Sept. 26, 1967 J. W. ROGERS ETAL 3,343,400

IMPACT TEST APPARATUS

Filed June 2, 1965

FIG. 1.

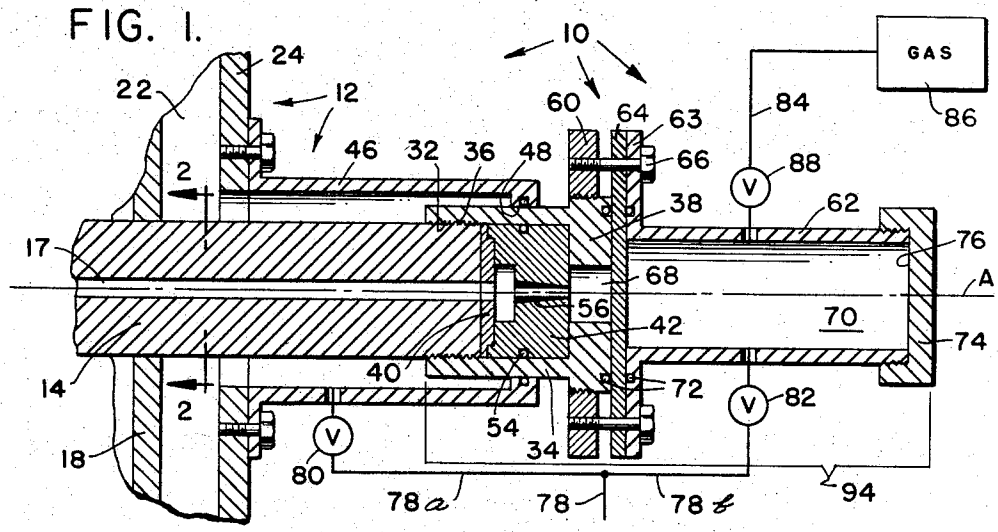


FIG. 3.

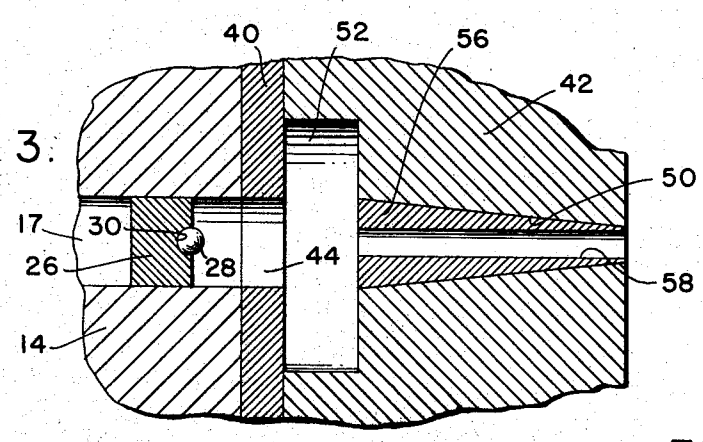


FIG. 2.

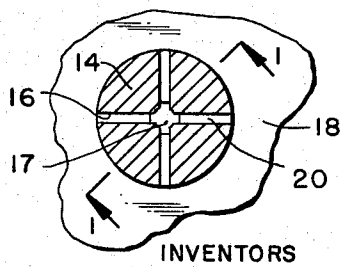
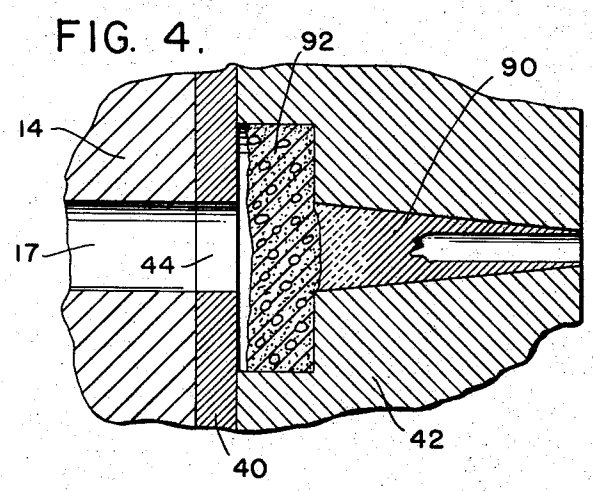


FIG. 4.



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IMPACT TEST APPARATUS

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ABSTRACT OF THE DISCLOSURE

Apparatus for use in combination with a high velocity impact test gun for investigation of the effects of high velocity impact of a specimen of a given material against a rigid surface in a sealed gaseous atmosphere. The test gun is of the type in which the projectile travels through an arrangement comprising a gas venting barrel extension surrounded by a baffled vacuum chamber, which arrangement maintains a vacuum in the bore of the gun barrel, the bore of the barrel extension, and the space ahead of the extension before the projectile is fired, and delays gases preventing their emergence ahead of a projectile. The gun fires a sabot projectile carrying a smaller projectile at its front end. The sabot and smaller projectile are fired at a sleeve having a central bore through which the smaller projectile may pass. The exterior of the sleeve is tapered to fit into a forwardly constricted space of a block for receiving same. After the smaller projectile passes through the bore of the sleeve, the impact of the sabot against the sleeve causes same to collapse and form a hermetic seal behind the smaller projectile and thereby stops the forward flow of the delayed gases. The smaller projectile is impelled on and perforates a diaphragm of the specimen material and thence is impelled on into a chamber containing the gas. The fragment of the specimen material produced by the perforation impacts the end wall of the chamber.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to the art of testing the high velocity impact properties of materials. More particularly the invention relates to a test apparatus for attachment to the muzzle end of a high velocity impact test gun for investigating the effects of high velocity impact of a given specimen metal against a rigid surface in a sealed atmosphere consisting of a given specimen gaseous medium.

One object of this invention is to provide a test apparatus of the type referred to for receiving a projectile fired from a gun, and which seals itself before any of atmosphere sealed therein escapes.

Another object is to provide such a self-sealing test apparatus which may be conveniently detached from the gun after firing, and which then forms a portable unit which is convenient to handle in connection with chemical laboratory type gas analysis equipment.

A still further objective is to provide such a self-sealing impact chamber in which impact of the specimen metal is caused to occur at a velocity which is higher than the muzzle exit velocity of the gun.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is a longitudinal section of apparatus embodying the invention shown attached to the front end of an impact test gun, and taken along line 1—1 of FIG. 2;

FIG. 2 is a section taken along line 2—2 of FIG. 1;

FIG. 3 is enlarged detail of FIG. 1; and

FIG. 4 is an enlarged detail, like FIG. 3, showing its condition after the gun is fired.

Referring in detail to the drawing and particularly to FIG. 1, the subject of the invention is test apparatus **10** for use in investigating the results of impact of a small sample of a specimen metal material against a rigid impact surface in a sealed atmosphere containing a precisely determined amount of a specimen gaseous medium. Apparatus **10** comprises a conventional smooth bore impact test gun **12** (only partially shown) of the type disclosed in U.S. Patent No. 3,130,575, to J. W. Rogers, entitled "Impact Test Apparatus," to which reference is made for a full description of the device. Briefly, the parts of gun device **12** shown in the present drawing include a barrel extension **14** having four longitudinal slots **16**, FIG. 2, which are equiangularly spaced about the bore axis A and which run along the length of barrel extension **14** and provide lateral openings between the bore **17** and the outer surface of the barrel extension for venting propellant gases. A series of circular baffle plates **18**, FIGS. 1 and 2, (only one of the series is shown, and it is only partially shown) are disposed in axially spaced relationship about the barrel extension. At each baffle plate, the longitudinal passage area of the slots are restricted by triangular elements **20**, FIG. 2. Only one edge of elements **20** are shown in the drawing. Reference should be made to the drawing in the cited U.S. patent if a better understanding of the triangular shape of element **20** is desired. Barrel extension **14** and baffle plates **18** are disposed in a vacuum chamber **22**. Chamber **22** is formed by an outer cylindrical wall, not shown, disposed adjacent the periphery of the baffle plates. The front end of the vacuum chamber is formed by a transverse wall **24**. The function of the restricted slots, baffles, and the vacuum chamber is to laterally vent the propellant gases from behind a projectile as it travels along the barrel extension, and to vent these gases in such a manner that they initially remain entrained in the axial compartments of the vacuum chamber formed by the baffles, for a residence time of sufficient duration that gases cannot bypass ahead of the projectile. As a result, the propellant gas pressure behind the projectile is largely relieved when the projectile emerges from the front end of barrel extension **14**, so that the muzzle blast does not disturb the precise rectilinear trajectory of the projectile. Also, the projectile emerges from the front end of barrel extension **14** ahead of all propellant gases.

A cylindrical sabot projectile **26**, FIG. 3, is loaded for firing from the gun device **12**, in the same manner as described in the above referred to patent. The drawing shows sabot projectile **26** at a position in the bore of the muzzle extension just before it emerges from its muzzle end. Sabot projectile **26** is made of a relatively light weight, ductile metal such as aluminum. A separable projectile **28** of spherical shape, is mounted in a semispherical recess **30** formed in the front face of sabot projectile **26**. Spherical projectile **28** is held in recess **30** in any suitable man-

ner permitting same to separate under impact shock, such as by means of an adhesive. It may be made of any suitable material capable of punching out, or "plugging" a fragment sample from a transverse plate made of the specimen material, as will be understood as the description of this specification proceeds. Projectile **28** may, itself, be of the specimen material, provided that the aforementioned criteria of being capable of punching out the fragment sample is satisfied. Typical muzzle exit velocities of an aluminum sabot projectile from gun device **12** are of the order of 10,000 feet per second, and above. Barrel extension **14** has external threads **32** formed about its outer surface adjacent its front end. A first cylindrical housing member **34** is provided with matching internal threads **36**, and the rear end of housing member **34** is threadedly fastened to the front end of barrel extension **14**. An internal shoulder **38** is formed on housing member **34** adjacent its front end. An apertured circular plate **40** and a cylindrical sabot impact block **42** are disposed in the central space within housing member **34**. Plate **40** has a central circular opening **44** of the same diameter as the gun bore. Plate **40** is renewable and is made of copper. It serves to protect the muzzle end of barrel extension **14** against being "scoured." Housing member **34** is tightly threaded onto the barrel extension to fasten plate **40** and block **42** in rigidly clamped relationship between the front end of barrel extension **14** and the confronting interior surface the internal shoulder **38** at the front end of the housing member **34**. A tubular extension wall **46** projects from the vacuum chamber wall **24** and surrounds the projecting portion of gun barrel extension **14** and the rear half of housing member **34**. The front end of extension wall **46** is provided with a small inwardly directed annual portion forming an O ring bearing surface **48**, which is in gas sealing engagement with the outer surface of housing member **34**.

Sabot impact block **42** has a tapered internal bore **50** extending between its ends. A circular cavity **52**, FIG. 3, having a diameter larger than that of the gun bore, is formed in the rear end face of sabot impact block **42**, and tapered bore **50** opens into the bottom of cavity **52**. The internal diameter of bore **50** is maximum at its rear end where it opens into cavity **52**, and at that point is equal to the internal diameter of the gun bore. The diameter of tapered bore **50** linearly decreases in the forward direction, tapering to an internal diameter essentially equal to that of the spherical projectile **28**, carried at the front end of sabot projectile **26**. An O ring **54**, FIG. 1, is provided between the outer surface of sabot impact block **42** and the inner surface of cylindrical housing **34**, forming a gas seal therebetween. As a result of sealing these surfaces, tapered bore **50** is the sole gas passage between the front and rear ends of cylindrical housing **34**. A tapered walled sleeve **56** is disposed in bore **50**. The internal bore **58** of sleeve **56** is of a uniform diameter equal to that of spherical projectile **28**. The wall thickness of sleeve **56** is maximum at its rear end and decreases linearly in the forward direction to a thickness of essentially zero at its front end. The taper of the wall thickness is chosen to provide a matched machine fit within the tapered internal bore **50** of the sabot impact block. Sleeve **56** is made of copper or other suitable material which exhibits ductility and a high specific density relative to that of the light weight metal sabot projectile **26**. Sabot impact block **42** is preferably made of mild steel.

A flange member **60** containing a circle of tapped bolt holes, is threadedly secured to the outer surface of housing member **34** adjacent its front end. A second cylindrical housing member **62** has a matching flange portion **63** at its rear end for axially tandem mounting adjacent to the front end of housing member **34**. A circular plate **64** of the specimen material to be tested has a matching ring of bolt holes, and is clamped between the front face of housing member **34** and the face of flange **63** at the rear end of housing member **62** by means of bolts **66**.

Plate **64** is disposed across bore axis A in transverse relationship thereto. A pair of O rings **72** provide a gas seal between the front face of housing member **34** and the rear face of plate **64**, and between the front face of plate **64** and the face of flange **63**. A short axial zone **68**, which is of importance in the description of the operation, to follow, comprises the central opening within the internal annular projection **38** of housing member **34**, and is bounded at the rear by the plane of the front end of impact block **42**, and bounded at the front by the rear face of plate **64**. The central space within housing member **62** forms a cylindrical chamber **70**. Plate **64** serves as a gas tight barrier between zone **68** and chamber **70**. A closure cap **74** closes the front end chamber **70**. The interior face of cap **74** lies in direct line of travel of the impelled spherical projectile **28** and the punched out fragments of the specimen plate **64**, and forms the impact surface against which these fragments and the spherical projectile are impacted.

A vacuum line **78** has a branch **78***a* communicating with the interior of vacuum chamber extension wall **46** through a suitable port connection, and another branch **78***b* communicating with chamber **70**. Valves **80** and **82**, are connected in branches **78***a* and **78***b*, respectively. Each valve has its vacuum line side connected to a pipe union (not shown) or other suitable disconnectible joint. Another line **84** communicates a source **86** of the specimen gaseous medium to be tested with chamber **70**. A valve **88** and associated disconnectible joint (not shown) are connected in line **84** in similar manner to those in the vacuum line branches.

The operation of apparatus **10** is as follows: Prior to the firing of gun device **12**, the vacuum chamber **22**, including the portion thereof defined by the interior of tubular extension wall **46**, is evacuated through vacuum line branch **78***a*. The zone **68** within housing member **34** also becomes evacuated as the result of this space being communicated with chamber **22** through the longitudinal slots **16** and the bore **17**, of barrel extension **14**. Chamber **70** is evacuated through vacuum line branch **78***b*. After chamber **70** is evacuated valve **82** is closed, and a precise amount of the specimen gaseous medium is metered into chamber **70** through gas line **84** by means of valve **88**. Gun **12** is fire, impelling sabot projectile **26** into impact with the rear end of tapered sleeve **56**, with the annular surface of the front end of projectile **26** striking the confronting annular face at the rear end of tapered sleeve **56**. Sleeve **56** is constrained against forward axial movement by the constrictive effect of the decreasing diameter of tapered bore **50**. Spherical projectile **28** separates from sabot projectile **26** under its own momentum, and under momentum energy imparted to it by the collision of sabot projectile with tapered sleeve **56**. Momentarily after the projectile has cleared the internal bore of the sleeve, the energy of impact of the sabot projectile and the sleeve causes the rear end of the sleeve to collapse and form a plug **90** of fused copper, which closes, and hermetically seals the passage through impact block **42**. It is to be noted that the propulsion gases of impact gun **12** remain completely behind the sabot projectile **26**, as is described in the aforementioned U.S. Patent 3,130,575, and therefore are not introduced into zone **68** prior to hermetic sealing of the passage. Projectile **28** continues its travel along axis A. The collision of projectile **28** and specimen plate **64** ruptures plate **64** and punches out a fragment (not shown) of the specimen metal, which together with projectile **28** are axially impelled through chamber **70** into impact against surface **76** in the presence of the specimen gaseous medium. Upon rupture of the specimen plate **64**, the gaseous medium in chamber **70** flows through the opening into zone **68**, but is prevented from further escape through the muzzle of the gun device by plug **90**. Sabot projectile **26** shatters, and its fragments disperse into circular cavity **52**, forming an agglomeration **92**.

After the firing, the vacuum line 78*b*, and the gas line 84 are parted at their disconnectible joints, and housing member 34 is detached from the gun barrel extension 14, by unscrewing the threaded joint 32. Housing member 34 and 62 are left fastened together by the gas tight joint between them. It will be apparent that after unscrewing joint 32, housing member 34 and housing member 62 and their associated parts form a sealed unit 94 containing the gaseous medium, present in chamber 70 at the time the sample of specimen metal was impacted against surface 76, and also containing the fragmented products of the impact. Unit 94 is relatively compact and light in weight and may be taken to a chemistry laboratory equipped for gas analyses to determine changes, if any, in the chemical composition of the specimen gaseous medium after the high velocity impact. The fragments of the special metal will, in the typical case, become attached to impact surface 76, and these fragments, too, are accessible for chemical analysis by removing cap 74. It has been found that unit 94 maintains the gases therein in a completely sealed condition for at least several days after the firing. This is important where it is desirable to have flexibility to schedule the firing, and the chemical analysis independent of one another.

As a further feature of apparatus 10, it has been discovered that the mechanism of the impact of sabot projectile 26 against sleeve 56 increases the kinetic energy of spherical projectile 28, causing it to accelerate to higher velocities than that at which it emerged from the barrel extension. Certain experimental results have indicated that increases in velocity of as much as 50% may be achieved in this manner.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In combination with a smooth bore impact test gun of the type for impelling a projectile along a rectilinear trajectory, apparatus for use in investigating the results of impact of a fragment of a sample of a specimen metal material against a rigid impact surface in an effectively sealed chamber for containing a sample of a specimen of a gaseous medium, comprising:

(a) said gun having a barrel with a front end and being of a type having a gas venting barrel extension and having a vacuum chamber surrounding the barrel extension, the wall of the barrel extension containing a plurality of longitudinally extending lateral openings equiangularly spaced about the bore axis to vent the gun propellant gases from behind a projectile during the period same travels along the barrel extension, said vacuum chamber having evacuation port means for connection to a vacuum line,

(b) a first cylindrical housing defining a cylindrical space adjoining the front end of muzzle extension, said first housing being rigidly connected to the front end of the gun barrel in coaxially aligned relationship about the gun bore axis, said space enclosed by said first housing communicating with the interior of the vacuum chamber through the bore and lateral openings of the barrel extension,

(c) a second coaxially aligned cylindrical housing, said second housing disposed axially adjacent the front end of the first housing and having evacuation and gas entry port means for evacuating gas from the interior of the second housing and for admitting a precisely metered sample of a specimen gaseous medium thereto,

(d) a specimen plate of said specimen metal material disposed between the first and second housings and transversely across the projectile trajectory path from the gun,

(e) a pair of flanges, one rigidly affixed to the forward end of the first cylindrical housing, and the other to the rearward end of the second cylindrical housing, the flanges having confronting faces, and means to rigidly fasten said flanges together with their respective faces in clamping and sealing engagement against opposite faces of the specimen plate, said specimen plate forming a rupturable wall between the interiors of the first and second housings,

(f) a closure affixed over the front end of the second housing, the interior surface of the closure forming the rigid impact surface against which the fragment of specimen metal material is impacted,

(g) a sleeve support block having a coaxially aligned tapered bore extending between its ends and rigidly supported in said space within the first housing, the sleeve support block having its outer surface in gas sealing engagement with the wall of the first cylindrical housing, said tapered bore having its maximum internal diameter at the bore opening at the rear end of the sleeve support block, which maximum internal diameter is equal to the internal diameter of the gun bore, said diameter of the bore decreasing in the forward direction along the sleeve support block,

(h) a tapered walled sleeve of ductile material fitted into the tapered bore of the sleeve support block, said tapered walled sleeve having a uniform diametered bore between its ends, the wall thickness decreasing in the forward direction to provide an outer sleeve surface matched to fit the tapered bore of the sleeve support block, the rear end of the sleeve forming a transverse annular sabot impact surface,

(i) a first projectile forming a sabot for forward propulsion along the bore of the gun and barrel extension and for exit from the front end of the barrel extension along a rectilinear trajectory, said sabot projectile being of an external diameter essentially equal to that of the gun bore for engagement with the internal surface of the bore, said first projectile at its front end forming an annular transverse impact surface confronting the impact surface at the rear end of the tapered wall sleeve,

(j) a second projectile for punching out a sample of the specimen plate, said second projectile being separably carried by the first projectile at its front end in the central zone inside the impact surface,

(k) the construction and arrangement of the first and second projectiles, the sleeve support block, and the tapered walled sleeve being such that upon impact of the transverse impact surfaces of first projectile and the tapered walled sleeve, the tapered walled sleeve is constrained against forward axial movement by constriction effects provided by the forwardly decreasing diameter of the tapered bore in the sleeve support block, and the second projectile separates from the first projectile and passes through the bore of the tapered wall sleeve and out of the front end of the latter along a rectilinear trajectory into collision with the specimen plate to punch out and impel a fragment of the latter into impact with the impact surface at the front end of the gas and impact chamber, and such that after said second projectile has passed through the bore of the tapered walled sleeve the energy imparted to the tapered walled ductile sleeve by the impact of the first projectile causes the tapered walled sleeve to collapse to close and hermetically seal the bore of the sleeve support block to prevent escape of the gases flowing from the interior of the second housing through the fractured specimen plate, said second projectile accelerating to a velocity greater than that of the first projectile under the energy imparted thereto by the impact between the projectile and the tapered walled sleeve.

2. Apparatus in accordance with claim 1;

(l) said first housing being rigidly attached to the front end of barrel extension by means of internal threads

at its rear end adapted for threadedly engaging external threads formed on the outer circumferential surface of the barrel, said first housing at its front end having an internal shoulder, said internal and external threads cooperating to rigidly fasten the sleeve support block in clamped relationship between the front end of the barrel extension and the confronting transverse face of said shoulder.

3. Apparatus in accordance with claim 1;

(m) said first projectile being made of a light weight ductile metal material and said tapered walled sleeve being made of a heavier ductile metal.

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