means responsive to the relation of the temperature at the surface of said bar adjacent to said additional source to a preselected temperature for activating said additional source of heat to maintain said preselected temperature and for actuating said plurality of sources of heat concurrently therewith while said plurality of heat sources remain subject to said controlling means.

3. A method for heat-sealing a material by means of a bar having a predetermined temperature characteristic, the bar being formed of heat-conductive material extending continuously from one end to the other end thereof and providing thereby a thermal conductive path from one end of the bar to the other, said bar having along its length a surface adapted to apply heat to material to be heat-sealed, and a plurality of sources of heat being spaced apart from one another along the length of said bar, comprising the steps of:

a. controlling each of said plurality of sources of heat to maintain a predetermined temperature at said surface of the bar adjacent to each source of heat;

b. applying the surface of the bar to the material to be heat-sealed;

c. providing an additional source of heat on the bar; and

d. actuating the additional source of heat to maintain a preselected temperature at the surface of said bar adjacent to the additional source and actuating said plurality of sources of heat concurrently therewith while the plurality of heat sources remain subject to the step of controlling, whereby a predetermined temperature condition extending and varying continuously along said surface of the bar can be maintained.

4. Apparatus for heat-sealing material comprising:

a. a bar having a surface extending along its length adapted to apply heat to material to be heat-sealed, said bar being formed of heat-conductive material extending continuously from one end to the other thereof and providing thereby a continuous thermal conductive path from one end to the other;

b. a plurality of sources of heat mounted upon said bar spaced apart from one another along the length of said bar;

c. means for controlling each of said plurality of sources of heat to maintain a predetermined temperature at the surface of said bar adjacent to each of said plurality of sources of heat;

d. means mounted on said bar adjacent each of said plurality of sources of heat for producing an electrical signal which is a function of the temperature of the surface of the bar adjacent each of said plurality of sources of heat; and

e. a plurality of means connected to each of said plurality of signal producing means for simultaneously indicating each temperature of which each of the electrical signals of said signal producing means is a function, whereby a predetermined and continuously varying temperature condition, extending lengthwise along the surface of said bar, can be maintained.

5. Apparatus in accordance with claim 1 and further comprising:

a. an additional bar disposed spaced apart with its length substantially parallel to that of said bar; and

b. means for moving at least one of said bar and said additional bar relative to one another in the manner of a pair of jaws between an opened position and a closed position under controlled closing force, said moving means enabling said bar and additional bar to apply a controlled sealing pressure to material disposed therebetween.

6. Apparatus in accordance with claim 5 in which said means for moving at least one of said bar and said additional bar relative to one another in the manner of a pair of jaws comprises a plurality of actuators disposed along the length of at least one of said bar and said additional bar for applying a uniformly distributed force to produce a uniformly distributed sealing pressure.

7. Apparatus in accordance with claim 6 in which said plurality of actuators are operated in response to the application of fluid pressure thereto and further comprising means for controlling the magnitude of fluid pressure to be applied to said plurality of actuators, whereby the sealing pressure is determined.

8. Apparatus in accordance with claim 5 and further comprising means for maintaining said means for moving at least one of said bar and said additional bar relative to one another in the closed position for a predetermined period of time, whereby the dwell time period of the application of sealing can be controlled.

9, Apparatus in accordance with claim 8 in which said means for maintaining said moving means in the closed position for a predetermined period of time is activated in response to the closing of said bar with respect to said additional bar.