United States Patent

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[73] Assignee **The United States Steel Corporation**

[54] **IMPACT-TESTING APPARATUS**
11 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **23/101,** 73/12
[51] **Int. Cl.** **G01n 3/24**
[50] **Field of Search** 248/15, 18, 20, 22; 72/435, 453; 100/256; 267/1; 73/103, 101, 12

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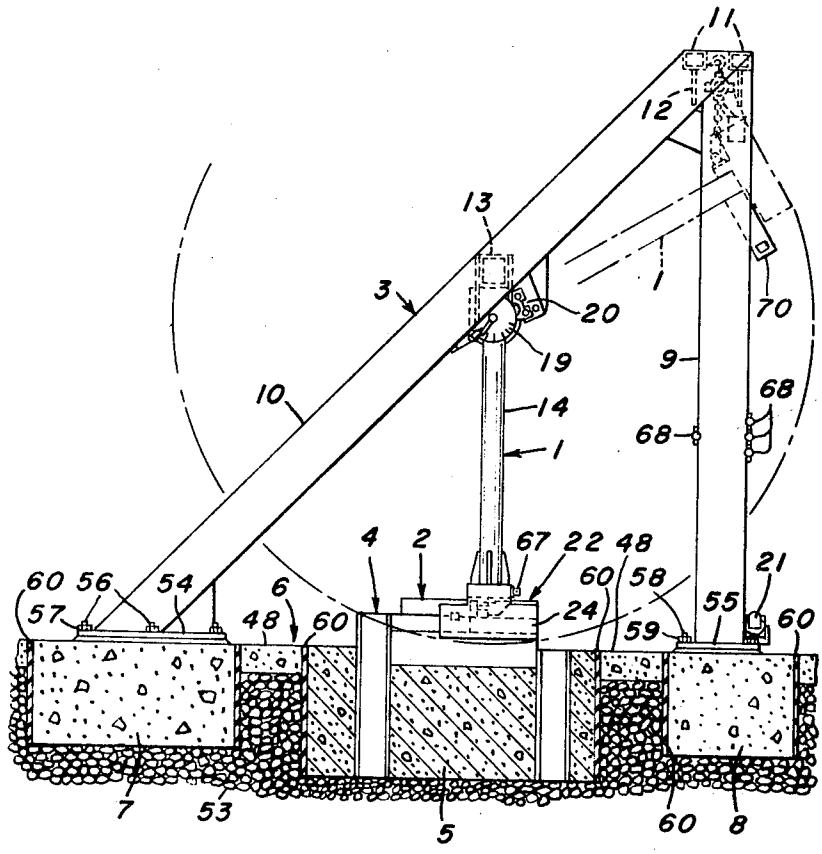
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Primary Examiner—Richard C. Queisser
Assistant Examiner—John Whalen
Attorney—William G. Young

ABSTRACT: An impact tear-test machine having a concrete foundation constructed to dampen the transmission of impact force between the anvil on which a steel test specimen is mounted and the frame for a pendulous hammer which is used to fracture the specimen. The foundation comprises a reinforced concrete floor or base which has a centrally located reinforced concrete pier for supporting the anvil and reinforced concrete pads on opposite sides of the anvil pier for supporting the hammer frame. The anvil pier and the pads for the hammer frame are positioned in rectangular openings in the floor of the foundation and are vibrationally insulated with respect thereto by strips of composite-vibrational-damping material about the edges of the pads and pier openings in the floor.



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SHEET 1 OF 2

FIG. 2.

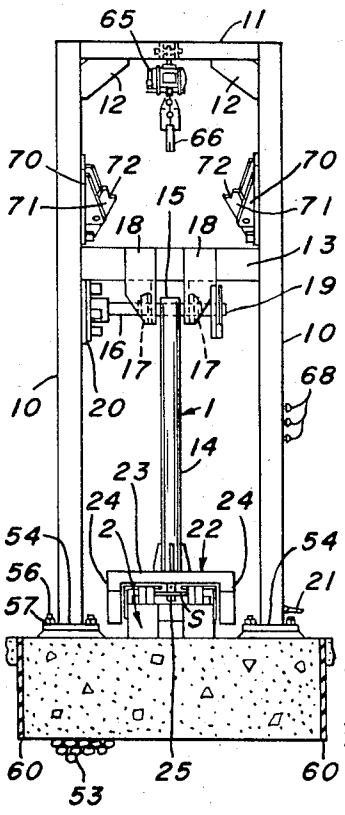


FIG. 1.

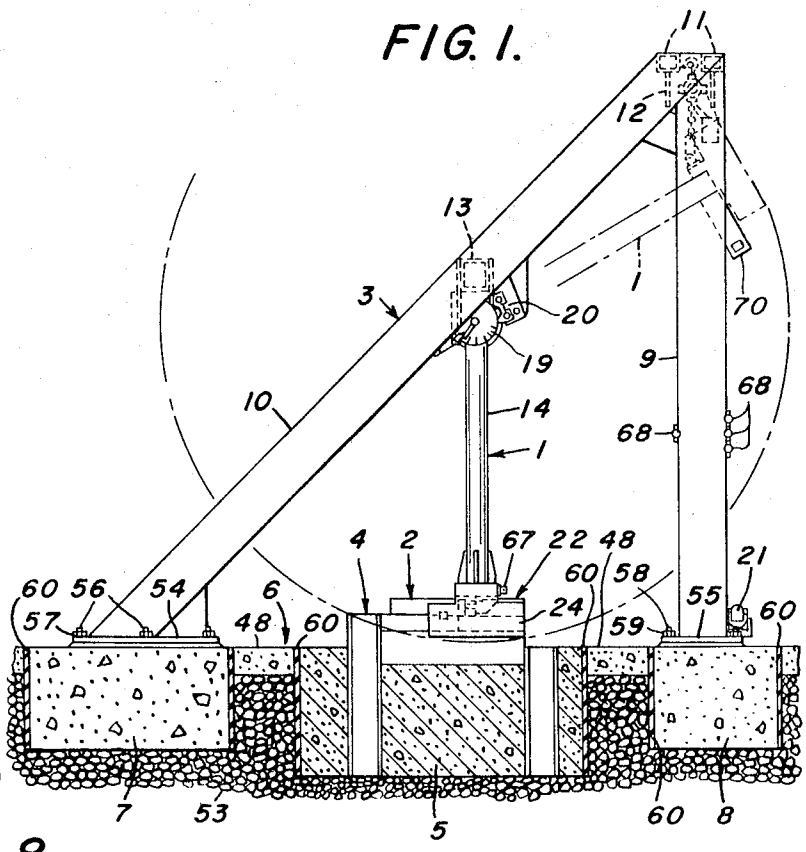


FIG. 8.

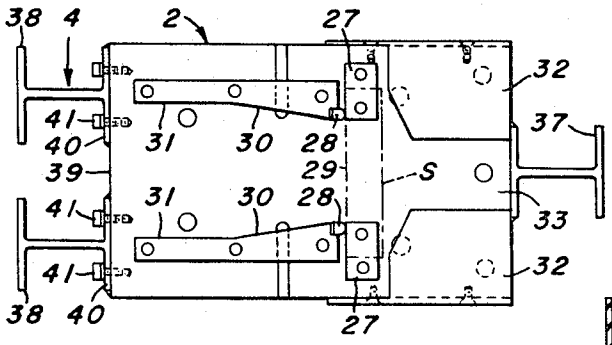


FIG. 6.

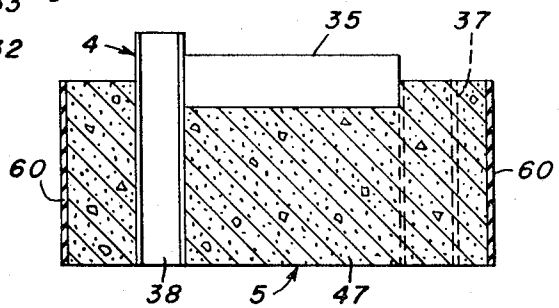
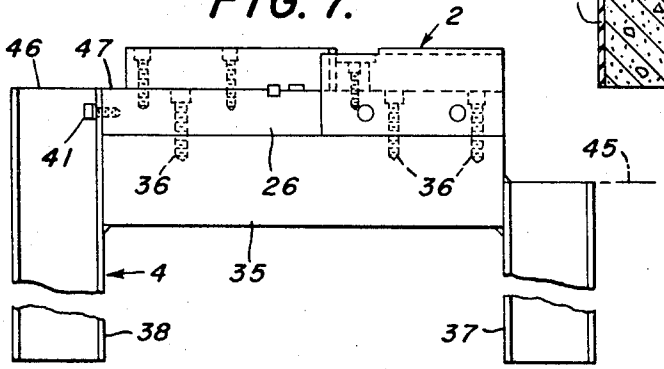


FIG. 7.



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FIG. 3.

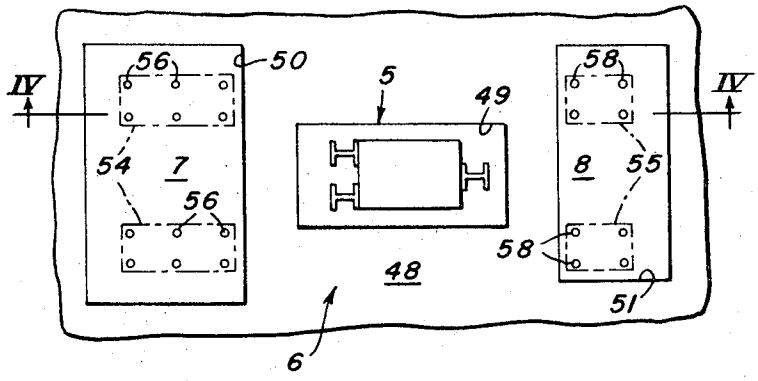


FIG. 4.

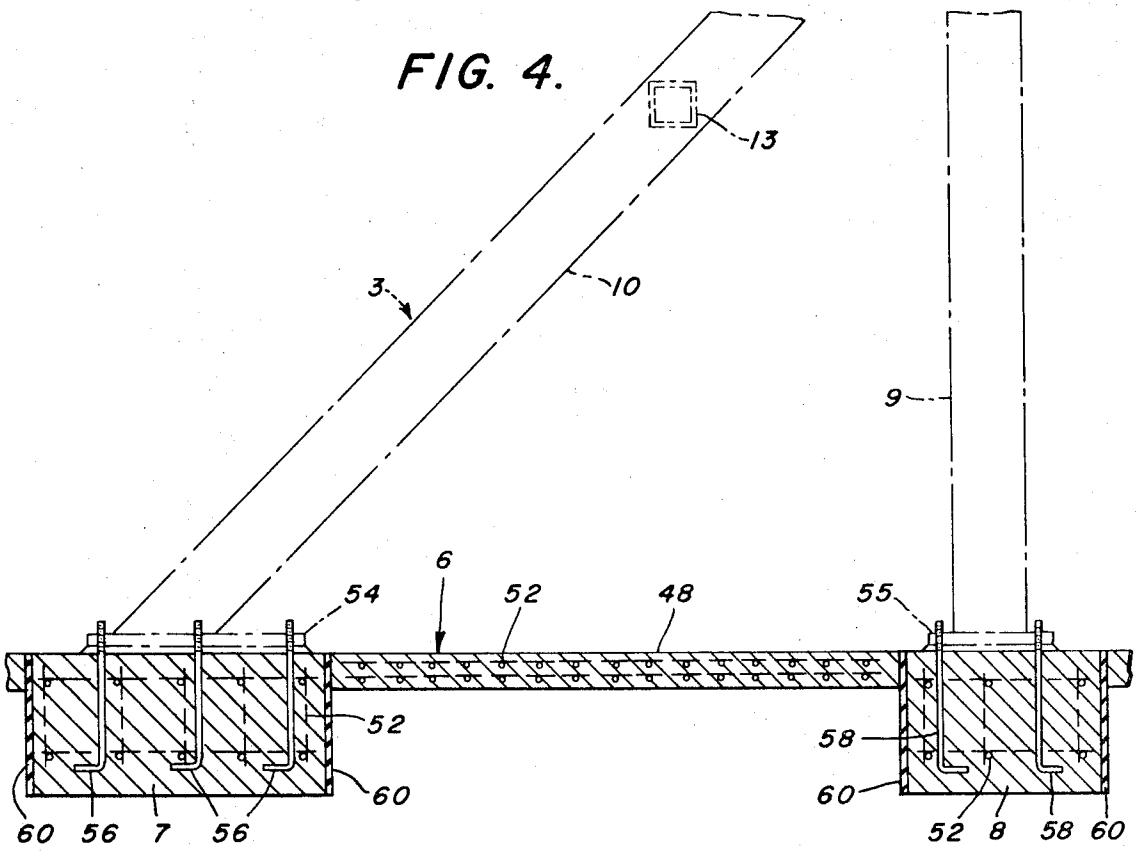
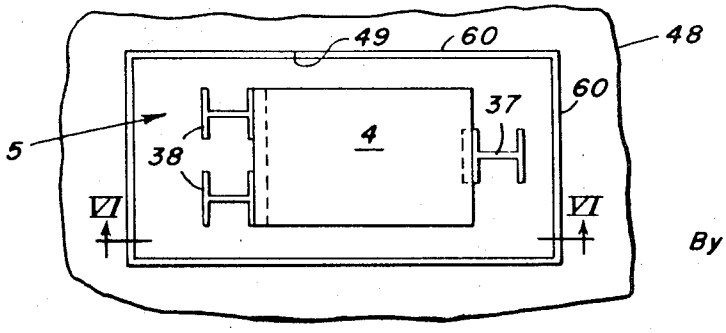


FIG. 5.



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IMPACT-TESTING APPARATUS

This invention relates to impact-testing apparatus of the dynamic-tear-test type in which a steel plate or other test-piece is supported on an anvil and is fractured by a pendulous hammer to obtain an indication of the notch toughness of the steel from which it is made. The invention relates, more specifically, to a reinforced concrete foundation which is constructed to prevent the transmission of impact forces from the anvil to the hammer frame that might otherwise affect the results of the test. In a manner to be described, this is accomplished by providing separate reinforced concrete supporting slabs or piers for both the anvil and the frame on which the hammer is supported for movement as a pendulum.

A primary function of an impact or dynamic-tear-test is to determine the energy required to fracture the specimen. In most impact machines this energy is indicated by the residual swing of the pendulum after the specimen is broken. The energy absorbed when the specimen is broken is related to the difference between the initial and residual swings of the pendulum. The energy measured by this method, however, is affected by several factors: energy to fracture specimen, any contact that is made between the broken sections of the specimen and the pendulum after the specimen is fractured, strain energy induced in the machine structure, bearing friction and windage loss. The elimination of contact between the pendulum and broken sections of the specimen can be achieved by proper design of the pendulum head and anvil, such as the straddle-type head used for the machine of this invention. The problem associated with strain energy induced in the machine structure is not so evident, however.

Strain energy is a result of deflections in the various machine parts caused by the force of impact. The deflection is a maximum if the force is applied at the natural frequency rate of the part. The various parts of the machine have different natural frequencies of vibration. The strain energy would be directly related to the energy level if the applied force of impact were of constant duration or rate of application. However, it has been observed that the force of impact for the same type of specimen at the same fracture energy level is not constant, but is related to the amount of shear-type of failure in the fracture of the specimen. At a given energy level, a low shear-type of fracture requires more force and less duration of force application than a high shear-type of fracture. Strain energy induced in the testing machine can, therefore, vary at the same energy level.

The force of impact on the machine parts must be eliminated if accurate fracture energy measurement is to be obtained. The pendulum of most pendulum-type impact machines is designed using classical dynamic theory so that the specimen is struck at the center of percussion to eliminate any reaction at the pivot shaft of the pendulum. Pendulum machines of this type, however, usually have a unitized construction in which the specimen anvil is a part of the machine structure. The machine structure, therefore, still experiences the shock of the impact through the anvil, and for the reasons mentioned above, does not give accurate strain energy readings.

The machine structure of this invention has been devised so that the structure does not experience any force of impact with the specimen. The reaction at the pivot shaft is eliminated by striking the specimen at the center of percussion of the pendulum, but the base of the machine structure is also isolated from the anvil by one or more materials that have a much lower ratio of modulus of elasticity to density than that of the material from which the machine structure is made. Rigidity of the anvil also is important, and the anvil therefore, is embedded within a large mass of concrete that is isolated from the foundation for the machine structure by an asphalt-type filler material. In the design of this invention, the machine structure is completely free of the force of impact and the effect of strain energy is minimized, a feature not recognized in the design of previous machines for this type of test.

One of the principal objects of this invention, accordingly, is to provide an impact test machine of improved construction in which impact forces are not transmitted from the anvil to the frame on which a hammer in the form of a pendulum is mounted, so that such forces do not affect the results of the impact test. To this end, and as indicated above, the anvil and the hammer frames are independently supported by a reinforced concrete foundation, the anvil being mounted on a reinforced concrete pier, and the hammer frame being mounted on physically separate slabs that are located in positions spaced from opposite ends of the anvil pier.

Other objects and advantages of the invention will become apparent from the following description and the accompanying drawings, in which:

FIG. 1 is a side elevation of an impact testing machine constructed in accordance with the principles of this invention;

FIG. 2 is an end view taken in a direction looking from the left of FIG. 1;

FIG. 3 is a somewhat diagrammatic plan view showing the relative arrangement in a reinforced concrete foundation of the separate supports for anvil and the hammer frames shown in FIGS. 1 and 2;

FIG. 4 is a sectional view drawn to an enlarged scale and taken substantially along the line IV–IV of FIG. 3;

FIG. 5 is a plan view of the pier for supporting the anvil, this figure being drawn on the same scale as that of FIG. 4;

FIG. 6 is a sectional view taken substantially along the line VI–VI of FIG. 5;

FIG. 7 is a side elevational view of the anvil and the steel frame on which it is supported; and

FIG. 8 is a plan view of the assembled anvil and frame shown in FIG. 7.

The impact testing machine of this invention, as shown in FIGS. 1 and 2 of the drawings, comprises a hammer pendulum 1 that is centered over a support for a test specimen on an anvil 2 in a manner to be described. The pendulum 1 is supported for swinging movement on a steel frame 3, and the anvil 2 is supported on a steel frame 4 that forms part of a steel-reinforced concrete pier 5. The pier 5 is part of a reinforced concrete foundation 6 and is constructed to prevent the transmission of impact forces from the anvil 2 to the frame 3, the frame 3 being supported on reinforced concrete pads 7 and 8 which also form part of the foundation 6 and are constructed to dampen the transmission of such impact forces.

The steel frame 3 comprises a pair of laterally spaced and vertically extending beams 9 which are supported at their lower ends on opposite ends of the pad 8. A pair of laterally spaced beams 10 are secured as by welding at their upper ends to the tops of the beams 9 and extend angularly downwardly therefrom, the lower ends of the beams 10 being supported on opposite ends of the reinforced concrete pad 7. At their upper ends, the beams 9 and 10 are connected and held in spaced relation by a pair of crossbeams 11, gusset plates 12 being provided for bracing the beams 9 and 10 at their points of connection to the crossbeams 11. At about their mid points, the angularly inclined beams 10 are connected and held in spaced relation by a crossbeam 13 on which the pendulum 1 is supported in a manner to be described. The beams 9, 10, 11 and 13 are hollow rectangular box-beams, but any other suitable beam construction may be used.

The pendulum 1 comprises a hollow steel tube 14 which has its upper end 15 connected to a horizontal shaft 16 for rotation therewith. The shaft 16 is supported for rotation in laterally spaced bearings 17 carried by plates 18 that are supported by and depend from the crossbeam 13. An angle indicator 19 of the usual and conventional construction is provided at one end of the shaft 16 for indicating the angular swing of the pendulum 1 and thus the energy expended thereby in breaking a test specimen on the anvil 2. A disc-brake assembly 20 is provided at the opposite end of the shaft 16 for stopping the swinging movement of the pendulum 1. The brake 20 is conveniently operated by a foot treadle 21 at the base of one of the vertical columns 9.

A straddle-head 22 is secured to the lower end of the tube 14. As shown in FIG. 2, the straddle-head 22 comprises a horizontal plate 23 having vertical side plates 24 depending from opposite edges thereof. The spacing of the plates 24, as shown in FIG. 2, is such that they clear the sides of the anvil 2 during swinging movement of the pendulum with respect thereto. A striker element or hammer 25 is secured to the horizontal plate 23 in a central position extending axially with respect to the pendulum 1. By reason of the relatively large mass of the straddle-head 22, the hammer 25 engages the test specimen on the anvil 2 at the center of percussion of the pendulum 1. As a consequence, there is no reaction at the shaft 16 from the impact of the hammer 25 when it breaks a specimen on the anvil 2.

As shown in FIGS. 7 and 8, the anvil 2 comprises a baseplate 26 in the form of a thick steel slab. A pair of laterally spaced blocks 27 bolted to the upper surface of the plate 26 forms a support for a test specimen S, which is supported thereon in a position as indicated schematically in dotted lines. The test specimen S abuts against and is held against movement upon impact by the hammer 25 by a pair of vertically extending keepers 28 which engage the forward edge 29 of the specimen S. The keepers 28 are held against movement by a pair of laterally spaced anchor blocks 30 which are bolted and keyed in spaced positions to the upper surface of the plate 26. The facing surfaces 31 of the blocks 30 operate to deflect and guide the forward movement of the fragments of a specimen S when it is broken by the impact of the hammer 25. The spacing of the surfaces 31 is such that the pieces of the specimen S do not bind between the hammer 25 and the surfaces 31 during forward travel of the hammer 25 through the space therebetween. Spaced guards 32 on the plate 26 define a space 33 through which the hammer 25 swings into engagement with the specimen S. The guards 32 operate to constrain the broken pieces of the specimen S against deflecting movement upwardly and outwardly, to the rear and to the right as viewed in FIGS. 7 and 8.

The steel frame 4 on which the anvil 2 is supported comprises a steel slab 35, which is coextensive with the anvil plate 26 and to which the anvil plate 26 is secured by bolts 36. Opposite ends of the slab 35 are welded to a vertically extending column 37, which is arranged centrally under the path of swinging movement of the hammer 25, and to a pair of laterally spaced steel columns 38 on opposite sides of the path of swinging movement of the hammer 25. The columns 37 and 38 as illustrated are preferably H-beams. The plate 26 has one edge 39 thereof secured to the flanges 40 of the beams 38 by bolts 41. The upper end of the column 37 coincides with the floor surface 45 of the reinforced foundation 6 on which the apparatus is mounted. The upper ends 46 of the beams 38 are at a level which is flush with the upper surface 47 of the anvil plate 26. As indicated above, the beams 37 and 38 are embedded in the concrete 47 of the pier 5 and thus reinforce and form a part of such pier.

As best shown in FIGS. 3—6, the foundation 6 comprises a reinforced concrete floor 48 which includes the anvil pier 5, and the slabs 7 and 8 for supporting the frame 3. The floor 48 has a rectangularly shaped opening 49 (FIG. 3) in which the pier 5 is located, and similar openings 50 and 51 for the frame pads 7 and 8. The floor 48, pier 5, and pads 7 and 8 are fabricated from poured concrete with steel reinforcing rods, diagrammatically indicated by the numeral 52, interlaced therethrough, and are supported on a foundation base 53 of crushed rock, clay, granulated slag, or other suitable base material.

The frame 3 has anchor plates 54 welded to the lower ends of each of the beams 10, and similar plates 55 welded to the lower ends of each of the vertical beams 9. The anchor plates 54 and 55 provide for attachment of the frame 3 to the reinforced slabs 7 and 8. For this purpose, opposite ends of the slab 7 are provided with a plurality of vertically extending anchor bolts 56 which are embedded in the concrete therein and extend upwardly through openings in the anchor plates 54 so that the plates 54 may be secured to the pad 7 by nuts 57 threaded on the upper ends of the bolts 56. Similarly, opposite ends of the pads 8 are provided with anchoring bolts 58 which are embedded in the concrete therein and extend upwardly through openings in the anchoring plates 55 which are securely fastened to the slabs 8 by nuts 59 threaded on the upper ends of the rods 58.

As shown in the various figures of the drawings, the side surfaces of the pier 5 and each of the slabs 7 and 8 are covered with a layer 60 of vibration-damping material, which operates to dampen the transmission of vibration and impact force from the pier 5 to the slabs 7 and 8 and thus to the steel frame 3 on which the pendulum 1 is supported. The vibration-damping material 60 is preferably an asphalt-type filler material, such as heavy tar paper, but it will be understood that other suitable materials such as rubber and cork composite materials, and synthetic materials such as neoprene and plastic may be used for this purpose as desired.

A power-operated chain hoist 65 is suspended from the crossbeams 11 for raising the pendulum 1 to the position shown in dotted lines in FIG. 1 from which it is released to break a test specimen S on the anvil 2. The hoist 65 includes a clasp or grapple 66 for connection with an eyelet 67 on the straddle-head 22 for elevating the pendulum 1 to its upper position. The grapple 66 is equipped with suitable mechanism (not shown) for latching it to the connector 67 and for unlatching it to release the pendulum 1 for gravitational downward movement. The motor for operating the hoist 65 is preferably a rotary air motor, which may be for example that of the ARO Company of Bryan, Ohio. Operation of the motor for the hoist 65 and for unlatching the grapple 66 is effected by safety controls 68 in the form of manually operable valves mounted on the columns 9.

Safety latches 70 are mounted on the facing surfaces of each of the vertical columns 9 to prevent accidental lowering movement of the pendulum 1. Each of the latches 70 includes the latching member 71 which is pivotally supported for movement to and from its operative latching position as shown in FIG. 2, and has a notch 72 in its upper end for engaging the sides 24 of the straddle-head to prevent lowering movement of the pendulum 1. Operation of the latching members 71 is under the control of air cylinders (not shown) which are actuated to pivot the members 71 to positions out of the path of movement of the straddle-head 22 when the hoist 65 is actuated to elevate the pendulum 1 to its upper position, and to return the latching members 71 to their operative latching position when the supply of air for operating the motors for the hoist 65 is interrupted. When the grapple 66 is operated to release the pendulum for downward movement, the safety latches 71 are pivoted to their inoperative positions in which they will not interfere with downward movement of the pendulum.

In operation, the hoist 65 is operated to raise the pendulum 1 to the elevated position shown in dotted lines in FIG. 1, after which a specimen S is placed on the blocks 27 against the keepers 28 of the anvil 2 as shown in FIGS. 7 and 8 of the drawings. When the specimen S is in position, the controls 68 are actuated to move the safety latches 71 to their inoperative positions and to release the grapple 66 so that the pendulum 1 may gravitate downwardly to break the specimen S, breakage of the specimen S being effected when it is struck by the hammer 25 at the center of percussion of the pendulum 1. Due to the separate supports provided by the anvil pier 5 and the reinforced slabs 7 and 8, it will be apparent that the impact of the hammer 25 against the specimen S and the anvil 2 is not transmitted to the steel frame 3. In this manner, the impact force from breaking a specimen does not enter the machine structure where it can cause vibrations that may affect the energy absorbed at impact, and a more accurate indication of the energy required to fracture the specimen S is thus obtained.

While one embodiment of my invention has been shown and described, it will be apparent that adaptations and modifica-

tions may be made without departing from the scope of the appended claims.

I claim:

1. In an impact tear-test apparatus of the type including an anvil for supporting a steel test-piece and a pendulous hammer for fracturing said test-piece, and wherein the energy required to fracture the test-piece is indicated by the residual swing of the hammer following said fracture the combination with a steel frame on which said hammer is supported for swinging movement, and a steel frame for supporting said anvil, of a concrete foundation, and separate means respectively supporting said hammer frame and said anvil frame on said foundation, said foundation being constructed and including means for damping the transmission of impact forces from said anvil frame to said hammer frame.

2. An impact test apparatus as defined in claim 1 characterized by said concrete foundation comprising reinforced concrete pads on opposite sides of said anvil, and by said hammer frame being secured to and supported on said pads.

3. An impact test apparatus as defined in claim 1 characterized by a reinforced concrete pier for supporting said anvil, said pier being positioned in and forming a part of said foundation.

4. An apparatus as defined in claim 3 characterized by said pier comprising a horizontal steel plate at its upper end on which said anvil is mounted, and vertically extending steel columns embedded in the concrete of said pier, the upper ends of said columns having engagement with opposite sides of said anvil plate and operating to hold said plate against horizontal movement by impact forces transmitted thereto through said anvil.

5. An apparatus as defined in claim 4 characterized by the provision of a strip of composite-vibration-damping material about said pier for damping the transmission of impact vibration from said pier to said concrete foundation.

6. An impact test apparatus as defined in claim 1 characterized by said foundation comprising a reinforced concrete floor, and a reinforced concrete pier on which said anvil is supported, said floor having an opening in which said pier is positioned so that it forms a part of said concrete foundation.

7. An apparatus as defined in claim 6 characterized by there being a composite layer of vibration-damping material about the edges of said floor opening and operating to dampen the transmission of vibratory impact forces from said pier through said concrete floor.

8. An apparatus as defined in claim 6 characterized by said floor having rectangularly shaped openings therein respectively spaced outwardly with respect to opposite ends of said anvil and pier, reinforced concrete pads in each of said openings, and by said hammer frame being secured to and supported by said pads.

9. In an impact testing machine, the combination comprising a pair of spaced reinforced concrete pads, a frame including a pair of vertically extending and laterally spaced steel columns having their lower ends secured to and supported on opposite ends of one of said pads, and second pair of laterally spaced steel columns supported on opposite ends of the other of said pads and extending angularly upwardly therefrom, said second pair of columns being secured at their upper ends to the upper ends of said first pair, means including a crossbeam connecting said columns in laterally spaced relation, horizontal pivot means supported on said second pair of columns at a point intermediate their upper and lower ends, a pendulum having a hammer at its lower end supported for swinging movement on said pivot means, an anvil under said pivot means for supporting a steel specimen in a position to be broken by said hammer, a reinforced concrete pier between said pads for supporting said anvil, and means spacing the sides of said pier from the facing sides of said slabs, whereby the energy required to brake said specimen is indicated by the residual swing of said hammer following breakage of the specimen.

10. An impact testing machine as defined in claim 9 characterized by a reinforced concrete floor having openings therein through which said pier and said pads project.

11. An impact testing machine as defined in claim 10 characterized by there being a lining of vibration insulating material between the sides of said pier and said slabs and the edges of said floor openings for damping the transmission of impact force from said pier to said slabs.