

June 20, 1961

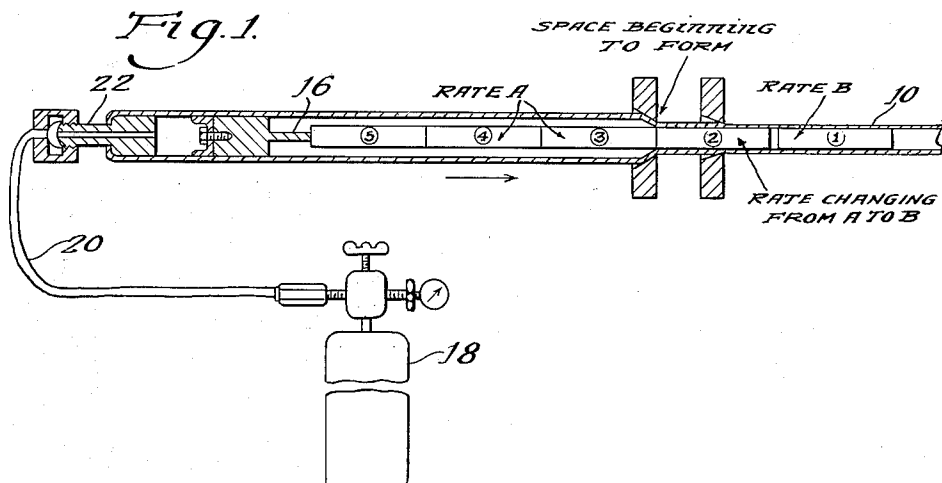
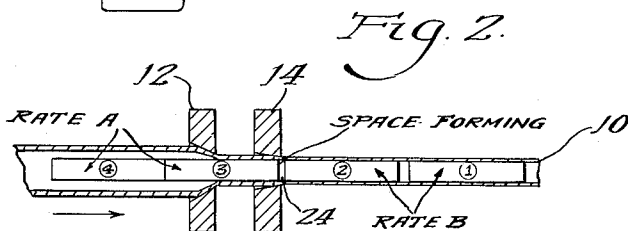
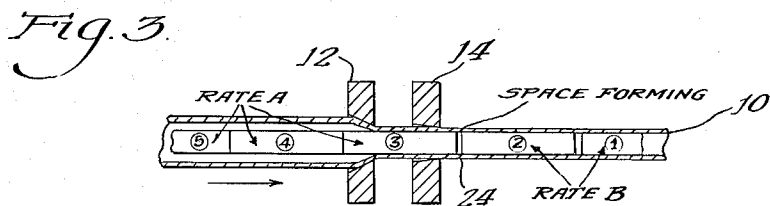
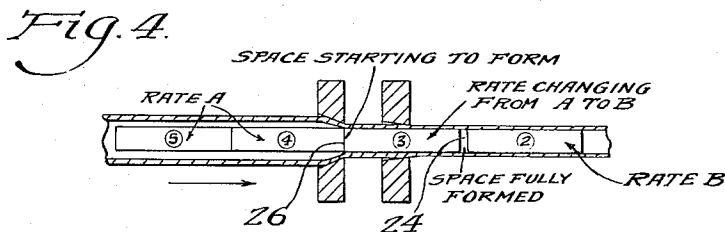
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2,988,812

METHOD OF FABRICATING TUBULAR UNITS

Filed Jan. 9, 1947

2 Sheets-Sheet 1



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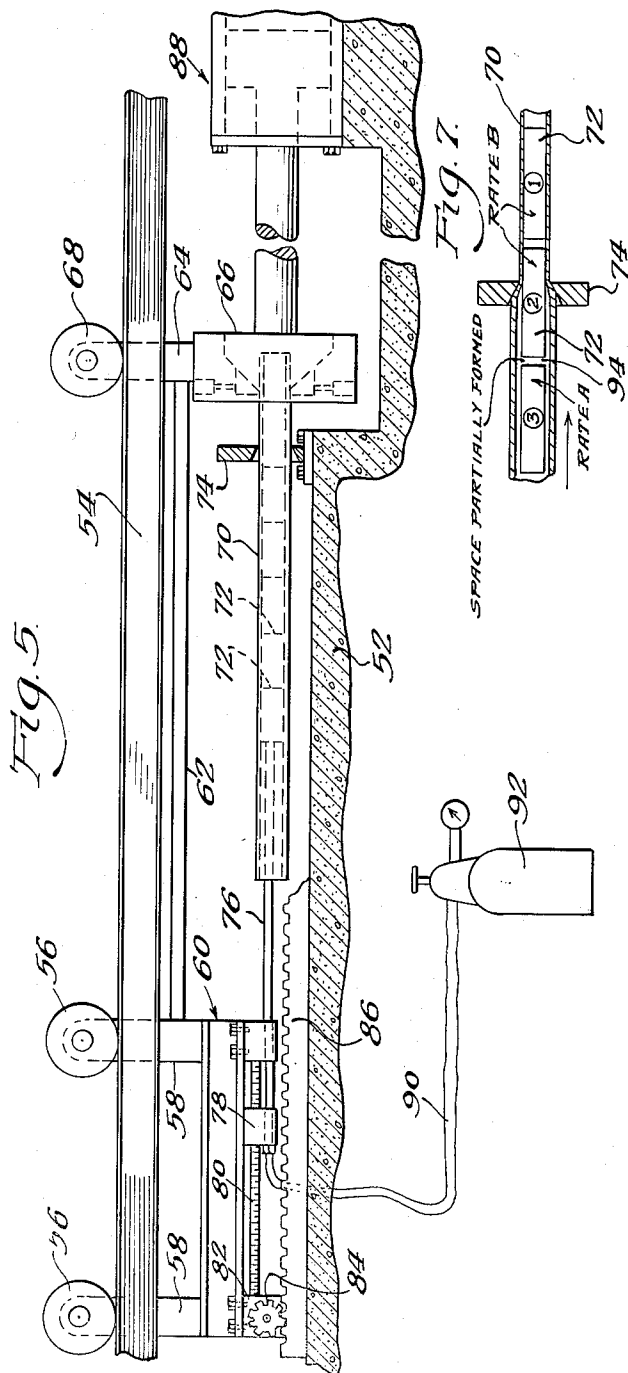
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2 Sheets-Sheet 2



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Fig. 7.

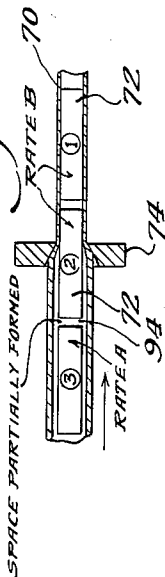


Fig. 6.

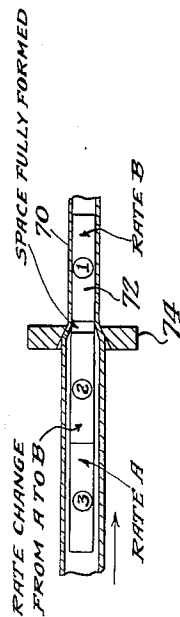
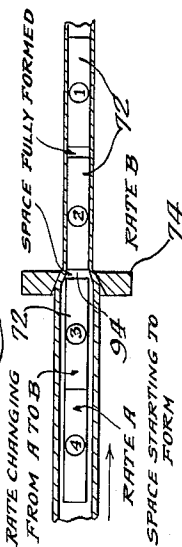


Fig. 8.



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METHOD OF FABRICATING TUBULAR UNITS

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This invention relates to fabrication of a unit containing a plurality of elements tightly fitted within a tube, and more particularly to a novel method of producing any desired spacing between said elements, or, if desired, for preventing spacing thereof while clamping the tube therearound.

The present invention relates more particularly to a novel method of fabricating composite reactive units containing fissionable material and adapted for utilization as a source of fuel for a self-sustaining nuclear fission chain reaction. Units of this type consist of cylindrical slugs containing uranium or other fissionable material tightly fitted within an aluminum tube or cartridge, spacing being provided between the slugs to accommodate thermal expansion and flexibility of the unit. The slugs are preferably from 2 to 8 inches long with spaces therebetween of from $\frac{1}{16}$ of an inch to $\frac{1}{4}$ of an inch, and preferably the slugs have a diameter of about 1.4 inches with a ground finish on the cylindrical perimeter thereof to accommodate a tight fit within the aluminum tube, which preferably has an outer diameter of about 1.5 inches.

Attempts in the prior art to fabricate a unit, such as above described, by drawing the assembly through a single die to contract the tube tightly around the slugs have resulted in non-uniform spacing of the slugs with variances of over 100 percent.

It is, therefore, an object of the present invention to provide a novel method of equidistantly spacing the slugs or, if desired, for preventing spacing thereof while drawing the tube thereover into tight thermal contact therewith.

The foregoing and other objects and advantages of the invention will be understood by a consideration of the following specification and the accompanying drawings, wherein:

FIGS. 1 to 4 are diagrams illustrating a preferred embodiment of the invention, wherein the tube is drawn through two dies; and

FIGS. 5 to 8, inclusive, illustrate another embodiment of the invention wherein the tube is drawn through one die, FIG. 5 being a somewhat diagrammatic illustration partly in section and partly in elevation of an apparatus for carrying out the process, and FIGS. 6 to 8, inclusive, being diagrams showing the passage of the tube and slugs through the die of the apparatus shown in FIG. 5.

Describing the invention in detail and referring first to the embodiment thereof illustrated in FIGS. 1 to 4, inclusive, FIG. 1 shows an aluminum tube 10, such as above described, passing in the direction of the arrow through a relatively large die 12 and a relatively small die 14. In drawing the tube through the first die 12, the tube is reduced to a uniform outside diameter determined by the die opening and the spring-back of the aluminum tube, thus fixing the jacket thickness beyond the first die rather closely. The slugs or cylindrical members numbered 1 to 5, inclusive are held tightly together in end to end relationship, as hereinafter described, when passing through the first die so that the slugs emerge therefrom with substantially no space therebetween and with a very uniform aluminum jacket formed by the tube 10 which tightly clamps the slugs after they have passed through the first die. Accordingly, the drawing of the tube 10 through the second die always displaces a substantially

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constant volume of the tube metal, thereby producing substantially uniform spacing of the slugs.

The tube 10, as above noted, moves relative to the dies in the direction of the arrow, and it will be understood that this relative movement may be effected by moving the tube or the dies or both the tube and the dies, as desired. Preferably, the tube is passed through the dies by conventional drawing apparatus (not shown).

The slugs are forced through the first die 12 by a pusher rod 16 actuated by any desired pressure fluid, such as oil, water or air supplied by any suitable source, such as a reservoir or pressure tank 18 connected by a flexible tube 20 to a coupling 22 clamped into the end of the tube 10. Preferably, the tank 18 contains a pneumatic fluid, such as air, or a hydraulic fluid under pneumatic pressure to exert a resilient force against the slugs.

In FIG. 1, slug No. 1 has passed through both dies 12 and 14 and is moving at rate B, the rate of movement of the tube 10 from the exit side of the die 14, which is the right side thereof, as seen in this figure. Slug No. 2 is moving at a relatively slow rate A which is the rate of movement of the tube 10 at the exit side of the die 12, and slug No. 2 is about to move at rate A having passed through the die 12 and almost half way through die 14.

In FIG. 2, slug No. 2 is moving at rate B having passed through die 14, and a space is forming at 24 between slugs Nos. 2 and 3 inasmuch as the latter is moving at the relatively slow rate A.

In FIG. 3, slug No. 3 has entered the second die 14 but is still moving at rate A so that the space at 24 is enlarging.

In FIG. 4, the space at 24 is fully formed and slug No. 3 is about to move at rate B to form a space at 26 between slugs 3 and 4.

It will be understood that while only five slugs are shown, any desired number may be utilized depending upon the desired length of the unit.

While the tube 10 in the diagrams of FIGS. 1 to 4 is drawn through both dies 12 and 14 in a single pass, if desired, the tube may be drawn through die 12 in one pass and through die 14 in another pass. If no substantial spacing is desired between the slugs, the tube may be drawn through die 12 only.

Referring now to FIGS. 5 to 8, inclusive, another embodiment of the invention is shown wherein the method is practiced by passing the tube through a single die.

Referring first to FIG. 5, the novel apparatus disclosed therein comprises a foundation or drawbench 52 and a rail or track 54 thereabove affording support for a pair of wheels 56, the axles of which are journaled in upstanding pedestals 58 of a frame or carriage 60, said carriage being connected by a rod 62 to a similar pedestal 64 supporting a pulling head 66 from a wheel 68 on the track 54.

The pulling head 66 grips one end of an aluminum tube 70, such as above described, filled with a plurality of cylindrical uranium slugs 72. The tube 70 is drawn through a die 74 to contract the tube around the slugs into tight thermal contact therewith, the slugs 72 being pushed through the die by a hollow pusher rod 76 connected to a travelling nut 78 threadably engaged with a rotatable shaft 80 actuated by a gear box 82 mounted on the carriage 60. The gear box is operatively connected to a gear 84 which is meshed with a rack 86 on the drawbench 52. Thus, as the pulling head 66 is moved on the advance or pulling stroke thereof by an associated conventional hydraulic motor 88, the tube 70 is drawn through the die, and the travelling nut 78 moves to the left, as seen in FIG. 1, relative to the carriage 60 so that the hollow pusher rod 76 moves to the right at a slower rate of speed than that at which the pulling rod 66 moves,

thus causing the pusher rod 76 to fall back or lag with respect to the head 66 to accommodate spacing of the slugs 72 within the tube 70 as the latter is drawn into tight thermal contact with the slugs.

The pusher rod 76 is connected by a flexible tube 90 to a source 92 of inert gas, such as helium. Thus, the spaces between the slugs are filled with helium for indicating leaks in the tube 70 and for increasing heat conduction between the tube and slugs at the ends of the slugs.

As above noted, the advance movement of the pusher rod 76 to the right as shown in FIG. 1, is preferably at a predetermined slower rate than that of the head 66, thus accommodating equidistant spacing of the non-compressible elements 72 within the tube 70. If desired, the travelling nut 78 may be rendered inoperative, as for example, by disconnecting the gear 84 from the gear box 82 thus causing the pusher rod 76 to move on its advance stroke to the right, as seen in FIG. 1, at the same rate as the pulling head 66. This would substantially eliminate spacing between the slugs although slight spacing would be present due to stretching of the tube 70 at the right of the die 74.

Referring now to FIGS. 6 to 8, the spacing of the slugs in the tube is diagrammatically illustrated. Thus, in FIG. 6, slug No. 1, which has passed through the die, is clamped by the tube and is moving with the same in the direction of the arrow at rate B, which is approximately the pulling rate of the head 66 and the rate of movement of the tube 70 at the right or exit side of the die. Slug No. 2 which is moving at rate A, the rate of movement of the pusher rod 76, is just entering the die 74 in FIG. 6. In FIG. 7, slug No. 2 has partially passed through the die and is moving with the tube at rate B, causing a space to form at 94. This space is shown fully formed in FIG. 8, wherein slug No. 3 has entered the die and is about to move at rate B to produce a space between slug No. 3 and slug No. 4. It will be understood that the spacing between the slugs 72 is dependent upon the relative movement of the pulling head 66 and the pusher rod 76.

As above discussed in connection with FIG. 5, the carriage 60 and the pulling head 66 are connected as by a rod 62 so that the pusher rod 76, the head 66 and the tube 70 are moved by the hydraulic motor 88 toward the right, as seen in this figure. Thus, although the pusher rod 76 moves toward the right relative to the die 74, the pusher rod 76 is, in a sense, retracted from the tube 70 by relative motion with respect thereto, thus producing the before-mentioned spacing of the slugs, although the total retraction of the pusher rod 76 from the tube 70 may be less than the elongation thereof by the draw-

ing process. This retraction of the pusher rod 76 from the tube 70 may, if desired, be effected by connecting the carriage 60 to the die 74 and moving these parts to the left as by a hydraulic motor (not shown) while maintaining the head 66 in a stationary position. Under these conditions the rod 76 would also be retracted relative to the tube 70, but would move toward the die 74 to diminish the distance therebetween, and thereby push the slugs 72 therethrough. Thus, it will be understood that the rate at which the pusher rod 76 is retracted relative to the tube 70 will be less than the rate at which the tube 70 enters the die 74 regardless of whether the tube is pulled through the die or the die is pulled along the tube. In other words, as the tube is drawn by relative motion between the die and the tube, the distance between the die and the adjacent end of the pusher rod 76 is diminished to force the slugs through the die.

It will be understood that the above-described method and apparatus embodying the invention are merely by way of illustration and not limitation, inasmuch as various and other forms of the invention will be readily apparent to those skilled in the art without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. A method which comprises inserting a plurality of members in end-to-end abutment into a tube, said tube having greater ductility than said members and then contracting the tube tightly around the members by passing the tube through a die while exerting a force against said members to urge the same in abutting relationship through said die, and passing the composite through a second die to reduce the outside diameter of the tube thereby spacing said members.

2. A method which comprises loading a tube with a plurality of substantially non-compressible end-to-end members and then passing the tube through a die to contract the tube into tight contact with said members while urging said members through said die, and passing the tube through a second die by relative movement between said tube and said members to space the members.

3. A method of fabricating a unit containing a plurality of evenly spaced members within a tube, comprising the steps of inserting said members in end-to-end abutment into said tube having greater ductility than said members, drawing said tube into tight contact with said members, and redrawing said tube to a smaller outside dimension to space said members from each other.

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