

March 24, 1970

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3,501,997

DYNAMIC FORCE ATTENUATOR FOR A MORTAR

Filed March 21, 1968

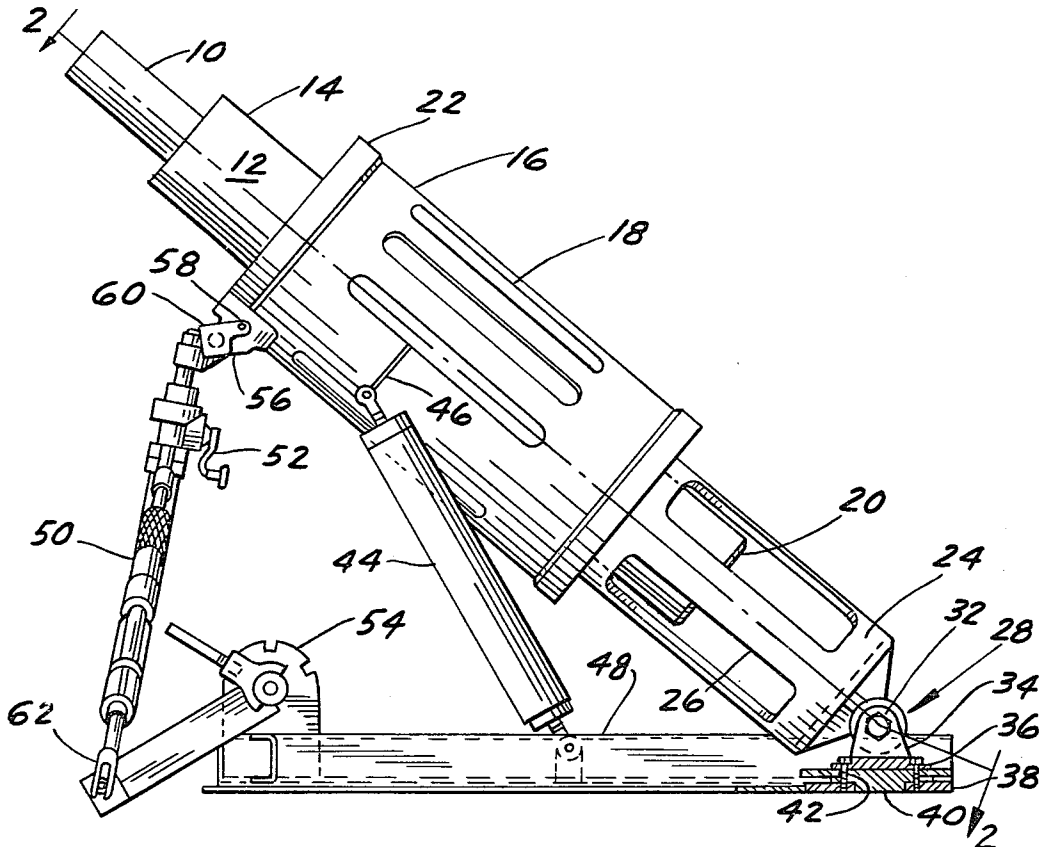
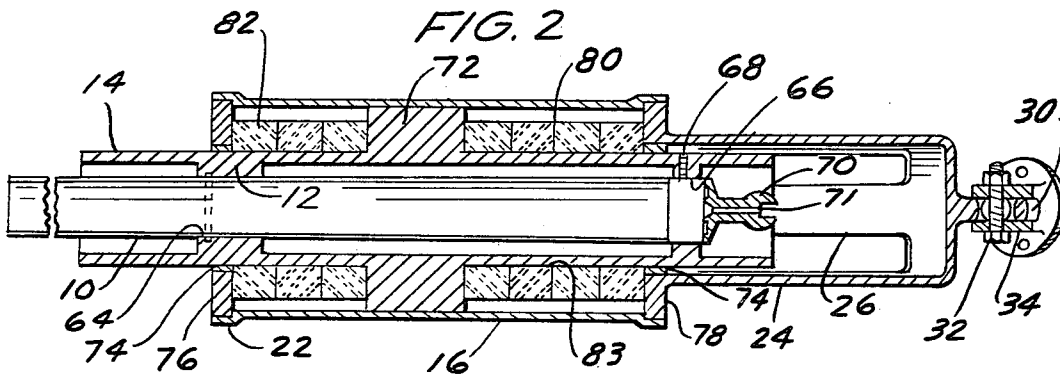


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3,501,997

DYNAMIC FORCE ATTENUATOR FOR A MORTAR
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ica as represented by the Secretary of the Army
Filed Mar. 21, 1968, Ser. No. 714,868
Int. Cl. F41f 19/06

U.S. Cl. 89-44

3 Claims

ABSTRACT OF THE DISCLOSURE

A mortar which utilizes an attenuating mechanism to sharply reduce the peak impact force of recoil. A volumetrically compressible material which surrounds the mortar tube absorbs the recoil force resulting in a substantially reduced counter-recoil force. The attenuating material is compressed against a housing by a compressing means which is connected to the tube.

The invention described herein may be manufactured, used and licensed by or for the Government for governmental purposes without payment to us of any royalty thereon.

This invention relates to mortars. More particularly this invention relates to energy absorbing devices utilized in mortars.

Conventionally, mortars have been utilized as ground based weapons. Much of the terrain in which mortars are utilized is composed of extremely soft soil. Repeated firing of a mortar in this loose or soft soil will cause the weapon to "bury itself." For this reason, plus the desire for increased mobility, the mortar is desirably mounted on a vehicle. The vehicle thus provides a base of a much larger area and will therefore eliminate the problem of the mortar sinking into the ground. Additionally, the vehicle provides a means of increasing mobility.

Mounting the mortar in this fashion, however, has given rise to attending problems. If the mortar is mounted on the truck and no recoil mechanism is used to absorb the shock, in a relatively short time, the vehicle structure will deteriorate to an unacceptable level. This is due to the great impact of the recoil force which must be absorbed entirely by the vehicle structure as a peak load rather than a distributed load. To distribute this load, conventional recoil mechanisms have been utilized. In this environment, however, their use has generated further problems. Generally, these recoil systems are effective in keeping the vehicle structure from becoming decadent, however, the counter-recoil force inherent in this type of system is sufficiently large to dismantle the mortar from the vehicle. Obviously, this type of system is unacceptable.

One of the devices utilized in the past to attenuate the force has employed a hydraulic shock absorber such as that disclosed in U.S. Patent No. 2,790,357. This type of device has proved unacceptable for several reasons among which include the fact that it is expensive, complex, and difficult to maintain.

Other devices which have been utilized in an attempt to attenuate force have included both the use of spring devices and expanding rings. Both of these devices have many disadvantages, the most serious of which is the fact that tremendous oscillations are set up in the system after the initial cushioning force, hence the dampening is not quickly effected. A device which has radially expanding rings to absorb the recoil energy may be seen in U.S. Patent No. 3,115,063. This device, however, does not operate on a principle of compression, but rather that of radial expansion, and hence is quite dissimilar to the instant invention.

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It is one of the objects of the invention therefore to eliminate the aforementioned disadvantages of the prior art systems.

Another object of the present invention is to enable a mortar to be fired from a vehicle.

It is another object of the present invention to provide a new and improved means of absorbing the recoil shock of a mortar.

It is yet another object of the present invention to provide a means for attenuating force that exists in a mortar system and means for securing the mortar to a vehicle.

A further object of the present invention is to substantially reduce the peak force transmitted to the vehicle which results from recoil of a mortar mounted thereon.

It is a still further object of the present invention to attenuate the recoil and counter-recoil force of a mortar by means of a compressible material mounted about the mortar.

Other objects and advantages of the present invention will become apparent to those of ordinary skill in the art by the following description when considered in relation to the accompanying drawing of which:

FIGURE 1 is an elevational side view of the mortar as it is mounted on the vehicle according to the invention.

FIGURE 2 is a cross-sectional view of the mortar incorporating the energy attenuating device according to the invention.

Briefly, in accordance with the invention, it has been discovered that the force transmitted by the firing of a mortar can be greatly attenuated by the use of a compressible material which surrounds the mortar tube. When the mortar is fired, the recoil source is transmitted from the mortar tube to layers of compressible material which exhibits a relatively soft response. These layers provide excellent cushioning and vibration damping whereby a large proportion of the recoil force is attenuated by the compressible structure. On counter-recoil, only a very low percentage of the initial recoil force will remain. On counter-recoil, additional layers of material which surround another portion of the mortar tube attenuate a similar percentage of the remaining force. The use of the material around the mortar tube will quickly attenuate the shock load and hence will permit the mortar to be mounted on a vehicle without impairing the vehicle structure.

Referring now to the drawing, wherein similar numerals will refer to similar parts in the various figures, a mortar is shown as being mounted on a vehicle bed. As is well known, a mortar is a muzzle loading cannon having a short tube in relation to its caliber that is used to throw projectiles with low muzzle velocities and at high angles. This short mortar tube in which the projectile is placed is shown at 10. Mortar tube 10 is mounted within a hollow piston rod 12, a portion of which is shown is shown at 14. Hollow tubular member 12 is mounted within a hollow cylinder 16, having slots 18 cut therein for improving ventilation and reducing mount weight.

The opposite end of tubular member 12 can be seen extending out the opposite end of the cylindrical support member 16 as shown at 20. A flange 22 is also formed on either end of support member 16.

A tubular end receiving member 24 is secured to the lower end of support member 16 and is adapted to receive portion 20 of tubular member 12. As can be seen in the drawing, ventilation slots 26 are cut therein to improve air circulation, reduce weight and process access to spring pin 71. At the lower end of end receiving member 24, a rear mount is shown generally at 28. A bushing 30 which may be integrally formed with end receiving piece 24 is rotatively mounted on trunnion pin 32 which extends through apertures formed in clevis type

receptacle 34. The clevis type receptacle 34 is attached to base plate 36 and mounting plate 40. The relatively complex rear mount structure 28 could be replaced by a relatively simple ball and socket wherein the ball is attached to tubular end receiving member 24 and the socket is attached to the base. This would enable the mortar to rotate freely about the base. Bolts 42 are provided to secure base plate 36, base assembly 38, and mounting plate 40.

Intermediate to flanges 22 mounted at opposite end of support housing 16 an equilibrator 44 is rotatively mounted in slot 46. The opposite end is suitably journaled on trunnion bearing 48, which provides the lower mounting means therefore. A spring is mounted within equilibrator 44 which tends to hold hollow cylinder 16 in the upright position as shown in the drawing.

An attitude and altitude positioning device is shown generally at 50 and may generally be composed of either a bifurcated single assembly or two individual legs which are spread in opposite direction from a common point adjacent the mortar housing. The two legs in conjunction with the mortar tube and its associated tubular end receiving member form a tri-pod supporting structure.

A coarse altitude adjustment device is attached to altitude positioning device 50 as shown at 62. A crank as shown at 52 is provided on base 50 to adjust the altitude of the mortar tube. A similar lateral positioning device (not shown) is also provided with the supporting structure to obtain correct lateral position. Adjustment of altitude position devices 50 and 54 causes the mortar tube to rotate about trunnion pins 58 and 60, which are secured in an adapted plate 56. Plate 56 may be attached to cylindrical supporting member 16 in any suitable mechanical manner such as by welding.

The particular details of the supporting system are not peculiar to nor an important part of the invention. Any other suitable supporting structure by which the altitude and lateral position of the mortar tube can be controlled will suffice.

Referring now to FIGURE 2, the mortar tube 10 is connected to tubular member 12 in the areas designated generally as 64 and 66. Mortar tube 10 may be threadedly engaged to tubular member 12 or secured in any other suitable manner. For instance, a set screw 68 may be utilized to secure the two tubular assemblies.

At the end of mortar tube 10 a spherical ball 70 is shown. Ball 70 is used to adapt the mortar for a direct connection to a vehicle without the use of the mounting assembly according to the present invention. Shown generally at 71 is the conventional firing pin mechanism utilized to initiate firing of the mortar. If desired, of course, the threads as shown at 64, and set screws as shown at 68 may be eliminated in favor of a connecting system whereby the ball 70 is connected directly to tubular member 12.

Intermediate the oppositely disposed ends of tubular member 12, a ring 72 is rigidly attached thereto. Ring 72 may be formed as an integral part of tubular member 12 as shown, or may be individually formed and subsequently attached by any mechanical, suitable means such as by welding. The outside diameter of ring 72 should enable the clearance between cylindrical housing 16 and rod 12. Mounted on the opposite ends of cylindrical support member 16 are end pieces indicated generally at 76 and 78. End piece 76 is securely fastened to cylindrical housing 16 by any suitable manner such as pinning. A bushing 74 is secured to end piece 76 and is engaged with tubular member 12 which is movable relative thereto. End piece 78 is secured to cylindrical housing 16 and is shown as being formed as an integral part of end receiving member 24. Obviously, end member 78 could be formed individually and secured to member 24 in any other suitable mechanical manner. As shown, a bushing 74 is secured to end member 78, and is adapted to receive tubular member 12, which slides back and forth relative thereto.

Secured about tubular member are a plurality of rings of cushioning or attenuating material shown generally at 80 and 82. Rings 80 encircle the lower portion of tubular member 12 and are mounted intermediate ring 72 and end piece 78. Rings 82 similarly surround tubular member 12 and are positioned intermediate rings 72 and the opposite end piece 76. The inside diameter of rings should be just large enough to enable them to slide easily over the tubular member 12. The material utilized for rings 80 and 82 is one having excellent energy absorbing characteristics which makes it an excellent vibration damper at both high and low frequency. The counter-recoil force of a mortar, utilizing this type of material, is very low compared to the recoil force. For example, empirical tests have shown that a 12,000 pound counter-recoil force resulted from a system utilized initially at 80,000 pounds of recoil force. This reduction in force cannot be obtained with a system such as a coil spring, but requires a material which exhibits a very soft response, which cushions the shock and reduces the vibration damping. The material utilized is a "micro-cellular" urethane elastomer which was developed for heavy duty mechanical applications. This material provides the advantages of a cellular product with the additional properties of solid cast elastomers. One of the many advantages of this micro-cellular structure is its linear deformation, wherein the material will deflect proportionally to the load until the deflection reaches approximately 40 to 50% of the total height of the material. In contrast to materials such as rubber, which are noncompressible, this material has the additional advantage of being compressible.

A material which will meet the requirement of the above described system is known as Celasto.

Celasto exhibits a combination of open and closed cells—predominantly open. This material is volumetrically compressible. This material should not be confused with the very low density urethane foams used for padding and seat cushions. Even if totally confined, Celasto can be compressed to less than one-fourth its original height. Due to its cellular nature, it is possible to compress Celasto springs to a small fraction of their free length with very little change in diameter. This is of peculiar importance where there are space limitations.

In contrast to the cellular elastomeric substance which is utilized in the present invention, solid elastomers have a common limitation of being incompressible. If squeezed in one direction, they must expand proportionally in another; hence, they offer no spring action when confined.

A urethane elastomer which is suited for this purpose has a specific gravity of 0.45 and weighs 0.45 gram per cubic centimeter or 28 pounds per cubic foot. The various grades of material may vary from 20 to 40 pounds per cubic foot or 0.3 to 0.6 gram per cubic centimeter.

The attenuating rings 80 maintain the tubular member 12 in the position shown in the drawing under no-load conditions. The two masses of attenuating material, such as Celasto, are maintained in position with either a light or a preloaded pressure, due to the manner of assembling the end pieces, the cellular structure and the tubular support member 12. The hollow cores 83, formed in each of rings 80 and 82, are aligned with the openings of the bushings 74, attached to opposite ends of the hollow cylinder 16. The piston rod or tubular member 12 extends through the cores of the cushioning material and the bushings 74. The piston rod or tubular member 12 is of sufficient length to maintain contact with the full bearing surface of bushings 74, at maximum displacement in either direction of the piston rod. The inside diameter of the respective rings should be just large enough to enable them to slide easily over the tubular member 12.

The mortar is suitably aligned by means of positioning means 50 and 54. The mortar rotates about its mounts 28, 48, etc., until it is aligned in the desired position. The projectile is inserted in the mortar tube and fired. The force is applied to the load receiving part of mortar tube

10, and is transmitted to the tubular piston 12. The energy is transmitted through ring 72 as the piston is forced backwards against the cushioning material 80, compressing it against the end piece 78, until the energy of the impact has been dissipated.

As the tubular piston 12 moves rearwardly toward end piece 78, it slides through the cores 83 of the attenuating material 80 and through the bushing 74. Due to compression of the cellular structure, a part of the impact energy is absorbed and a part is dissipated. Obviously, a portion of the force is transmitted through the rear mount and into the base structure. However, the force transmitted to the base structure is reduced because of the energy dissipated by the cushion. When the energy of the impact has been dissipated, the cellular structure rebounds, pushing the piston 12 back towards a neutral position, but with a drastically reduced force. When the neutral position is reached, the piston is traveling at its highest velocity and its momentum carries it forward past the neutral position. Ring 72 now begins to compress rings of the attenuating material 82. Because of the reduced force of the counter-recoil, the number of rings 82 may be less than that of rings 80.

The process of energy dissipated and force reduction are now repeated with a reduced force being transmitted to the base structure, but in the opposite direction as previously described. The mortar tube again rebounds with the force still further reduced and the piston is pushed back through the neutral position to complete one cycle. This cycle is repeated through a short series of rapid oscillations of decreasing amplitude until the force is reduced to zero. The piston will then have returned to the neutral position where it will be prepared to receive the next impact load, thus repeating the cycle.

Although the system has been shown and described with an assortment of various pieces, it is to be understood that the force may be further attenuated by the addition of mass to the recoiling parts, which will cause energy to be consumed in accelerating this mass.

It should be further understood that force attenuation may also be accomplished by embodying concepts of this invention in a configuration of piston and cushioning masses 80 and 82 which are external to the load receiving part. This configuration would permit the arrangement of one or more pistons about the periphery of the lower receiving part and is accomplished by containing the piston, cushioning material, and supporting plate in an assembly supported by the base structure.

In this event each piston would receive the load from the load receiving part through an arm attached to the end of one of the piston rods.

Another modification of the present invention provides for the assembly of supporting plates and end pieces, designated above as 78, and cushioning material 80 and 82 to be connected to the load receiving parts such as 10. In this modification the piston or tubular member 12 is supported rigidly by the base structure. The force of recoil is transmitted from the mortar tube 10 to the supporting plate, which moves forward, thus compressing the cushioning material against the stationary piston 12. The relative motion of the parts, the oscillating movements, and the disposition of energy and force is the same, in principle, as the basic invention herein above described.

Although each mass of attenuating material has been described as being composed of a single layer comprised of rings of material disposed in axially abutting relation, it should be understood that additional concentric layers of rings may also be utilized. Moreover, the plurality of axially abutting rings could be replaced by a single ring if desired.

It should be further understood that to eliminate binding of the disks against the rings and against each other, the cushioning material may be assembled with a stiff washer, such as one composed of steel which is located between each disk. The inside diameter of the washers placed intermediate the rings of the material should be

just large enough to enable the washers to slide easily over the piston rod. The outside diameter should be a little larger than the outside diameter of the cushioning material so as to maintain separation of the rings when their diameters are increased during compression. All surfaces of every disk should be well greased to facilitate relative motion between the disk and washers and between the disk and piston rods.

What has been shown and described therefor is a device which provides a simple and yet relatively inexpensive means of effectively attenuating recoil energy and reducing the peak force which exists in a mortar system. This has been accomplished by use of relatively few parts and associated lower and reduced maintenance of the mortar system. This invention has enabled the mortar to be mounted on a vehicle without damage to the vehicle due to shock. It has enabled a mortar system to be utilized with a vehicle without an unacceptably high counter-recoil force and accompanying oscillations. The use of the plastic resilient material in any of the above described configurations as a dynamic force attenuator is a new and novel concept.

Since it is obvious that many changes and modifications can be made in the above described details without departing from the nature and spirit of the invention, it is to be understood that the invention is not limited to said details except as set forth hereinafter.

What we claim is:

1. In a mortar, in combination,

a support housing,

a mortar tube mounted in said support housing,

volumetrically first and second compressible attenuation means mounted intermediate said mortar tube and said support housing for causing the force of the counter-recoil to be substantially less than the force of the recoil of the mortar tube,

compressing means connected to said mortar tube for compressing said attenuation means,

said first attenuating means being mounted adjacent a first means of said compressing means and said second attenuating means being mounted adjacent an oppositely disposed means of said compressing means such that said first attenuating means reduces the peak recoil force and said second attenuating means reduces the peak counter-recoil force;

and wherein said attenuating means comprises at least one layer of cellular urethane elastomeric material which is compressible to a small fraction of its free length under impact loads without substantial deterioration.

2. In a mortar, in combination,

a mortar tube having first and second ends,

a tubular support member, radially inwardly protruding portions at its oppositely disposed ends in which said mortar tube is rigidly mounted,

a radially outwardly protruding portion intermediate said oppositely disposed ends,

a support housing in which said tubular support member is movably located therein,

a tubular receiving member mounted to one end of said support housing for receiving a portion of said tubular support member,

a first and second plurality of layers of attenuating devices axially disposed on opposite sides of said radially outwardly protruding portion,

said attenuating devices being composed of volumetrically compressible cellular material having a density within the range of 0.3 to 0.6 gram per cubic centimeter, which reduces the peak force of recoil.

3. In a mortar, in combination,

a support housing,

a mortar tube,

a tubular support member mounted in said support housing, volumetrically compressible attenuation means mounted intermediate said mortar tube and

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said support housing for causing the force of the counter-recoil to be substantially less than the force of the recoil of the mortar tube;
compressing means rigidly secured to said tubular support member, and
said motor tube being rigidly secured to said tubular support member,
said tubular support being movable relative to said support housing, and
said compressible attenuation means comprising first and second layers of volumetrically compressible cellular structure mounted on oppositely disposed sides of said compressing means and surrounding said tubular support member such that said first layer attenuates the recoil force and the second layer attenuates the counter-recoil force, and a tubular end receiving member mounted on one end of said sup-

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port housing and adapted to receive a portion of said tubular support member during recoil of said mortar.

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U.S. Cl. X.R.

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