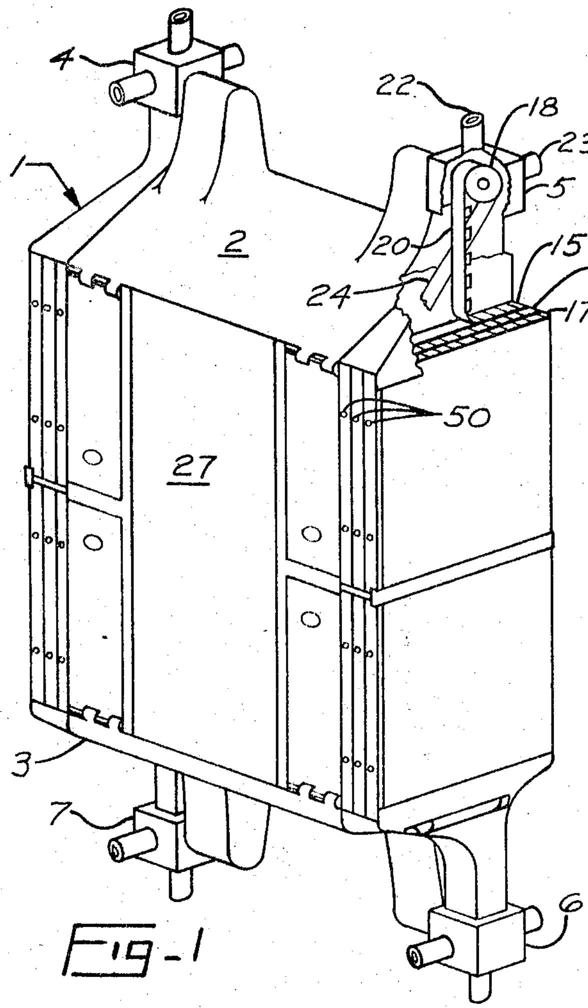

Fig-1

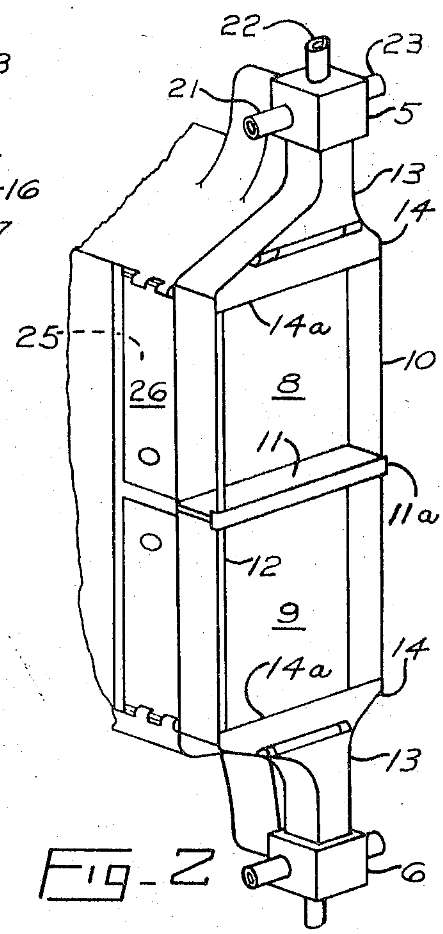

Fig-2

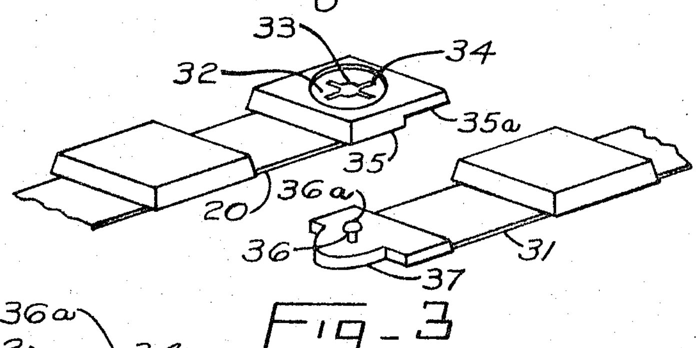

Fig-3

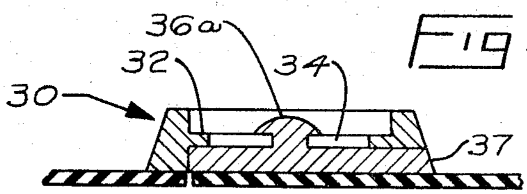

Fig-3A

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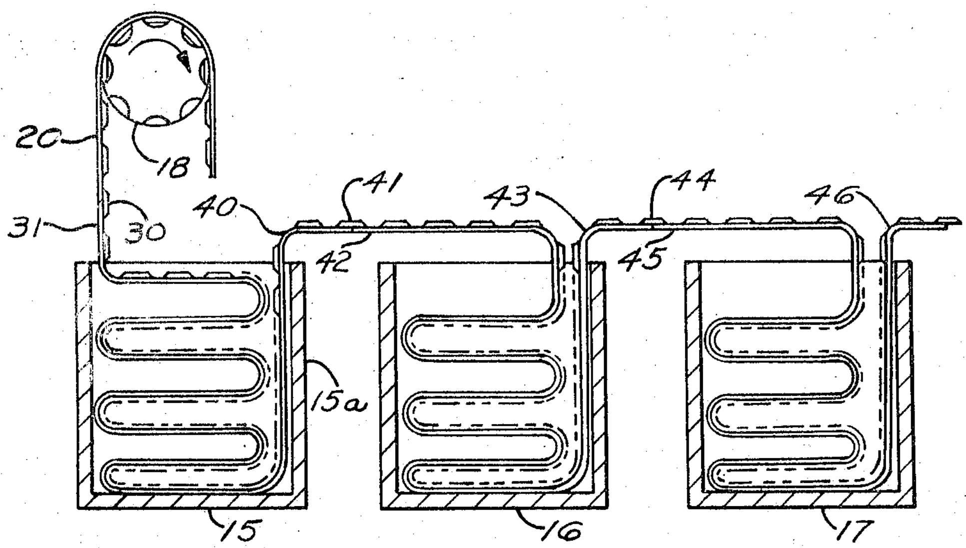

Fig-4

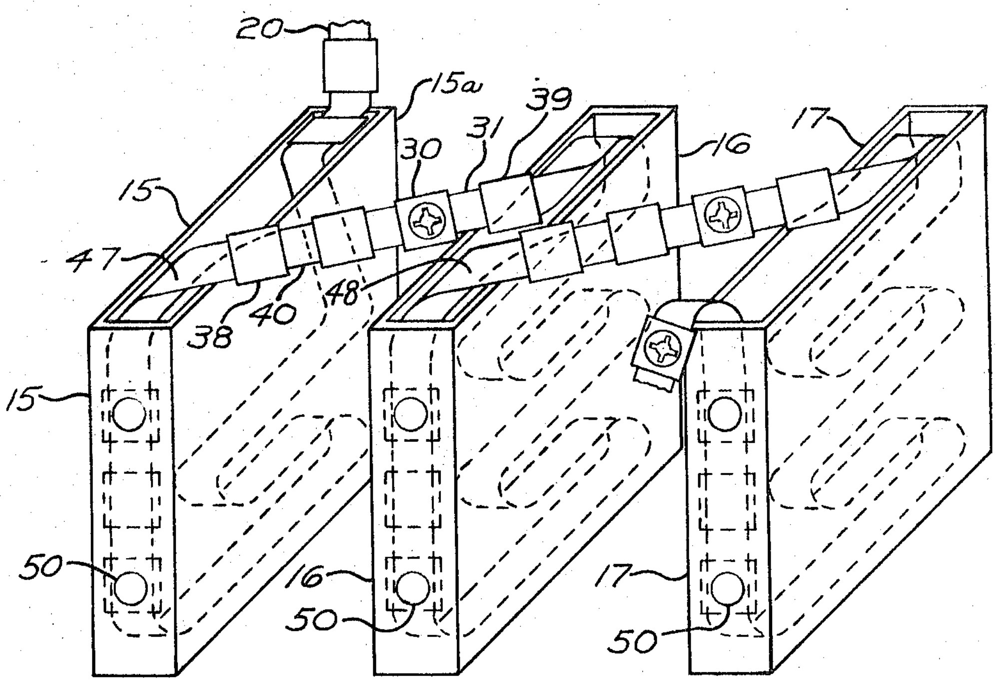

Fig-5

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United States Patent Office

3,456,445
Patented July 22, 1969

3,456,445

MODULAR REFUELING SYSTEM FOR ASTRONAUT MANEUVERING UNITS AND THE LIKE

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Filed Apr. 17, 1967, Ser. No. 631,224
Int. Cl. B64g *1/00;* F03h *5/00*
U.S. Cl. 60—250 8 Claims

ABSTRACT OF THE DISCLOSURE

An astronaut maneuvering unit (AMU) having a reaction engine of the intermittent thrust pulse or "cap-pistol" type, is refueled by modular packs comprising a plurality of separate, standard-length feed tape sections, each section carrying a supply of solid propellant type capsules spaced thereon for linear feed to the engine and being individually packed in a supply canister of uniform size for modular interchangeability and replacement in the AMU fuel supply line. Each end of a tape section has a snap-fastener element for section splicing. Capsule supply to the AMU is continuous from the spliced sections of successive canisters. Empty or partially empty canisters are replaced as required by pre-packed supply canisters; a new pack is inserted by unsnapping the supply feed line at an appropriate point and resplicing the new section (or sections) into the line.

This invention concerns multiple-unit or modular refueling of reaction engines of the intermittent thrust pulse or "cap-pistol" type, such as are used for maneuvering and orienting objects in space. For example, in a specific application, a "burst" or train of jet pulses from a reaction engine (sometimes called "pulser") has magnitude and direction for varying the attitude and/or translational movement of an astronaut maneuvering outside the space vehicle. Where such maneuvering requires considerable time, the problem of refueling the AMU may limit the usefulness of the maneuver due to the necessity of frequent return to the space vehicle for fresh supplies of propellant. The so-called "cap-pistol" reaction engine conveniently uses a feed tape carrying linearly spaced solid propellant type capsules that are progressively advanced, one by one, by a stepper motor and fired according to required thrust. Prior methods of refueling can be time-consuming and wasteful of unused capsules due to frequent rethreading of the reaction engine with fresh feed tape. A possible alternative to this procedure is manual splicing of the new tape supply to the unused supply connected to the engine; however, this method also is unsatisfactory as the splice must be precisely spaced from the adjacent capsules according to uniform capsule pitch, and the splice thickness must conform to the tape standard for proper feed through the engine.

In accordance with the invention, modular type refueling is used wherein a plurality of pre-packed canisters, each containing a separate, uniform length section of supply tape (fresh capsules) are replaceably positioned in the AMU for continuous and automatic capsule feed from successive canisters to the reaction engine. The entire supply tape is packed for ease of retrieval from the canisters in succession and the respective sections are serially connected by uniformly positioned and readily detachable splicing. When a canister or canisters in the pulser feed line are emptied at the end of a mission, the empty canisters are withdrawn. The regular feed line is interrupted at a convenient splice position and new pre-

packed canister supply sections are inserted in modular manner in the line at the "snap" splices.

The invention will be more fully set forth in the following description referring to the accompanying drawings, and the features of novelty will be pointed out with particularity in the claims annexed to and forming a part of this specification.

Referring to the drawings, FIG. 1 is a perspective view of a "back-pack" type of AMU having a plurality of reaction engines and respective modular fuel supply units in pre-packed canisters;

FIG. 2 is a fragmentary view of FIG. 1 showing receptacle spaces in which the modular type canisters are positioned;

FIG. 3 is a detailed view showing in disconnected position snap-type splicing elements for joining the respective ends of two supply type sections;

FIG. 3A is a side view of the completed splice joining the tape sections of FIG. 3;

FIG. 4 illustrates schematically the packing arrangement for the individual modular canisters, and the series-splicing of the corresponding tape sections for continuity of tape feed from successive canisters to the pulser; and

FIG. 5 is a perspective view of three pre-packed canisters with spliced tape sections for side-by-side positioning in one of the receptacle spaces of FIG. 2.

The assembly unit shown in FIG. 1 comprises a supporting frame **1** of generally rectangular shape constructed generally of suitable lightweight sheet material. The upper and lower sides **2** and **3** of the unit may comprise more rigid pre-formed portions for supporting at the opposite ends reaction engines at **4**, **5**, **6**, and **7**, respectively. The opposite ends of the frame also include similar canister receptacle spaces **8** and **9**, FIG. 2, adjacent to the engines **5** and **6**. Each receptacle space is defined by a rear wall or flange **10** and a bottom seat **11**, the latter constituting a divider wall between the upper and lower receptacle spaces. The divider **11** has a lip-flange **11*a*** for retaining the lower ends of the canisters, and a supporting rod **12** for the divider wall **11** extends the length of the entrance side for also guiding the canisters into the corresponding receptacle space.

The upper (or feed) end of each receptacle space opens into a funnel-shaped chute **13** leading to the respective reaction engine, and the front side of the chute has a hinged cover **14** providing access to the tape splices for facilitating canister loading and unloading operations, as presently described. The free edge of the cover has a depending lip-flange **14*a*** that cooperates with the lower divider lip **11*a*** for retaining the canisters in position.

FIG. 1 shows three pre-packed supply canisters **15**, **16**, and **17** in operative position in the AMU, the upper ends of the canisters being open for progressive feed of the capsule supply tape upward through the chute **13** to the reaction engine **5**. The engine is indicated generally as having a tape feed sprocket wheel **18** that is driven by a stepper motor at **19** (not shown). Live capsules on the feed tape portion **20** drawn from the first canister **15** are advanced by discrete steps, one at a time, to the engine for command firing. The reaction engine or pulser, including the sprocket wheel capsule feed may be, for example, of the character disclosed in a copending application, Ser. No. 438,943, filed Mar. 11, 1965, now Patent No. 3,316,719, by Joseph F. Loprete for "Intermittent Thrust Device" and owned by the assignee of the present invention.

The capsule firing positions are indicated by the directional nozzles **21**, **22** and **23** that are located for obtaining vectoring of combined thrust pulses as indicated near the periphery of the sprocket wheel. As the present invention is not concerned with pulser thrust vectoring by simultaneous multiple-nozzle firing, the pulser nozzles may be arranged in number and direction with reference to a two or three axis system as preferred.

The spent (and any unused) capsules are carried from the pulser by the tape portion **24** to a bin at **25** that is adjacent to the supply canisters in the receptacle space **8**, FIG. 2, and communicates with the chute **13**. The bin may comprise a return-container (not shown) that is removable from the AMU at the side of the frame normally closed by a hinged cover **26**. At the end of a mission, the bin container is simply slid from the frame, the spent tape line leading from the engine severed, and an empty bin placed in collecting position. A central portion of the AMU located between the end bins forms a control equipment compartment **27** for the stepper motor control, firing circuitry, etc., (not shown).

Reference is made to the schematic of FIG. 4 for showing the preferred method of packing the supply canisters. For convenience of description, the pre-packed canisters **15**, **16**, and **17** are shown aligned end-to-end with the feed or No. 1 canister (**15**) beneath the sprocket wheel **18** of pulser **5**. The portion **20** of live feed tape, FIGS. 1 and 2, is in operative engagement with the sprocket wheel that has equally spaced pockets at the wheel periphery to correspond with the spacing or pitch distance of the capsules on the feed tape. As the sprocket wheel periphery to correspond with the spacing or pitch live capsules which are on the inner side of the tape approaching the sprocket wheel, nest in order in respective pockets as the feed tape is picked up by the wheel. At each step, respective capsules are advanced to positions opposite the direction nozzles for firing according to command.

The capsule tape portion **20** represents the trailing end of a nearly spent tape section that is threaded in the pulser. This portion is snap-spliced at **30**, FIGS. 3 and 3A, to the leading end **31** of a fresh supply section packed in canister No. 1.

A simple and convenient form of snap-splice is that of the well-known "snap-fastener" type shown by FIGS. 3 and 3A. The socket element of the fastener is a thin, flexible metal disk **32** having a central aperture **33** with short radial slits **34** extending therefrom. The mounting **35** for the disk (socket) is secured to, say, the trailing end of the pulser tape portion **20**, FIG. 4. The coacting plug element is a stud **36** mounted on a pad **37** secured to the loading end **31** of the No. 1 canister section. The stud **36** has a detent portion **36***a* at its extremity somewhat larger than the diameter of the disk aperture for interlocking engagement with the disk, FIG. 3A. The socket unit simulates a capsule in size and configuration and has uniform capsule pitch spacing with respect to the adjacent live capsules **38** and **39** on tape **20** and the No. 1 tape section respectively, FIGS. 3A and 4. For exact conformity, the disk **32** may be enclosed within a standard capsule casing. For ensuring uniform tape thickness and alignment, the socket casing is undercut or notched at **35***a* for receiving in flush relation the stud pad **37** in the fastened or spliced position. Axial alignment of the spliced tape is provided by the abutting pad and socket casing shoulders.

For efficient packing and simplicity of retrieval, the No. 1 tape section, FIG. 4, is alternately folded starting with the trailing end **40** that extends into the open top of canister **15** and along one end wall thereof to the bottom, on which the supply tape is progressively laid in alternate folds to fill the canister. The top fold, i.e., the leading end **31** is connected to the snap-splice **30**.

The No. 2 and 3 canisters are similarly packed with fresh supply sections, the trailing end **40** of No. 1 section being spliced at **41** to the leading end **42** of the No. 2 section, whose trailing end **43** is in turn spliced at **44** to the lead end **45** of the No. 3 section. The trailing end **46** and attached socket of the No. 3 section are, as shown, outside the canister for ready splicing to a storage reserve section, as required.

When the canisters schematically shown in FIG. 4 are stacked side-by-side in the AMU receptacle space **8**, FIG. 1, the spliced ends of the canister tape sections are turned through a half-twist, as shown in FIG. 5. This counteracts the natural twisting motion as the tape is fed from one container to the next. Accordingly, when new canister sections are inserted in the main feed line, the trailing end of the No. 1 section, for example is given a half-twist at **47** for maintaining the proper capsule alignment on the tape. The same connection is made at **48** between the trailing end of the No. 2 section and the leading end of the No. 3 section. As the reaction engine uses the supply tape, the No. 1 canister is emptied by progressive unfolding of the tape. The trailing end of the section extending along the side wall **15***a* of No. 1 canister is then drawn clear of the canister; the No. 2 canister is emptied in the same manner as are the successive serially connected supply canisters.

Assuming that a space maneuver is completed, during which the pulser has emptied the No. 1 and No. 2 canisters, the AMU is refueled simply by sliding the empty canisters from the receptacle space **8**, moving the No. 3 canister laterally against the receptacle wall **8** nearest the reaction engine and snap-splicing the trailing end of the No. 3 section to fresh supply canister packs, as required. Finger holes **50** for convenient removal are formed in the canister end walls, FIGS. 1 and 5; also suitable detents can be used for holding the canisters firmly in the AMU. It will be understood that the number of serially connected supply canisters is limited only by practical considerations.

This ivention is a practical and simple solution of the AMU propellant logistics problem. The fresh tape supply packs in book-like form, can be more readily stored in the limited space available in spacecraft; moreover, the solid propellant capsule and tape combination eliminates problems of toxicity, leakage, pressurization, shock sensitivity, environmental temperature limitations, and storage accommodation, all involved to greater or less degree in liquid propellants.

It should be understood that this invention is not limited to specific details of construction and arrangement thereof herein illustrated, and that changes and modifications may occur to one skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. In an astronaut maneuvering unit having a supporting frame, a reaction thrust engine of the intermittent jet-pulse type mounted thereon, and a fed-tape with solid-propellant type capsules spaced thereon for linear feed to the engine for pulse command firing of the capsules, the improvement comprising:

(a) a plurality of interchangeable fuel supply modules consisting of containers for live capsules individually mounted in the supporting frame and separately removable therefrom for replacement;

(b) individual feed-tape sections of predetermined length, each having a supply of live capsules thereon and packed in layers for orderly retrieval in a respective container from which each end of the tape section extends to form respectively, a leading end and a trailing end;

(c) and means for detachably splicing the trailing end of a tape section in a first container to a leading end of a section in a second container, the containers being supported in said frame with all the respective tape sections therein serially connected with the leading end of the first section for continuity of capsule feed in order from successive containers to the engine.

2. In an astronaut maneuvering unit, as specified in claim **1**, wherein the frame defines receptacle space for positioning of the containers in slide-drawer manner within the unit.

3. In an astronaut maneuvering unit, as specified in claim 1, wherein each capsule feed tape section is compactly folded in progressive layers within a respective container, one section end being the leading end and extending in order of layers to the container bottom, and thence along one side of the container to the trailing section end at the container top.

4. In an astronaut maneuvering unit, as specified in claim 1, wherein the feed tape splicing means is a detachable snap-fastener and the mating elements thereof are secured respectively to the trailing end of one section and the leading end of the next succeeding section, the fastener in splicing position simulating in size, and spacing on the tape, a feed capsule for uniform feed through the reaction engine.

5. In an astronaut maneuvering unit, as specified in claim 2, wherein the frame has a housing positioned between the engine and receptacle space containing stacked supply canisters, said housing having a cover for direct access to the receptacle space for disconnecting and connecting tape sections according to canister removal and replacement.

6. In an astronaut maneuvering unit, as specified in claim 2, wherein each container is a rectangular canister having height and width for accommodating a material number of layers of the capsule feed tape, and the depth corresponds to a single width of the feed tape.

7. In an astronaut maneuvering unit, as specified in claim 6, wherein the canisters are compactly stored side-by-side in the receptacle space and adjacent to a bin formed by the frame, said bin having a volume materially greater than the combined volume of the canisters for random reception of the spent capsules and tape from the reaction engine.

8. In an astronaut maneuvering unit, as specified in claim 7, wherein the frame forms a chute communicating with the reaction engine and the open feed ends of the canisters in the receptacle space and also with the reception bin for discharge of spent tape and capsules from the engine into the reception bin, said chute having access means for splicing and disconnecting canister tape sections without removal thereof from the receptacle space.

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U.S. Cl. X.R.

60—228, 255; 89—33.16