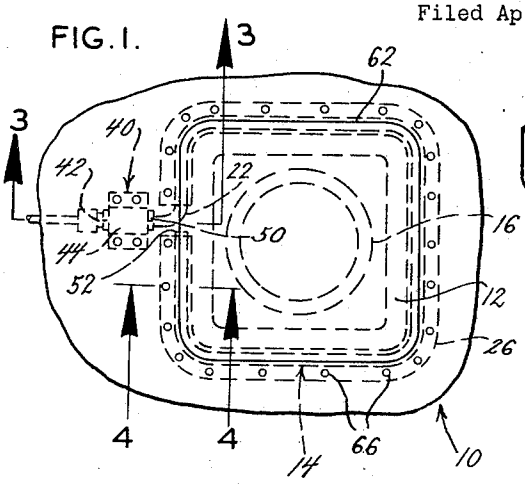
Dec. 30, 1969 V. W. DREXELIUS ET AL 3,486,410

EXPLOSIVE SEVERANCE MEANS

Filed April 18, 1968

FIG. 1.



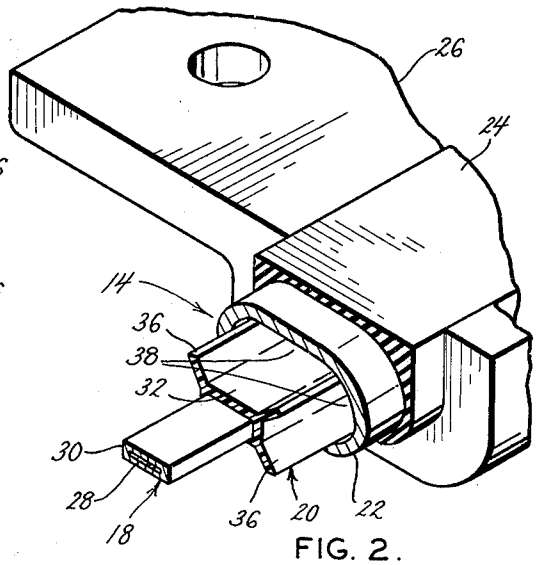


FIG. 2.

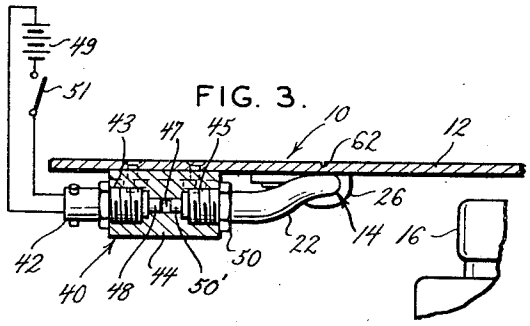


FIG. 3.

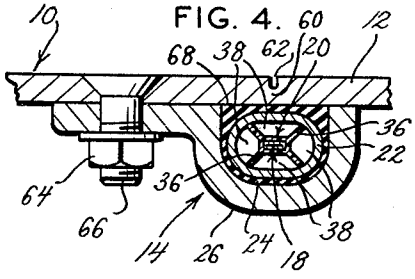


FIG. 4.

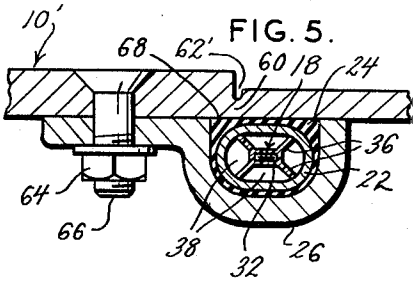


FIG. 5.

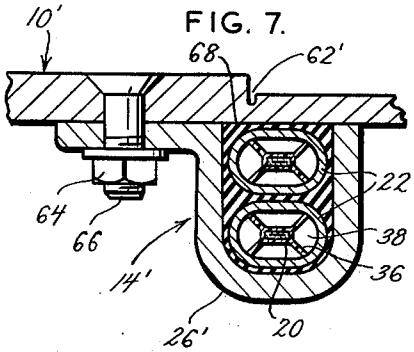


FIG. 7.

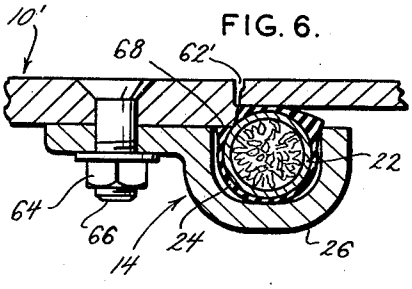


FIG. 6.

United States Patent Office 3,486,410
Patented Dec. 30, 1969

3,486,410

EXPLOSIVE SEVERANCE MEANS

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Filed Apr. 18, 1968, Ser. No. 722,250
Int. Cl. F42b 3/02, 1/02
U.S. Cl. 89—1 16 Claims

ABSTRACT OF THE DISCLOSURE

A device for explosively severing panels and other like devices from structures including a tubular member constructed to be mounted in a holder adjacent to a panel portion of the structure to be severed, said tubular member having an explosive charge position therein and extending therealong, the tube forming a chamber about the explosive charge, and detonator means operable to initiate the charge, said tubular member being constructed of a material such as a malleable material, which member changes volume and/or shape in response to the forces produced therein by the exploding charge, said forces acting on the tubular member being applied against the adjacent edge of the panel portion of the structure to be severed to force separation thereof, the tubular member being constructed to resist rupture during the explosion, to confine the products of the explosion therein, and to attenuate the shocks accompanying the explosion.

Many explosive severance devices are in existence but the known devices for the most part are used in applications where the shocks and debris associated with explosion can be tolerated by the surroundings. However, in devices where the shocks associated with the explosion are objectionable for some reasons, means such as baffles or similar devices are provided to attenuate them. Baffles and such make the known structures relatively complicated, bulky, heavy, expensive, and unsuitable and unreliable in some environments, and such devices may include components which must work under the force of the explosion such as bellows or diaphragms and these devices may be adversely affected by environmental extremes such as extremes of temperature, humidity, and so on. Known severance devices also fail to protect against the release of contaminants usually associated with an explosion. Most known devices are also objectionable and unsatisfactory because of their relatively large weight and complexity as well as their inability to be able to withstand hostile environmental conditions.

These and other disadvantages and shortcomings of known explosive severance devices are overcome by the present invention which teaches the construction and operation of a relatively simple, inexpensive and versatile severance means which can be constructed to be relatively small, compact, and lightweight for the amount of severance force it produces. The present device is particularly well suited to applications where it is to be used in a hostile environment and where the shocks normally incident to severance cannot be tolerated. In its preferred form the device is also constructed in a way so that there is little or no likelihood that it will be affected by environmental extremes and so that when it is operated it will confine the products of the explosion and therefore prevent contamination or damage to other devices in the area. The present severance means can also be used with relative safety even in the near presence of people.

The present device in its preferred form is in a hermetically sealed condition before detonation to protect the components from the surrounding environmental conditions. The explosive is also protected by support means which reduce the chances for damage due to rough handling and other conditions. The present device preferably remains in a substantially sealed condition before as well as after explosion and severance. This is particularly important in some applications where even small amounts of contamination are objectionable such as when the present device is used in areas where personnel and/or delicate equipment are present as for example, when blowing out emergency exit doors on aircraft and when removing a panel from in front of an optical device such as a camera or television tube in outer space or elsewhere. The present device also lends itself to remote operation.

A principal object of the present invention is to provide improved and more versatile means for explosively severing a member or a portion thereof from another member or structure.

Another object is to reduce shocks and noise transmitted from an explosive severance device when the device is detonated.

Another object is to contain the flame, debris and noise associated with an explosive severance.

Another object is to provide versatile and reliable severance means.

Another object is to provide explosive severance means which can tolerate extreme temperatures and other environmental conditions.

Another object is to provide explosive severance means which can be made in many different sizes and shapes and which can be constructed to provide almost any desired amount of severance force.

Another object is to provide means whereby an explosive force can be relatively uniformly distributed along almost any desired length.

Another object is to provide explosive severance which are relatively easy to construct and install.

Another object is to provide explosive severance means utilizing explosive dynamics principles in combination with known material limits in a device which is relatively lightweight and compact.

Another object is to provide explosive severance means which can be safely detonated even in the near presence of people and delicate instruments.

Another object is to provide explosive severance means which can be installed in a plural manner to increase reliability and/or force.

Another object is to provide precisely controlled means for usefully detonating an explosive charge without producing contamination.

Another object is to provide explosive severance means which in the unfired state provide structural integrity to the associated structure thus minimizing the overall required structure weight.

These and other objects and advantages of the present invention will become apparent after considering the following detailed specification which covers several embodiments of the subject device in conjunction with the accompanying drawing, wherein:

FIG. 1 is a plan view showing a portion of a structure having a panel portion to be removed by explosive severance means constructed according to the present invention;

FIG. 2 is an enlarged perspective view showing the details of a portion of the subject explosive severance means;

FIG. 3 is an enlarged cross-sectional view taken on line 3—3 of FIG. 1;

FIG. 4 is an enlarged cross-sectional view taken on line 4—4 of FIG. 1;

FIG. 5 is an enlarged cross-sectional view similar to FIG. 4 but showing the subject severance means installed on a somewhat different form of severable structure;

FIG. 6 is an enlarged cross-sectional view showing the severance means of FIG. 5 during or slightly after the explosive charge has been detonated; and,

FIG. 7 is an enlarged cross-sectional view showing a construction in which two similar explosive severance devices are installed side-by-side in the same enclosure.

Referring to the drawing more particularly by reference numbers, number **10** in FIG. 1 denotes a structure having a severable panel or firing **12** which is to be jettisoned from the structure **10** of which it its a part by explosive severance means **14** constructed according to the present invention. When the panel **12** is severed from the structure **10**, a sensor **16** or other device such as a camera or a television tube is exposed and then can be used for its intended purpose. It is important to the present invention that when the panel **12** is severed from the structure of which it is a part that the shocks associated with the severance be attenuated as much as possible to prevent damage to the sensor **16** or other near by delicate equipment or furnishings. It is also important that the products of the severance explosion including any debris that may be produced by the explosion be confined so that they cannot get onto and damage or otherwise impair the functioning of the sensor **16**. The present device can be used for many other applications as well, including removing or severing escape hatches even in the near proximity of people and so on. When personnel are expected to be close to the exploding device it is also important that the noise of the explosion be attenuated as much as possible to avoid alarm and possible injury.

The details of the subject explosive severance means **14** are shown in FIG. 2 and include an explosive detonating cord **18** mounted in a support member **20** which is shown extending longitudinally through a tubular member **22**. The tube **22** is preferably constructed of a malleable or malleable-like material so that it can expand and/or reshape itself during explosion without rupturing. A typical material from which to construct the tube **22** is stainless steel or a like material. The tubular member **22** is shown optionally mounted in a surrounding layer **24** of a shock absorbing material such as a potting compound or sheathing, and the entire assembly is positioned and supported against the structure to be severed by suitable holder means such as illustrated by channel shaped clamping means **26** which are shown extending around the edge of the panel **12** in FIG. 1. The detonating cord **18** may be constructed having any suitable cross-sectional shape and as shown the cord **18** includes an explosive core **28** which extends through a non-explosive sheathing **30**. Detonating cords of this general construction are very fast acting so that for some such cords many thousands of feet will detonate in a second or less time making the entire operation substantially instantaneous.

The detonating cord **18** is shown extending through a tubular central portion **32** of the support member **20**, and the support member **20** is also shown provided with four spaced outwardly extending flanges **36** which extend from the corners of the portion **32** for engagement with the inner wall of the tubular member **22** to provide the support therefor. In this way, the explosive element is supported centrally in the tube **22** and at the same time a plurality of compartment chambers **38** are formed in the tube around the explosive. The size of the chambers **38** should be selected taking into account the size and characteristics of the detonator cord **18**, the size, shape and thickness of the tube **22**, the materials used in the various elements, and the forces necessary to produce severance. This is important because, as stated, the tube **22** is preferably constructed of a malleable or malleable-like material so that the tube can expand and/or reshape itself during the explosion without rupturing. The above parameters can be determined for the particular explosive selected keeping in mind that a margin of safety should be provided both as to the severance force and burst strength of the tube **22**. The support member **20** is preferably constructed of a plastic or plastic-like material and in addition to centrally supporting the explosive member **18** it also reduces the impact force of fragments of the sheathing material **30** against the inner surface of the tube **22**. The tube **22** is shown having an oval shape cross-section but it is anticipated that other shapes can also be used without departing from the invention including tubes having triangular, rectangular or circular shapes to name a few.

FIG. 3 shows a form of electrically excited detonator means **40** for the subject device. The detonator means **40** include a detonator element **42** which is threadedly engaged with a threaded bore **43** in a detonator fitting **44** attached to the structure **10**. The fitting **44** has a second threaded bore **45** shown in alignment with the bore **43**, and the bore **45** receives a threaded member **50** which is sealably attached to one end of the tube **22**. An end booster member **50'** operatively connected to the end of the cord **18** extends through the member **50** into a detonator chamber **47** formed in the fitting **44**. The opposite end of the chamber **47** receives the explosive detonator **42** which includes a bridge wire which initiates a detonator output charge **48**, thereby detonating the cord **18** when a circuit such as that shown is energized. The circuit as shown is in simplified form and includes a battery **49**, and a switch **51** connected by leads to the detonator element **42**. Various other detonator means, however, including those available commercially can be used for this purpose. Other similar detonator means (not shown) can optionally also be provided at the opposite end **52** of the tube **22**, if desired.

It is usually desirable to construct the subject device as a hermetically sealed construction since this not only confines the explosion but also seals the device before detonation and prevents exposure of the explosive core **28** to the surrounding conditions and prevents contamination and deterioration of the device. The seal at one end is formed by the detonator means **40** which is sealably attached to the tube **22**. The opposite end of the tube **22** can be sealed by any convenient method such as by crimping or plugging and welding or by providing a second detonator means which forms an end seal like the first. The device will operate and produce severance force, however, even if it is not sealed but for some purposes an unsealed construction is not as desirable as a sealed construction.

The shock absorbing layer of filler material **24** is an optional feature which is desirable for some applications. The layer **24** may also provide some cushioning of the structure and while it is usually preferable to attach the layer to the tube **22**, it may also be attached to the holder or clamping means **26** or it may be poured or injected into the channel around the tube by suitable means. The shock absorbing layer **24** may also have resilient and elastic characteristics which help to prevent rupture of the tube and help to deaden the noise as well as the shock associated with operation of the device. Another purpose of the layer **24** is to fill the space between the tube **22**, the clamping means **26**, and the structure **10** so that a little or no energy is wasted expanding the tube **22** in an open space thus increasing the efficiency of the device, so a maximum amount of the explosive energy is directed against the part of the structure where severance is to take place. The layer **24** may also serve to more uniformly distribute the severance force over the area of the structure along the place where severance is to occur.

The subject severance means **14** including the shock absorbing layer **24** are mounted in and supported adjacent the structure **10** from which the panel **12** is to be

severed. The mounting means or support structure as shown for illustrative purposes include the clamping means **26** which in the form of the invention disclosed extend substantially all the way around the panel **12** and substantially completely enclose the severance means.

In the device as disclosed a groove or notch **62** is provided in the structure **10** to weaken the structure at the desired fracture or break point **60** and to outline the panel to be severed. Several different forms of the groove **62** are shown in the drawing including the form shown in FIGS. 3 and 4. Another similar form of intentional structure weakening is groove **62'** shown in the structures of FIGS. 5–7. In this form the groove or notch **62'** is between different thickness portions of the structure to be severed and the groove is shown located off center relative to an imaginary vertical center line through the severance means. This is done to increase the force applied against that portion of the structure which is to be severed, but the groove should preferably not be offset too far from the center line or too close to one edge of the severance means so that the severance means are prevented from coming out of the holder after detonation. The clamp means **26** in these structures **10** and **10'** are shown attached by suitable means such as nuts **64** and bolts **66**. If desired, the clamp means could also be welded or otherwise attached to the main structure.

In the embodiments disclosed it is usually also preferable to have the clamp means **26** and the tube **22** oriented on the structures in positions substantially as shown with respect to the location where the structures are to be severed. The precise location for a particular application can be determined experimentally and should be the location that produces the most efficient operation in terms of the device to be severed and the characteristics of the severance means. At the same time a structural overhang portion **68** which remains after detonation and severance extends part way over the space in which the severance means are positioned to help retain the severance means in the holder means as already stated. The severance means can also be mounted on the removable panel portion **12** of the structure, if desired, in which case the severance means will remain with the panel after severance.

The subject device in addition to being able to separate a panel from a structure as disclosed, can also be used to open a door, break threaded or other type fastener members, actuate an operator member and many other applications, and it is not intended to limit the device to a particular application or structure. The device can also be used in the near presence of personnel and delicate instruments with safety.

When the detonating cord **18** is initiated by the detonator means **40**, the resultant explosion takes place entirely within the tube **22** and the forces thereby cause the tube to bulge outwardly. If the device were in an unconfined condition when detonated the tube **22** after detonation, depending on the tube construction and the explosion forces, would probably assume a shape similar to its shape before detonation but with its cross-sectional dimensions reversed, that is with its longer dimension becoming its shorter dimension and its shorter dimension becoming its longer dimension. However, with the device confined as is the usual case it would instead probably try to assume a more nearly round shape after detonation and at the same time increase in displaced volume. Since the device before detonation is confined in a relatively non-round enclosure the expansion and/or the change in shape of the tube operates against the panel along the weakening groove **62** to cause the weakening groove to break to allow the panel to be severed from the rest of the structure. In the case shown in FIG. 6 the shock absorbing layer **24** is shown for illustrative purposes being ruptured during detonation and severance although this is not always necessary or desirable.

FIG. 7 shows a modified construction **14'** similar to the construction of FIG. 5 in which two similar explosive severance devices sometimes called a redundant construction or a single device folded back on itself is positioned in a single holder or channel formed by a single clamp member **26'** similar to the clamping member **26**. In the modified construction **14'** either one or both severance devices can be operated. Usually, however, only one need be operated to develop sufficient severance force, the other serving as a safety in case the first one fails for some reason. In this case, the non-operated one undergoes little change in size or shape because of the detonation of the other so that if the non-operated one is positioned further from the structure to be severed than the operated one, it merely acts as backing for the detonated one, while if the one adjacent to the structure to be severed is the one that is not detonated it acts substantially like a non-compressible member to transport the forces to the severable structure. Except for the fact that two lengths of similar severance means are laid side-by-side, the device of FIG. 7 is similar structurally and operationally to the forms discussed above.

Thus there has been shown and described novel explosive severance means which fulfill all of the objects and advantages sought therefor including being able to operate reliably and accurately in almost any environment including the hostile environments that exist in space and including applications where the shock noise and debris normally associated with explosions cannot be tolerated. Many changes, alterations, modifications and other uses and applications of the subject explosive severance means will become apparent to those skilled in the art after considering this specification and the accompanying drawings.

What is claimed is:

1. An explosive device for severing one portion of a structure from another, said structure including means forming a chamber adjacent to the portion to be severed, the improvement comprising a hollow member constructed of a sze and shape to be positioned in said chamber, said hollow member being constructed of a material capable of undergoing a change in size or shape without rupturing, an element constructed of a substance capable of exploding when excited positioned inside the said hollow member, the inside of the hollow member being larger than said explosive element so that a space is formed around said element in said member, means along said explosive element for supporting the explosive element in a position spaced from the hollow member, said support means including a wall portion surrounding the explosive element, said wall portion being constructed of a substance which upon detonation of the explosive element disintegrates into fragments in which particles of the explosive element lodge to minimize the effect of impact of the particles on the hollow member, and means operatively connected to said explosive element including means to detonate same, detonation of the explosive element producing outwardly directed forces inside the hollow member which operate to expand the said member outwardly against the chamber in which it is positioned and against the chamber forming structure in a direction to sever said one portion of the structure from the other.

2. The device defined in claim **1** wherein said hollow member is tubular in shape, said hollow tubular member being constructed of a material having the characteristic of being resistant to elastic deformation to provide structural integrity to the structure on which it is installed.

3. The device defined in claim **1** wherein said means for supporting the explosive element include means for supporting said element at a central location in the hollow member.

4. The device defined by claim **1** wherein said support means include a plurality of outwardly extending members formed integral with said wall portion extending to abut the hollow member.

5. The device defined in claim **1** wherein said hollow member has a substantially oval cross-sectional shape before detonation of the device.

6. The device defined in claim 1 wherein said hollow member is constructed of malleable metallic material.

7. The device defined in claim 1 wherein the hollow member is smaller than the chamber and wherein a layer of a filler material is positioned around the hollow member substantially completely filling the chamber therearound, said filler layer being of a substance capable of transmitting forces produced during detonation to the surrounding structure thereby increasing the efficiency of the said explosive device.

8. The device defined in claim 1 wherein said explosive element includes an explosive core positioned in a sheath-like wrapper and wherein the particles which lodge in the fragments of said wall portion are mostly fragments of the sheath-like wrapper which fragmentize when said explosive core is detonated.

9. A device for explosively severing a first integral portion of a structure from a second integral portion comprising a tubular member having inner and outer surfaces, explosive means including an elongated explosive member positioned inside the tubular member, means supporting the explosive member in a substantially central location in said tubular member, said explosive member extending along the length of the inside of said tubular member, said tubular member and said support means defining therebetween a space around the explosive means, means forming a substantially enclosed chamber in which said tubular member is positioned, said chamber being formed in part by the first and second portions of the structure to be severed, and detonation means operatively connected to said explosive means whereby the first portion of the structure is severed from the second portion when the explosive means are detonated.

10. The device defined in claim 9 wherein said tubular member is formed of a malleable material and the chamber forming structure is weakened along a line formed between said first and second portions adjacent to said chamber, said line defining and outlining said first portion of the structure which is to be severed, said second structure portion and said chamber forming means being constructed to confine the tubular member even after severance of said first and second structural portions.

11. The device defined in claim 9 wherein a second tubular member similar to the aforesaid tubular member having similar explosive means and support means positioned therein is positioned in the said chamber in side-by-side relationship to the aforesaid tubular member.

12. Means for separating a portion of a structure from the rest of the structure comprising tube means of generally oval cross-section having inner and outer surfaces and opposite end portions, said tube means being constructed of a malleable material, said tube means also being capable of increasing in volume without rupturing, a detonator cord positioned in the tube means, means for supporting the detonator cord in a central location extending lengthwise along the inside of said tube means, said support means having portions extending outwardly from adjacent to the detonator cord to abut the inner surfaces of said tube means, detonator means operatively connected to the detonator cord, means sealing the ends of said tube means, and means on the structure to be severed forming a substantially closed chamber in which to position the said tube means, said structure to be severed being weakened adjacent to said closed chamber so that detonation of the said detonator cord will produce outward forces in the tube means which operate against the structure to sever the said structure portion from the rest of the structure along where the structure is weakened.

13. Means for severing one portion of a structure from another comprising a structure including a main portion and a severable portion, a notch in the structure defining and outlining the severable portion and weakening the structure therearound, means forming a chamber in the structure adjacent to said notch, a tubular member positioned in said chamber and extending along the length thereof adjacent the notch, a support member positioned inside the tubular member, said support member having a central tubular portion and outwardly extending rib portions which extend to abut the inner surface of the tubular member and to define a space around the central tubular portion, an explosive cord positioned extending through and being enclosed and supported by the central tubular portion of the support member, detonator means operatively associated with the explosive cord including means for exciting said detonator means to detonate the explosive cord, means closing the ends of the tubular member to form a sealed chamber therein, said tubular member being formed of a material capable of undergoing a physical change without rupture when the detonator cord member is detonated, said physical change causing force against the severable structure adjacent to the notch.

14. The severing means defined in claim 13 wherein a body of a yieldable shock attenuating substance is positioned in the chamber around the tubular member, said body substance being capable of transmitting the forces produced during detonation to the structure.

15. Explosive severance means comprising a tubular member having an inner surface, said tubular member being constructed of a relatively hard but deformable malleable material, an element constructed of a substance capable of exploding when excited positioned inside said tubular member and extending along the length thereof, the transverse dimensions of the inner surface of said tubular member being larger than the transverse dimensions of the explosive element so that a space is formed around said element in said tubular member, means for supporting the explosive element in the tubular member in a position spaced from the inner surface of the tubular member, and means operatively connected to said explosive element including means for detonating same, said tubular member having a generally oval cross-sectional shape before detonation defined by angularly related major and minor dimensions, detonation of the explosive element producing outwardly directed forces against the inner surface of the tubular member which operate to change the shape of the tubular member in the manner which tries to reverse the positions of the major and minor dimensions.

16. The explosive severance means defined in claim 15 wherein said tubular member is constructed of stainless steel.

References Cited

UNITED STATES PATENTS

3,032,356	5/1962	Botsford	102—49.5
3,070,018	12/1962	Fahl	102—49.5
3,119,302	1/1964	Barr	89—1
3,139,031	6/1964	Schroter et al.	102—49.5 X
3,311,056	3/1967	Noddin	102—27
3,362,290	1/1968	Carr et al.	102—49.5 X

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U.S. Cl. X.R.

102—24, 49.5