March 24, 1959 S. H. EDGE ET AL 2,878,646

SERVO BRAKING APPARATUS

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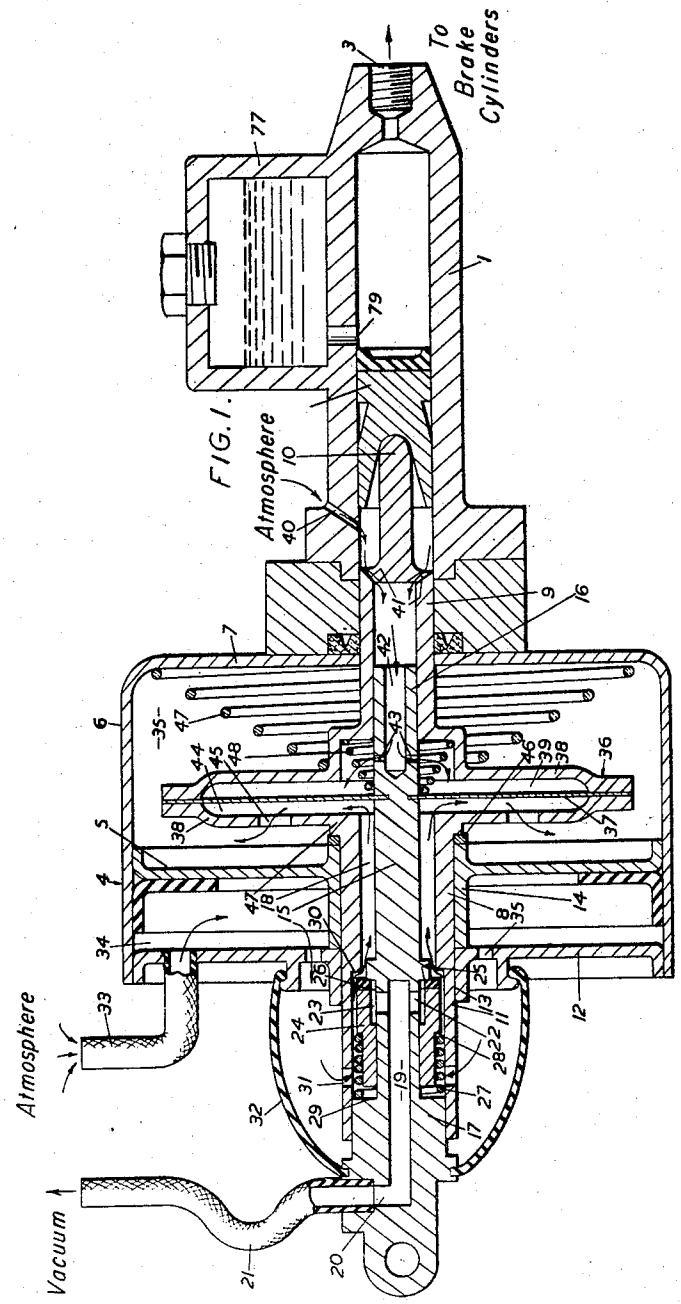


FIG. 1.

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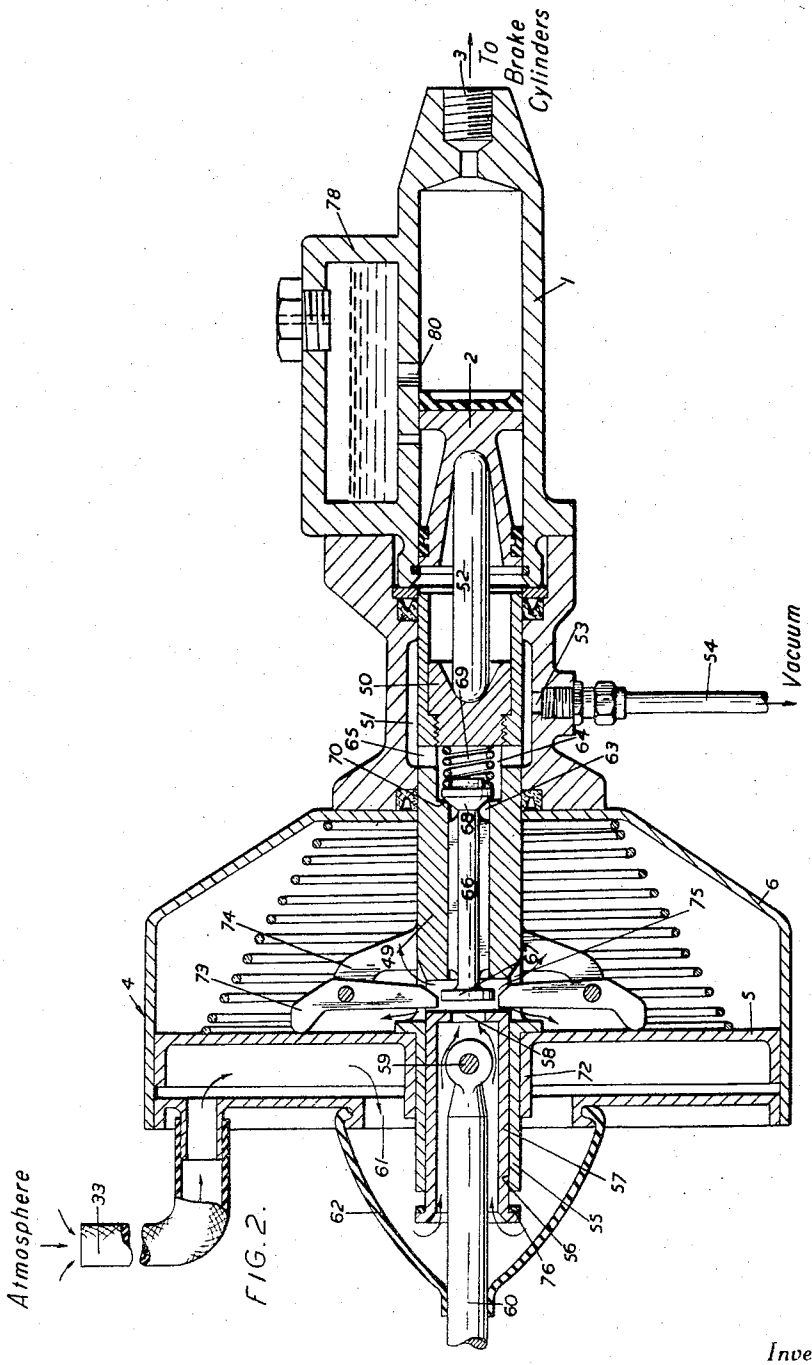


FIG. 2.

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2,878,646

SERVO BRAKING APPARATUS

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Claims priority, application Great Britain February 16, 1953

5 Claims. (Cl. 60—54.6)

This invention relates to servo-assisted brake-operating mechanisms for road-vehicles and particularly to such mechanisms of the kind wherein the output of a fluid-pressure operated servo-device employing a piston or diaphragm as the pressure-responsive operating member is transmitted hydraulically to the brake-actuating cylinders of the road-wheels of the vehicle.

The object of the invention is to provide an improved and simplified mechanism of the above kind which is of compact construction and which is designed to facilitate manual operation of the brakes in the event of the servo-device becoming inoperable.

According to the invention there is provided a servo-assisted brake-operating mechanism including a fluid-pressure operated servo-device controlled by a pedal or like actuated valve means and mounted at one end of and in alignment with an hydraulic cylinder which is adapted to be connected to the brake-actuating cylinders, and means extending through said servo-device in alignment with said hydraulic cylinder and operable to transmit to the liquid therein effort produced by the servo-device and manual effort applied to the pedal or like actuator, said means being movable independently of the operating member of the servo-device so that, in the event of the latter being in an inoperable condition, manual effort can be transmitted to the liquid in the hydraulic cylinder without any obstruction or interference from said operating member of the servo-device.

Reference will now be made to the accompanying drawings in which:

Fig. 1 is a sectional elevation of one embodiment of the invention in its inoperative condition, and

Fig. 2 is a sectional elevation of another embodiment of the invention also in its inoperative condition.

In the embodiment illustrated in Fig. 1, the servo-assisted brake-operating mechanism includes an hydraulic cylinder 1 in which a piston 2 is slidably mounted and which is formed with an outlet port 3 at one end (hereinafter regarded as the forward end of the mechanism) adapted to be connected with the brake-actuating cylinders of the road-wheels of the vehicle. At the other end of the hydraulic cylinder there is mounted a fluid-pressure operated servo-device 4 consisting of a piston 5 slidably mounted within a cylinder 6 to the forward end wall 7 of which the hydraulic cylinder is co-axially fixed.

Extending concentrically through the servo-cylinder and slidably supported thereby is a thrust-transmitting assembly which includes a hollow, cylindrical outer component 8 whose forward end portion 9 is slidably supported in the rear portion of the hydraulic cylinder and is formed with a co-axially projecting rod 10 for engaging the rear face of the piston 2. Adjacent its rear end portion 11, which projects externally of the rear end wall 12 of the servo-cylinder, the outer component is slidably supported in an aperture 13 formed in the centre of said end wall. In its central portion the servo-piston is formed with a sleeve 14 which closely surrounds the outer component of the thrust-transmitting assembly but in a manner such as to permit axial movement of said outer component independently of the servo-piston. Within said outer component there is slidably and concentrically mounted an inner thrust-transmitting component 15 which is of elongated cylindrical form. The forward end portion 9 of the outer thrust-transmitting component is of reduced diameter for slidably supporting the forward end portion 16 of the inner component which, at its rear end, is formed with an enlarged portion 17 slidably supported in the rear end of the outer component and projecting externally thereof, The rear end of the inner component is adapted to be mechanically connected to the brake-pedal of the vehicle. Between the intermediate portions of the inner and outer components an annular space 18 is formed. In the rear portion of the inner thrust-transmitting component there is provided an axial passage 19 whose rear end is in communication with a source of vacuum by way of a transverse port 20 and a conduit 21 connected thereto. At the forward end of this passage the inner component is formed with radial ports 22 through which the passage communicates with an annular recess 23 formed in the inner surface of a hollow, cylindrical valve element 24 which is slidably mounted upon the inner component and whose outer surface is spaced from the inner surface of the outer thrust-transmitting component. The annular recess 23 opens out of the forward end of the valve element but is normally closed at that point by an annular valve seat 25 which is provided on the surface of the inner component and with which an annular valve facing 26 formed at the forward end of the valve element engages. The valve element is normally held against the valve seat 25 by a compression spring 27 which is disposed between an annular shoulder 28 formed on the outer surface of the valve element and the shoulder 29 formed by the enlargement of the rear end portion of the inner thrust-transmitting component. At a point slightly forward of the valve seat 25 the outer component is formed on its inner surface with an annular valve seat 30 with which the valve element 24 is adapted to co-operate during the operation of the mechanism as will be described later herein. The portion of the annular space 18 which lies to the rear of the valve seat 30, in which portion the valve element 24 is located, is in constant communication with atmosphere through ports 31 provided in the outer component. A flexible gaiter 32 is preferably provided to prevent dust or dirt entering the interior of the thrust-transmitting assembly, the gaiter being fixed at one end to the rear end portion of the inner thrust-transmitting component and at the other end to the rear end wall 12 of the servo-cylinder. This end wall is provided with a breather 33 so that the space 34 in the servo-cylinder to the rear of the servo-piston is at all times open to atmosphere. The atmospheric ports 31 in the outer thrust-transmitting component are in communication with atmosphere through ports 35 in the rear end wall of the servo-cylinder, the space 34 and the breather 33.

In the space 35 in the servo-cylinder forward of the servo-piston there is located a reaction device 36 which is embodied in the thrust-transmitting assembly. This reaction device ensures that the effort produced by the servo-piston, which effort is dependent upon the degree of vacuum to which the piston is subjected, is at all times proportional to the manual effort applied to the pedal, and the device reacts through the thrust-transmitting assembly to provide the operator with "feel" of the degree to which the braking is being power-assisted. The device consists of a diaphragm 37 supported within a housing 38 which forms part of the outer component of the thrust-transmitting assembly. This can conveniently be done by dividing the outer thrust-transmitting component into two co-axial sections and the housing 38 into two com-

plementary parts of circular shape each formed integrally and concentrically with one of the sections of said outer component. By securing the two parts of the housing together at their peripheries, the two sections of the outer thrust-transmitting component are united into one rigid body. The edge of the diaphragm is secured between the peripheral portions of the two parts of the housing, and the centre of the diaphragm is fixed to the inner of the two thrust-transmitting components. The space **39** within the housing forward of the diaphragm is at all times open to atmosphere through a port **40** in the rear end of the hydraulic cylinder **1**, ports **41** in the forward end of the outer thrust-transmitting component and an axial passage **42** and transverse ports **43** in the forward end portion of the inner thrust-transmitting component. The space **44** in the housing **38** to the rear of the diaphragm is at all times open to that portion of the annular space **18** between the two thrust-transmitting components which lies forwardly of the valve seat **30** on the inner surface of the outer of said components. The rear space **44** in the diaphragm housing also communicates through a port **45** in the rear part of said housing with the space **35** in the servo-cylinder forward of the servo-piston.

In order to prevent any leakage of air between the outer surface of the outer thrust-transmitting component and the inner surface of the sleeve **14** formed in the central portion of the servo-piston, a sealing ring **46** is provided between the forward end of said sleeve and a shoulder **47** formed on the outer surface of the outer thrust-transmitting component.

The thrust-transmitting assembly and servo-piston are normally biassed in the rearward direction by a coil spring **47** which is disposed between the forward end wall **7** of the servo-cylinder and the diaphragm housing.

A smaller coil spring **48** arranged within the forward part of the diaphragm housing urges the diaphragm and the inner thrust-transmitting component in a rearward direction so as normally to hold the valve element **24** away from the valve seat **30**. In this condition, which is the inoperative condition of the mechanism, both sides of the servo-piston are exposed to atmosphere, the rearward side by way of the breather **33** and the forward side by way of the atmospheric ports **31** in the outer of the two thrust-transmitting components, the annular space **18** between said components, the space **44** to the rear of the diaphragm and the port **45** in the rear part of the diaphragm housing.

The operation of the mechanism described above is then as follows:

When manual effort is applied to the brake-pedal this effort is transmitted mechanically to the inner thrust-transmitting component **8** which is consequently moved in the forward direction. During the first part of this movement the valve element **24** is carried forward with the inner component through the agency of the compression spring **28**. The annular facing **26** at the forward end of the valve element then engages the valve seat **30** with the result that the portion of the annular space **18** forward of the valve seat is cut off from atmosphere. This engagement also arrests movement of the valve element, so that further movement of the inner thrust-transmitting component moves the valve seat **25** thereon away from the valve element to place the portion of the annular space **18** forward of the valve element, and, therefore, the rear part **44** of the diaphragm housing and the forward space **35** in the servo-cylinder, in communication with vacuum. This creates a pressure differential over the servo-piston which is consequently advanced and moves the thrust-transmitting assembly forward to advance the piston in the hydraulic cylinder and thereby actuate the brakes. A pressure differential is simultaneously created over the reaction diaphragm **37** which is subjected to the same degree of vacuum as the servo-piston. The pressure differential acts on the diaphragm in the reverse direction, however, and tends to restore the inner thrust-transmitting component and the valve element to their initial positions. Thus an increased manual effort is required to counter the reaction of the diaphragm and maintain the further application of vacuum necessary for the continued operation of the servo-piston. If the manual effort remains constant the valve element will assume a lapped condition in which its annular facing **26** is in engagement with the valve seat **30** on the outer of the thrust-transmitting components and is in turn engaged by the seat **25** on the inner of said components. Thus a progressive control of the servo output is established, and the reaction of the diaphragm to the manual effort applied to the pedal provides the operator with a "feel" of the degree to which his own effort is being assisted by the servo. The proportion which exists between the manual effort and the effort produced by the servo-piston is governed by the ratio between the effective areas of the reaction diaphragm and the servo-piston.

In the event of the servo-device being inoperable in any way, such as, for example, if no vacuum is available, the manual effort is transmitted directly to the piston in the hydraulic cylinder by the thrust-transmitting assembly without any obstruction or interference from the servo-piston, such as, for example, the "cushioning" effect which might otherwise be caused by the piston being moved in the servo-cylinder when no vacuum is being applied. This is made possible by the fact that the thrust-transmitting assembly extends in a slidable manner through the central sleeve of the servo-piston and is thus movable independently thereof.

In the embodiment of the invention illustrated in Fig. 2 a different form of reaction means is employed and the thrust-transmitting assembly is modified accordingly. The thrust-transmitting assembly includes an elongated cylindrical component **49** which extends concentrically through the servo-cylinder and whose forward end portion **50** projects through a chamber **51** at the rear of the hydraulic cylinder **1**. A short thrust-rod **52** is interposed between the forward end of the thrust-transmitting component **49** and the piston **2** in the hydraulic cylinder. The chamber **51** is provided with a port **53** adapted to be connected by a conduit **54** with a source of vacuum. The rear end portion **55** of the thrust-transmitting component **49** is hollowed out to provide an axial bore **56** in which is slidably and concentrically mounted a tubular component **57** which is open at its rear end and closed at its forward end but for a central port **58**. The tubular component is provided internally with a cross pin **59** to which a rod **60** is pivotally connected. This rod is adapted to be connected with the brake-pedal of the vehicle. The rear end portion of the thrust-transmitting component **49** projects with clearance through a large aperture **61** formed centrally in the rear end wall of the servo-cylinder **6**, and in order to keep dust and dirt out of the mechanism a flexible gaiter **62** is connected at one end to the rod **60** and at the other end to the rear end wall of the servo-cylinder outwardly of the central aperture **61** therein.

In its intermediate portion the thrust-transmitting component **49** is formed with an axial bore **63** whose rear end opens into the forward end of the bore **56** in the rear end portion **55** of said component, and whose forward end opens into a valve chamber **64** formed in the forward end portion of said component. This valve chamber is provided with ports **65** opening into the chamber **51** which is at all times in communication with the source of vacuum through the conduit **54**. Slidably mounted in the bore **63** is the fluted stem **66** of a double-acting valve member which is formed at its rear end with a disc valve-head **67** for cooperating with the port **58** in the tubular component **57**, and at its forward end with a coned valve-head **68** which is normally biased by a coil spring **69** housed in the valve chamber **64** into clos-

ing engagement with an annular valve seat **70** surrounding the forward end of the bore **63**.

In its central portion the servo-piston is formed with a sleeve **72** similar to the sleeve **14** described earlier herein and which closely surrounds the thrust-transmitting component **49** but in a manner such as to permit axial movement of said component independently of the servo-piston.

The reaction means consist of a number of beams **73** which lie in a substantially radial plane with respect to the thrust-transmitting assembly and the servo-piston, and each of which is pivotally mounted intermediate its ends upon a radial arm **74** fixed to or formed integrally with the thrust-transmitting component **49** and of which there is one for supporting each beam. The outer ends of the beams are cranked rearwardly to engage the forward face of the servo-piston, and their inner ends project into the forward end of the bore **56** in the thrust-transmitting component **49** through openings **75** provided therein.

When the mechanism is in its inoperative condition, the tubular component **57** occupies a rearward position wherein the port **58** in its forward end is disengaged from the disc valve-head **67** of the double-acting valve member whose coned valve-head **68** is consequently seated. In this condition the space within the servo-cylinder forward of the servo-piston is open to atmosphere via the breather **33**, the space to the rear of the servo-piston, the central aperture **61** in the rear end wall of the servo-cylinder, the interior of the tubular component **57**, the port **58** in the latter's forward end and the openings **75** in the thrust-transmitting component **49**. Thus, with both of its sides under atmospheric pressure, the servo-piston is at rest.

When the operator depresses the brake-pedal his effort is transmitted through the rod **60** to advance the tubular component **57** so that its forward end engages the inner ends of the reaction beams **73**. The latters' outer ends are consequently rocked rearwardly and move the servo-piston in the rearward direction. Continued movement of the component **57** firstly brings its forward end into engagement with the disc valve-head **67** of the double-acting valve member to close the port **58** and thereby cut off the forward space of the servo-cylinder from atmosphere, and thereafter moves the said valve member forwardly to unseat its coned valve-head **68** and thereby place the forward face of the servo-piston under vacuum via the chamber **51**, the valve chamber **64**, the flutes in the valve stem **66**, and the openings **75** in the thrust-transmitting component **49**. The resultant pressure differential advances the servo-piston whose movement is transmitted through the reaction beams and their supporting arms to the thrust-transmitting component **49**. The latter advances the piston in the hydraulic cylinder and thereby causes the operation of the brakes.

As the output effort of the servo-piston is transmitted to the thrust-transmitting component **49** through the reaction beams, this effort will react through the said beams against the tubular component **57** and, therefore, against the manual effort applied to the brake-pedal. This reaction is proportionate, being governed by the ratio between the two arms of each beam either side of its fulcrum. The latter's position intermediate the ends of its respective beam is nearer the outer end of the beam, i. e., the end engaging the forward face of the servo-piston, and is the same for each beam.

Since the reaction is proportionate, the relation between the input and output efforts is proportionate also as with the embodiment of the invention described earlier herein, and a similar progressive control of the servo output is established. During the operation of the mechanism, when the effort produced by the servo-piston exceeds the manual input effort the tubular component **57** is moved rearwardly by the inner ends of the beams and

allows the coned valve-head **68** to seat and cut off the forward space of the servo-cylinder from vacuum. If the input effort is maintained constant at this point both valves will remain closed. If, on the other hand, the input effort is reduced the tubular component **57** will be moved further in the rearward direction and its forward end will consequently become disengaged from the disc valve-head **67** of the double-acting valve member. The port **58** in the forward end of the tubular component will thereby be opened to admit atmosphere to the forward space of the servo-cylinder until the balance between input and output is restored, when both valves will again be in the closed condition. Thus the proportion between the manual input effort and the output effort produced by the servo is maintained.

When the manual input effort exceeds the reactive force transmitted through the beams **73**, a flange **76** on the rear end of the tubular component **57** abuts the rim at the rear end of the thrust-transmitting component **49** and the coned valve-head **68** controlling the application of vacuum to the servo-cylinder is fully opened. Thereafter, any increase in the input effort will not produce an increase in the servo assistance, and the manual effort will be transmitted through the thrust-transmitting components **57** and **49**, the thrust-rod **52** and the piston **2** to the liquid in the hydraulic cylinder, thus being added to the effort produced by the servo-piston.

As with the embodiment of the invention described earlier herein, the thrust-transmitting assembly is movable independently of the servo-piston so that, if the servo-device becomes inoperable in any way, the manual effort is transmitted directly through the thrust-transmitting components to the piston in the hydraulic cylinder without any obstruction or interference from the servo-piston.

In both embodiments of the invention a reservoir **77** or **78** is provided on top of the hydraulic cylinder and communicating therewith through a port **79** or **80** to replenish the liquid therein.

We claim:

1. A servo-assisted brake-operating mechanism, comprising a hydraulic cylinder having means for connecting it to the brakes, a differential fluid-pressure energized servo-device mounted at one end of the hydraulic cylinder and in alignment therewith and having an operating element operative by differential fluid-pressure acting thereon, a thrust member extending through and movable axially relatively to said operating element in alignment with the hydraulic cylinder and having liquid displacement means associated therewith and operative in the hydraulic cylinder in response to movement of said thrust member to displace liquid from the hydraulic cylinder for application of the brakes, means for connecting the thrust member to the operating element of the servo-device for movement therewith in liquid displacing direction in response to energizing of the servo-device but permitting movement of said member in liquid displacing direction relatively to said operating element to an extent sufficient for application of the brakes independently of the operating element of the servo-device while said device is de-energized, valve means mounted within the thrust member and movable relatively thereto to control the differential fluid-pressure acting on the operating element of the servo-device and also movable with the thrust member, and manually operable means for controlling the valve means and for imparting thrust to the thrust member in liquid displacing direction.

2. A servo-assisted brake-operating mechanism comprising a hydraulic cylinder having means for connecting it to the brakes, a servo-device mounted at one end of the hydraulic cylinder and having a differential fluid-pressure energized operating element, an assembly mounted in alignment with the hydraulic cylinder and extending through and movable axially relatively to said operating element, said assembly comprising an outer

thrust-transmitting member having means associated therewith and operative in the hydraulic cylinder for displacing liquid therefrom and application of the brakes, and said outer member being engageable by the operating element of the servo-device in response to energizing thereof for movement in liquid displacing direction but movable freely relatively to said operating element and independently thereof in liquid displacing direction, and a manually operable inner member movable axially relatively to said outer member, and valve means within the outer member for controlling the action of the differential fluid-pressure on the operating element of the servo-device, the inner member being operative initially during its movement relatively to the outer member to operate the valve means to condition the servo-device for operation of the outer member thereby, and operative by its further movement relatively to the outer member to engage the outer member and to transmit its movement thereto to move the outer member in liquid displacing direction relatively to and independently of the operating element of the servo-device.

3. A servo-assisted brake-operating mechanism, comprising a hydraulic cylinder having means for connecting it to the brakes, a servo-device mounted at one end of the hydraulic cylinder and having a differential fluid-pressure energized operating element movable in axial alignment with the hydraulic cylinder, an assembly mounted in axial alignment with the hydraulic cylinder and extending through and movable axially relatively to the operating element of the servo-device, said assembly comprising a hollow outer thrust-transmitting member having means associated therewith and operative in the hydraulic cylinder for displacement of liquid therefrom and application of the brakes and having means for connecting it to the operating element of the servo-device in response to energizing thereof for movement thereby in liquid displacing direction and movable in liquid displacing direction freely and independently of said element, and an inner member mounted to slide axially in the outer member and having a portion thereof of reduced diameter intermediately of its ends to form an annular space between said members, a valve seat on the inner member at one end of said annular space, one side of the operating element of the servo-device having means of communication at all times with the atmosphere, and one side of said valve seat having means of communication with the atmosphere and with a source of vacuum, and the other side of said seat having means of communication with the other side of said operating element, and the outer member of the assembly having a valve seat adjacent to but spaced axially from the valve seat on the inner member and having means of communication at one side with the atmosphere and means at its other side for communication with said other side of said operating element, and an annular valve member slidable axially in said annular space between said members and engageable with the valve seat on the inner member while disengaged from the valve seat on the outer member to close communication between said other side of said operating element and the source of vacuum and provide communication between said other side of said operating element and the atmosphere in one position of said inner member, and said valve member being disengageable from the valve seat on the inner member and engageable with the valve seat on the outer member by movement of the inner member into another position to close communication between said other side of said operating element and atmosphere and to establish communication between said other side of said operating element and the source of vacuum.

4. A servo-assisted brake-operating mechanism, comprising a hydraulic cylinder having means for connecting it to the brakes, a servo-device mounted at one end of the hydraulic cylinder and having an operating piston provided with means of communication at one side at all times with the atmosphere and with means of communication at its other side with a source of vacuum, a thrust-transmitting assembly mounted in alignment with the hydraulic cylinder and extending through the piston of the servo-device, said assembly comprising an outer member operable by the piston of the servo-device and also operable independently of said piston to produce hydraulic brake-applying pressure in the hydraulic cylinder, and a manually operable inner member movable axially within the outer member and operable upon the outer member to impart movement thereto to produce hydraulic brake-applying pressure, valve means responsive to relative axial movement between said members of the assembly for controlling said means of communication with the source of vacuum to produce a variable differential pressure between the opposite sides of said piston, a housing fixed to one of the members of the assembly, and a reaction diaphragm having its periphery secured to said housing and its inner portion connected to the other member of the assembly and provided with means of communication at one side thereof with the side of said piston which is provided with means of communication with the source of vacuum.

5. A servo-assisted brake-operating mechanism, comprising a hydraulic cylinder having means for connecting it to the brakes, a servo-device mounted at one end of said cylinder and having a differential fluid-pressure energized operating element, a thrust-transmitting assembly mounted in alignment with the hydraulic cylinder and extending through the operating element of the servo-device, said assembly comprising an outer member operative to produce hydraulic pressure in said cylinder and engageable by the operating element of the servo-device when energized for movement in hydraulic pressure producing direction but movable in hydraulic pressure producing direction relatively to and independently of said operating element while said element is de-energized, and an inner manually operable member movable axially within the outer member of the assembly and having a port in an end thereof to provide communication between one side of said operating element and the atmosphere, a valve reciprocable within the outer member and having a valve element engageable by said inner member to close the port therein and having another valve element to control communication between said side of the operating element and a source of vacuum, and a reaction beam pivotally connected intermediately of its ends to the outer member of the assembly and engageable at one end by said inner member of the assembly for rocking movement on its pivot under manual effort applied to said inner member, the other end of the beam being positioned to abut against a side of the operating element of the servo-device.

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