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K. DIEHL

3,465,942

FASTENER DRIVING TOOL

Filed Nov. 3, 1966

4 Sheets-Sheet 1

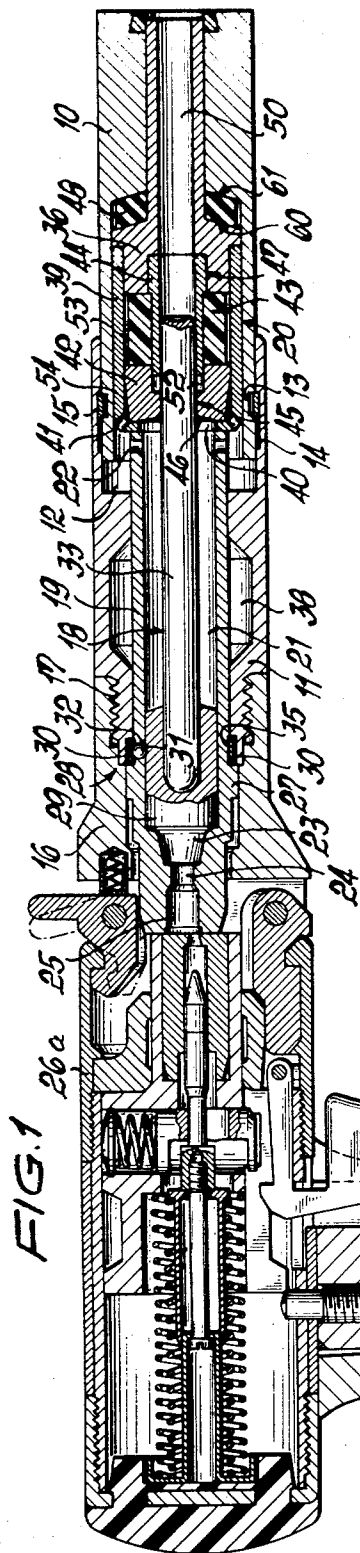
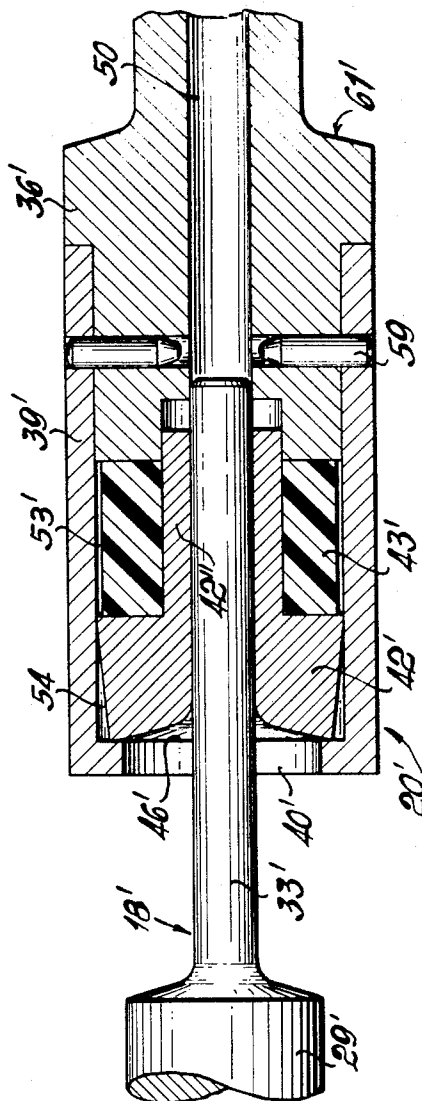


FIG. 4



INVENTOR
Karl DIEHL
BY
Michael J. Striker
his ATTORNEY

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K. DIEHL

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FIG. 2

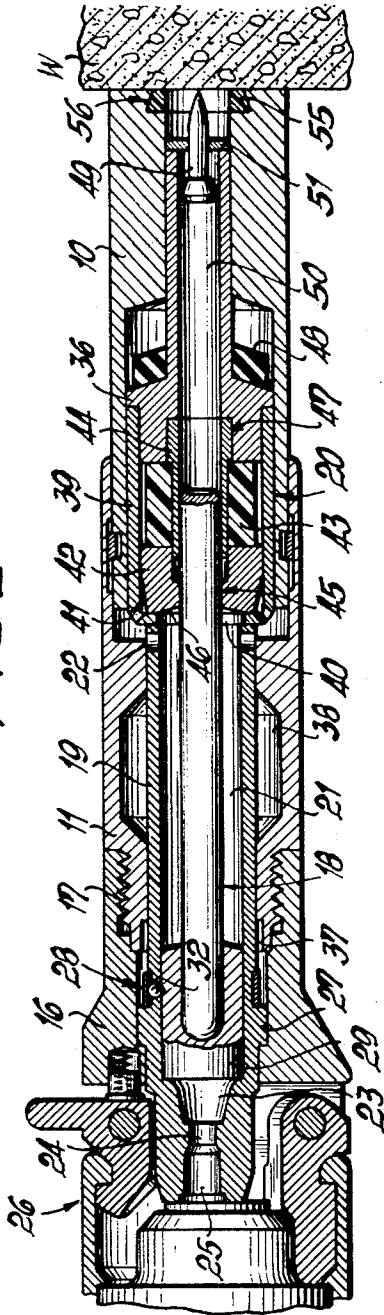
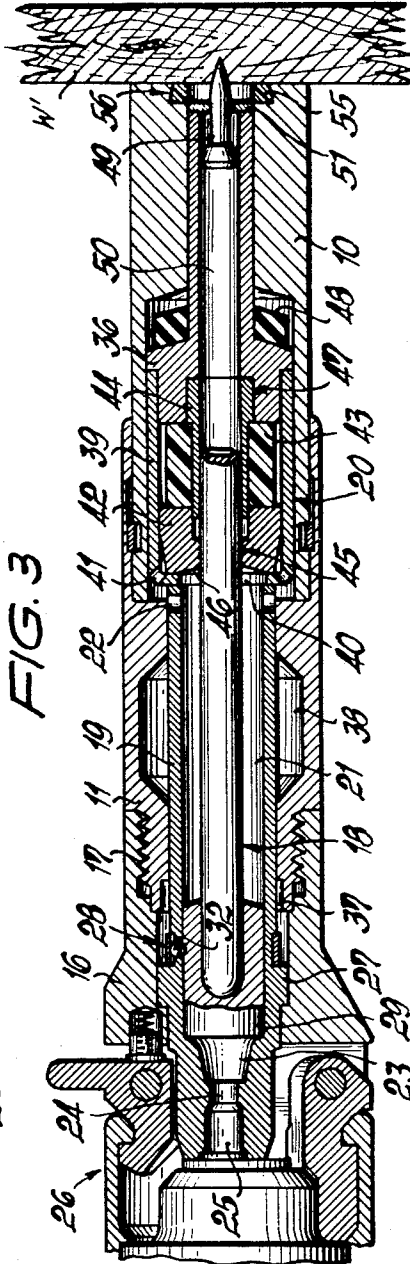


FIG. 3



INVENTOR
Karl DIEHL

BY
Michael S. Striker
his ATTORNEY

Sept. 9, 1969

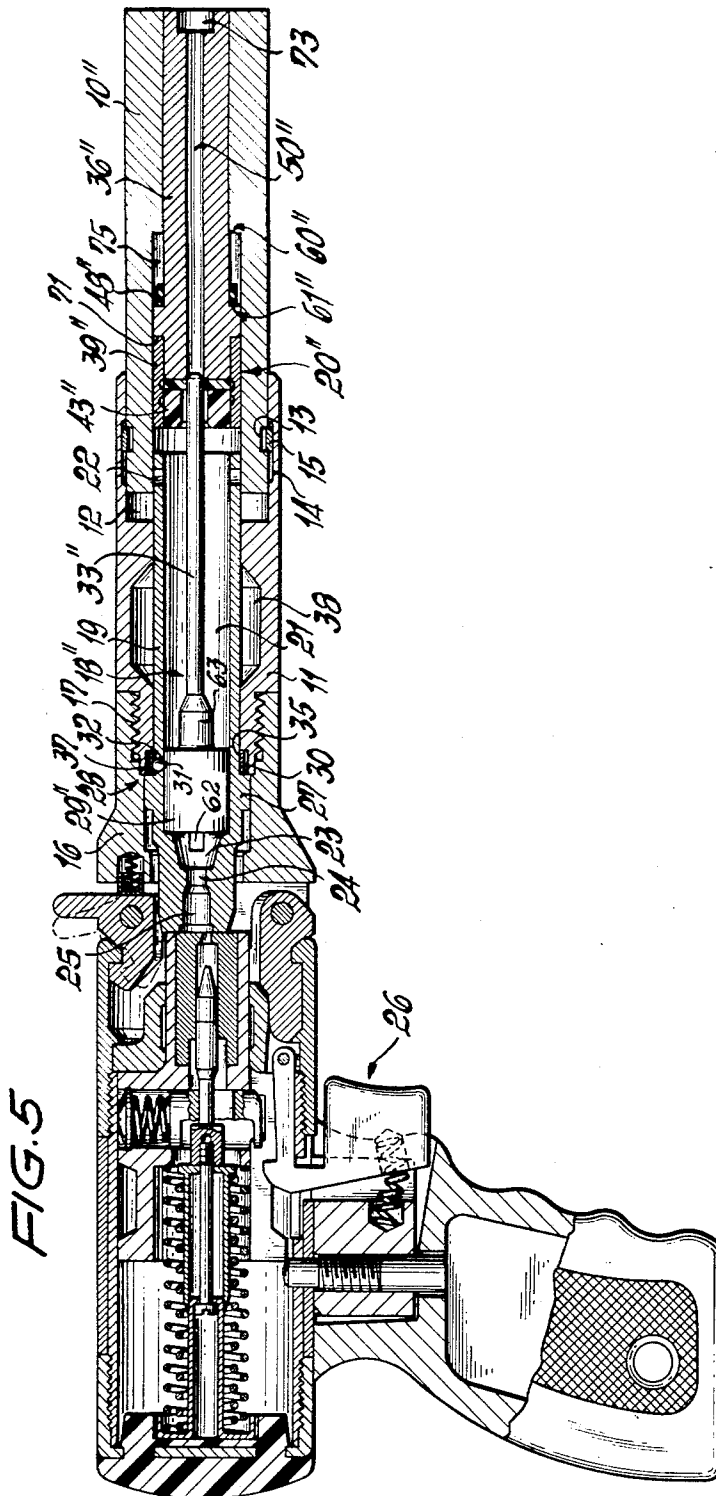
K. DIEHL

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INVENTOR
Karl DIEHL
BY

Michael J. Striker
his ATTORNEY

Sept. 9, 1969

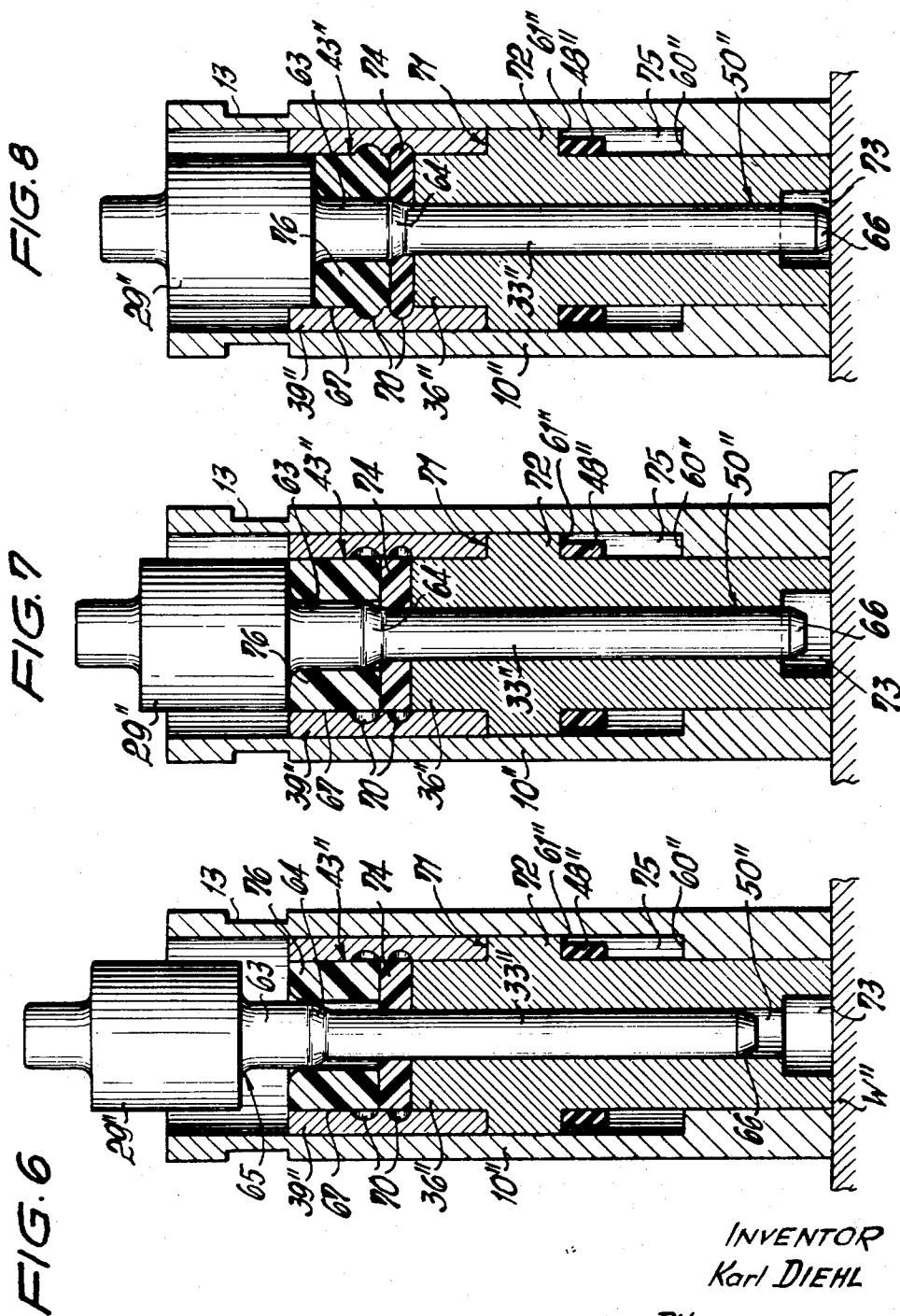
K. DIEHL

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Michael J. Striker
his ATTORNEY

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3,465,942

FASTENER DRIVING TOOL

Karl Diehl, Wuppertal-Elberfeld, Germany, assignor to
Carl Bauer, Wuppertal-Cronenberg, Germany

Filed Nov. 8, 1966, Ser. No. 592,770

Claims priority, application Germany, Nov. 11, 1965,

B 84,456; Nov. 26, 1965, B 84,708

Int. Cl. B25c 1/12, 1/14

U.S. Cl. 227—10

7 Claims

ABSTRACT OF THE DISCLOSURE

An explosion-actuated fastener driving tool in which a piston reciprocally arranged in a housing is propelled forwardly in response to firing of a charge in a firing chamber in the housing to drive a fastener from the front end of the housing into a workpiece, and wherein means are provided in the housing for braking forward movement of the piston to dissipate such surplus of energy which is not required for satisfactory introduction of the fastener into the workpiece.

The present invention relates to improvements in explosion-actuated fastener driving tools or pistols, and more particularly to improvements in fastener driving tools of the type disclosed in my copending application Ser. No. 592,771, filed Nov. 8, 1966.

In a fastener driving tool wherein the fastener is inserted into the front end of a barrel and is driven into a workpiece in response to impact transmitted thereto by a piston which is reciprocable in the barrel and is propelled forwardly in response to firing of an explosive charge, some surplus energy remains and must be dissipated without causing excessive wear upon or damage to the tool. Such energy is released in response to firing of the explosive charge in a cartridge and is converted into kinetic energy of the piston which is propelled from a retracted position into actual engagement with the fastener. Surplus energy will develop because an explosion-actuated tool is normally intended for driving of fasteners into relatively hard or soft workpieces, for example, into walls, panels or boards made of concrete, plaster, wood, plastic or the like. The explosive charge is calculated for use of the tool in connection with hardest workpieces, such as concrete walls, and, therefore, a fastener which is driven into soft wood will encounter much less resistance than a fastener which is to be driven into concrete. Heretofore known fastener driving tools are not entirely satisfactory because the dissipation of surplus energy which is released on firing of a cartridge causes excessive wear on the piston, barrel and certain other component parts of the tool. As a result, such parts have a very short life expectancy.

In accordance with presently prevailing practice, surplus energy is dissipated in response to plastic and/or elastic deformation of certain component parts of the fastener driving tool, for example, by providing the piston with an annular flange which strikes against an internal shoulder of the barrel when the piston completes a forward stroke of predetermined length. Such impact of the flange against the internal shoulder produces extremely high stresses which are particularly damaging to the piston so that the latter breaks, either entirely or in part, and must be replaced at frequent intervals.

It is also known to dissipate surplus energy outside of the fastener driving tool. This can be accomplished by permitting the leading end of the piston to project forwardly and beyond the barrel and to actually penetrate into the workpiece. In other words, surplus energy is used up by deforming the workpiece so that the barrel need not

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be subjected to excessive stresses. Of course, such mode of operation affects the quality of work since it is normally desirable to limit the extent to which a fastener is driven into the workpiece, i.e., to insure that a fastener will penetrate to the same depth irrespective of the hardness of the workpiece. In some instances, tools operating on the just outlined principle cannot be used at all, for example, if the extent to which the piston is expelled from the barrel exceeds the thickness of a soft panel or wall made of wood, plastic or the like. The piston would merely make a hole through such panel and the fastener would be propelled through such hole with resulting danger to personnel and property. Many explosion-operated tools can propel fasteners at speeds of up to and in excess of 100 meters per second so that an errant fastener can reach an involuntary target stationed at a considerable distance from the muzzle of the barrel.

It is an important object of the present invention to provide a fastener driving tool with a novel and improved braking assembly which can dissipate or destroy surplus energy released on firing of a cartridge and to construct and assemble the improved braking assembly in such a way that the dissipation of energy takes place without damage to other parts of the tool and without defacing the workpiece.

Another object of the invention is to provide a braking or energy dissipating assembly which occupies little room and which comprises a small number of simple parts.

A further object of the invention is to provide a braking or energy dissipating assembly which enables the fastener driving tool to dissipate or destroy surplus energy without damage to its parts.

An additional object of the invention is to provide a fastener driving tool wherein a large number of parts participate in dissipation of surplus energy and wherein such energy is dissipated in a series of stages.

A concomitant object of the invention is to provide a surplus energy dissipating assembly which can brake forward movement of the piston with a force proportional to the kinetic energy of the piston.

Still another object of the invention is to provide a fastener driving tool wherein the major part of surplus energy can be dissipated by component parts of the tool and the remainder of such energy is dissipated by the workpiece without, however, causing undue deformation of the workpiece.

Briefly outlined, one feature of my invention resides in the provision of an explosion-actuated fastener driving tool which comprises a housing having a front end adapted to receive a fastener and a rear end adjacent to a firing chamber for an explosive charge, a piston reciprocally accommodated in the housing for movement to and from a retracted position, the piston having forward and rearward portions and being propelled from retracted position in response to firing of a charge in the aforementioned chamber whereby the forward portion propels the fastener from the housing and into a workpiece, and an assembly for braking forward movement of the piston to thereby dissipate such surplus of energy which is not needed for satisfactory introduction of the fastener into a workpiece. The braking or energy dissipating assembly comprises a preferably expansible annular enclosure provided in the housing and an elastic annular cushion received in the enclosure. The cushion is compressible axially by the rearward portion during forward movement of the piston to expand radially against the enclosure in order to dissipate some surplus energy. Additional surplus energy is dissipated in response to expansion of the enclosure against the housing, and still more energy can be dissipated by arresting means provided in the housing to limit forward movement of the enclosure with reference to the housing. Such arresting means may com-

prise an annular guide for the forward portion of the piston forwardly of the cushion, cooperating stop shoulders provided on the guide and in the housing to limit forward movement of the guide, and one or more elastic washers interposed between such shoulders. Still more surplus energy may be dissipated if the forward end of the guide is permitted to actually abut against a work-piece which is placed against the front end of the housing prior to actual firing of the explosive charge.

The rearward portion of the piston can be moved into direct or indirect compressive engagement with the cushion. In the latter instance, the braking assembly comprises a suitable barrier, for example, a relatively short cylinder of spring steel or the like, which is installed in the enclosure and bears against the rear end face of the cushion.

The cushion may consist of one or more elastic cushioning elements, for example, of two annuli of different axial length. The shorter annulus is preferably located in front of the longer annulus so that the latter takes up the brunt of the impact in response to forward propulsion of the piston.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved fastener driving tool itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is an axial section through a fastener driving tool which is provided with an energy dissipating assembly embodying one form of the present invention, the tool being shown in idle position;

FIG. 2 is a similar axial section through the barrel of the fastener driving tool which is shown in cocked position ready to drive a fastener pin into a hard work-piece;

FIG. 3 shows the structure of FIG. 2 ready to drive a fastener pin into a relatively soft workpiece;

FIG. 4 is an enlarged fragmentary axial section through the housing of a second fastener driving tool having a modified energy dissipating assembly;

FIG. 5 is an axial section through a third fastener driving tool which is shown in idle position;

FIG. 6 is an enlarged fragmentary view of a detail of the tool shown in FIG. 5;

FIG. 7 is a similar view but showing the piston in a different position; and

FIG. 8 again shows the structure of FIGS. 6 and 7 but with the piston in a third position.

Referring to the drawings in detail, and first to FIGS. 1 to 3, there is shown a fastener driving tool or pistol which comprises a composite housing including a tubular front portion 10 and a tubular rear portion 11. The front portion 10 is reciprocable, within limits, with reference to the rear portion 11 and its rear end is telescoped into the front end of the rear portion. The volume of an annular compartment 12 in the front end of the rear portion 11 will increase or decrease, depending on the axial position of the front portion 10. This compartment 12 is constituted by a counterbore drilled into the front end of the rear portion 11. The means for guiding the front portion 10 during its axial movement comprises a split ring 15 extending into a circumferential groove 13 of the front portion 10 and into an elongated annular groove 14 machined into the internal surface of the rear portion 11. The axial length of the groove 14 exceeds the axial length of the split ring 15 so that the front portion 10 can be shifted by a distance corresponding to the axial length of the unfilled portion of the groove 14. The ring 15 simultaneously serves as a means for coupling the portion 10, 11 to each other. The axial length of the circumferential groove 13 equals or approximates that of

the ring 15. It is clear that the groove 13 will be longer if the groove 14 receives the ring 15 without any or with minimal freedom of axial movement.

In order to permit separation of tubular portions 10 and 11, the depth of the groove 13 is sufficient to accommodate the entire split ring 15. To this end, the rear portion 11 is provided with one or more openings (not shown) which communicate with the groove 14 and enable the operator to force the ring 15 into the groove 13 by resorting to a rudimentary tool, whereupon the rear end of the front portion 10 is readily withdrawable from the compartment 12.

The firing mechanism is denoted by the numeral 26. The details of this firing mechanism are known from the art of conventional fastener driving tools and need not be described here. It is to be noted that other types of firing mechanisms can be employed in the tool of FIGS. 1 to 3 without departing from the spirit of the present invention. The front end of the casing 26a of the firing mechanism 26 is adjacent to the rear end of the tubular portion 11, and more particularly to a ring 16 which is affixed to and extends rearwardly from the tubular portion 11. In the illustrated embodiment, the ring 16 constitutes a further or rearmost tubular portion of the housing and is detachably coupled to the rear portion 11 by threads 17. Such detachability of the ring 16 is desirable in order to afford access to component parts which are installed in the interior of the housing. In fully assembled position, the front end face of the ring 16 bears against an external annular shoulder of the rear portion 11.

The housing 10, 11, 16 accommodates a piston 18 which is reciprocable in an elongated cylindrical barrel 19, a composite resilient element 20 which constitutes a braking assembly for dissipating eventual surplus of energy, a cylindrical piston guide 36 which forms part of an arresting unit in the braking assembly, and detent means 28 for the piston 18. The major part of the barrel 19 is accommodated in the rear portion 11 and has a cylindrical bore 21 for the piston 18. The front end portion of the barrel 19 has radially extending ports 22 and its rear end portion extends into and rearwardly beyond the ring 16. The rear end of the bore 21 communicates with a forwardly flaring conical passage 23 located in front of a short cylindrical throat 24, the latter being provided in front of a cylindrical cartridge chamber or firing chamber 25. The throat 24 constitutes a combustion chamber.

The rear end portion of the barrel 19 which defines the passage 23, throat 24 and firing chamber 25 is provided with an external flange 27 which is fitted into the ring 16. The flange 27 constitutes one element of means for limiting axial movements of the barrel 19 and its end faces respectively cooperate with an internal shoulder of the ring 16 to determine the rear end position and with the rear end face of the rear portion 11 to determine the front end position of the barrel. FIG. 1 shows the barrel 19 in its front end position in which the flange 27 abuts against the rear end face of the tubular portion 11. In FIGS. 2 and 3, the barrel 19 is shown in its rear end position in which the flange 27 abuts against the internal shoulder of the ring 16. Rearwardly of the flange 27, the external diameter of the barrel 19 decreases and such decrease is in part stepwise and in part gradual. Portions of the barrel 19 are slidably guided in the rear portion 11 and ring 16. The rear portion 11 is provided with one or more internal recesses 38 which surround an intermediate portion of the barrel 19.

The piston 18 comprises an elongated forward portion or stem 33 and a larger-diameter rearward portion or boss 29 which is adjacent to the passage 23. This boss 29 is slidably guided in the bore 21 of the barrel 19. The stem 33 is slidably guided in parts which are installed in the front portion 10. The detent means 28 is installed in the barrel 19 forwardly of the flange 27 and cooperates with the boss 29. The exact construction of detent means 28 will be described hereinafter.

The aforementioned braking or surplus energy dissipating assembly 20 is installed in the rear region of the front portion 10. This assembly 20 comprises a substantially cup-shaped enclosure or shell 39 whose bottom wall is provided at its rear end, namely, at that end which is nearer to the firing mechanism 26. The bottom wall has an opening 40 whose diameter exceeds slightly the diameter of the boss 29 so that the latter can enter the bottom wall when the piston 18 is propelled forwardly to perform a working stroke. In the region where the bottom wall meets the annular side wall of the cup-shaped shell 39, the latter comprises apertures or ducts 41 which communicate with the compartment 12.

The shell 39 accommodates a barrier in the form of a short cylinder 42 which is of substantially U-shaped cross-sectional outline and preferably consists of spring steel or the like. The bottom wall of the cylinder 42 is adjacent to the bottom wall of the shell 39 and has an opening 45 which receives, without clearance, the stem 33 of the piston 18. Thus, the bottom wall of the cylinder 42 serves as a means for guiding the stem 33 when the piston reciprocates in the barrel 19. The external surface of the cylinder 42 tapers rearwardly toward the firing mechanism 26 so that the cylinder 42 and the shell 39 define between themselves an annular clearance or gap 54 of wedge-like cross-sectional outline. This enables the cylinder 42 to expand radially in response to engagement of its bottom wall by the boss 29 of the piston 18. As clearly shown in FIG. 1, the rear surface of the bottom wall of the cylinder 42 is inclined forwardly toward the axis of the housing as indicated at 46.

The cylinder 42 is installed immediately behind an annular shock absorber or cushion 43 which consists of rubber or highly elastic synthetic plastic material. The cushion 43 is separated from the stem 33 by a cylindrical liner 44 whose rear end face is normally separated from the bottom wall of the cylinder 42 by an annular clearance or gap 52. The clearance 52 is adjacent to the peripheral surface of the stem 33. The cushion 43 is enclosed in the annular wall of the cup-shaped shell 39 but is normally separated therefrom by a narrow annular clearance or gap 53. The latter will disappear in response to axial compression and resulting radial expansion of the cushion 43 when the boss 29 of the piston 18 strikes against the inclined rear end face 46 of the cylinder 42. The cushion 43 abuts against the front end face of the cylinder 42 and against the rear end face of the cylindrical guide 36 for the stem 33, the guide 36 having a bore 50 which can snugly receive the stem 33 and is coaxial with the bore of the liner 44. The front end face of the cushion 43 also abuts against a circumferential shoulder of the liner 44. Such shoulder is formed at the point where the smaller-diameter rear portion of the liner 44 meets its larger-diameter front portion. The front portion of the liner 44 is received in a counterbore 47 of the guide 36. A washer 48 of rubber or other suitable elastomeric material is installed between an external stop shoulder 60 of the guide 36 and an internal stop shoulder 61 of the front portion 10. The parts 36, 48, 60 and 61 together constitute an arresting unit which limits forward displacement of the shell 39 and cushion 43.

As stated before, FIG. 1 shows the fastener driving tool in idle position in which the flange 27 of the barrel 19 abuts against the rear end face of the rear portion 11. FIG. 2 illustrates the tool in cocked position with a short fastener pin 49 inserted into the front end of the front portion 10. The shaft of the fastener pin 49 carries a collar 51 which abuts against the front end face of the guide 36. The larger-diameter rear portion of the pin 49 is received with little or no clearance in the front part of the bore 50. The front end face of the front portion 10 has a concentric undercut recess 56 which receives a ring 55 consisting of highly heat-resistant elastomeric material. The tip of the pin 49 abuts against a relatively hard workpiece W, e.g., a masonry wall made of concrete

or the like. This workpiece does not yield to manually applied pressure so that, when the operator exerts pressure against the housing 10, 11, 16, the guide 36 yields and moves rearwardly by pushing the cup-shaped shell 39 and cushion 43 toward the firing mechanism. The bottom wall of the shell 39 is in actual abutment with the front end face of the barrel 19 so that the latter is shifted rearwardly and moves the firing chamber 25 to the operative position of FIG. 2. In FIG. 3, the front end face of the front portion 10 is pressed against a relatively soft workpiece W', e.g., a board made of soft wood, whereby the tip of the fastener pin 49 penetrates into the workpiece W' and the rearward axial displacement of the guide 36 is shorter than in FIG. 2. In other words, the exact axial position of the fastener pin 49 prior to firing of a cartridge in the chamber 25 depends on the hardness of the workpiece into which the pin is to be driven in response to actuation of the firing mechanism 26. Irrespective of the starting position of the fastener pin 49, the tool of FIG. 2 or 3 is ready for firing when the barrel 19 is shifted rearwardly through a predetermined minimal distance while the piston 18 is in its retracted position in which the stem 33 is spaced from the fastener pin 49.

The detent means 28 of FIGS. 1 to 3 is constructed and installed for the purpose of yieldably holding or retaining the piston 18 in the retracted position shown in FIG. 2 or 3, namely, in a position in which the front end of the stem 33 is spaced from the fastener pin 49. This detent means comprises a spherical retainer 31 and an elastically deformable annular biasing member here shown as a split elastic ring 30. The retainer 31 is reciprocable in a radial aperture 32 of the barrel 19 and this aperture is dimensioned in such a way that a portion of the retainer can extend into the bore 21 to engage the peripheral surface of the boss 29. Another portion of the retainer 31 extends radially outwardly beyond the aperture 32 and is biased by the ring 30 which latter tends to urge the retainer against the peripheral surface of the boss. Such bias suffices to yieldably hold the piston 18 in retracted position so that the stem 33 is spaced from the fastener pin 49.

The rear portion 11 is provided with an internal annular groove 37 (see FIG. 2 or 3) which receives the ring 30 when the barrel 19 is held in its front end position shown in FIG. 1. The rear portion of the barrel 19 is formed with a peripheral groove 35 which can receive at least a portion of the ring 30 so that the latter is thereby held against axial displacement with reference to the sleeve.

It will be seen that the provision of the detent means 28 does not in any way weaken the piston 18 and that the major part of this detent means is located outside of the path of hot combustion products and is not subjected to excessive pressures. The holding action of the spherical retainer 31 is very reliable but this retainer will immediately release the boss 29 when a cartridge in the chamber 25 is fired in response to actuation of the firing mechanism 26. The piston 18 is then propelled forwardly and its stem 33 drives the fastener pin 49 into the workpiece W or W'. The detent means 28 is claimed in my aforementioned copending application Ser. No. 592,771 which discloses several additional embodiments of detent means capable of being used in the fastener driving tool of the present invention.

The improved biasing assembly 20 enables the fastener driving tool to dissipate or destroy surplus energy in a series of stages. When the boss 29 strikes against the rear end surface 46 of the barrier or cylinder 42, the latter expands radially and fills the clearance or gap 54. This dissipates some surplus energy. Additional energy is dissipated in response to frictional engagement of the thus expanded cylinder 42 with the enclosure or shell 39. Furthermore, energy is dissipated on axial compression of the cushion 43 which expands radially and fills the clear-

ance or gap 53. Energy is also dissipated in response to axial compression of the washer 48 between the stop shoulders 60 and 61.

It will be seen that a large number of parts cooperate in dissipation of surplus energy and that such dissipation takes place in the fastener driving tool. The annular wall of the shell 39 also undergoes some radial expansion and dissipates some energy in response to stronger frictional engagement with the front portion 10 of the barrel. In the embodiment of FIGS. 1-3, the boss 29 of the piston 18 cannot move into direct compressive engagement with the cushion 43 because the assembly 20 comprises the aforementioned barrier or cylinder 42. The provision of this cylinder is advisable if the internal diameter of the annular wall of the shell 39 exceeds the diameter of the boss 29. Were the boss 29 permitted to engage the rear end face of the cushion 43, the latter would expand radially and also rearwardly and would fill the clearance between the boss and shell 39. Thus, in the fastener driving tool of FIGS. 1 to 3, the diameter of the boss 29 can be selected independently of the outer diameter of the cushion 43, as long as the boss can reach the cylinder 42. The front end of this cylinder has a tight sliding fit in the shell 39 and prevents rearward expansion of the cushion 43.

FIG. 4 illustrates a portion of a second fastener driving tool which comprises a modified braking assembly 20'. This assembly comprises a cup-shaped enclosure or shell 39' of U-shaped cross-sectional outline provided with an opening 40' in its bottom wall which is distant from the guide 36'. The diameter of the opening 40' exceeds the diameter of the boss 29' which is provided at the rear end of the stem 33' forming part of a piston 18'. The boss 29' can abut against the radially inwardly and forwardly slanting rear end face 46' of the barrier or cylinder 42'. The liner 44 of FIG. 1 is replaced by a cylinder extension 42'' of the cylinder 42' and this extension or liner 42'' receives without clearance a portion of the stem 33'. The cushion 43' surrounds the extension 42'' and defines with the annular wall of the shell 39' an annular clearance or gap 53'. The front end face of the cushion 43' abuts against the rear end face of the guide 36'. In this embodiment of my invention, the shell 39' is connected with the rear portion of the guide 36' by one or more radially extending coupling pins 59'. The stop shoulder 61' of the guide 36' corresponds to the stop shoulder 61 of the guide 36 shown in FIG. 1. This stop shoulder abuts against an elastic washer, corresponding to the washer 48, which is not shown in FIG. 4. The numeral 54 denotes an annular clearance or gap between the conical external surface of the cylinder 42' and the cylindrical internal surface of the shell 39'.

The liner 44 or 42'' contributes to longer useful life of the cushion 43 or 43' because the latter is held out of direct contact with the reciprocating piston 18 or 18'. The liner 44 or 42'' will be compressed radially in response to axial compression and resulting radial expansion of the cushion 43 or 43'. This causes the liner to move into frictional engagement with and to participate in forward movement of the piston 18 or 18'. The liner 44 or 42'' may consist of spring steel or analogous elastically deformable material.

FIGS. 5 to 8 illustrate a third fastener driving tool. Certain reference numerals used in FIGS. 5-8 are identical with those used in FIGS. 1-3 because they denote identical parts. The piston 18'' comprises an elongated stem 33'' and a boss 29''. The boss 29'' has a rearwardly projecting smaller-diameter extension 62 which is coaxial therewith. The major part of the stem 33'' is constituted by a cylindrical rod of constant diameter but its rearmost section 63 has a somewhat larger diameter with a conical transition zone 64 into the cylindrical rod. The transition between the section 63 and boss 29'' is gradual, as shown at 65. The tip 66 of the stem 33'' is slightly conical and tapers forwardly. When it reciprocates, the piston 18'' is

guided along the peripheral surface of the boss 29'' and also along the peripheral surface of the stem 33''.

The rear part of the front portion 10'' of the housing accommodates a composite braking assembly 20'' which is constructed and assembled in accordance with a third embodiment of the present invention. This assembly 20'' comprises an annular enclosure or shell 39'' which is analogous to the cup-shaped shell 39 or 39'. The medium zone of the cylindrical internal surface of the shell 39'' is provided with two annular grooves or clearances 70 bounded by concave surfaces and the interior of each of these grooves serves as a space for temporary storage of elastically deformable material of a two-piece annular cushion 43''.

The front portion of the shell 39'' surrounds the rear portion of an annular guide 36''. This guide has an external collar 72 whose rear end face 71 abuts against the front end face of the shell 39''. The collar 72 is reciprocable in a counterbore of the front portion 10'' and this front portion defines with the guide 36'' an annular compartment 75 which accommodates an elastic washer 48''. The front part of the guide 36'' is reciprocally received in the forward zone of the bore in the front portion 10''. The diameter of the bore at the forward end of the front portion 10'' is smaller than the diameter of the collar 72. The front part of the bore 50'' in the guide 36'' is enlarged, as at 73. The stem 33'' of the piston 18'' is slidably fitted into the bore 50''. In other words, the guide 36'' prevents wobbling of the stem 33'' but permits reciprocatory movements of the piston 18''. The diameter of the enlarged front part 73 of the bore 50'' is constant.

The annular compartment 75 is provided for the purpose of permitting limited axial displacement of the guide 36'' with reference to the front portion 10''. The stop shoulder 61'' constituted by the front end face of the collar 72 cannot strike directly against the internal stop shoulder 60'' of the front portion 10'' but can deform the washer 48''. This washer consists of soft rubber or synthetic plastic material.

The two-piece cushion 43'' is inserted into the bore 67 of the shell 39''. This cushion comprises a relatively short elastic element or annulus 74 and a longer elastic element or annulus 76. The annulus 74 is disposed between the annulus 76 and the rear end face of the guide 36'', and the diameter of its central opening equals the diameter of the stem 33''. The annulus 76 is accommodated in the rear part of the shell 39'' and, when not compressed by the boss 29'', its rear end face is flush or nearly flush with the rear end face of the shell. The diameter of the opening in the annulus 76 is greater than that of the opening in the annulus 74 and preferably equals or approximates the diameter of the piston section 63. As clearly shown in FIGS. 6-8, the rear end of the surface surrounding the opening in the annulus 76 is rounded and flares rearwardly.

The rear annulus 76 may receive an elastic liner, not shown, which can be compressed radially inwardly into frictional engagement with the section 63.

FIG. 6 shows the fastener driving tool in an intermediate position. The piston 18'' has left its retracted position but the boss 29'' is still spaced from the cushion 43''. FIG. 7 shows the piston 18'' in a position it assumes when the boss 29'' reaches the rear end face of the rear annulus 76. The rearmost section 63 of the stem 33'' has penetrated into the opening of the annulus 76. The diameter of the boss 29'' approximates closely the internal diameter of the shell 39'' and the section 63 fits snugly into the annulus 76. Tight fitting of the boss 29'' into the shell 39'' insures that the annulus 76 cannot expand rearwardly, i.e., that the surface of the transition zone 65 pushes the annulus 76 forwardly and causes a portion of its material to penetrate into the rear groove or clearance 70. The annulus 76 transmits compressive stresses to the front annulus 74 which latter expands into the front groove or clearance 70 in a manner as shown

in FIG. 8. In this illustration, the boss 29'' has actually penetrated into the shell 39'' to such an extent that the tip 66 of the stem 33'' abuts against the workpiece W'', and more particularly against a fastener (not shown) which has been driven into the workpiece. The expansion of the shorter annulus 74 takes place in two stages. In the first stage, the annulus 74 is expanded from within because its opening receives the conical transition zone 64 of the piston 18'' whose mean diameter exceeds the internal diameter of the annulus 74 when the latter is not subjected to expanding stresses. The zone 64 transmits to the annulus 74 strong radially outwardly directed stresses which cause the circumferential portion of this annulus 74 to penetrate into the front groove 70.

The deformation of the two-piece cushion 43'' (annuli 74 and 76) is accompanied by elastic deformation of the shell 39'' which preferably consists of spring steel capable of undergoing repeated elastic expansion. Special types of spring steel may be used. Such elastic expansion takes place radially outwardly so that the shell 39'' is pressed against the internal surface of the front portion 10''. This destroys additional surplus energy, i.e., the front portion 10'' also participates in dissipation or destruction of surplus energy when the piston 18'' is propelled forwardly. Since the guide 36'' abuts against the workpiece W'', the latter also absorbs some surplus energy.

By proper selection of the axial length of the rear annulus 76, the designer of the fastener driving tool can determine the exact moment when the braking or energy dissipating assembly 20'' becomes effective, i.e., the exact axial position of the piston 18'' when the boss 29'' begins to compress and deform the rear annulus 76. In the embodiment of FIGS. 5-8, deformation of the rear annulus 76 begins shortly before the piston 18'' reaches the end of its working stroke. This insures that the movement of the piston 18'' is unimpeded during the major part of the working stroke and, since the rear annulus 76 is relatively long, it is caused to move into strong frictional engagement with the shell 39''. Tensioning of the annuli 74, 76 produces a braking force which opposes further forward movement of the piston 18'' and a radially directed force which urges the shell 39'' into frictional engagement with the front portion 10'' of the barrel. The material which penetrates into the annular clearances or gaps 70 hinders forward movements of the annuli 74, 76 so that these annuli exert a very strong radially outwardly directed force which effects expansion of the shell 39''.

If the coefficient of friction between the piston 18'' and the annuli 74, 76 is the same, the magnitude of the braking force is a function of the strength of impact of the piston against the cushion 43''. Thus, the braking force increases and decreases automatically in response to changes in the impact and opposes surplus kinetic energy of the piston 18'' to eliminate peak stresses in regions where the diameter of the piston varies.

Of course, the improved fastener driving tool is susceptible of many additional modifications without departing from the spirit of my invention. For example, the assembly 20, 20' or 20'' can be replaced by other types of analogous or equivalent assemblies which can dissipate surplus energy. Not only the shell but also the cushion, the guide and/or the cylinder of the assembly can be changed in size, composition and/or shape. It is also possible to omit the barrier or cylinder 42 or 42' altogether if the boss 29 or 29' is dimensioned in such a way that it can completely fill the opening in the rear wall of the enclosure 39 or 39'. In other words, the boss 29 or 29' then moves into direct compressive engagement with the cushion 43 or 43'. Also, the cushion 43'' of FIGS. 5-8 can consist of a single piece of elastomeric material and the cushion 43 or 43' may consist of two or more annular elements.

Without further analysis, the foregoing will so fully

reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is:

1. An explosion-actuated fastener driving tool, comprising a housing having a front end adapted to receive a fastener and a rear end adjacent to a firing chamber for an explosive charge; a piston reciprocably accommodated in said housing and movable to and from a retracted position, said piston having a forward portion and a rearward portion of a greater diameter than said forward portion and being propelled from said retracted position in response to firing of a charge in said chamber whereby said forward portion propels the fastener from the front end of said housing into a workpiece; and an assembly for braking forward movement of said piston to thereby dissipate such surplus of energy which is not required for satisfactory introduction of the fastener into a workpiece, said assembly comprising an annular substantially cup-shaped enclosure provided in said housing and an elastic annular cushion received in said enclosure, said cup-shaped enclosure having a bottom wall facing the rear end of said housing and being formed in said bottom wall with a central opening dimensioned to permit passage of said rearward portion of said piston, said cushion being compressible axially by said rearward portion during forward movement of said piston to expand radially against said enclosure, and arresting means for limiting forward movement of said enclosure in said housing.

2. A fastener driving tool as defined in claim 1, wherein said assembly further comprises an annular barrier rearwardly adjacent to said cushion in the interior of said enclosure and slidably surrounding said forward portion, said cushion undergoing axial compression in response to forward axial displacement of said barrier by the rearward portion of said piston.

3. An explosion-actuated fastener driving tool comprising a housing having a front end adapted to receive a fastener and a rear end adjacent to a firing chamber for an explosive charge; a piston reciprocably accommodated in said housing and movable to and from a retracted position, said piston having a forward portion and a rearward portion of a diameter greater than said forward portion and being propelled from said retracted position in response to firing of a charge in said chamber whereby said forward portion propels the fastener from the front end of said housing and into a workpiece; and an assembly for braking forward movement of said piston to thereby dissipate such surplus energy which is not required for satisfactory introduction of the fastener into a workpiece, said assembly comprising an annular enclosure of elastic material provided in said housing, said annular enclosure having an internal surface defining a cylindrical bore and at least one annular groove extending from said surface into the material of the enclosure, an elastic annular cushion located in said bore and surrounding the forward portion of said piston, said cushion being axially compressible by said rearward portion of said piston during forward movement of the latter to expand radially against said enclosure, whereby said enclosure expands radially against said housing in response to such radial expansion of said cushion while some of the material of said cushion will be accommodated in said annular groove, and arresting means for limiting forward movement of said enclosure in said housing.

4. An explosion-actuated fastener driving tool comprising a housing having a front end adapted to receive a fastener and a rear end adjacent to a firing chamber for an explosive charge; a piston reciprocably accommodated in said housing and movable to and from a retracted posi-

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tion, said piston having a forward portion and a rearward portion of greater diameter than said forward portion and being propelled from said retracted position in response to firing of a charge in said chamber whereby said forward portion propels the fastener from the front end of said housing and into a workpiece; and an assembly for braking forward movement of said piston to thereby dissipate such surplus of energy which is not required for satisfactory introduction of the fastener into a workpiece, said assembly comprising an annular enclosure provided in said housing, said annular enclosure having an internal surface defining a cylindrical bore and a plurality of annular grooves extending from said surface into the material of the enclosure, an annular cushion located in said bore and surrounding the forward portion of said piston and comprising a plurality of elastic elements arranged end-to end, said cushion being axially compressible by said rearward portion of said piston during forward movement of the latter to expand radially against said enclosure whereby each of said annular grooves receives some material of the respective element in response to such radial expansion of said cushion, and arresting means for limiting forward movement of said enclosure in said housing.

5. A fastener driving tool as defined in claim 4, wherein each of said elastic elements is constituted by an annulus.

6. A fastener driving tool as defined in claim 5, wherein said annuli include a first annulus and a second annulus

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located forwardly of said first annulus, said first and second annuli respectively having central openings of larger and smaller diameter, said forward portion being slidably received in the opening of said second annulus and said piston further comprising a third portion disposed between said forward and rearward portions and slidably receivable in the opening of said first annulus so that said second annulus is expanded by the third portion from within when said piston advances forwardly to move such third portion beyond the opening of said first annulus.

7. A fastener driving tool as defined in claim 5, wherein said annuli include a rear annulus of greater axial length and a front annulus of shorter axial length.

References Cited

UNITED STATES PATENTS

3,126,630	3/1964	Catlin et al.	227—10	XR
3,172,119	3/1965	Siddons	227—10	XR
3,297,224	1/1967	Osborne	227—10	
3,341,101	9/1967	Butler et al.	227—10	XR
3,348,751	10/1967	Henning	227—8	

FOREIGN PATENTS

169,919	9/1934	Switzerland.
618,546	2/1949	Great Britain.

TRAVIS S. McGEHEE, Primary Examiner