July 12, 1960 B. E. DEL MAR 2,945,222

MULTIPLE SMOKE-SIGNAL UNIT

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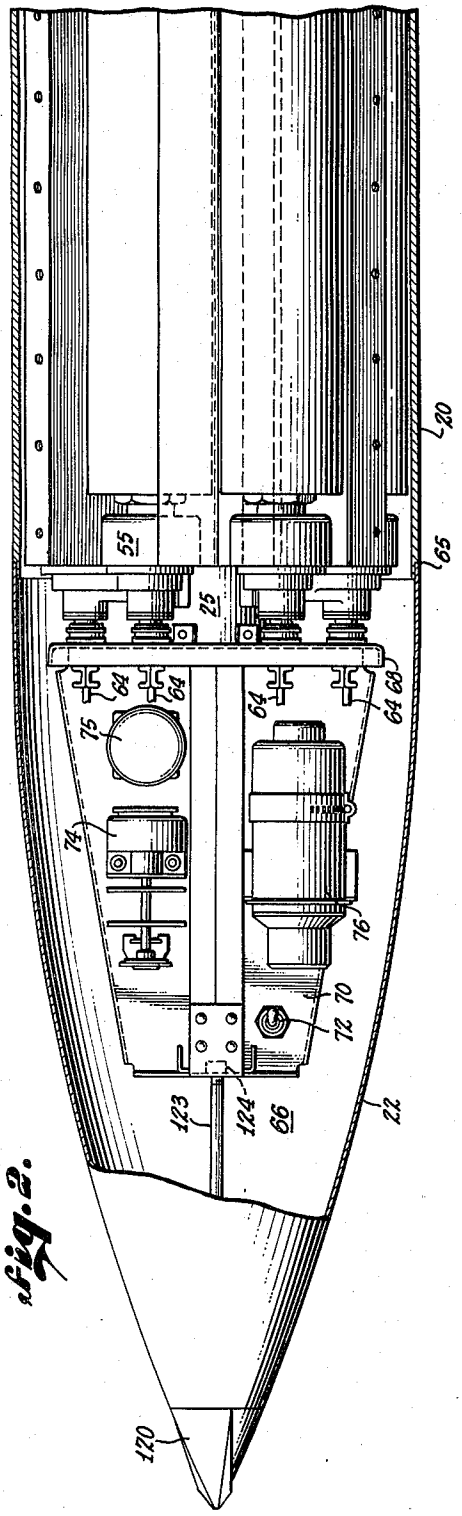

Fig. 2.

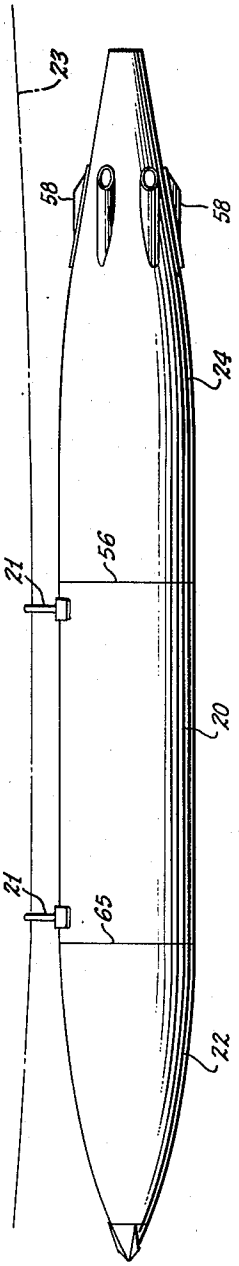

Fig. 1.

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MULTIPLE SMOKE-SIGNAL UNIT

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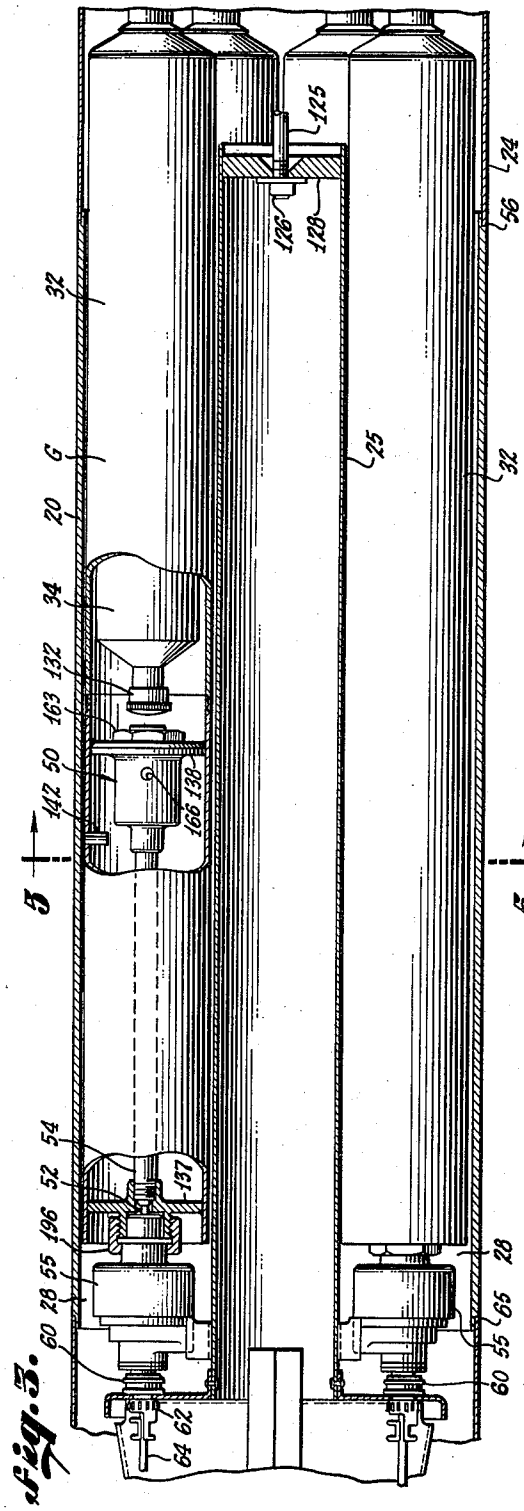

Fig. 3.

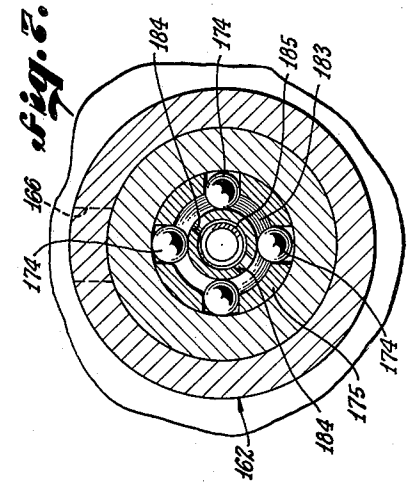

Fig. 7.

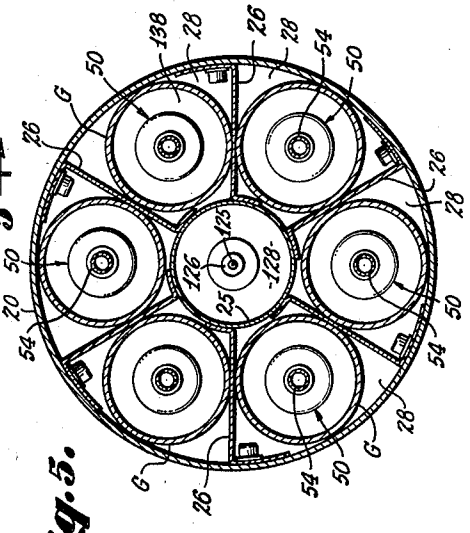

Fig. 5.

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Fig. 4.

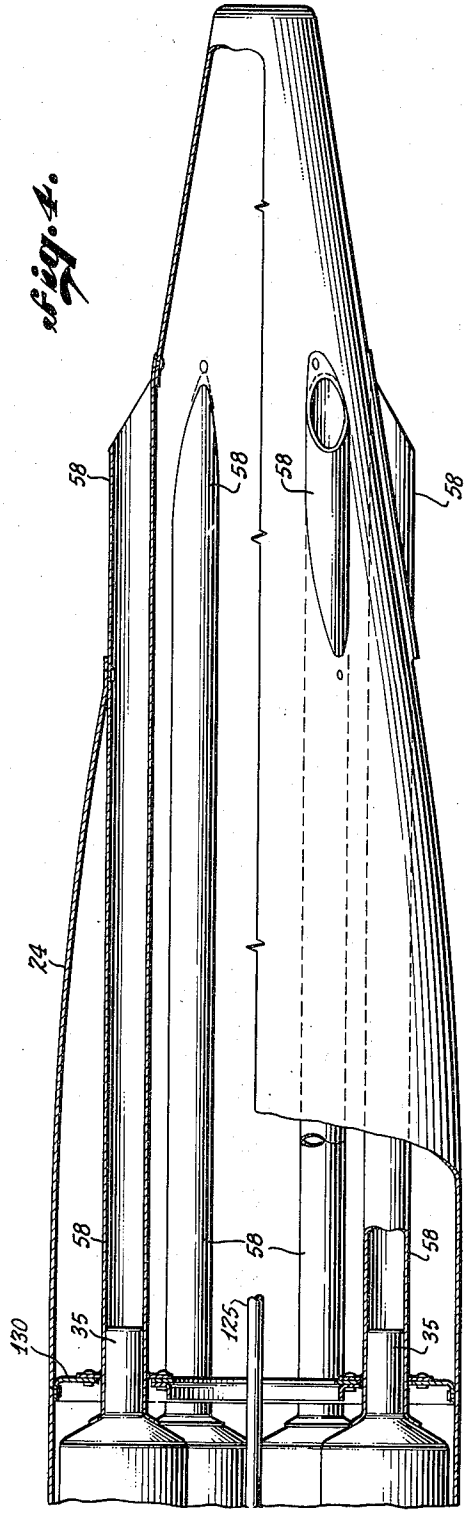
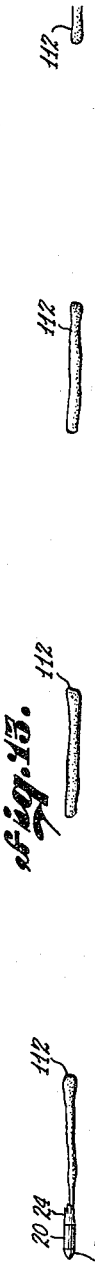


Fig. 11.

Fig. 12.

Fig. 13.



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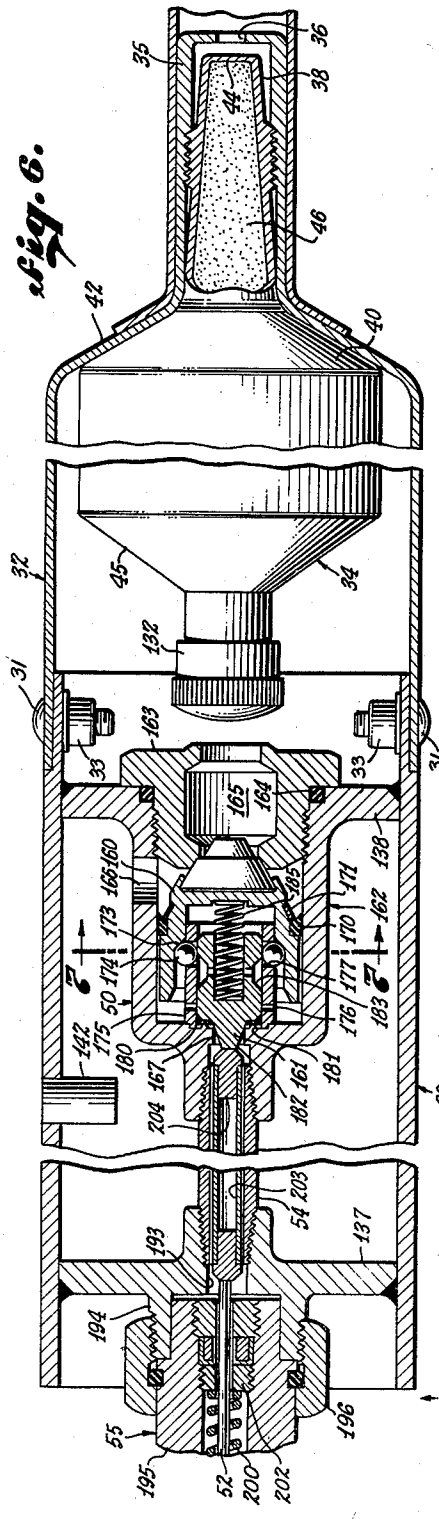

Fig. 6.

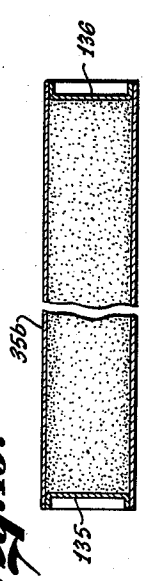

Fig. 15.

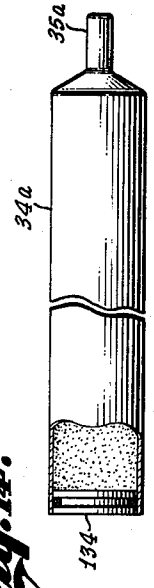

Fig. 14.

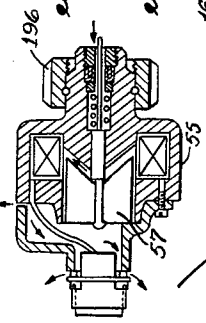

Fig. 6b

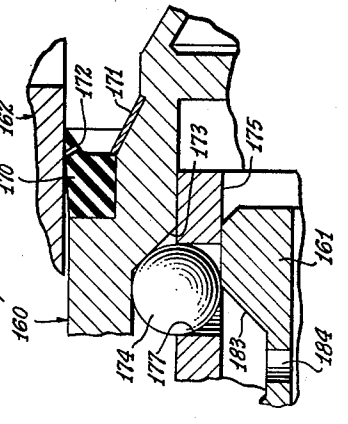

Fig. 6a.

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Fig. 8.

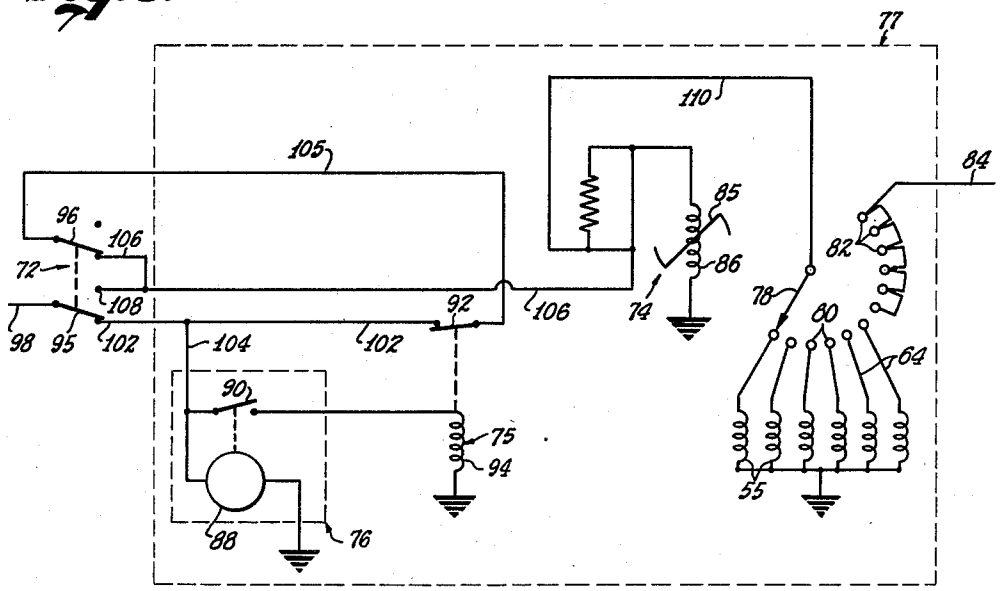


Fig. 9.

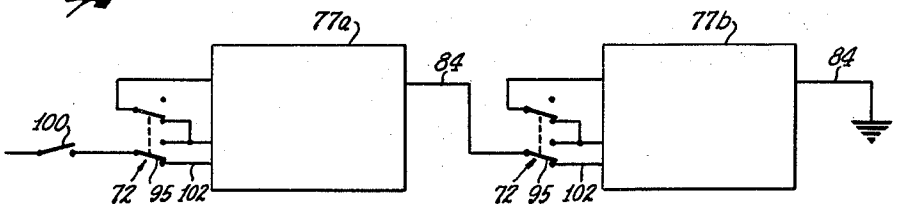
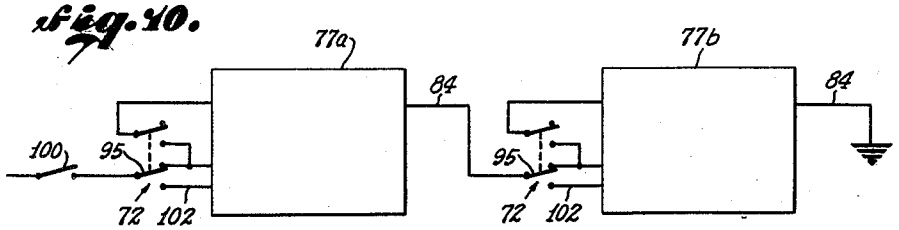


Fig. 10.



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United States Patent Office 2,945,222
Patented July 12, 1960

2,945,222

MULTIPLE SMOKE-SIGNAL UNIT

Bruce E. Del Mar, Los Angeles, Calif., assignor to Del Mar Engineering Laboratories, Inc., Los Angeles, Calif., a corporation

Filed Dec. 5, 1955, Ser. No. 550,995

10 Claims. (Cl. 340—366)

This invention relates to a device for use on an airborne vehicle to produce smoke signals to assist in visual orientation, identification and tracking of the airborne vehicle. The invention is particularly directed to an apparatus for this purpose that is capable of creating a plurality of such signals in controlled sequence.

The preferred method of producing a smoke signal is disclosed in the copending Del Mar application, Ser. No. 410,392, entitled Smoke Signal Device, now Patent No. 2,923,930, which disclosure is hereby incorporated in the present disclosure by reference. The smoke signal is created by using a disposable cartridge that has at least one inwardly movable wall to permit the cartridge to be collapsed and discharged by exteriorly applied fluid pressure. The cartridge is placed in a chamber having a suitable discharge nozzle and high-pressure fluid, for example, compressed air, is admitted to the cartridge chamber to cause the desired collapse and discharge of the cartridge when desired. The duration of a single smoke signal is determined by the size of the discharge nozzle orifice, and cartridges having nozzle orifices of different sizes may be used interchangeably to produce smoke signals ranging in duration, for example, from one to thirty seconds each.

The material that is used in the cartridge to produce a smoke signal may be, for example, titanium tetrachloride which reacts with the moisture of the atmosphere to produce smoke. The cartridge may contain two chemicals if desired for reaction without assistance from the atmosphere. In some practices of the invention, the cartridge contains inert powder which may be colored to produce a colored smoke signal.

The present invention is directed to a multiple-signal unit of this character which may be permanently incorporated in the construction of an airborne vehicle or may be in the form of a self-contained stream-lined unit provided with shackle loops or shackle lugs to permit the unit to be temporarily mounted on the airborne vehicle in the same manner as a bomb or a jettisonable fuel tank.

The present apparatus makes it possible to initiate an automatic signal cycle in which the individual smoke signals are produced at predetermined equal time intervals. Thus the smoke signals may be produced in immediate succession in a cycle to produce a composite continuous signal of relatively long duration or may be spaced in time to create a dash-type visual signal of longer overall duration. The present apparatus also makes it possible, if desired, to produce single smoke signals on demand.

The self-container multiple-signal unit of the preferred practice of the invention has a built-in control system for response to a master control switch. This master control switch may be in the cabin of the aircraft for operation by the aircraft pilot or may be remotely controlled by radio. The preferred control system for the self-contained multiple-signal unit includes a rotary stepping relay, a normally closed relay for controlling the stepping relay and an intervalometer for sending current pulses to the normally closed relay.

The selector switch of the master control may be set for two different modes of operation. When the selector switch is set at its first position for what may be termed the first mode of operation, closing the master switch results in automatic cyclic operation of the stepping relay by the intervalometer in cooperation with the normally closed relay. When the selector switch is set at its second position for what may be termed the second mode of operation, the master control switch is connected directly to the stepping relay to create the individual smoke signals on demand, the master control switch being closed and opened to produce each signal.

One feature of the invention is that two such self-contained multiple-signal units may be mounted on an aircraft to provide twice as many signals and the two controls may be connected either in series or in parallel for various signal programs. For example, to carry out a program comprising a single extensive automatic cycle, the two units are connected in series with the selector switches of both units set at their first positions. Closing the master control switch initiates the automatic cycle in which the first unit discharges all of its signal discharges in timed succession and then, without interruption, the second multiple-signal unit continues the cycle.

With the same series arrangement, the selector switch of the first unit may be set at its first position and the selector switch of the second unit set at its second position so that when the master switch is closed the first unit will go through its automatic cycle thereafter the second unit will create individual smoke signals in response to operation of the master control switch. Also with the same series arrangement, both selector units may be set at their second positions for demand operation by the master control switch, the first multiple-signal unit automatically connecting the second multiple-signal unit with the master control switch when all of the signal charges of the first unit are exhausted.

The features and advantages of the invention may be understood from the following detailed description considered with the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

Figure 1 is a side elevation of the presently preferred embodiment of the invention as a multiple-signal unit adapted to be mounted detachably on an aircraft;

Figure 2 is an enlarged side elevation of the nose end of the unit with housing wall broken away;

Figure 3 is a similar view of the intermediate portion of the unit;

Figure 4 is a similar view of the tail end of the multiple-signal unit;

Figure 5 is a transverse section taken along the line 5—5 of Figure 3 showing how six signal guns are stored in the unit;

Figure 6 is an enlarged longitudinal sectional view of one of the signal guns;

Figure 6*a* is an enlarged detail of Figure 6;

Figure 6*b* is a longitudinal sectional view of a valve-actuating solenoid;

Figure 7 is an enlarged cross section of the signal gun valve taken along the line 7—7 of Figure 6;

Figure 8 is a wiring diagram of the control system of the multiple-signal unit;

Figure 9 is a diagram showing how two of the signal units may be connected in series with the master control switch for an automatic signal cycle;

Figure 10 is a similar diagram showing how two multiple-signal units may be connected in series with the mas-

ter control switch to produce individual smoke signals on demand;

Figure 11 is a diagrammatic view showing how a continuous composite smoke signal may be produced by the multiple-signal unit when adjusted for a cycle of immediately successive signals;

Figure 12 is a similar view showing how a dash-type composite signal may be produced by the multiple-signal unit when adjusted for a signal cycle with short time intervals between the individual signals;

Figure 13 is a similar view showing a dash-type composite signal comprising a succession of smoke signals at greater spacing that may be produced by adjusting the multiple-signal unit for cyclic operation at longer time intervals;

Figure 14 is a view partly in side elevation and partly in section showing a second form of collapsible cartridge for smoke-producing material, which cartridge has an end wall that functions in the manner of a piston in response to applied external fluid pressure; and

Figure 15 is a longitudinal sectional view of another form of collapsible cartridge containing powdered material to create a smoke signal, the cartridge having two frangible end walls.

General arrangement

The presently preferred embodiment of the invention shown in the drawings is a multiple-signal smoke unit having a stream-lined housing made in separable sections, the housing including a central cylindrical section **20**, a removable nose cone **22**, and a removable tail cone **24**. Preferably the central housing section **20** is provided with spaced shackle elements **21** whereby the multiple-signal unit may be removably mounted on an aircraft **23**. As best shown in Figure 5, the central cylindrical housing section **20** has a rigid internal structure comprising an axial cylinder **25** and six longitudinal radially disposed partitions **26** that divide the interior into six longitudinal compartments **28**.

The six longitudinal compartments **28** store six corresponding signal guns, each of which is generally designated by the letter G. As best shown in Figure 6, each of the signal guns G is of cylindrical construction and may comprise a forward pressure chamber **30** or high-pressure fluid reservoir and an aft cartridge chamber **32** which normally houses a disposable or throw-away collapsible smoke signal cartridge **34**. The cartridge chamber **32** is removably mounted on the end of the pressure chamber **30** by screws **31** and anchor nuts **33** so that removal of the cartridge chamber affords access to the interior thereof to permit replacement of the cartridges therein.

The cartridge chamber **32** of each of the signal guns G has a discharge nozzle **35** (Figure 6) with a nozzle aperture **36** therein and since this nozzle aperture restricts the discharge flow, the size of the aperture determines the duration of a smoke signal. The cartridge chamber nozzle **35** has an interior screw thread as shown to receive the external screw thread **37** of a cartridge nozzle **38** and these two screw threads may be tightened by rotation of the cartridge to draw the forward conical wall **40** of the cartridge against the forward conical wall **42** of the cartridge chamber.

The cartridge nozzle **38** is closed and sealed by a thin frangible wall **44** that is designed to rupture in response to pressure internally of the cartridge. The cartridge **30** has at least one inwardly movable wall so that the cartridge will collapse in response to external fluid pressure. In this instance, the whole cartridge is made of a soft metal alloy so that both the forward end wall **45** and the longitudinal cylindrical wall of the cartridge will readily collapse in response to fluid pressure thereby to cause rupture of the frangible wall **44** with consequent discharge of the smoke producing content **46** through the nozzle aperture **36**. As heretofore stated, this smoke producing material may be, for example, titanium tetrachloride.

The pressure chamber high-pressure fluid reservoir **30** may confine compressed air at 650 p.s.i., for example, and has a normally closed discharge valve, generally designated **50** (Figure 3), for communication with the interior of the cartridge chamber **35**. This valve may be opened when desired by means of an axial push rod **52** (Figure 6) in an axial tube **54**, the push rod being in turn actuated by a suitable solenoid **55** (Figure 3) on the forward end of a smoke signal gun, the solenoid having an armature **57** as shown in Figure 6*b*.

The tail cone **24** is mounted on the central cylindrical section **20** of the housing in a suitable removable manner, the joint being a telescoping joint indicated at **56** in Figure 3. The tail cone **24** has six tail pipes **58** which are removably and telescopically connected with the corresponding cartridge chamber nozzles **35**, as shown in Figures 4 and 6. Removal of the tail cone exposes the aft ends of the longitudinal compartments **28** for removal of the signal guns G therefrom.

The individual signal guns G are removably mounted in the individual longitudinal compartments **28**. For this purpose, each of the solenoids **55** has an electrical plug **60** on its forward end that plugs into a corresponding fixed adapter **62**. Each of the adapters **62** has an insulated wire **64** connected thereto for energization of the corresponding solenoid **55**, the solenoid being grounded to complete the circuit.

The nose cone **22** which is removably mounted on the central cylindrical section **20** of the housing along a telescoping joint **65** (Figure 2) forms a control compartment **66** for the control system of the multiple-signal unit. For the purpose of mounting the components of the control system, a circular frame member **68** is rigidly mounted on the forward end of the previously mentioned axial cylinder **25** and a longitudinal platform **70** extends rigidly forward from the circular frame member. The circular frame member carries the six fixed adapters **62** corresponding to the six smoke signal guns G, and the longitudinal platfom **70** carries a two-position selector switch **72**, a rotary stepping relay **74**, a normally closed relay **75** for actuating the stepping relay, and, finally, a suitable intervalometer **76** for controlling the normally closed relay **75**.

Electrical control system

The electrical control system of the multiple-signal unit is shown in Figure 8 in which the dotted rectangle **77** represents a multiple-signal unit. The rotary stepping relay **74** which is of a familiar construction that need not be described in detail, has a ratchet-actuated switch arm **78** that traverses a first series of six contacts **80** and a second series of similar contacts **82**. The first series of contacts **80** are connected respectively to the previously mentioned insulated wires **64** that lead to the corresponding adapters **62** for energizing the smoke gun solenoids **55**. The second series of contacts **82** are interconnected as shown and are connected to a wire **84**, the purpose of the wire **84** being to permit two of the multiple-signal units to be connected in series.

The rotary stepping relay **74** includes the usual mechanical actuator **85** which is actuated by a grounded coil **86**, the actuator and coil functioning as a solenoid. The mechanical actuator **85** carries a pawl (not shown) which is provided with a suitable spring (not shown) and which engages successive ratchet teeth (not shown) to advance the rotary switch arm **78**. When the coil **86** is energized, it retracts the pawl in opposition to the pawl spring to engage a new ratchet tooth and does so without affecting the rotary switch arm **78**. When the coil **86** is subsequently energized, however, the spring acting on the pawl causes the rotary switch arm **78** to advance one step.

The intervalometer **76** which is of a well known type

that need not be described in detail, includes a timing motor 88 and a normally open switch 90 that is controlled by the motor. The normally closed relay 75 comprises a relay arm 92 that is actuated by a coil 94. The selector switch 72 has two switch arms 95 and 96 that are mechanically interconnected to operate in unison. Switch arm 95 is connected to an input lead 98 which is connected to a suitable voltage source through a master control switch 100 (Figure 9). As heretofore stated, if the multiple-signal unit is carried by a manned aircraft, the master control switch 100 may be on the control panel in the aircraft, but if the airborne vehicle is not manned, the master control switch 100 may be operated by radio from a remote station.

At the first position of the selector switch 72 which is shown in Figure 8 and which is used for the first mode of operation of the unit, the switch arm 95 of the selector switch connects the input lead 98 with a wire 102 that leads to one side of the normally closed relay 75. A wire 104 branches from the wire 102 to one side of the intervalometer switch 90 and to one side of the intervalometer motor 88, the second side of the motor being grounded as shown. The other side of the relay arm 92 is connected by a wire 105 with the second arm 96 of the selector switch 72. At this first position of the selector switch, switch arm 96 connects the wire 105 with a wire 106 which is connected to one side of the coil 86 of the stepping relay and which is also connected to a contact 108 of the selector switch 72. A branch wire 110 connects the wire 106 with the rotary switch arm 78.

Modes of operation

The manner in which the control system of Figure 8 serves its purpose may be understood from the diagram and the foregoing description. At the start of a flight, the selector switch 72 is at its first position shown in Figure 8, the master control switch 100 is open, the intervalometer switch 90 is open, the relay 75 is in its normal closed position, the stepping relay coil 86 is deenergized and the rotary switch arm 78 is at its first circuit-closing station. When the master control switch 100 is closed, it completes the following circuit to energize the stepping relay coil 86: wire 98, switch arm 95 of the selector switch, wire 102, relay arm 92, wire 105, selector switch arm 96, and wire 106 to one side of the stepping relay coil 86, the other side of the coil being grounded. This energization of the coil 86 retracts the mechanical actuator 85 and the pawl thereon against spring pressure without shifting the rotary switch arm 78.

With the switch arm 78 remaining at its first station, it connects wire 110 with the insulated wire 64 at the first stepping relay station to energize the solenoid 55 of the corresponding signal gun G for creation of a smoke signal in the manner heretofore described. After a predetermined time interval, the intervalometer switch 90 is closed by the intervalometer motor 88 for a brief period to open the normally closed relay 75 momentarily. The momentary opening of the relay 75 permits spring actuation of the mechanical actuator 85 to advance the rotary switch arm 78 to its second station. This advancement of the rotary switch arm 78 immediately closes the circuit through the solenoid 55 of the next successive signal gun G. Thus closing of the master control switch 100 while the selector switch 72 is at its first position causes the six signal guns G to be actuated in sequence at equally spaced time intervals.

If the time intervals are substantially equal to the time duration of the individual smoke signals the result is a composite continuous signal such as shown in Figure 11 in which the individual smoke signals 112 are positioned end to end. If the time intervals from initiation to initiation of the successive signals are somewhat longer, the individual smoke signals 112 are spaced apart by relatively short distances to produce the longer composite dash-type signal shown in Figure 12. Still longer time intervals between the starting points of the successive signals produces the elongated dash-type composite signals shown in Figure 13. Thus the composite signal may be stretched out both in time and in space and usually without loss of visibility.

Figure 9 shows how two signals units may be connected in series with the signal unit 77*a* serving as a master unit and the signal unit 77*b* serving as a slave unit. It will be noted that the selector switches 72 of both units are in their first positions and that the previously mentioned wire 84 from the master unit is connected to the switch arm 95 of the slave unit.

When the master control switch 100 is closed, the master unit 77*a* operates in the manner above described to produce its six signals in a cycle and then the rotary switch arm 78 reaches the first of the second series of contacts 82 to energize the control circuit of the slave unit 77*b*. As the rotary switch arm 78 in the master unit 77*a* traverses the second series of contacts 82, the intervalometer of the slave unit 77*b* carries on the signal cycle without interruption by operating the signal guns of the slave unit in the same sequential manner. Thus the two units cooperate to produce a composite signal comprising twelve individual smoke signals.

It is apparent from an inspection of Figure 8 that if the selector switch 72 is in its alternate second position the selector switch arm 95 will cooperate with the switch contact 108 to connect the master control switch 100 directly with the coil 86 of the stepping relay 78. The six signal guns G of the unit may now be operated one at a time by closing and opening the master control switch 100. Closing the master control switch energizes the stepping relay coil 86 and subsequent opening of the master control switch permits the rotary switch arm 78 to be advanced to the next station by spring action.

Figure 10 shows how the two multiple signal units 77*a* and 77*b* may be connected in series with both of their selector switches 72 in their second positions. In this arrangement, the individual smoke guns are operated in sequence on demand. Each time the master control switch 100 is closed and opened one of the signal guns is operated. It is apparent that the rotary switch arm 78 of the first unit 77*a* operates the six signal guns in the first unit in succession and then cooperates with the second series of contacts 82 to connect the master control switch 100 directly to the second unit 77*b*. The second unit then responds to opening and closing of the master switch 100 in the same manner. Thus Figure 10 provides twelve smoke signals on demand in response to closing and opening of the master control switch 100 twelve times.

Details of construction

The nose cone 22 is retained in assembled position by a nose fitting 120 (Figure 2) on the end of a longitudinal tie rod 123, which tie rod screws into a fixed nut 124 on the forward end of the longitudinal platform 70. In like manner the tail cone 24 is held in position by a tail fitting (not shown) on the rear end of a tie rod 125 (Figure 3), the other end of the tie rod being threaded into a fixed nut 126 of the axial cylinder 25. It is apparent that the nose cone 22 may be readily removed for access to the control compartment 66 and that the tail cone 24 may be readily removed for access to the six longitudinal compartments 28. As best shown in Figure 4, the tail cone 24 is provided with an internal transverse frame member 130 which holds the forward ends of the tail pipes 58 in fixed spaced relation to mate with the cartridge chamber nozzles 35.

The particular smoke signal cartridge 34 shown in Figures 3 and 6 is in the form of a collapsible cylindrical tube which is filled with the smoke-producing material 46 and is then sealed by a cap 132. The cartridge may be

made of a suitable non-metallic plastic material or may be made of a soft metal alloy, the material being sufficiently pliable to permit the cartridge to collapse for discharge of its contents in response to exteriorly applied fluid pressure. It is apparent that when compressed air is admitted to a cartridge chamber **32** from the corresponding fluid pressure reservoir **30**, the cartridge **34** therein will collapse and the frangible wall **44** at the end of the nozzle **38** will rupture to permit the material to be discharged through the aperture **36** of the cartridge chamber nozzle **35**.

In some instances, a collapsible cartridge **34***a* shown in Figure 14 may be substituted for the collapsible cartridge **34**. The cartridge **34***a* has a rigid cylindrical wall and is closed at its forward end by a floating wall or piston **134** in cooperation with a suitable O-ring. When the container **34***a* is subjected to external fluid pressure, the piston **134** is moved longitudinally inward to cause collapse of a frangible wall (not shown) that closes the cartridge nozzle **35***a* in the manner heretofore described.

Figure 15 shows a third cartridge **35***b* that may be used interchangeably with the cartridges **35** and **35***a*. The cartridge **35***b* is used for the creation of a smoke signal by the discharge of a suitable inert powder, for example, chrome yellow. The cartridge **35***b*, which may be made entirely of cardboard, has a cylindrical shell closed at its ends by suitable walls in the form of frangible cardboard discs **135** and **136**.

As best shown in Figure 6, the pressure chamber or reservoir **30** of each of the smoke signal guns G may be closed at its opposite ends by heavy transverse walls **137** and **138**. To permit replenishment of the charge of compressed air in the reservoir **30**, the cylindrical wall of the reservoir is provided with a suitable check valve **142** to function as an intake valve.

Any suitable valve arrangement may be employed for release of the high pressure fluid from the high pressure reservoir **30** into the adjoining cartridge chamber **32** to cause collapse of the smoke producing cartridge therein. Preferably, a pilot-operated valve is provided for this purpose to be actuated by the corresponding solenoid **55**.

In the present construction, a main valve **160** and a pilot valve member **161** are mounted in a cylindrical valve casing **162** that is integral with the end wall **138** of the high pressure reservoir **30**, the valve casing being surrounded by the pressurized gaseous fluid in the reservoir. The rear end of the valve casing **162** carries a threaded bushing **163** provided with a sealing ring **164**, which bushing forms an outlet port **165** in communication with the cartridge chamber **32**.

The main valve member **160** has a conical nose which normally seats in the threaded bushing **163** to close the outlet port **165** as shown in Figure 6. The cylindrical valve casing **162** has a peripheral inlet port **166** at the same end as the discharge port **165** to admit high pressure fluid from the chamber **30** and at the other end has an axial relief port **167** for communication with the atmosphere. When the main valve member **160** is retracted out of its normal seat in the bushing **163** the gaseous fluid confined under pressure in the high pressure reservoir **30** may pass through the peripheral inlet port **166** into the valve casing **162** and out of the valve casing through the outlet port **165** into the cartridge chamber **32** containing the collapsible cartridge **34**.

The main valve member **160** is surrounded by a suitable sealing ring **170** held in place by a tapered split retaining ring **171**. It is contemplated that a suitable bleeder passage will be provided for equalizing the pressure in the valve casing **162** on the opposite sides of the main valve member **160**. For this purpose, the sealing ring **170** may be provided with a small bleeder bore **172** as indicated in Figure 6*a*.

The main valve member **160** is of hollow cylindrical construction and is formed with an inner conical shoulder **173** to cooperate with a circumferential series of four balls **174** that are best shown in Figure 7. Telescoped into the main valve member **160** is a fixed sleeve **175** in which the pilot valve member **161** is slidingly mounted. The fixed sleeve **175** has small vent bores **176** and is formed with circumferentially spaced apertures **177** to retain the four balls **174**.

The pilot valve member **161** carries a resilient ring **180** to seat against an annular rib **181** at the closed position of the valve mechanism to seal off the previously mentioned relief port **165** that communicates with the atmosphere. As shown in Figure 6, the pilot valve member **161** has an axial projection **182** which extends into the relief port **167** at its closed position. The pilot valve member **161** is preferably of hollow construction and is formed with a circumferential groove **183** for cooperation with the four balls **174**. Suitable vent bores **184** (Figure 7) may be provided in the bottom of the circumferential groove **183**, as best shown in Figure 7. Preferably a suitable coil spring **185** is in compression between the main valve **160** and the pilot valve member **161** to provide a relatively light force that constantly urges both valve members to their closed positions.

In the normal closed position of the valve mechanism shown in Figure 6, with the main valve member **160** closing the outlet port **165** and the pilot valve member **161** closing the relief port **167**, the high pressure fluid confined in the pressure reservoir **30** is in communication with the interior of the valve casing **162** through the peripheral inlet port **166**. The fluid pressure in the valve casing **162** on the opposite faces of the main valve member **160** is equalized by virtue of the bleeder bore **172** in the sealing ring **170**. Since the nose of the main valve member **160** extending into the outlet port **165** is not exposed to this high pressure the main valve member is subject to a pressure differential that holds it in closed position. In like manner, since a portion of the pilot valve member **161** in the area of the relief port **167** is cut off from the high fluid pressure, the pilot valve member is subject to a similar pressure differential that holds it in closed position. This last pressure differential is of relatively low magnitude, however, because of the smaller areas involved. Thus, only a relatively light mechanical pressure is required to open the pilot valve member **161** in opposition to its normal pressure differential and in opposition to the relatively light spring **185**.

In addition to a pressure differential to urge the main valve member **160** to closed position, the described arrangement further provides a latch to lock it in closed position. The latch mechanism includes the four balls **174**, the inner conical shoulder **173** of the main valve member, the fixed sleeve **175** and the circumferential groove **183** around the pilot valve member **161**. When the main valve member **160** and the pilot valve member **161** are in their normal closed positions shown in Figure 6, the circumferential groove **183** of the pilot valve is out of register with the four apertures **177** in the fixed sleeve **175** in which the four balls **174** are mounted. When the parts are in these positions, opening movement of the main valve member **160** is prevented in a positive manner by abutment of the inner conical shoulder **173** of the main valve member against the balls **174** and by abutment of the balls **174** against the fixed sleeve **175** inside the four apertures **177**. The inner conical shoulder **173** tends to shift the four balls **174** radially inward, but such inward movement of the balls is blocked by the peripheral surface of the pilot valve member.

If the pilot valve member **161** is moved by mechanical force to its open position, the main valve member **160** is unlatched and simultaneously the pressure differential against the main valve member is reversed to move the main valve member to its open position. The reversal of the pressure differential to cause opening movement of the main valve member **160** occurs because the opening of the relief port **167** by the pilot valve member **161**

releases one face of the main valve member from the high pressure. Unlatching of the main valve member **160** occurs because the opening movement of the pilot valve member **161** places the circumferential groove **183** of the pilot valve member in register with the apertures **177** in the fixed sleeve **175** to permit the four balls to be cammed radially inward into the circumferential groove **183** by the inner conical shoulder **173** of the main valve member **160**, thus freeing the main valve member for opening movement.

Since one side of the main valve member **160** is under only atmospheric pressure, the main valve member remains open as long as any substantial fluid pressure exists in the region of its nose. When the compressed gaseous fluid is completely discharged, however, the relatively light coil spring **185** returns the main valve member to its closed position and also returns the pilot valve member **161** to its closed position to latch the main valve member.

Any suitable arrangement may be provided to open the pilot valve member **161** in response to energization of the corresponding solenoid **55**. In the present construction, the previously mentioned axial tube **54** connects the relief port **167** of the valve casing **162** with an axial port **193** in the end wall **137** of the high pressure reservoir **30**. The outer side of the end wall **137** is formed with a threaded cylindrical skirt **194** to receive a cylindrical extension **195** of the solenoid **55** for the purpose of supporting the solenoid. The solenoid **55** which is of a construction to provide communication with the atmosphere is held in place by a suitable bushing **196** that threads onto the cylindrical skirt **194**.

The electrically responsive core or armature **57** of the solenoid **55** is normally maintained in retracted position by a suitable spring **200** and is operatively connected with the pilot valve member **161** by a push rod assembly that includes the previously mentioned axial push rod **52**. The push rod **52** slidingly extends through a pair of bushings **202** in the cylindrical extension **195** of the solenoid and is connected to a tubular member **203** that slidingly extends through the tube **54**. The tubular member **203**, in turn, terminates in a plug or nose member **204** that abuts the axial projection **182** of the pilot valve member **161**. It is apparent that normally the spring **200** holds the push rod assembly in retracted position to permit the pilot valve member **161** to remain in closed position, but that energization of the solenoid **55** causes the push rod assembly to shift the pilot valve member **161** from the closed position shown in Figure 6 to its open position, thus causing the main valve member **160** to open in the manner heretofore described.

When the solenoid **55** is energized in the course of flight, the push rod assembly including the push rod **52** is actuated to unseat the pilot valve member **161**. This action unlatches the main valve member **160** and simultaneously causes reversal of the pressure differential to cause the opening movement of the main valve member. The high pressure gaseous fluid released from the reservoir **30** into the cartridge chamber **32** by the opening of the main valve member **161** causes sufficient external fluid pressure to be applied to the periphery of the cartridge **34** to cause the cartridge to collapse. The main valve member **160** remains open during this discharge operation but is closed by the spring **185** automatically when the operation terminates.

My description in specific detail of the presently preferred embodiment of the invention will suggest various changes, substitutions and other departures from my disclosure that properly lie within the spirit and scope of the appended claims.

I claim:

1. A multiple-signal unit having in combination: an elongated central housing section for mounting on an airborne vehicle, said housing section having a plurality of longitudinal compartments open at the rear of the housing section; a tail housing section mounted on the rear end of said central housing section, said tail housing section having a plurality of discharge passages leading rearwardly from said longitudinal compartments respectively, said tail housing section being removable for access to said longitudinal compartments; a plurality of signal guns in said longitudinal compartments for discharge of signal material through said discharge passages; and a nose housing section mounted on the forward end of said central housing section, said nose housing section being removable for access to the interior thereof; and control means enclosed by said nose housing section for operation of said guns sucessively by remote control.

2. A combination as set forth in claim 1 in which each of said signal guns comprises a fluid pressure reservoir and a cartridge chamber to hold a collapsible cartridge, said cartridge chamber having an open end removably joined with said reservoir for access to the interior of the cartridge chamber to permit replenishment of a cartridge therein.

3. A multiple-signal unit for use on an aircraft to trace the path of flight of the aircraft for detection of the path from a great distance, said unit having in combination: a plurality of longitudinal chambers; a plurality of corresponding discharge passages extending from said chambers to the atmosphere; a plurality of corresponding collapsible containers in said chambers, respectively, each of said containers containing smoke-producing material and having a normally closed pressure-responsive outlet at the inner end of the corresponding discharge passage; a corresponding plurality of valve means and pressurized fluid controlled thereby to create fluid pressure differentials between said chamber and the corresponding discharge passages to open said outlets and to collapse the containers for discharging the contents of the containers into said discharge passages; and control means to operate said plurality of valve means in sequence.

4. A combination as set forth in claim 3, in which said control means includes: a plurality of corresponding electrical actuating means to operate said valve means; and a stepping switch to energize said electrical actuating means in sequence.

5. A combination as set forth in claim 4, in which said stepping switch has more operating positions than the number of said valve means whereby the stepping switch may be connected to a second similar multiple-signal unit for operation thereof.

6. A combination as set forth in claim 4, which includes an intervalometer to control the stepping action of said stepping switch.

7. A combination as set forth in claim 6, which includes a normally closed relay responsive to said intervalometer, said stepping switch being responsive to said relay.

8. A combination as set forth in claim 3, in which each of said valve means comprises a normally closed pilot valve and a normally closed main valve responsive thereto; and in which said control means includes a plurality of corresponding solenoids to open said pilot valves.

9. A combination as set forth in claim 3, in which said control means includes: a plurality of corresponding electrical actuating means to open said valve means; a stepping switch to energize said electrical actuating means in sequence; an intervalometer to actuate said stepping switch; a normally open master switch; and a selector switch, said selector switch having one position to connect said master switch directly to the stepping switch and a second position to connect the master switch to said intervalometer for energization thereof.

10. A multiple signal unit for use on an aircraft to trace the path of flight of the aircraft, said unit comprising: a streamlined housing for attachment to the aircraft on the exterior thereof, said unit having a trailing portion; a plurality of longitudinal chambers in said housing; a plurality of corresponding discharge passages extending from said chambers, respectively, to said trailing portion of the housing; a plurality of corresponding collapsible containers in said chambers; respectively, each of said containers containing smoke-producing material and having a normally closed pressure-responsive outlet at the inner end of the corresponding discharge passage; a plurality of corresponding actuating means to create fluid pressure differentials between said chambers and the corresponding discharge passages to open said outlets and to collapse the containers for discharging said containers into said discharge passages; and control means to operate said plurality of actuating means in sequence.

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