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European Patent Specification 0,016,491

Apparatus for making moving parts visible

5 The invention relates to an apparatus for making fast-moving parts in a housing visible, especially projectiles in a firearm, with an accelerator which generates invisible radiation at at least 300 pulses per second, with a recording unit containing lead plates as radiation protection, an image converter for converting the radiation of
10 the accelerator into visible radiation, a deflecting device for deflecting the image out of the region of the accelerator radiation and a camera for at least 500 images per second.

15 An apparatus of this type for making fast-moving parts visible in a housing is known from U.S. Patent Specification No. 4,092,537. This apparatus consists of an accelerator generating invisible radiation at at least 300 pulses per second and of a recording unit containing lead
20 plates as radiation protection, an image intensifier for converting the radiation of the accelerator into visible radiation, a deflecting device to deflect the image out of the region of the accelerator radiation and a film camera for at least 500 images per second.

25 However, this known apparatus is highly sensitive to shocks and is therefore unsuitable for making projectiles in a firearm visible.

 The object to be achieved by means of the present invention is to provide an apparatus in which shocks
30 occurring when the apparatus is in operation are prevented from being transmitted to the accelerator.

This object is achieved, according to the invention, when a protective box for receiving the shock-sensitive accelerator has a double trough, and a space between the two troughs is filled at the front, on both sides, at the rear and on the bottom with several layers of felt-covered elastic balls.

It has, admittedly, been known for a long time in the art to make shock-sensitive equipment damped in respect of vibration, whenever this has been necessary. Attention is drawn to U.S. Patent Specification No. 1,870,310. However, in this known damping device, the internal friction is much too low to reduce the vibrations within a useful period of time.

It is also known to use beam diaphragms between the accelerator and the parts to be made visible. Attention is drawn to the publication "Soldat und Technik", ("Soldier and Technology") No. 2, 1968, Figure 5, page 71.

An exemplary embodiment of the apparatus according to the invention is described in detail below with reference to the drawings in which:

Figure 1 shows the construction of the apparatus as a whole in a plan view,

Figure 2 shows a diagrammatic representation of the accelerator in a plan view,

Figure 3 shows a diagrammatic representation of the image intensifier,

Figure 4 shows a plan view, side view and elevation of the double trough of the protective box.

According to Figure 1, the object to be transilluminated, for example a gun 1, stands, together with a beam diaphragm 2, between an accelerator 3 and an image intensifier 4. Located behind the image intensifier 4 is a light deflection tube 5 which deflects the light beam to a camera which is protected from short-wave radiation and which is located in a lead housing. To protect this camera, lead walls 7 and 8 are also arranged on two sides of the lead housing.

The protective box 28 of the accelerator 3.

The accelerator 3 is shock-sensitive, and the gun 1 to be transilluminated causes strong vibrations during firing. It is therefore necessary to protect the accelerator 3 from shock in a protective box 28. This protective box 28, which is also used for transporting the accelerator 3, has a double trough. According to Figure 4, the space between the two troughs is filled at the front, on both sides, at the rear and on the bottom with three layers each of tennis balls, for example 4,000 tennis balls altogether. Furthermore, but not shown, there are on the protective box 28 four individually pivotable wheels and three individually adjustable lifting devices which make it possible to bring the accelerator 3 easily to the desired location and into the desired position. The outer trough is also mounted on conventional vibration dampers.

Because of the powder gases generated when the gun is fired, the protective box of the accelerator 3 is closed in a gas-tight manner in a way which is not illustrated. The protective box can be heated for the purpose of transporting the accelerator 3. Sufficiently large orifices for maintenance are provided.

To estimate the vibration damping required, it was assumed that the accelerator is not damaged when the shock accelerations caused when the gun 1 is fired are less than the acceleration due to gravity $g = 9.81 \text{ m/sec}^2$, and that operating capacity is maintained when these shocks accelerations are less than one-third of the acceleration due to gravity g .

However, it was shown in firing tests that the outer trough of the protective box mounted on conventional vibration dampers is still exposed to shock accelerations of 10 g , and that by means of the three layers of tennis balls the inner trough of the protective box is exposed only to shock accelerations of approximately one-third of the acceleration due to gravity g . A damping from 10 g to 0.3 g is thus obtained by means of the tennis balls, and

this cannot be achieved with conventional vibration dampers.

With this vibration damping with high frictional effect caused by the felt-covered surfaces of the balls, the decay time to 10% of the original amplitude level of the vibration caused by a shot amounts to less than 50 milliseconds. Measurements have also shown that the vibration caused by shocks when the gun is fired decays so quickly as a result of the damping that repetition firing does not differ from an individual shot in vibration terms.

10 The accelerator 3

A conventional unit is suitable for the accelerator 3 as a generator of radiation in the 1 - 10 megaelectron volt range. According to Figure 2, this unit has an accelerator tube 9 which contains a standing electromagnetic wave for accelerating the electrons. Located outside the accelerator tube 9 is a magnetron 10 for generating the wave and an electron source 11 for generating free electrons. To limit the beam, a collimator 12 is located at one end of the accelerator tube 9. To generate the necessary vacuum, an ion getter pump 13 is provided. There is also a circulator 14 for deflecting the reflecting wave which is to be annihilated.

Since, as mentioned, this unit is obtainable commercially from Varian under the name of Linatron 1500, there is no need for a detailed description here.

Electrons, on which the standing wave of the accelerator tube acts, escape from the electron source at one end of the accelerator tube 9. The field strength of this standing wave accelerates the electrons. The electrons accelerated approximately to the velocity of light then strike a tungsten plate and generate collision radiation which for the most part escapes in a beam cone with a cone angle of approximately 30° .

The exemplary embodiment described here makes use of a machine which can work in three energy ranges at 5, 7.5 and 10 MeV (megaelectron volt energy), that is to say an energy corresponding to a transit voltage difference

of the electrons of 5, 7.5 or 10 million volts. The electron current of approximately 70 micro amperes, flowing at 10 MeV, gives a power of approximately 700 watts at 10 million volts.

- 5 The radiation capacity of the accelerator amounts to 10,000 rads per minute at 300 pulses per second.

The beam diaphragm 2

- Since the firearm to be investigated has different wall thicknesses in the relevant region, it is necessary
10 to arrange a beam diaphragm 2 between the firearm 1 and accelerator 3, to prevent the beam from striking the image intensifier 4 unattenuated at individual points when it passes through the firearm 1. An unattenuated beam is capable of destroying the image intensifier 4. The hardness
15 of the radiation used means that a large number of lead plates are necessary for the beam diaphragm 2, in order to protect the image intensifier 4 effectively. Tests have shown that a substantial image improvement can be achieved by changing the aperture width of the beam
20 diaphragm. If only 1% of the recording surface of the image intensifier receives too much radiation, the sensitivity of the image intensifier becomes so low that the image becomes useless.

The protective box 27 for the recording unit 26

- 25 The recording unit 26 is also arranged in a protective box 27. This protective box 27 can be provided with vibration dampers and can be lifted and lowered hydraulically (not shown). The image intensifier 4 is arranged directly on a vibration-damped plate. The light
30 deflection tube 5 and the camera 6 are fastened to an optical bench located on the said vibration-damped plate.

- The image intensifier 4 is positioned in the beam cone 29 emitted by the accelerator 3 and is protected against powder gases and airborne sound by a thin aluminum
35 plate. The camera 6 is located outside the beam cone

and is protected from radiation by lead plates 7, 8 weighing, for example, approximately one ton. The side and ceiling walls of the protective box for the recording unit are lined with lead walls for protection against scattered rays.

- 5 The protective box 27 protects the recording unit from powder gases and has orifices for the passage of cables for the image intensifier 4 and the camera.

The image intensifier 4.

- According to Figure 3, the image intensifier 4 has
10 a first layer 16 of caesium iodide which generates light flashes when gamma rays strike against it. Behind this first layer 16 is located a second layer 17, a so-called photocathode, into which the light flashes can penetrate, thereby generating free electrons. These free electrons
15 are located inside a focussing electrode 21. Here, a strong potential acts on the electrons, as a result of which the electrons, accelerated and focussed, strike against a small surface 18 of a phosphorus layer. Two anodes 19 and 20 are located in front of this surface 18.

- 20 The sensitivity of the caesium iodide layer is dependent upon the energy range of the radiation, that is to say the number of light flashes generated in this caesium iodide layer by the accelerator radiation depends on the radiation energy. However, the efficiency of the
25 caesium iodide layer depends not only on the radiation energy, but also on the layer thickness. The greater the layer thickness, the more gamma quanta are retained in the caesium iodide layer. If the layer is too thick, however, the light flashes generated in the front are no longer
30 present at the rear, because they have been absorbed or reflected.

The electrons make the phosphorus layer of the surface 18 luminous.

- The persistence time of the phosphor layer of
35 the relatively small surface 18 determines the number of images which can be recorded per second. The time taken for the luminous layer to fade to one-tenth of its initial

brightness amounts to 1 millisecond. It is thus possible to record 500 images per second.

Since approximately 176 photons are formed from one gamma quantum and the area ratio of the entrance screen to the exit screen is approximately 100:1, an intensification factor of 17,600 is obtained.

Conversion electron foil 25

Located in front of the image intensifier 4 is a conversion electron foil 25 which likewise ensures an improvement in the image quality. A gold foil 0.5 to 1.0 mm thick is preferably used. This foil serves for converting the "hard" rays emitted by the accelerator into "softer" rays more suitable for the image intensifier. The foil consists of a material, for example gold, which, when irradiated, generates a relatively large number of conversion electrons.

The light deflection tube 5

Located behind the image intensifier is the light deflection tube 5 which has an angled, telescopically extendable tube and a deflecting mirror of the highest possible optical quality. This light deflection tube 5 entails an undesirable light loss, but is necessary because 90% of the radiation from the accelerator 3 passes through the image intensifier 4. However, this radiation passing through the image intensifier 4 would blacken the film completely if the camera 6 were arranged directly behind the image intensifier 4. The light deflection tube 5 makes it possible to arrange the camera 6 outside the beam cone. It is therefore impossible to avoid a long light path from the exit screen of the image intensifier 4 to the lens of the camera 6.

The camera 6.

The camera 6 located behind the light deflection

5 tube 5 will have as low an internal light loss as possible. It works with intermittent film transport and allows at most 500 images per second to be recorded. Such a camera 6 is highly sensitive mechanically and requires expensive semi-conductor electronics. Both the film and these electronics must therefore be carefully protected from the gamma quanta of the beam cone by means of lead plates. Consequently, the camera 6 is surrounded by, for example, approximately one ton of lead.

Patent claims

1. Apparatus for making fast-moving parts in a housing visible, especially projectiles in a firearm, with an accelerator (3) which generates invisible radiation at at least 300 pulses per second, with a recording unit (27) containing lead plates (7, 8) as radiation protection, an image convertor (4) for converting the radiation of the accelerator into visible radiation, a deflecting device (5) for deflecting the image out of the region of the accelerator radiation and a camera (6) for at least 500 images per second, characterised in that the protective box (28) for receiving the shock-sensitive accelerator (3) has a double trough (22, 23), and the space between the two troughs (22, 23) is filled at the front, on both sides, at the rear and on the bottom with several layers of felt-covered elastic balls (24).
2. Apparatus for making fast-moving parts visible, according to Claim 1, characterised in that the protective box (28) for receiving the shock-sensitive accelerator (3) contains a heating system.
3. Apparatus for making fast-moving parts visible, according to Claim 1, characterised in that the balls (24) are gas-filled.

Claims (as printed)

1. An apparatus for rendering visible moved objects within a housing, especially projectiles in a firing weapon, comprising:



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- an accelerator (3) producing an invisible radiation having at least 300 pulses per second;
- a recording equipment (26) containing lead plates (7, 8) serving as radiation protection means;
- an image amplifier (4) for conversion of the radiation of the accelerator into visible radiation;
- a light deflection tube (5) for deflecting the image out of the region of the radiation of the accelerator (3) and
- a film camera (6) for at least 500 images per second characterised in that
- protective box (28) is provided for housing the accelerator (3) which is vibration sensitive
- a double through arrangement (22, 23) forming there between a space which is filled at the front, at both sides, at the rear and at its base with a number of respective layers of felt covered elastic ball elements (24).

2. An apparatus for rendering visible moved objects as defined in Claim 1, wherein said protection cabinet (28) for housing the vibration sensitive accelerator (3) contains heating means.

3. An apparatus for rendering visible moved objects as defined in Claim 1 wherein said balls (24) are gas filled ball elements.

Revendications

1. Installation pour visualiser des pièces se déplaçant rapidement dans un boîtier notamment des obus dans une arme à feu avec un accélérateur (3) qui génère un rayonnement invisible d'au moins 300 impulsions par seconde, avec un appareil de réception (27) comportant des plaques de plomb (7, 8) comme moyens de protection contre le rayonnement, un convertisseur d'image (4) pour convertir l'irradiation accélérée en un rayonnement visible, une installation de déviation (5) pour extraire l'image de la zone du rayonnement de l'accélérateur et une caméra (6) pour au moins 500 images par seconde, caractérisée en ce qu'un boîtier de protection (28) pour recevoir l'accélérateur (3) sensible aux secousses, comporte une double cuvette (22, 23) et l'intervalle entre les deux cuvettes (22, 23) est rempli à l'avant, sur les deux côtés, à l'arrière et sur le fond par plusieurs couches de balles (24) élastiques revêtues de feutre.

2. Installation pour visualiser des pièces déplacées rapidement selon la revendication 1, caractérisée en ce que le boîtier de protection (28) pour recevoir l'accélérateur (3) sensible aux secousses comporte un chauffage.

3. Installation pour visualiser des pièces déplacées rapidement selon la revendication 1, caractérisée en ce que les balles (24) sont remplies de gaz.

