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FIRE FIGHTING TRAINER

1 The invention relates to a fire fighting trainer, and in
2 particular the invention relates to a fire fighting trainer
3 having single-and multi-element, flame generation burner
4 units, and having a multi-sensor unit, and having a smoke
5 generator.

BACKGROUND OF THE INVENTION

6 The prior art fire fighting trainer is described in U.S.
7 Patent Number 4,526,548, issued July 2, 1985. Related
8 patents include U.S. Patent Numbers 3,071,872, issued January
9 8, 1963; 3,156,908, issued November 10, 1964; 3,451,147,
10 issued June 24, 1969; 3,675,342, issued July 11, 1972;
11 3,675,343, issued July 11, 1972, and 4,001,949, issued
12 January 11, 1977 and 4,303,396 issued Dec. 1, 1981.

13 Other related patents include U.S. Patent Numbers
14 4,526,548, issued July 2, 1985; 4,303,396, issued December 1,
15 1981; 3,071,872, issued January 1983; 3,156,908, issued
16 November 1964; 3,451,147, issued June 1969; 3,675,342, issued
17 July 1972; 3,675,343, issued July 1972; 4,001,949, issued
18 January 1977; 4,299,579, issued November 10, 1981; and
19 4,303,397, issued December 1, 1981.

20 The prior art fire fighting trainer includes a plurality
21 of chambers having respective contents including items chosen
22 from a group of items including furniture and fixtures and
23 equipment, a smoke generating system having a plurality of
24 outlets disposed in the respective chambers, and a flame
25 generating system having a plurality of outlets disposed in
26 the respective chambers, and a control and monitoring system.

27 One problem with the prior art fire fighting trainer is
28 that there is no way to determine which ones of the
29 extinguishment agents are being used by the fire fighters
30 simultaneously with the testing of the fire fighters.

31 Another problem is that the trainer is not adapted to
32 simulate a spreading fire. In addition, the commercial gas
33

1 burners used to produce the flames allow an unacceptable
2 build up of unburned gas when the flames are suppressed with
3 water application.

4 A third problem is inefficiency of production and
5 distribution of the simulated smoke that is used for safety
6 and to eliminate pollutants.

7 SUMMARY OF THE INVENTION

8 According to the present invention, a fire fighting
9 trainer is provided. This trainer comprises a plurality of
10 chambers having respective floors with gratings and with
11 spaces below the gratings and having contents including items
12 chosen from a group of items including furniture and fixtures
13 and equipment and disposed on the gratings, a smoke
14 generating system having plurality of outlets disposed in the
15 respective chambers, a flame generating system having a
16 plurality of single-element and multi-element burner units
17 with elements and outlets disposed in the respective spaces
18 of the chambers, and a sensing and control system having a
19 plurality of multi-sensor units disposed in the shares of the
20 respective chambers under the respective elements and each
21 multi-sensor unit connecting to a main control panel.

22 By using the sensing system having a plurality of
23 sensors disposed in the respective chambers and connecting
24 to control panel, the problem of not being able to determine
25 which ones of the materials are being used by the fire
26 fighters simultaneously with the testing of the fire fighters
27 is avoided. By using floors with spaces and gratings and
28 multi-element burner units in the spaces, the problem of not
29 being able to simulate a spreading fire is avoided.

30 By using the single-element and multi-element burners,
31 the problem of build up of unburned gas within the training
32 area is avoided. By using the particular smoke generation
33 system described herein the problem of inefficiency of
34 production and distribution of smoke is avoided.

35 The foregoing and other objects, features and the
36 advantages of the invention will be apparent from the

1 following description of the preferred embodiment of the
2 invention as illustrated in the accompanying drawings.

3 BRIEF DESCRIPTION OF THE DRAWINGS

4 Figure 1 is a schematic plan view of a fire fighting
5 trainer according to the present invention;

6 Figure 2 is an enlarged perspective view of a portion of
7 Figure 1;

8 Figure 3 is an enlarged perspective view of a portion of
9 Figure 1;

10 Figure 4 is an enlarged perspective view of a portion of
11 Figure 1;

12 Figure 5 is a schematic diagram corresponding to a
13 portion of Figure 1;

14 Figure 6 is an enlarged perspective view of a portion of
15 Figure 1;

16 Figure 7 is an enlarged perspective view of a portion of
17 Figure 1;

18 Figure 8 is an enlarged perspective view of a portion of
19 Figure 1;

20 Figure 9 is an enlarged perspective view of a portion of
21 Figure 1; and

22 Figure 10 is a section view as taken along the line
23 10-10 of Figure 9.

24 Figure 11 is a perspective view of an alternate
25 embodiment of the burner unit portion of Figure 2;

26 Figure 12 is a side elevation view of the burner unit
27 portion of Figure 11;

28 Figure 13 is a side elevation view of an alternate
29 embodiment of the burner unit Figures 11 and 12;

30 Figure 14 is a representation of a first step of a
31 spreading fire of contents of the chamber of Figure 11;

32 Figure 15 is a representation of a second step of the
33 spreading fire of Figure 14;

34 Figure 16 is a representation of a third step of the
35 spreading fire of Figure 14;

36 Figure 17 is an alternate embodiment of a smoke

1 generator corresponding to the smoke generator of Figure 4;

2 Figure 18 is a schematic representation of the smoke
3 generator of Figure 17 and its connecting units;

4 Figure 19 is an alternate embodiment of the multi-
5 sensor unit of Figure 7; and

6 Figure 20 is a section view of a chamber having a
7 plurality of the multi-sensor units of Figure 19.

8 DESCRIPTION OF THE PREFERRED EMBODIMENT

9 As shown in Figure 1, a fire fighting trainer 10 is
10 provided. Trainer 10 includes a plurality of chambers 12,
11 14, 16, 18, 20, 22, which are separate chambers in a building
12 structure, and which contain respective contents 24, 26, 28,
13 30, 32, 34, that are chosen from a group of items of
14 furniture and fixtures and equipment, which are fireplace
15 structures made of fireproof materials, such as steel, in
16 the shape of the represented combustible material or location
17 of the represented fire.

18 For example, chambers 12, 14 have representations 24, 26
19 of items such as wood items, that require water to extinguish
20 a fire therein. Chambers 16, 18 have representations 28, 30
21 of items, such as electrical equipment items, that require
22 dry powder or inert gas to extinguish a fire therein.
23 Chambers 20, 22 have representations 32, 34 of items, such as
24 certain liquid fuel items, that require a foam or water or
25 dry powder to extinguish a fire therein.

26 Trainer 10 also has a propane gas system 36, which has
27 a propane gas inlet pressure controller 37, and which has
28 distribution piping 38 and 40. Trainer 10 also has a smoke
29 generating system 42, which has a left smoke generator 44, a
30 right smoke generator 46, and smoke conduit 48 and smoke
31 conduit 50. Systems 36 and 42 generate flames and smoke
32 within selected ones of, or all of, the chambers 12, 14, 16,
33 18, 20, 22.

34 Trainer 10 also has a sensing and control system 52,
35 which has a control panel 54. Trainer 10 includes water
36 sensors 56, 58, 60, 62, 64, 66, and includes foam sensors 68,

1 second conductor connecting to foam sensor 68, a third
2 conductor connecting to powder sensor 80, and a fourth
3 conductor connecting to temperature sensor 81.

4 Each of the chambers 12, 14, 16, 18, 20, 22, stores or
5 contains a different item or items, so that each chamber has
6 a different type of fire, thereby requiring a different
7 medium to put out the fire in each chamber. The water sensor
8 56, foam sensor 68, and powder sensor 80 in chamber 12
9 detects three different extinguishing materials or mediums
10 or agents, which are reported to the control panel 54.
11 Control panel 54 can be operated to regulate the amount of
12 fire and smoke in typical chamber 12, or to shut off the fire
13 and smoke in chamber 12. Control panel 54 can also be used
14 to record the results of the actions of the trainees in
15 chamber 12. Some items in the chambers require two or more
16 combination extinguishing agents, such as water and foam, to
17 extinguish the fire.

18 A principal feature of the trainer is the design of the
19 burners used to generate flame for the training exercises.
20 Commercial burners, which are designed for efficient heating
21 of materials in industrial processes, are completely
22 unsuitable for use in a firefighting trainer. The trainer
23 requires a burner that can produce a realistic fire-type
24 flame safely and reliably even when inundated with water or
25 foam or other extinguishing agent.

26 In Figure 2, burner 104 is shown. Burner 104 is similar
27 in construction to burners 106, 108, 110, 111, 112. Burner
28 104 is suitable to simulate a relatively small fire. As
29 explained hereafter, an alternate burner can be used for
30 simulating a relatively large, spreading fire.

31 In Figure 3, burner control assembly 114 is shown.
32 Burner control assembly 114 is similar in construction to
33 burner control assemblies 116, 118, 120, 122, 124. Burner
34 control assembly 114 includes a supply gas inlet 186, pilot
35 gas components 188, main gas components 190, an air inlet
36 filter 192, and one or more motor controlled gas valves 194.
37 Burner control assembly also includes a pilot blower 196, a

1 70, 72, 74, 76, 78, and includes powder sensors 80, 82, 84,
2 86, 88, 90, and includes temperature sensors 81, 83, 85, 87,
3 89, 91, each of which are disposed in respective chambers 12,
4 14, 16, 18, 20, 22.

5 The water sensors, and foam sensors, and powder sensor
6 may be separate from each other, or may be part of a combined
7 or multi agent detector 69 which will be described herein.

8 Propane distribution pipe 38 has propane gas lines 92,
9 94, 96, which connect to respective chambers 12, 14, 16.
10 Propane distribution pipe 40 has propane gas lines 98, 100,
11 102, which connect to respective chambers 18, 20, 22.

12 Gas lines 92, 94, 96 connect to respective burners 104,
13 106, 108, which are disposed inside respective chambers 12,
14 14, 16. Gas lines 98, 100, 102 connect to respective burners
15 110, 111, 112, which are disposed inside respective chambers
16 18, 20, 22.

17 Burners 104, 106, 108 which are shown near the bottom of
18 Figure 1 have respective control units 114, 116, 118.
19 Burners 110, 111, 112 which are shown near the top of Figure
20 1 have respective control units 120, 122, 124.

21 Control units 114, 116, 118 have respective electrical
22 signal and power conductors 126, 128, 130, which connect to
23 panel 54. Control units 120, 122, 124 have respective
24 electrical signal and power conductors 132, 134, 136, which
25 connect to panel 54.

26 Smoke conduit 48 has smoke lines 138, 140, 142, which
27 connect to respective chambers 12, 14, 16. Smoke conduit 50
28 has smoke lines 144, 146, 148, which connect to respective
29 chambers 18, 20, 22.

30 Chambers 12, 14, 16, 18, 20, 22 have respective doors
31 150, 152, 154, 156, 158, 160.

32 Control panel 54 has cables 162, 164, 166, which go to
33 respective chambers 12, 14, 16. Control panel 54 also has
34 cables 168, 170, 172, which go to respective chambers 18, 20,
35 22. Each of the cables 162, 164, 166, 168, 170, 172 has four
36 conductors. For example, cable 162 has four conductors, in-
37 cluding a first conductor connecting to water sensor 56, a

1 flame safeguard unit 198, and an ignition transformer unit
2 200.

3 In Figure 3, gas enters supply line 92. A solenoid-
4 operated shutoff valve 175 in line 92 controls the flow of
5 gas to the pilot gas line 177 and to the main gas line 176.
6 The pilot system includes components 188, blower 196 and
7 pilot gas/air mixture line 178 to deliver a proper mixture of
8 propane and air to the burner head 174. The main gas system
9 includes supply line 92, components 190, one or more gas flow
10 control valves 194, and one or more main lines 176 to deliver
11 propane gas to one or more burner elements 180.

12 Burner head member 174 mounts within or below the
13 fireplace structure, or the like. The shape and
14 configuration and materials of burner head 174 are such as to
15 provide for reliable operation of pilot and main flames when
16 subject to any of the various extinguishing agents.

17 Pilot gas components 188 include a pressure regulator,
18 a pilot gas metering valve, and a solenoid-operated pilot gas
19 valve. The flame safeguard or pilot monitor unit 198 is an
20 automatic self-check unit that continuously monitors the
21 pilot flame and if the pilot flame is lost for any reason,
22 the flame safeguard unit shuts off all gas flow to the
23 burner. Main gas components 190 include a pressure
24 regulator, safety solenoid valve that is controlled by the
25 flame safeguard unit, and a solenoid-operated main gas valve.

26 Burner element 180 is enclosed in a fireplace (not
27 shown), which is disposed behind real or simulated items,
28 such as electrical or electronic consoles, or below a
29 mattress or the like, or behind a trash can or a kitchen
30 stove, or a sofa or the like. One or more elements may be
31 utilized for each burner.

32 In Figure 2, burner element 180 contains drilled holes
33 configured to satisfy a flame location. One or more elements
34 may be utilized. The holes are about one-quarter inch in
35 size and serve as gas nozzles. When main gas is introduced
36 to element 180, it is ignited by the pilot and produces a
37 flame appearance as desired. Cover plates 182, 184 prevent

1 materials from falling into the holes in element 180.

2 A second principal feature of the trainer is the smoke
3 generator 44. Unlike previous smoke generators, this smoke
4 generator must produce a large volume of simulated smoke, and
5 distribute it to various training compartments or chambers,
6 and produce and distribute the smoke efficiently with little
7 or no residue or pollutants.

8 In Figure 4, smoke generator 44 is shown. Smoke
9 generator 44 is similar in construction to smoke generator
10 46. Smoke generator 44 includes an air blower 202, an air
11 heater 204, a propane line 206, and an enclosure 208. Smoke
12 generator 44 also includes a smoke fluid tank 210, which has
13 a cap 212, a sight glass 214, and a level switch 216. Fluid
14 tank 210 has a line with a metering valve 218 and a solenoid
15 valve 220. Air heater 204 is connected by a line with a
16 temperature monitor 222 to an injector nozzle 224. Injector
17 nozzle 224 has an outlet line 226. In Figure 5, outlet line
18 226 connects to conduits 48 and 50.

19 Conduit 48 is supplied usually by smoke generator 44.
20 Conduit 50 is supplied usually by smoke generator 46.
21 Additional valves (not shown) in conduits 48 and 50 are
22 provided to use such smoke supply arrangement, or to change
23 such smoke supply arrangement as desired. Conduit 48 has
24 solenoid valves 228, 230, 232, which connect to respective
25 smoke lines 138, 140, 142 to respective chambers 12, 14, 16.
26 Excess air blowers 234, 236, 238, which add cooling air to
27 the respective smoke distribution lines, 138, 140, 142 are
28 also provided. Panel 54 controls valves 228, 230, 232 and
29 controls blowers 234, 236, 238.

30 Injector nozzle 224 is used to inject a fine mist of
31 light oil of selected content into a hot air stream produced
32 by air heater 204. High velocity air in injector nozzle 224
33 vaporizes the light oil fluid. With the added cooling air
34 produced by the excess air blowers sufficient simulated smoke
35 is delivered to the chambers in this way.

36 Outlets of smoke lines 138, 140, 142, 144, 146, 148,
37 which are disposed inside respective chambers 12, 14, 16, 18,

1 20, 22, connect to respective fireplaces (not shown), which
2 are in the form of selected fixtures, furniture or equipment,
3 as desired. Typical burner element 180 and typical smoke
4 line 138 connect to the same fireplace, in order to simulate
5 a fire at the fireplace. The fireplace is defined to mean
6 a common assembly area for training in extinguishment of a
7 particular fire, and not a residential type of fireplace.
8 Smoke generator 44 produces simulated smoke to chambers 12,
9 14, 16. Smoke generator 46 produces simulated smoke to
10 chambers 18, 20, 22. Shutoff valves (not shown) in conduits
11 48 and 50 can redistribute smoke to chambers as desired.

12 The smoke generating system 42 is necessary because the
13 propane gas system 36 produces virtually no smoke. The
14 propane in burners 104, 106, 108, 110, 112, 114 is burned
15 without additional combustion air to produce a large, yellow-
16 orange flame. The burners specifically use propane gas to
17 achieve realistic flame appearance and response to agent
18 application.

19 A third principal feature of the trainer is the combined
20 agent, or multi-agent detector. Previous detectors, each
21 designed to detect one extinguishing agent, were unable to
22 distinguish among agents applied. A water sensor in a funnel
23 also detected foam, and a carbon dioxide sensor also detected
24 water. By combining two or more sensors into a single
25 detector using mechanical separators and programming
26 logic as described herein, the detector senses each
27 extinguishing agent unambiguously.

28 Each of the chambers 12, 14, 16, 18, 20, 22 has a
29 different type of fire, and has a respective detector
30 assembly, which can sense and can report to control panel 54,
31 if water, foam, powder, or inert gas is being applied to the
32 fire. If the correct application is made, the fire is
33 extinguished. The control panel 54 is operated to control
34 each of the burners 104, 106, 108, 110, 111, 112, which are
35 located in respective chambers 12, 14, 16, 18, 20, 22, in
36 accordance with the intensity of the fire therein.

37 The operator of the control panel 54 can know which of

1 the materials, such as water, foam, or powder, is being used
2 in each chamber by the fire fighters, simultaneously with the
3 testing of the fire fighters. In this way, the operator can
4 regulate the intensities of the fires in the chambers, or can
5 shut off the fires and smoke inflow, if necessary, by
6 regulating the smoke generating system 42 and the fire
7 generating or system 36 from the control panel 54. The
8 control system 52 monitors conditions within the trainer and
9 is used to automatically shut the trainer down if safety is
10 jeopardized. Control panel 54 can have a computer, in order
11 to provide a scenario in the testing program. A menu of
12 selections can be used in the software of the computer. The
13 trainer is under the control of the instructor and exercises
14 can be repeated or changed at the control panel.

15 In Figure 6, water sensor 56 is shown. Sensor 56 is
16 similar in construction to sensors 58, 60, 62, 64, 66. Water
17 sensor 56 includes a collection funnel 246, a screen 248, an
18 opening 250, and a magnetostrictive or other fluid sensor
19 unit 252, which has a face 254 that protrudes into a pipe
20 256.

21 Sensor unit 252 is located in the neck of the collection
22 funnel pipe 256. Funnel 246 is shaped as required to fit
23 within or below or behind an item, such as a fixture or a
24 fireplace structure or grating or the like. Sensor unit 252
25 is located at the water drain of pipe 256, thereby preventing
26 the formation of puddles or the buildup of material on the
27 face 254 of unit 252.

28 In Figure 7, a multi-agent detector 69, is shown.
29 Detector 69 is capable of detecting and distinguishing
30 between water, foam and powder. Detector 69 includes a
31 collection funnel 258, an upper powder sensor unit 260, an
32 infrared source 261, an infrared detector 262, and a foam and
33 water separator 264. Detector 69 also includes an upper
34 shield 266, a magnetostrictive water sensor 268, a water
35 exhaust opening 270, and a foam exhaust chute 272. Detector
36 69 also has a lower throughbeam foam sensor unit 274 and a
37 lower shield 276.

1 Detector 69 separates the foam from the water, both of
2 which enter through funnel 258. Funnel 258 is shaped to fit
3 below or behind an item, such as a fixture or fireplace
4 structure or grating. Separator 264 separates the water from
5 the foam. Water passes to outlet 270. Foam passes to foam
6 chute 272. Foam sensor unit 274 is a commercially available
7 unit. Water sensor unit 268 and foam sensor unit 274 respond
8 to their particular agent or material.

9 Foam sensor unit 274 has a sonic beam, the breaking of
10 which causes a contact closure upon passage of foam, thereby
11 detecting the presence of foam as the extinguishing agent.

12 Foam sensor 68 functions as described for the foam
13 sensor portion of the combined agent detector, and is used
14 where only foam detection is required. Foam sensor 68 is
15 identical to foam sensors 70, 72, 74, 76 and 78.

16 In Figure 8, a powder sensor 80 is shown. Powder sensor
17 80 is identical in construction to powder sensors 82, 84, 86,
18 88, 90. Powder sensor 80 includes a collection funnel 278,
19 an infrared source 280, a shield 282, and a detector 284.

20 Sensor unit source 280 and detector 284 detect powder by
21 detecting the powder cloud that breaks the light beam passing
22 therebetween. Source 280 and detector 284 detect a powder
23 cloud but do not detect, or see, water or foam. The assembly
24 of source 280 and detector 284 is a commercially available
25 item. Funnel 278 is shaped to fit below or behind burner
26 104, or a fixture, or the like.

27 Source 280 and detector 284 have an infrared light beam,
28 the breaking of which by a powder cloud, signals the presence
29 of powder as the extinguishing agent.

30 Not shown is a carbon dioxide sensor, which consists of
31 a thermocouple, or other temperature measuring device that
32 measures the sudden decrease in temperature at the fire that
33 is the result of the cooling effect of the expanding carbon
34 dioxide gas as it is released from its extinguisher cylinder.

35 Two or more of these sensors are combined where required
36 to sense or multi-agent detectors for each type of fire. For
37 example, water and foam and powder sensors are combined for

1 use in an oil spill fire simulation; water and powder and
2 carbon dioxide sensors are combined for use in an electrical
3 panel fire. In addition to the mechanical separation feature
4 described above, the trainer's control system uses control
5 logic to distinguish among agents. For example, the carbon
6 dioxide sensor could react to water or carbon dioxide, but if
7 the water sensor does not detect water, the system logic
8 concludes that carbon dioxide is being applied.

9 In Figure 9 and 10, the temperature sensor 81 is
10 shown. Temperature sensor 81 is identical in construction to
11 sensors 83, 85, 87, 89, 91. Temperature sensor 81 includes
12 a black-ened copper sphere 286, a globe temperature
13 thermocouple 288, a dry-bulb temperature thermocouple 290, a
14 baffle 292, and a wet bulb temperature thermocouple 294.
15 Temperature sensor 81 also includes a liquid reservoir 296,
16 which has a wick 298 and a level switch 300. Temperature
17 sensor 81 also has a terminal board 302 and a housing 304,
18 which has louvers 306 and a slot 308.

19 Temperature sensor 81 is installed in chamber 12 to
20 insure that temperature levels never reach a dangerous level
21 for trainees and instructors and other users. Readings are
22 transmitted to control panel 54, where action is taken to
23 reduce the temperature in the chamber, or to close the smoke
24 and gas lines to the chamber. The temperature sensor 81 is
25 preferably located on or near the ceiling of chamber 12.

26 The trainer 10 also contains a propane gas detection
27 system, which is not shown on figure 1. The gas detection
28 system consists of combustible gas analyzers, sample points
29 located throughout the trainer where gas build ups could
30 occur, and a draw sample system that utilizes a vacuum to
31 draw air samples from each sample point to the corresponding
32 analyzer. If an unacceptable level of propane is detected
33 anywhere in the trainer, the control system shuts down all
34 burners and smoke generation, and begins ventilation of the
35 trainer.

36 As shown in Figure 11, a second embodiment or burner
37 unit 310 is provided. Burner 310 is similar to burner 104 of

1 Figures 2 and 3, except that burner 310 is a multi-element
2 burner unit and burner unit 104 is a single element burner
3 unit.

4 Parts of burner 310 in Figure 11 which are the same as
5 corresponding parts of burner 104 in Figures 2 and 3, have
6 the same numerals but with a subscript "a" added thereto.

7 Burner 310 connects to a burner control or enclosure
8 312, which has a control cable 314, that connects to a
9 control panel 54a. Burner control 312 has a pilot gas line
10 316, a center main gas line 318, a left main gas line 320, a
11 right main gas line 322, and an electrical conduit 324, all
12 of which connect to burner 310. Burner 310 also has a center
13 burner element 326, a left burner element 328, and a right
14 burner element 330.

15 Chamber 12a has a peripheral wall 332 and a recessed
16 floor slab 334. Wall 332 supports a floor grating 336 on
17 which boxes 338, 340, 342 are supported. These boxes are
18 made of fireproof material to resemble ordinary combustible
19 shipping crates. Boxes 338, 340, 342, which are spaced are
20 spaced near enough, so that a succeeding box appears to be
21 heated by the flame of a preceding box, and so that a
22 simulated spreading fire can be created. Grating 336 and
23 slab 334 have a space 344 disposed therebetween.

24 The main gas lines 318, 320, 322 have respective control
25 portions (not shown), which are disposed inside enclosure
26 312, and which are similar to corresponding parts of main gas
27 line 176 of burner control 114 of Figure 3.

28 As shown in Figure 12, which is a side elevation view of
29 burner 310, a horizontal configuration is provided. In this
30 view, one burner element only is shown. Burner 310 includes
31 a head member 346, which has a pilot chamber 348. Pilot gas
32 line 316 includes a pilot nozzle 350 and a spark igniter 352.
33 Burner 310 also has an air entrainment plenum 354, which
34 surrounds nozzle 350.

35 Gas lines 318, 320, 322 have respective main gas ports
36 356, which connect to elements 326, 328, 330. Pilot chamber
37 346 has pilot boost ports 358, which connect to gas lines

1 318, 320, 322, in order to increase the size of the pilot
2 flame. Head member 346 has a pilot flame deflector 360.
3 Elements 326,328,330 have respective gas distribution holes
4 362. The pilot monitor's flame rod 364 has its electrode 365
5 in the pilot flame path.

6 As shown in Figure 13, another embodiment or burner 310b
7 is provided. Figure 13 shows a vertical configuration of
8 burner 310b and shows one burner element only of a total of
9 four, which are oriented 90 degrees apart.

10 Parts of burner 310b, which are similar to corresponding
11 parts of burner 310 of Figure 12, have the same numerals, but
12 with a subscript "b" added thereto.

13 Burner 310b includes a head member 346b, with a pilot
14 chamber 348b. Burner 310b also includes a plenum 354b, main
15 gas ports 356b, pilot boost ports 358b, a flame deflector
16 360b, distribution holes 362b, and a flame rod 364b.

17 The pilot gas/air mixture from burner control enclosure
18 312 is introduced into the pilot chamber 348 via the pilot
19 nozzle 350 where it is ignited, using, in this embodiment, a
20 rear-mounted spark igniter 352, which provides spark within
21 the nozzle igniting the gas/air mixture before it exits the
22 nozzle for pilot ignition reliability. Once ignited, pilot
23 flame stability during extinguishing agent application is
24 enhanced by additional air introduced into the pilot chamber
25 348 through the air entrainment plenum 354 surrounding the
26 nozzle 350. The pilot flame is monitored by a commercial
27 pilot monitor utilizing a flame rod 364 to confirm pilot
28 flame. This is done by establishing an electric current flow
29 between the burner head 346, and the insulated flame rod
30 electrode 365, through the ionized gas of the pilot flame.
31 This is necessary to ensure that there is a reliable pilot
32 flame before main gas flow is begun.

33 When main gas flow to the burner head is begun,
34 undiluted gas is introduced at the main gas inlets 318,
35 320,322, through the burner main gas ports 356, to the burner
36 elements 358. A small amount of undiluted gas is directed
37 through the pilot boost ports 358 into the pilot chamber 348

1 to increase the size of the pilot flame over the burner
2 elements 326,328,330 to ignite the undiluted main gas emitted
3 through the burner element gas distribution holes 362. The
4 configuration of the pilot flame deflector 360 and the
5 location and shape of the burner main gas ports 356 and pilot
6 boost ports 358 assures ignition of main gas by
7 the pilot flame. In the case of the vertical orientation of
8 the multi-element burner shown in figure 13, four individual
9 pilot flame expansion channels 357b, are provided to direct
10 pilot flame from the central pilot chamber 348b to each of
11 the four flame elements 326b. In addition, the offset
12 internal path of the main gas ports 356 prevents water or
13 foam that may have entered a burner element 326,328,330
14 through its gas distribution holes 362 when main gas flow is
15 off from flowing back up the gas piping system. There is a
16 separate main gas inlet line 318,320,322 for each main gas
17 port 356 in the burner head 346.

18 Figures 14, 15 and 16 show the effect achieved with
19 the multiple-element burner. In Figure 14, pilot flame has
20 been confirmed, and gas flow is started to burner element 328
21 at one side of the storage area mockup 338, 340, 342
22 representing the start of the fire. In figure 15, gas flow
23 is started to the 16 burner element 326 as gas flow to the
24 element 328 approaches maximum. I figure 16, gas flow is
25 started to the burner element 330, as the elements 326, 328
26 are at high fire. The result is the effect of a fire
27 starting, spreading and growing until the entire storage area
28 mockup 338, 340, 342 is engulfed in flames.

29 In operations, the burner control enclosure 312 receives
30 control signals from the operator's console or panel 54a.
31 The enclosure 312 begins flow of a proper pilot gas/air
32 mixture to the pilot chamber 348 of the burner head 346.
33 This mixture is ignited by a spark igniter 352 located so as
34 to produce a spark within the pilot nozzle 350. The pilot
35 flame is ignited before the fuel/air mixture exits the nozzle
36 350, eliminating unstable ignition.

37 Pilot stability is further enhanced by air entrainment.

1 Additional air is provided to a plenum 354 at the rear of the
2 pilot chamber 348. This air surrounds the nozzle 350 and
3 pilot flame providing available combustion air to the pilot
4 flame should changes in environmental conditions at the
5 burner require changes in the fuel/air ratio. The pilot
6 flame must be confirmed before main gas flow is begun. The
7 burner system utilizes a conventional pilot monitor with a
8 flame rod 364 which provides an interlock against starting
9 main gas flow if there is no pilot flame.

10 With confirmation of pilot, main flame, which is the
11 large yellow-orange flame associated with the training
12 exercise, may be started. Undiluted main gas flow is now
13 begun from the enclosure 312 through the main gas ports 356
14 of the burner head 346 to the burner elements 326,328,330 are
15 connected to the burner head 346 so as to assure ignition for
16 the undiluted main gas from the pilot flame. Pilot boost
17 ports 358 are provided within the burner head 346 to increase
18 the size of the pilot flame to assure that adequate pilot
19 flame is available for main flame ignition during the extreme
20 changes in environmental conditions at the burner 310 that
21 occurring application of extinguishing agents to the training
22 fire.

23 Undiluted main gas flow to each burner element
24 326,328,330 is sequentially controlled to allow the training
25 fire to start at one point under the grated floor 336 and
26 then grow in height and spread across the fire area until a
27 full fire condition is reached.

28 Because of the design of the gas burner 310, water
29 applied to the fire by trainees will not extinguish the
30 flames, although the flames will be suppressed and cooled as
31 in a real fire. The control panel 54, which is operated by
32 the operator or instructor is used to begin sequentially
33 reducing, and then stopping main gas flow to the burner
34 elements 326,328,330 causing the flame to recede and
35 extinguish.

36 As shown in Figure 17, an alternate embodiment or smoke
37 generator 366 is provided, corresponding to smoke generator

1 44 of Figure 4.

2 Parts of smoke generator 366, which are similar to
3 corresponding parts of smoke generator 44, have the same
4 numerals but with a subscript "c" added thereto.

5 The smoke generator's components are contained within an
6 enclosure 368 that is weatherproof and that provides for
7 transportability. The volume and durability of the smoke-
8 like fog result from the use of a high-efficiency propane air
9 heater 204a which is fed by a high-flow combustion air blower
10 202c, heating the air to 1000°F.

11 The smoke generator is designed to use a very high
12 quality hydraulic fluid with a flame - retardant character-
13 istic that has been specifically tested for non-toxicity as
14 a fluid and as smoke, and for chemical integrity at high
15 temperature. This fluid is preferred. Other fluids may
16 break down at high temperatures into toxic or flammable
17 components, or may simply not produce good smoke. The
18 preferred fluid is stored in a tank 210c is and metered into
19 the hot air stream at the injection nozzle 224c where it is
20 atomized into extremely small droplets, which will give the
21 smoke its characteristic durability.

22 A balanced distribution manifold 370 provides up to four
23 separate distribution lines each with its own control valve
24 372 for selecting any or all lines. An excess air blower 374
25 dilutes the hot air/fluid mist which is clear cooling it to
26 below 200°F and now causing it to appear as a dense smoke-
27 like fog. This principle feature allows the smoke to be
28 distributed as a stable fog at cool temperatures rather than
29 as an unstable hot mist in which much more of the droplets
30 settle out within the distribution piping and on training
31 room walls as with previous smoke generator designs. Piping
32 is connected to the smoke outlet ports 376, 378, 380, 382 to
33 distribute the smoke-like fog to several training
34 compartments or to specific mock-up structures, such as of
35 electrical devices that would produce smoke if on fire.
36 Adjustable baffles 384 are provided at each port to limit
37 smoke out put for that port if needed.

1 Other components include the propane control valves and
2 regulator 386 the propane flow needle valve 388, which is
3 used to set operating temperature, the air temperature
4 monitor 390, the fluid metering valve 218c, which sets fluid
5 flow, the fluid solenoid valve 220c, which turns fluid flow,
6 and therefore smoke, on and off, and the electrical panel
7 392, which contains the electronics for ignition and
8 monitoring of the heater flame, and air temperature
9 monitoring, and is the connection point for wiring and cables
10 to the system control panel or console.

11 Figure 18 illustrates an alternate configuration of a
12 trainer 10c with a smoke generator 366. Control signal wires
13 167c convey signal information from the control panel 54c to
14 start and run the smoke generator 366. Smoke distribution
15 piping 138c, 140c, 142c, 148c distributes the smoke to four
16 training chambers 12c, 14c, 16c, 22c, ways the smoke is used.
17 In chamber 14c, smoke is distributed among is distributed
18 among fireproof mockups of wooden crates to simulate a Class
19 A fire (dry combustible material). Smoke in chamber 22c is
20 distributed under a grated floor along with a large volume of
21 flame to simulate a Class B fire (burning liquid fuel) in a
22 ship's bilge. A small amount of smoke in chamber 16c is
23 distributed to a fireproof mockup of an electrical panel to
24 simulate a Class C (electrical) fire. Smoke in chamber 22c
25 is distributed throughout the compartment for obscuration
26 training without fire.

27 As shown in Figure 19, a second embodiment or multi-
28 sensor unit 400 is provided, which corresponds to multi-
29 sensor unit 68 of Figure 7.

30 Parts of unit 400 similar to corresponding parts of unit
31 68 of Figure 7 have the same numerals but with a subscript
32 "d" added thereto.

33 Figure 19 shows the alternate embodiment or a multi-
34 sensor unit 400. The major components include the agent
35 collection funnel 258d, which is sized to meet the coverage
36 requirements of the particular fire it will be used with, the
37 water/foam separator 264d, which is attached to the bottom of

1 the funnel and contains a screen that separates foam from
2 water if both are used and shunts the foam to a foam detector
3 trough on the side while allowing the water to fall straight
4 through, the water sensor 268d, which is a magnetostrictive
5 cell or other proximity device mounted within the water drain
6 line at the bottom of the assembly, and provides an
7 electronic signal when water passes through it, a foam sensor
8 274d, which is an ultrasonic sender/receiver, that will be
9 sensitive to foam interrupting the signal path, mounted in
10 the foam detector trough and provides an electronic signal
11 when foam passes through it, and a powder sensor 260d, which
12 is an infrared sensor/receiver unit mounted on the top rim
13 of the funnel, and provides an electronic signal whe powder
14 between the sensor probes. Powder sensor 260d has two arms
15 401, 403 which are cantilevered from a rim 405 of funnel
16 258d.

17 Figure 20 shows an alternate chamber configuration, in
18 this case for training for a fire located in the bilge area
19 of a commercial or naval vessel. The major components in the
20 chamber are the multi-sensor units 400,402 that are installed
21 in the space 407 below a grated metal deck 403, under the
22 burner elements 404,406 that produce the flames for the
23 training fire. Mounted on the grated deck are mockup
24 structures 410 of bilge compartment components such as pumps,
25 valves, piping, etc.

26 When extinguishing agents are applied from a hose 412 to
27 the flames by the trainees, the agents fall through the
28 grated metal deck where they are collected and identified by
29 the multiple-agent detectors which then provide electronic
30 signals which convey a precise pattern of agent application
31 to the control panel 54d so that the operator or instructor
32 can initiate an adjustment to gas flow to the burners to
33 effect extinguishment or other response to the fire.

34 The advantages of trainer 10 are indicated hereafter.

35 1. The sensing and control system 52 determines the
36 material, such as water or foam or powder, which is being
37 used by the fire fighters in each chamber, and reports such

1 information to the control panel 54 at the same time; and the
2 amount of flames and smoke in any chamber can be reset
3 immediately, for better safety and teaching.

4 2. The sensing and control system 52 receives the
5 information about the material used in each chamber for
6 extinguishing the fire whereby the information can be
7 recorded in a report on the test of the fire fighters.

8 3. The items 24, 26, 28, 30, 32, 34, which are stored
9 in respective chambers 12, 14, 16, 18, 20, 22 can be house
10 items, such as respective living room items, bedroom items,
11 kitchen items, cellar items, attic items and office items, or
12 can be industrial items, such as respective chemical storage
13 items, electronic parts items, electronic console items,
14 laboratory items, office items and file room items, or can be
15 restaurant or hotel items, so that trainer 10 provides a
16 test ground for different situations.

17 4. In a test of fire fighters, some of the chambers can
18 be excluded or shut down, depending on the size of the test,
19 or the selection of chambers desired, for better operating
20 efficiency.

21 Advantages of the alternate embodiments of the trainer
22 10 are indicated hereafter.

23 1. Burner 310 operates effectively, when directly
24 exposed to extinguishing water, foam, and powder, because the
25 pilot flame, pilot ignites 352, flame rod 364 and main gas
26 ports 356 are protected as shown in Figure 12.

27 2. The appearance of a spreading fire is simulated by
28 multiple main gas ports 356 and multiple burner elements
29 326,328,330 as shown in Figures 11 and 12.

30 3. Vertically oriented burner 310, as shown in Figure
31 12, is very suitable for large, open area fires, such as
32 bilge or deck fires.

33 4. Horizontally oriented burner 310b, as shown in Figure
34 13, is very suitable for relatively smaller, single burner
35 fires, such as trash can, mattress, or electrical panel
36 fires.

37 5. Burner elements 326,328,330 avoids a hazardous gas

1 build up condition in a chamber, and minimizes the escape of
2 unburned gas therefrom, because the elements 326, 328, 330
3 are located in a well ventilated open space 344 under the
4 grating 336 of the chamber, as shown in Figure 11.

5 6. Smoke generator 366 is capable of producing
6 relatively large amounts of smoke-like fog, which is non-
7 toxic, from a relatively small-size type of smoke generator,
8 as shown in Figures 1 and 17.

9 7. Smoke generator 366 has an internal header 370, which
10 permits relatively quicker and easier distribution to
11 individual lines from outlets 376, 378, 380, 382 to respective
12 chamber smoke lines 138, 140, 142, 148, as shown in Figures
13 1 and 17.

14 8. Multi-sensor unit 400 has a rim 405 with cantilevered
15 arms 401, 403, which support transmitter and receiver parts
16 of powder sensor 260d, so that a powder cloud located
17 somewhat above the unit 400 can be sensed effectively, as
18 well as a powder cloud located within funnel 258d.

19 While the invention has been described in its preferred
20 embodiment, it is to be understood that the words which have
21 been used are words of description rather than limitation and
22 that changes may be made within the purview of the appended
23 claims without departing from the true scope and spirit of
24 the invention in its broader aspects.

What is claimed is:

1 1. A fire fighting trainer comprising: a plurality of
2 chambers having respective floors with gratings and with
3 spaces below the gratings and having contents including items
4 chosen from a group of items including furniture and fixtures
5 and equipment and disposed on the gratings;
6 a smoke generating means having a plurality of outlets
7 disposed in the respective chambers;
8 a flame generating means having a plurality of multi-
9 element burner units with elements and outlets disposed in
10 the spaces of the respective chambers; and
11 a sensing and control means having a plurality of multi-
12 sensor units disposed in the spaces of the respective
13 chambers under the respective elements and each multi-sensor
14 unit connecting to a main control panel.

1 2. The fire fighting trainer of claim 1 comprising:
2 a collection funnel for receiving an extinguishing
3 medium portion;
4 a separation means for separating out foam from the
5 extinguishing medium portion;
6 a foam chute connecting to the collection funnel;
7 a sonic beam source and detector mounted inside the
8 foam chute for sensing the presence of foam in the chute;
9 an outlet pipe connecting to the collection funnel
10 with an outlet opening disposed below the separation means;
11 a magnetostrictive fluid sensor unit mounted on
12 and extending into the outlet pipe above the outlet opening
13 for sensing the presence of water in the outlet pipe; and
14 an infrared source and detector mounted inside the
15 collection funnel for sensing the presence of a cloud of
16 powder in the collection funnel.

1 3. The trainer of Claim 2, wherein the flame
2 generating means comprises:
3 a propane gas inlet pressure controller;
4 conduit means connecting to the propane gas inlet

5 pressure controller;
6 A gas line to each chamber from the conduit means;
7 controal means for each chamber connecting to the
8 gas line; and
9 a burner inside each chamber connecting to the
10 control means.

1 4. The trainer of Claim 3, wherein said burner
2 comprises:
3 a main gas line;
4 a pilot gas line;
5 a head member connecting to the main gas line and
6 to the pilot gas line; and
7 a burner element having orifice holes for flames
8 and connecting to the head member.

1 5. The trainer of Claim 2, wherein the smoke
2 generating means comprises:
3 at least one smoke generator;
4 smoke conduit means connecting to the smoke
5 generator;
6 and
7 a smoke line to each chamber from the smoke conduit
8 means and having an outlet disposed inside each chamber.

1 6. The trainer of Claim 5, wherein said smoke
2 generator comprises:
3 an air blower;
4 an air heater connecting to the air blower;
5 an injector nozzle connecting to the air heater;
6 a fluid tank containing a selective light oil and
7 connecting to the injector nozzle; and
8 an outlet means connecting to the injector nozzle
9 at one end thereof and connecting to the smoke conduit at the
10 other end thereof.

1 7. The trainer of Claim 2, wherein each said sensor
2 assembly includes a temperature sensor comprising:

3 a globe temperature thermocouple surrounded by a
4 blackened metal sphere;

5 a housing for supporting the globe temperature
6 thermocouple and blackened metal sphere on the outside
7 thereof;

8 a dry-bulb temperature thermocouple means supported
9 by the housing on the inside thereof; and

10 a wet-bulb temperature thermocouple means supported
11 by the housing on the inside thereof.

1 8. A fire fighting trainer comprising:

2 one or more chambers having contents including a
3 series of items chosen from a group of simulated burnable
4 items including at least furniture and fixtures and
5 equipment;

6 a smoke generating means having an outlet disposed in
7 the chamber;

8 a flame generating means having an outlet disposed in
9 the chamber;

10 a sensing and control means having a series of multi-
11 sensor assemblies disposed in the chamber and connecting to
12 a main control panel;

13 wherein said multisensory assemblies each includes

14 a water sensor portion and

15 a foam sensor portion and

16 a powder sensor portion; and wherein said chamber has a
17 floor grating and a space disposed below the grating, and
18 wherein the flame generating means includes multi-element and
19 single element burner units disposed in said space and having
20 a series of elongate elements respectively disposed above a
21 series of multi-sensor assemblies and within the space.

1 9. The trainer of claim 8, wherein each multi-sensor
2 assembly comprises:

3 a water sensor portion including a collection funnel
4 having a screen and a first outlet opening disposed above the
5 screen and an outlet pipe with a second outlet opening
6 disposed below the screen and

7 a magnetostrictive fluid sensor unit mounted on and
8 extending into the outlet pipe above the second outlet
9 opening for sensing the presence of water;
10 a foam sensor portion including
11 a foam chute and disposed alongside the screen and a
12 sonic beam source and detector mounted inside the foam
13 chute for sensing the presence of foam; and
14 a powder sensor portion including
15 an infrared source and detector mounted inside the
16 collection funnel for sensing a cloud of powder, said
17 infrared source and detector having respective arm portions
18 cantilevered from a rim portion of the collection funnel.

1 10. The trainer of Claim 8, wherein the flame
2 generating means comprises:
3 a propane gas inlet pressure controller;
4 conduit means connecting to the propane gas inlet
5 pressure controller;
6 a gas line to the multi-element burner unit from the
7 conduit means;
8 and control means connecting to the gas line;

1 11. The trainer of claim 8, wherein the multi-element
2 burner unit comprises:
3 a plurality of gas lines respectively connecting to the
4 elements of the multi-element burner unit;
5 a pilot gas line; and
6 a head member connecting to the plurality of gas lines
7 and to the pilot gas line; wherein
8 each of the burner element has orifice holes for flames
9 and connects to the head member.

1 12. The trainer of claim 8, wherein the smoke
2 generating means comprises:
3 at least one smoke generator having a housing;
4 smoke conduit means disposed within the housing and
5 connecting to the smoke generator; and multiple
6 smoke lines to the chambers from the smoke conduit means

7 and having an outlet disposed inside each chamber.

1

2 13. The trainer of claim 12, wherein the smoke
3 generator comprises:

4 an air blower;

5 an air heater connecting to the air blower;

6 an injector nozzle connecting to the air heater;

7 a fluid tank containing a selective light oil and
8 connecting to the injector nozzle; and

9 a outlet means connecting to the injector nozzle at one
10 end thereof and connecting to the smoke conduit at the
11 other end thereof.

1 14. A method of training fire fighters in fighting a
2 spreading fire including: providing at least one training
3 chamber; choosing a series of items from a group of items
4 including at least furniture and fixtures and equipment;
5 placing the series of selected items in spaced relationship
6 within the chamber; introducing a series of gas flames and
7 simulated smoke into the chamber next to the selected items;
8 adjusting the sizes of the flames to simulate a spreading
9 fire; introducing fire fighters into the chamber to put out
10 the simulated spreading fire using one of a group of
11 extinguishing agents; sensing which one of the extinguishing
12 agents is being used by the fire fighters on each item in
13 the chamber; simultaneously regulating and setting a level of
14 spreading fire and a level of smoke in the chamber depending
15 upon the extinguishing agent being used; and recording the
16 test results of time and decisions of the fire fighters.

1 15. A method of training and testing fire fighters
2 including:

3 providing at least one training chamber;

4 choosing selected items from a group of items of
5 furniture and fixtures and equipment;

6 placing the selected items in the chamber;

7 introducing propane gas flames and simulated smoke
8 into the chamber next to the selected items;

1 introducing fire fighters into the chamber to put
2 out the simulated fire using one of a group of extinguishing
3 agents;
4 sensing which one of the extinguishing agents is
5 being used by the fire fighters in the chamber;
6 simultaneously regulating and setting a level of
7 fire and a level of smoke in the chamber depending upon the
8 extinguishing agent being used;
9 and recording the test results of time and
10 decisions of the fire fighters.

AMENDED CLAIMS

[received by the International Bureau on 12 December 1989 (12.12.89)
original claims 1-15 replaced by amended claims 1-12 (6 pages)]

1 1. A fire fighting trainer comprising: a plurality
2 of chambers having respective floors with gratings and
3 with spaces below the gratings and having contents
4 including items chosen from a group of items including
5 furniture and fixtures and equipment and disposed on the
6 gratings;

7 a smoke generating means having a plurality of
8 outlets disposed in the respective chambers;

9 a flame generating means having a plurality of multi-
10 element burner units with elements and outlets disposed in
11 the spaces of the respective chambers; [and]

12 a sensing and control means having a plurality of
13 multi-sensor units disposed in the spaces of the
14 respective chambers under the respective elements and each
15 multi-sensor unit connecting to a main control panel;

16 a collection funnel for receiving an extinguishing
17 medium portion;

18 a separation means for separating out foam from the
19 extinguishing medium portion;

20 a foam chute connecting to the collection funnel;

21 a sonic beam source and detector mounted inside the
22 foam chute for sensing the presence of foam in the chute;

23 an outlet pipe connecting to the collection funnel
24 with an outlet opening disposed below the separation
25 means;

26 a magnetostrictive fluid sensor unit mounted on and
27 extending into the outlet pipe above the outlet opening
28 for sensing the presence of water in the outlet pipe; and

29 an infrared source and detector mounted inside the
30 collection funnel for sensing the presence of a cloud of
31 powder in the collection funnel.

1 2. The trainer of Claim 1, wherein the flame
2 generating means comprises:

3 a propane gas inlet pressure controller;

4 conduit means connecting to the propane gas inlet

5 pressure controller;
6 a gas line to each chamber from the conduit means;
7 control means for each chamber connecting to the gas
8 line; and
9 a burner inside each chamber connecting to the
10 control means.

1 3. The trainer of Claim 2, wherein said burner
2 comprises:

3 a main gas line;
4 a pilot gas line;
5 a head member connecting to the main gas line and the
6 pilot gas line; and
7 a burner element having orifice holes for flames and
8 connecting to the head member.

1 4. The trainer of Claim 1, wherein the smoke
2 generating means comprises:

3 at least one smoke generator;
4 smoke conduit means connecting to the smoke
5 generator; and
6 a smoke line to each chamber from the smoke conduit
7 means and having an outlet disposed inside each chamber.

1 5. The trainer of Claim 4, wherein said smoke
2 generator comprises:

3 an air blower;
4 an air heater connecting to the air blower;
5 an injector nozzle connecting to the air heater;
6 a fluid tank containing a selective light oil and
7 connecting to the injector nozzle; and
8 an outlet means connecting to the injector nozzle at
9 one end thereof and connecting to the smoke conduit at the
10 other end thereof.

1 6. The trainer of Claim 1, wherein each said sensor
2 assembly includes a temperature sensor comprising:

3 a globe temperature thermocouple surrounded by a

4 blackened metal sphere;

5 a housing for supporting the globe temperature
6 thermocouple and blackened metal sphere on the outside
7 thereof;

8 a dry-bulb temperature thermocouple means supported
9 by the housing on the inside thereof; and

10 a wet-bulb temperature thermocouple means supported
11 by the housing on the inside thereof.

1 7. A fire fighting trainer comprising:

2 one or more chambers having contents including a
3 series of items chosen from a group of simulated burnable
4 items including at least furniture and fixtures and
5 equipment;

6 a smoke generating means having an outlet disposed in
7 the chamber;

8 a flame generating means having an outlet disposed in
9 the chamber;

10 a sensing and control means having a series of multi-
11 sensor assemblies disposed in the chamber and connecting
12 to a main control panel;

13 wherein said chamber has a floor grating and a space
14 disposed below the grating, and wherein the flame
15 generating means includes multi-element and single element
16 burner units disposed in said space and having a series of
17 elongate elements respectively disposed above the series
18 of multi-sensor assemblies and within the space; and
19 wherein each multi-sensor assembly comprises:

20 a water sensor portion including a collection funnel
21 having a screen and a first outlet opening disposed above
22 the screen and an outlet pipe with a second outlet opening
23 disposed below the screen and

24 a magnetostrictive fluid sensor unit mounted on and
25 extending into the outlet pipe above the second outlet
26 opening for sensing the presence of water;

27 a foam sensor portion including

28 a foam chute and disposed alongside the screen and a
29 sonic beam source and detector mounted inside the foam

30 chute for sensing the presence of foam; and
31 a powder sensor portion including
32 an infrared source and detector mounted inside the
33 collection funnel for sensing a cloud of powder, said
34 infrared source and detector having respective arm
35 portions cantilevered from a rim portion of the collection
36 funnel.

1 8. The trainer of Claim 7, wherein the flame
2 generating means comprises:
3 a propane gas inlet pressure controller;
4 conduit means connecting to the propane gas inlet
5 pressure controller;
6 a gas line to the multi-element burner unit from the
7 conduit means;
8 and control means connecting to the gas line;

1 9. The trainer of Claim 7, wherein the multi-
2 element burner unit comprises:
3 a plurality of gas lines respectively connecting to
4 the elements of the multi-element burner unit;
5 a pilot gas line; and
6 a head member connecting to the plurality of gas
7 lines and to the pilot gas line; wherein
8 each burner element has orifice holes for flames and
9 connects to the head member.

1 10. The trainer of Claim 7, wherein the smoke
2 generating means comprises:
3 at least one smoke generator having a housing;
4 smoke conduit means disposed within the housing and
5 connecting to the smoke generator; and multiple
6 smoke lines to the chambers from the smoke conduit
7 means and having an outlet disposed inside each chamber.

1 11. The trainer of Claim 10, wherein the smoke
2 generator comprises:
3 an air blower;

4 an air heater connecting to the air blower;
5 an injector nozzle connecting to the air heater;
6 a fluid tank containing a selective light oil and
7 connecting to the injector nozzle; and
8 a outlet means connecting to the injector nozzle at
9 one end thereof and connecting to the smoke conduit at the
10 other end thereof.

1 12. A method of training fire fighters in fighting
2 a spreading fire including: providing at least one
3 training chamber having a series of interconnected spaces
4 below a floor level; choosing a series of items from a
5 group of items including at least furniture and fixtures
6 and equipment; placing the series of selected items
7 respectively over the series of interconnected spaces in
8 spaced relationship within the chamber; introducing a
9 series of gas flames and simulated smoke into the series
10 of interconnected spaces in the chamber next to the
11 selected items; adjusting the sizes of the flames to form
12 a series of gradually enlarging flames in order to
13 simulate a spreading fire; introducing fire fighters into
14 the chamber to put out the simulated spreading fire using
15 one of a group of extinguishing agents; sensing which one
16 of the extinguishing agents is being used by the fire
17 fighters on each items in the chamber; simultaneously
18 regulating and setting a level of spreading fire and a
19 level of smoke in the chamber depending upon the
20 extinguishing agent being used; and recording the test
21 results of time and decisions of the fire fighters.

1 13. A method of training and testing fire fighters
2 including:
3 providing at least one training chamber;
4 choosing selected items from a group of items of
5 furniture and fixtures and equipment;
6 placing the selected items in the chamber;
7 introducing propane gas flames and simulated smoke
8 into the chamber next to the selected items;

9 introducing fire fighters into the chamber to put out
10 the simulated fire using one of a group of extinguishing
11 agents;

12 sensing which one of the extinguishing agents is
13 being used by the fire fighters in the chamber;

14 simultaneously regulating and setting a level of fire
15 and a level of smoke in the chamber depending upon the
16 extinguishing agent being used;

17 and recording the test results of time and decisions
18 of the fire fighters, wherein

19 the sensing of which one of the extinguishing agents
20 is being used by the fire fighters in the chamber
21 includes;

22 collecting a sample of the extinguishing agent within
23 a first funnel;

24 testing a first portion of the sample within the
25 first funnel for the presence of powder;

26 moving a portion of the sample to a second funnel;

27 testing a second portion of the sample within the
28 second funnel for the presence of foam;

29 moving a portion of the sample to a third funnel; and

30 testing a third portion of the sample within the
31 third funnel for the presence of water.

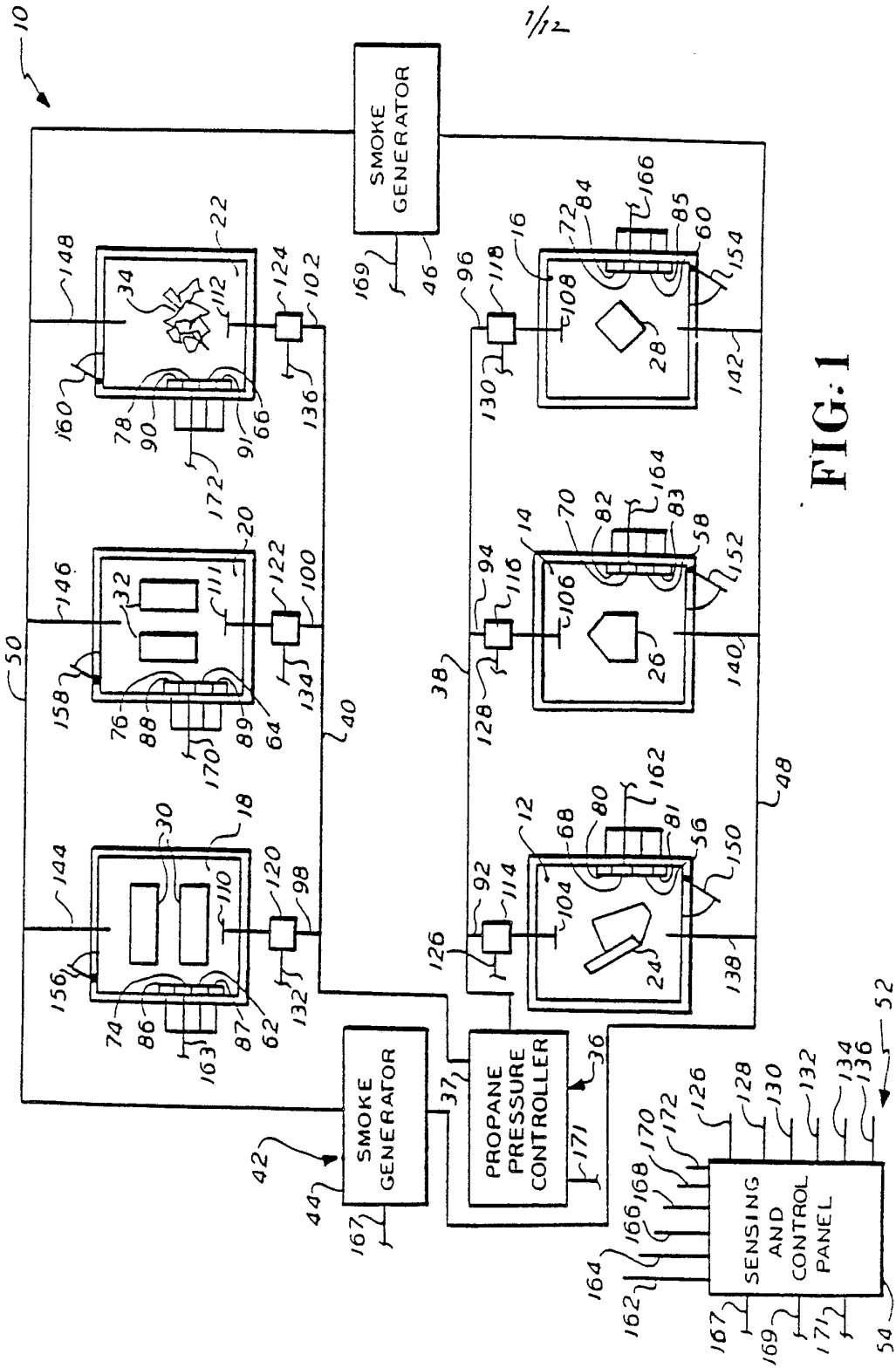


FIG. 1

3/12

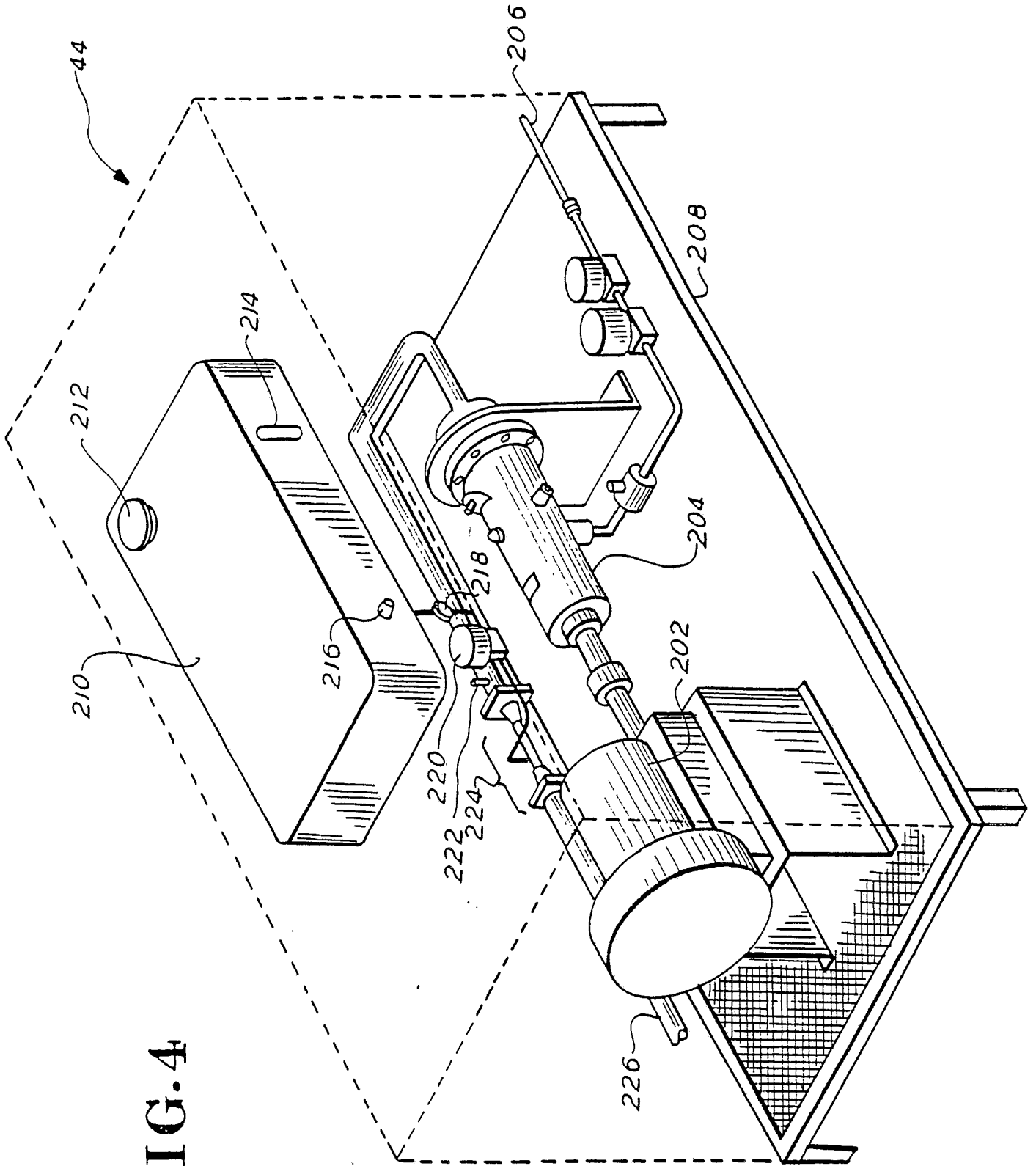


FIG. 4

4/12

FIG. 5

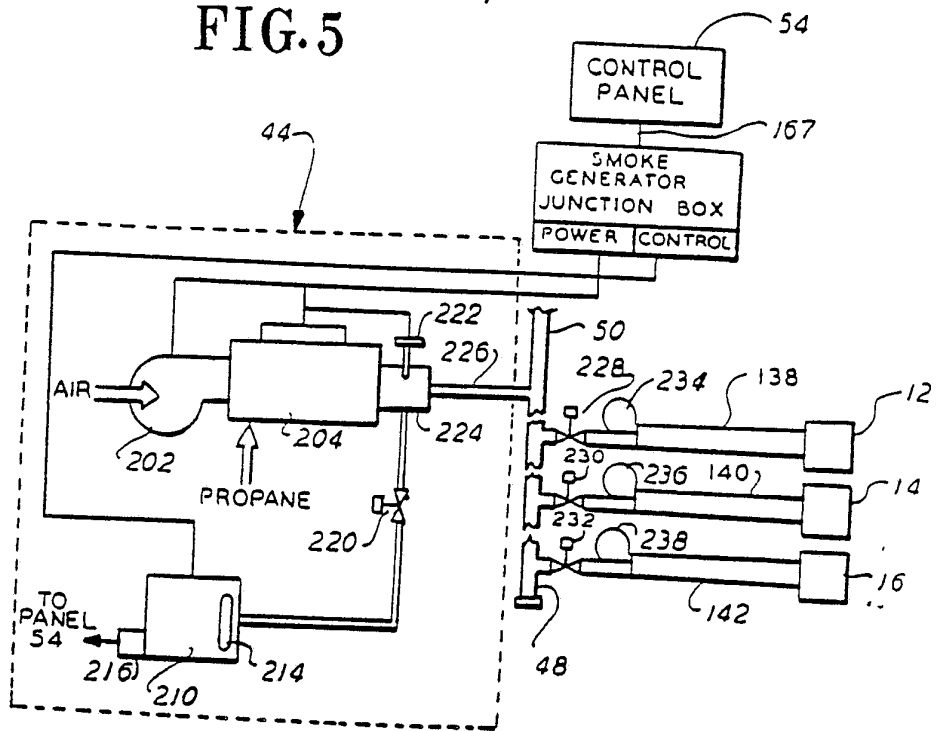
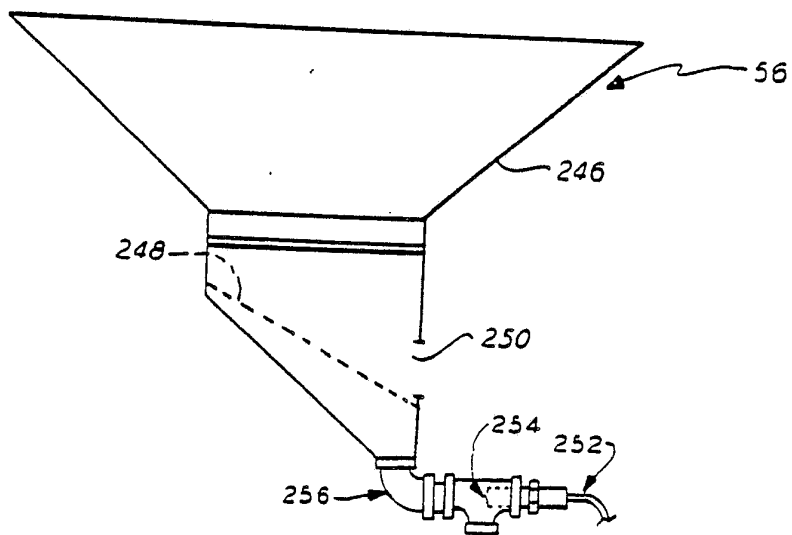


FIG. 6



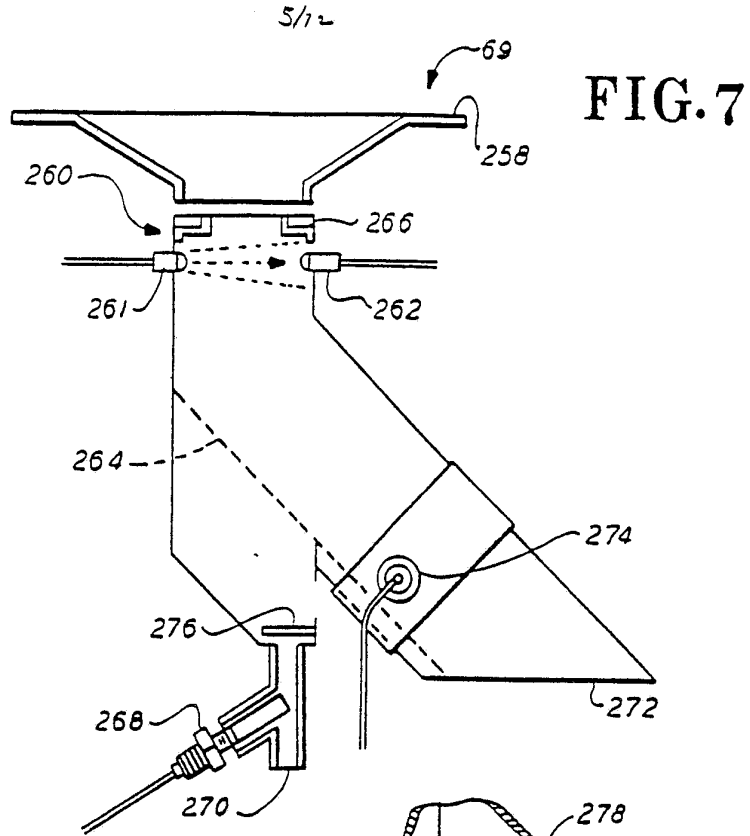
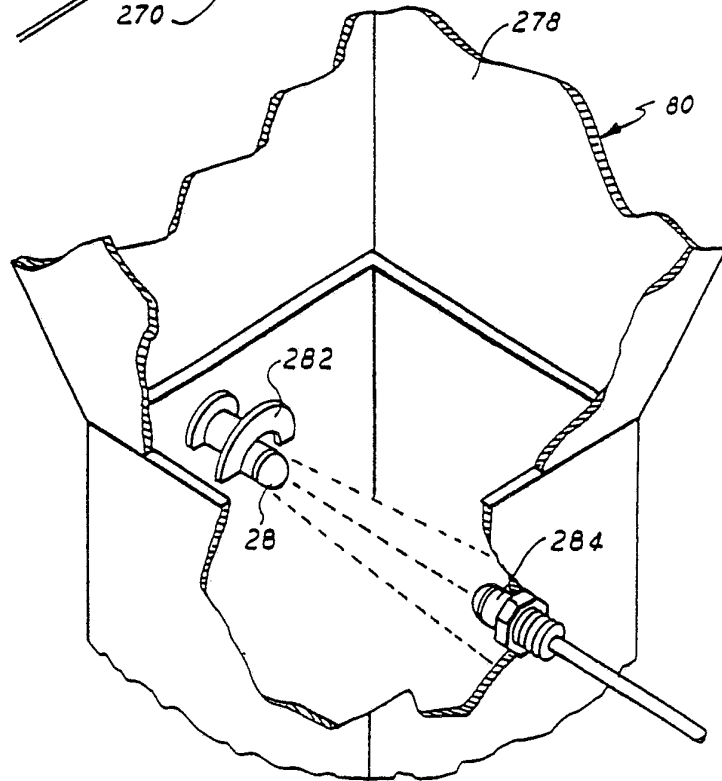


FIG.8



6/12

FIG. 10

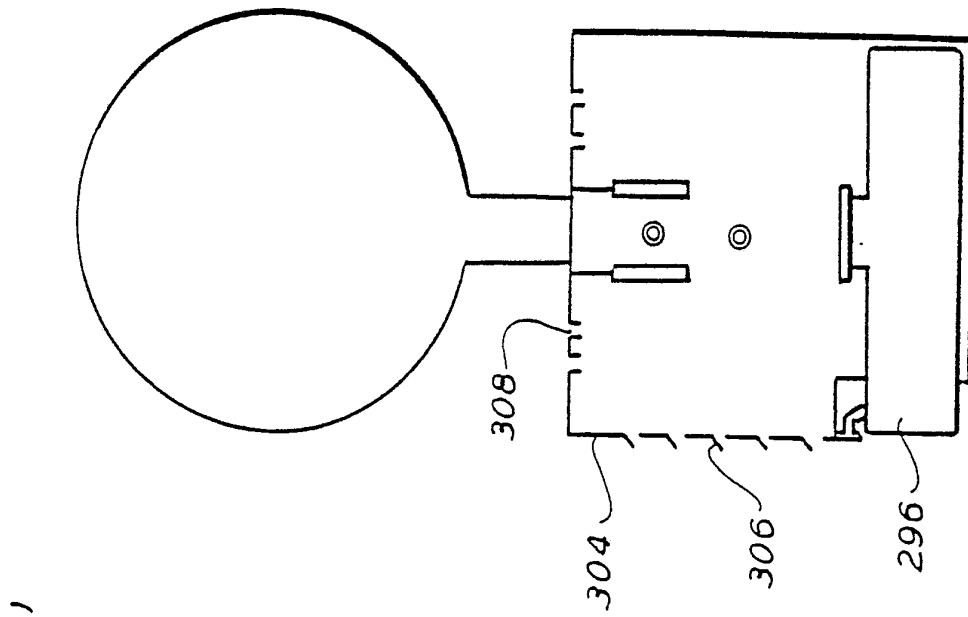
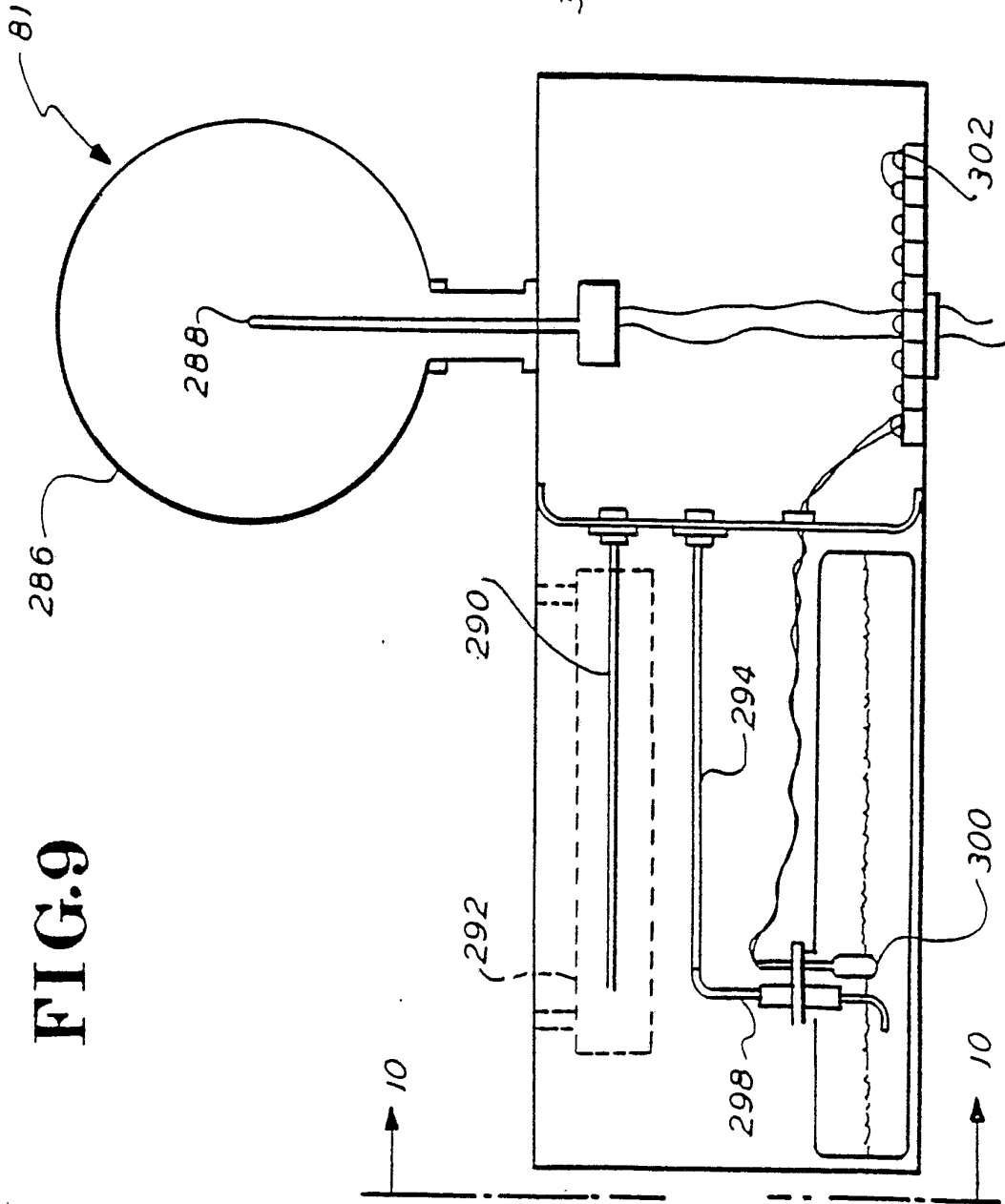


FIG. 9



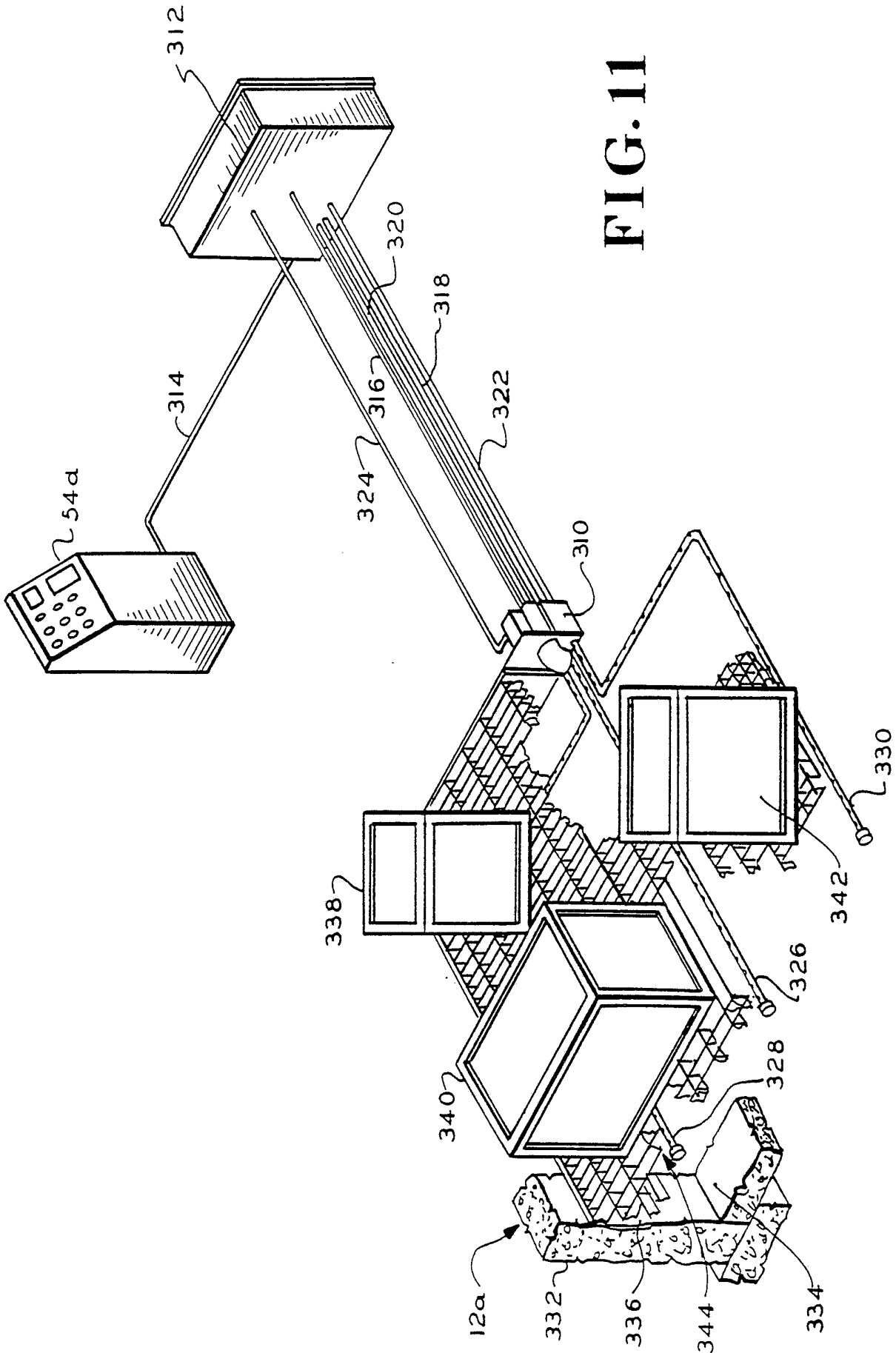


FIG. 11

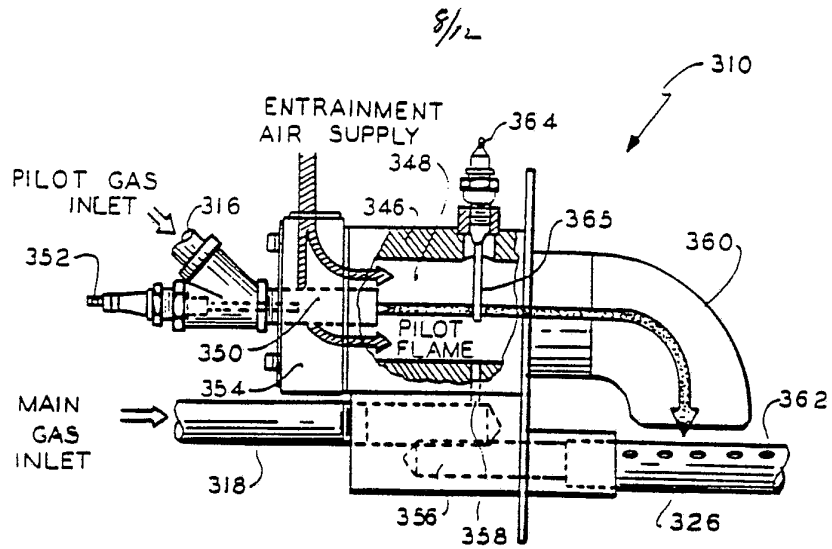


FIG. 12

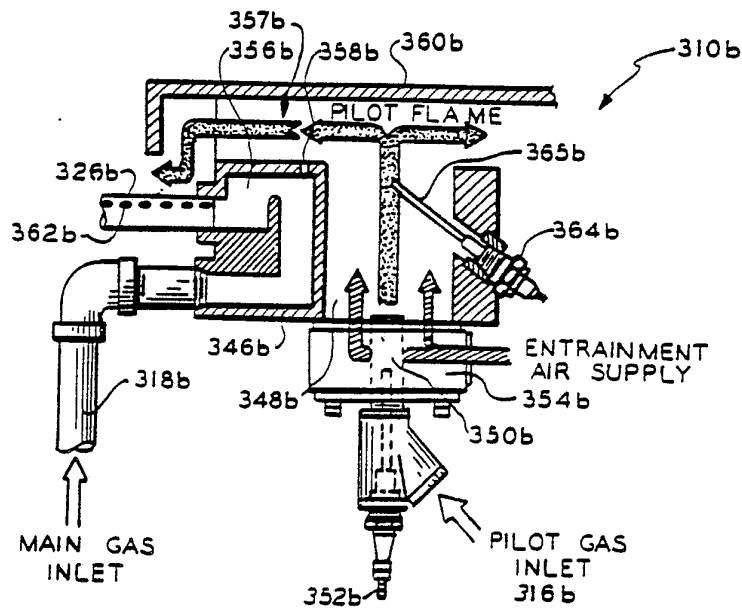


FIG. 13

9/12

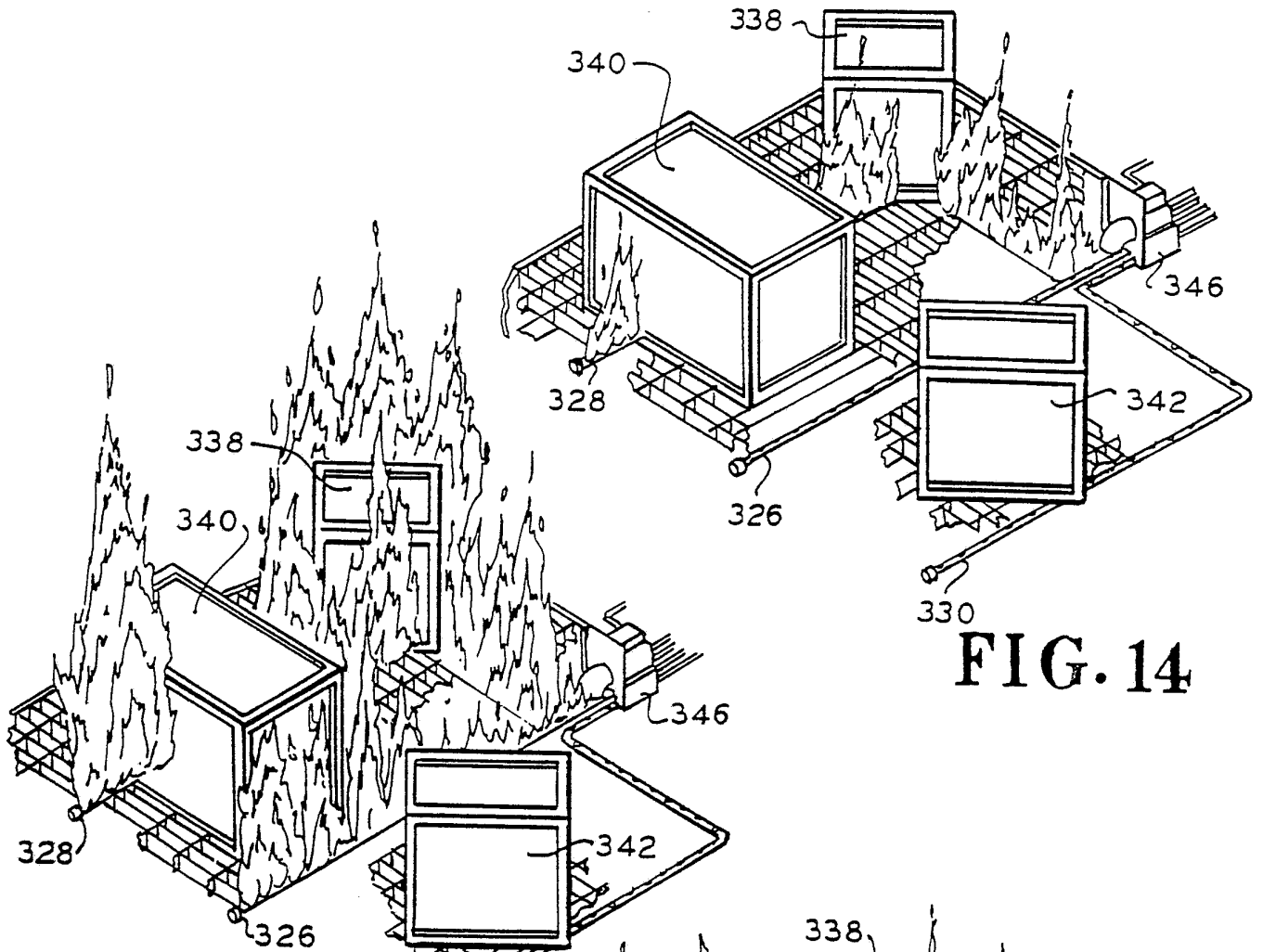


FIG. 14

FIG. 15

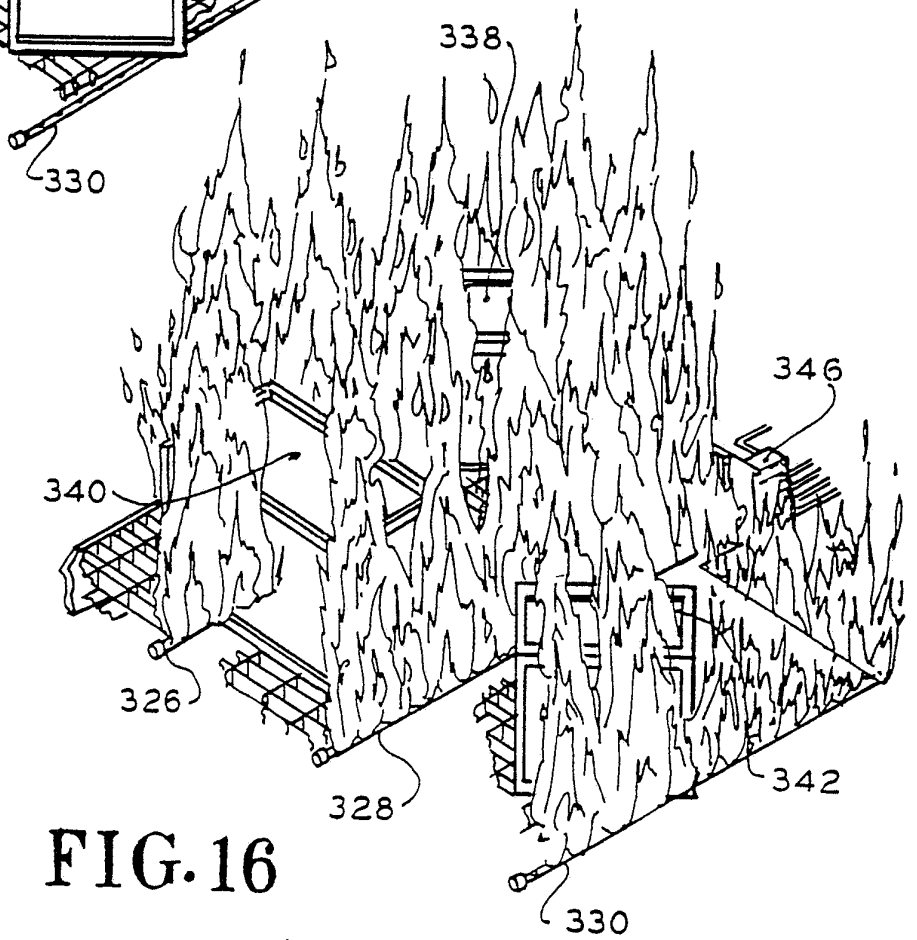


FIG. 16

10/12

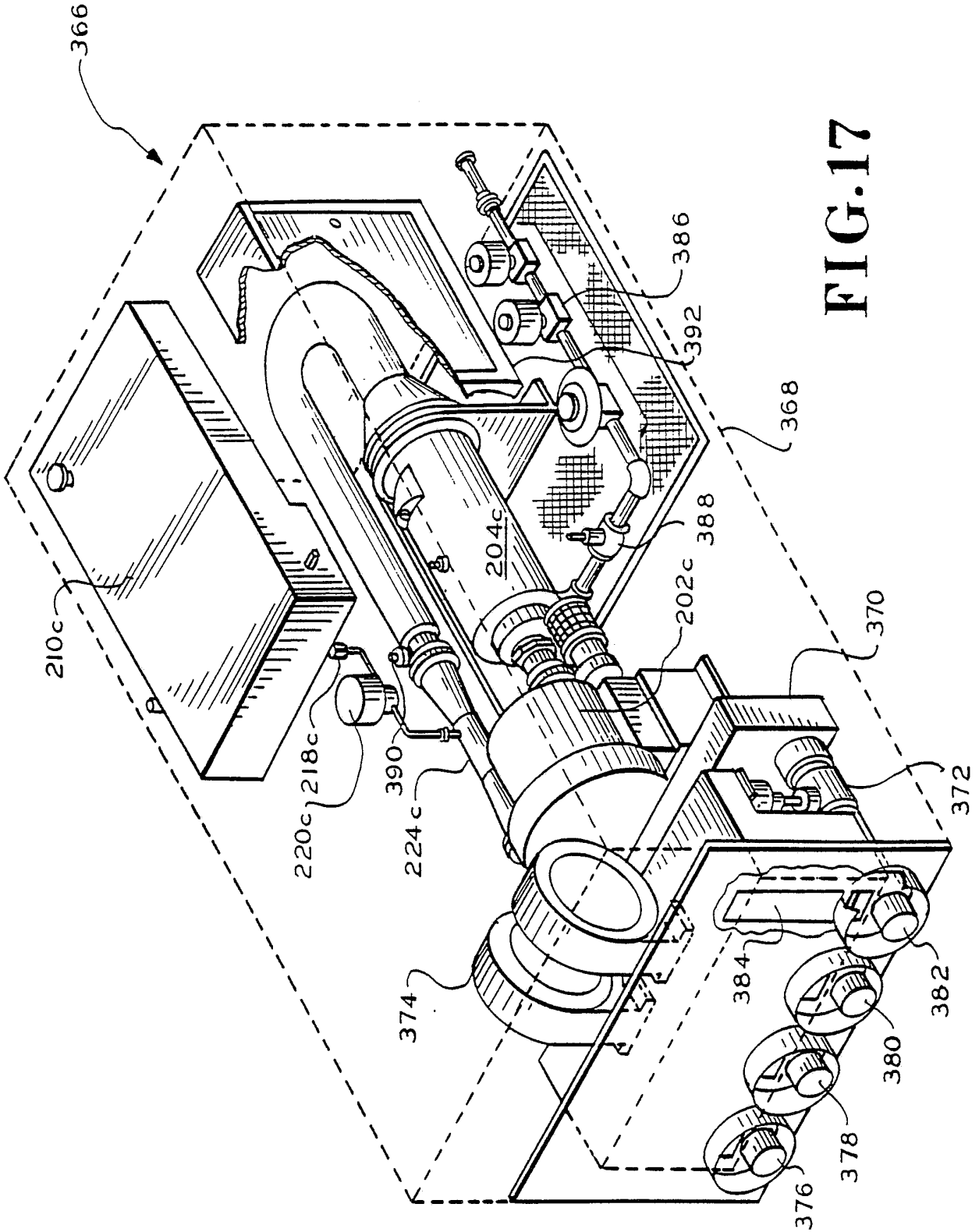


FIG. 17

11/2

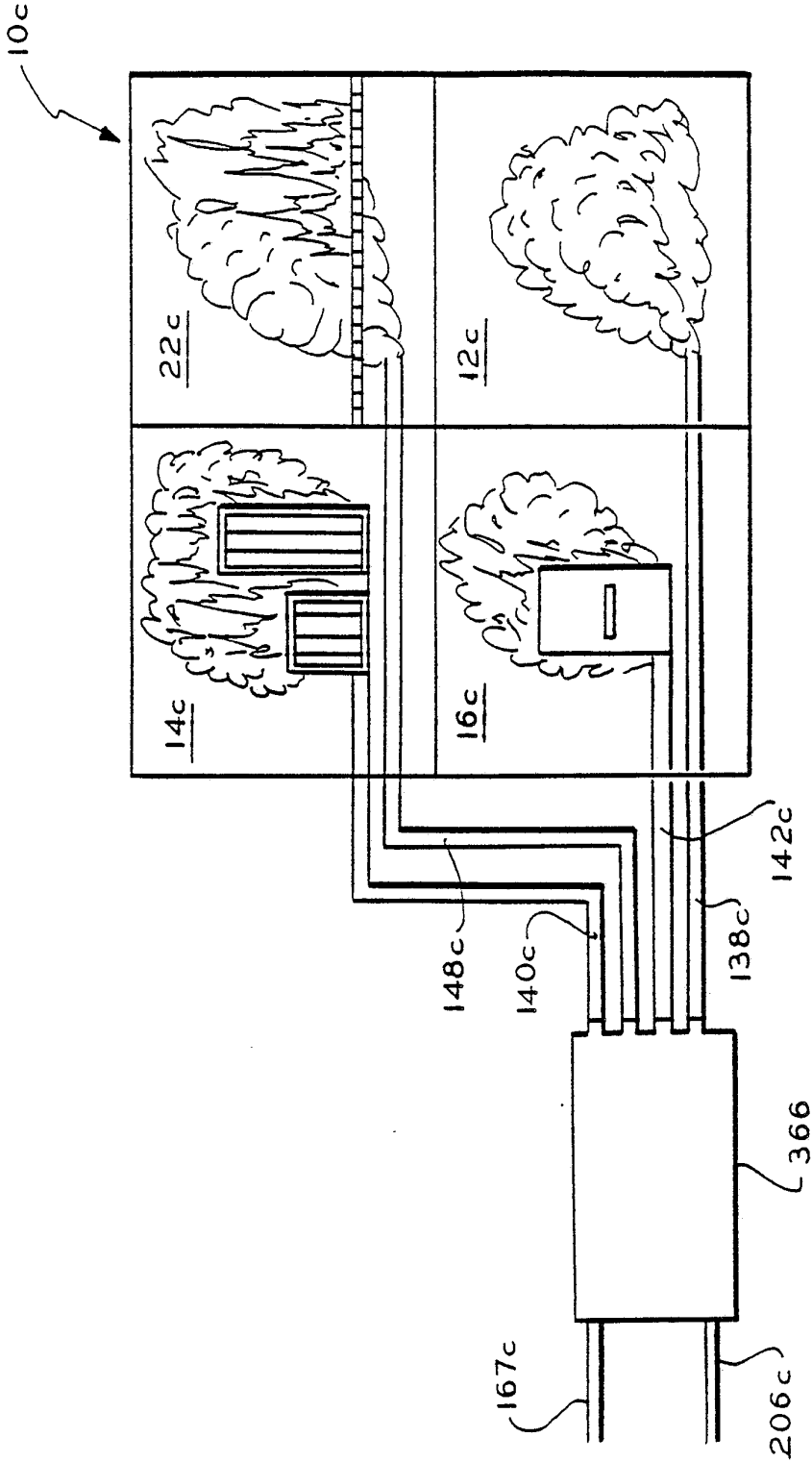


FIG. 18

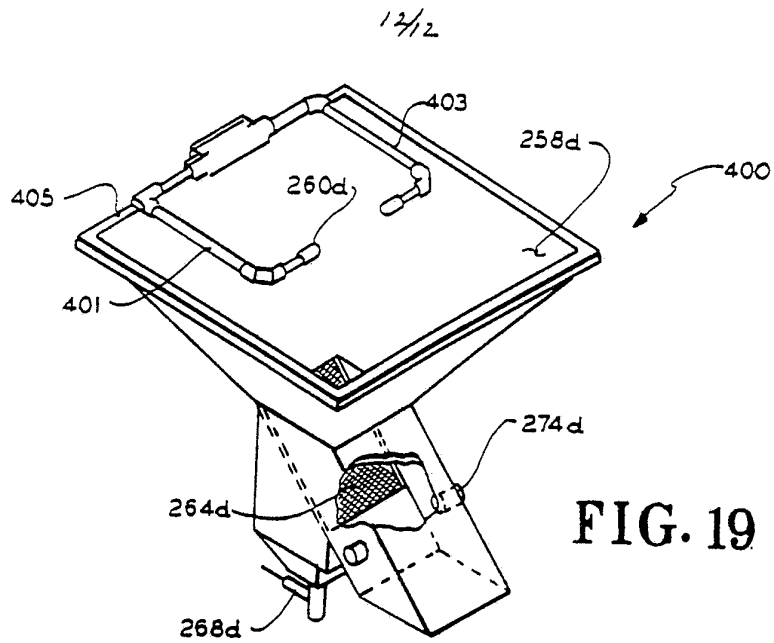


FIG. 19

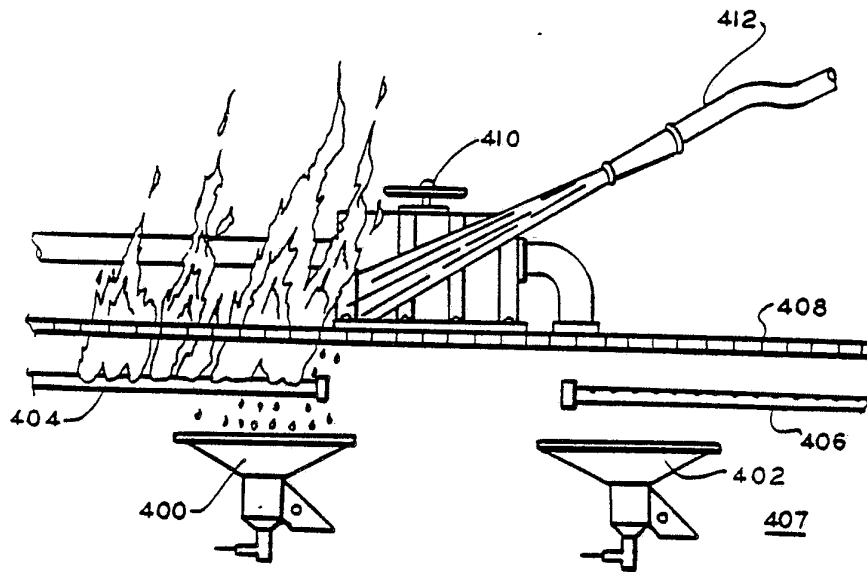


FIG. 20

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US89/03326

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC(4) G09B 9/00		
U.S. Cl. 434/226		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
U.S.	434/219,225; 169/1R	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X A	U,S,A, 4,526,548 02 July 1985 (LIVINGSTON) (See column 2, lines 43-65, column 3, lines 9-17 and column 4, lines 63-66).	<u>1,8,14,15</u> <u>2-7,9-13</u>
A	US,A, 4,299,579 10 November 1981 (SWIATOSZ et al) (See column 2, lines 30-45).	1-15
A	US,A, 4,303,396 01 December 1981 (SWIATOSZ) (See column 3, l. 54 to column 4, l. 2).	1-15
A	US,A, 4,303,397 01 December 1981 (SWIATOSZ) (See column 2, l. 11-15).	1-15
<p>* Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
18 September 1989		11 OCT 1989
International Searching Authority		Signature of Authorized Officer
ISA/US		<i>William A. Grieb</i> William A. Grieb