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ENGINE BRAKING SYSTEM WITH TRIP VALVE CONTROLLED PISTON

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FIG. 1

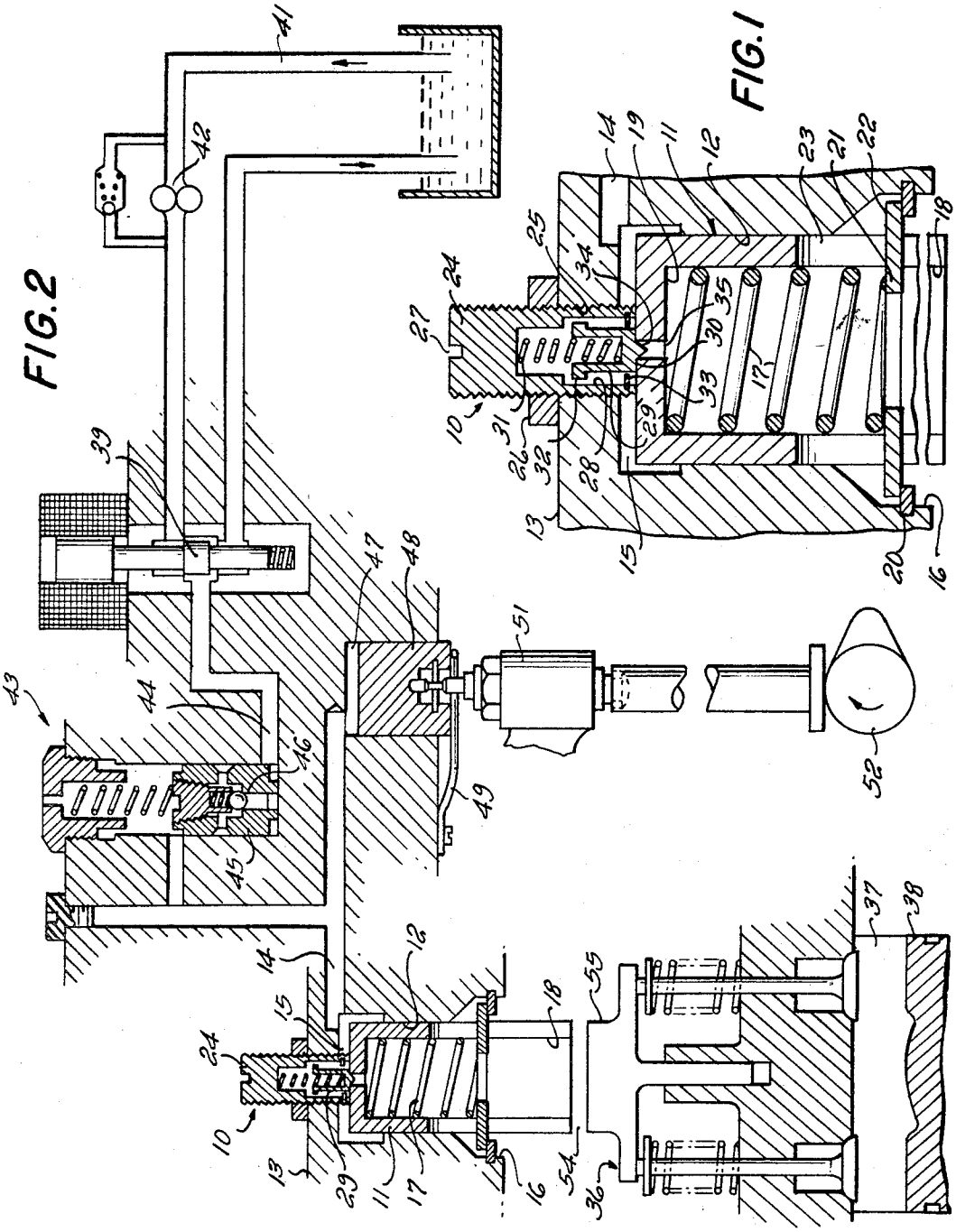

FIG. 2

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ENGINE BRAKING SYSTEM WITH TRIP VALVE CONTROLLED PISTON

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ABSTRACT OF THE DISCLOSURE

A work piston that is movable under hydraulic pressure applied to its head so as to move over a prescribed range to operate an associated device and is returnable by a spring, is controlled in its movement by means of a trip valve. The piston has a spill hole in its head normally closed by a spring loaded trip valve which follows the reciprocating movement of the piston. The trip valve is limited in the extent of its follower movement so that, should the work piston malfunction on a work stroke and move slightly beyond its normal range, it will separate from the trip valve causing the fluid acting upon the piston to dump through the spill hole and thereby prevent further work stroke movement of the piston. A tubular screw housing the trip valve is adjustable to regulate the extent of trip valve movement. The device is disclosed as applied to an engine braking system of the compression relief type. It enables the work piston to cause the exhaust valve of the engine to open at a time other than the normal time in the engine cycle, and insures that the work piston will not become hydraulically locked in a work stroke condition.

This invention is concerned with a trip valve controlled piston.

The piston is hydraulically movable on a work stroke to actuate an associated device, and is automatically returned by a spring. The piston is designed to reciprocate within a prescribed range from any adjustable starting position. To prevent movement of the piston beyond the prescribed range, the inventive concept concerns the provision of a trip valve seated over a spill-hole of the piston. If, because of some deficiency, the piston should move slightly beyond the prescribed range, it will become separated or unseated from the trip valve, and the operating fluid driving the piston will be dumped through the spill-hole of the piston and the piston will become disabled from further movement on a work stroke.

The invention is especially suited for use in an engine braking system of the compression relief type, such as that disclosed in Patient 3,220,392. This system is employed in vehicle engines to aid in slowing down the vehicle in normal operation by opening an exhaust valve to relieve the related cylinder of the gases of the compression near the end of a compression stroke. When the system is put into operation by the operator, a slave piston is hydraulically operable against a return spring to timely open an exhaust valve of a cylinder as the engine cycles. If the slave piston should fail to return after opening the exhaust valve, because of some fault such as a broken spring, the slave piston is likely to become hydraulically locked or progressively jacked downward relative to the exhaust valve by hydraulic fluid as the engine cycles. This action may prevent the exhaust valve from closing, or may cause it to project dangerously into the path of the cycling piston of the engine. A solution to this problem is provided by replacing the usual slave piston in the braking system with the combined safety trip valve and work piston of the present invention.

In the accompanying drawings:

FIG. 1 is a schematic showing of a trip valve controlled piston embodying the invention; and

FIG. 2 is a schematic showing of a braking system of the compression relief type in a diesel engine, illustrating a practical application of the invention.

FIG. 1 shows a safety trip valve unit **10** associated with a hydraulically operable work piston **11**. The piston is reciprocable in a cylinder **12** of a stationary block **13**. High pressure hydraulic fluid moving from a passage **14** of the block to a clearance **15** in the cylinder above the piston serves to force the piston downward upon a work stroke. In this action, the piston is projected downward relative to an open bottom end **16** of the cylinder to actuate whatever device it may be associated with in a practical application of the invention. When the hydraulic pressure over the piston is relaxed, a compression spring **17** operates to return the piston to its normal position. Extending into the piston from its bottom end is a recess **18** in which spring **17** is positioned between a head wall **19** of the piston and an annular slide plate **21**. The latter is formed with lugs **22** which extend radially through slots **23** of the piston and abut a retainer ring **20** mounted in the block. These slots are elongated vertically above the lugs so as to enable the piston to reciprocate in its cylinder relative to the lugs.

The safety trip value unit **10** includes a housing, defined by a cylindrical screw **24**. The latter is threadedly engaged in a hole **25** extending through block **13** axially into the top end of the piston cylinder **12**. The screw is adjustable in hole **25** so as to depend for a selected distance into the piston cylinder above piston **11**. An external lock nut **26** serves to lock the adjusted position of the screw. The depending end of the screw limits movement of the piston to a returned normal position, as in FIG. 1, wherein it is spaced by clearance **15** from the head wall of the piston cylinder. This clearance may be reduced or increased as desired by axial adjustment of the screw without affecting the constant trip distance described below.

The safety trip valve unit **10** is intended to have two purposes. It controls the initial or starting position of piston **11** as well as the total allowable stroke of the piston. The stroke of piston **11** during normal operation is controlled by other means, such as the stroke of a master piston **48** described herein with respect to FIG. 2. It is only during some malfunctioning of the piston **11** that the safety trip valve unit **10** comes into operation to limit the total movement of the piston from a predetermined adjustable upper position. The tripping distance or safety stroke limitation is built into the dimensions of the trip valve unit itself and is ideally a few thousandths of an inch more than the normal operating stroke of the piston **11** as determined by the master piston **48**. The tripping distance is independent of the starting position of the piston. To this end, screw **24** is hollow or provided with an axial bore **28** in its bottom end. A trip valve **29** of cup-form having a loose fit in this bore is axially movable relative to the bottom end of the bore. A spring **31** seated in the cup of the valve and abutting an overhead wall of bore **28** constantly urges the valve outwardly of the bore. A flange **32** about the upper end of the valve is cooperable with a retainer ring or stop **33** mounted in the screw near the mouth of the bore to limit the extent of outward movement of the valve. A nub **34** of conical form depending axially from the bottom face **30** of the valve provides initial alignment of the valve **29** so that the face **30** of the valve seats itself squarely over

a spill-hole **35** formed axially in the piston. The nub also provides sufficient alignment to prevent rubbing of the valve **29** against the bore **28** or lock ring **33** during normal operation. The seating of the face **30** against the top of the piston prevents discharge or dumping of hydraulic fluid from clearance **15** into the interior recess of the piston which is open to sump.

The operation of the device is as follows: Hydraulic fluid pressurized into the clearance **15** above the piston **11** sufficiently to overcome the resistance of the piston spring plus external work resistance, such as engine compression pressure on exhaust valve area and exhaust valve springs, forces the piston downward on a work stroke. The pressure of hydraulic fluid from the clearance **15** entering through end slots, not shown, of screw **24** to the bore **28** around the trip valve forces the latter to follow the downward movement of the piston and at the same time holds the valve seated in sealing relation over the spill-hole. When the hydraulic pressure in clearance **15** is relaxed, the piston spring **17** re-expands to return the piston and the trip valve to normal against the resistance of the valve spring **31** and oil supply pressure, the trip valve remaining seated over the spill-hole in this movement. The trip valve has a normal returned condition, as in FIG. 1, wherein its peripheral flange **32** is elevated a pre-set distance above the retainer ring **33** independent of adjustable clearance **15**. Accordingly, this distance determines the extent to which the trip valve can follow a downstroke movement of the piston; and it also prescribes a distance of safe downstroke movement for the piston. It is apparent that if the trip valve should move sufficiently to limit upon the retainer ring **33** during a downstroke of the piston, slight further movement of the piston would separate the piston from the trip valve and cause the valve to become unseated from the spill-hole. When this occurs, the hydraulic pressure acting over the piston will suddenly relax and the piston will be disabled from further downstroke movement as the hydraulic fluid is dumped through the spill-hole into the interior of the piston and allowed to escape from the open bottom **18** and slots **23** of the piston to sump.

A broken piston return spring **17** is one of the faults which may cause the piston to move sufficiently away from the trip valve to cause dumping of the hydraulic operating fluid through the spill-hole.

The combined trip valve unit **10** and work piston **11** may be applied to advantage as a component of an automotive engine braking system of the compression relief type, such as that schematically illustrated in a diesel engine in FIG. 2 and described in greater detail in Patent 3,220,392.

The illustrated braking system embodying the invention functions at the will of the operator of the vehicle to force the work piston **11** on a work stroke to actuate an exhaust valve unit **36** of a cylinder **37** of the engine to open condition at or near the end of a compression stroke of a related piston **38** of the engine. This will relieve the engine's cylinder of gases of compression, and thereby will avoid transmission of the expanding power of the compressed gases to the engine. Use of this braking system in normal operation tends to advantageously slow the engine.

When a solenoid valve **39** in this braking system is energized to open condition, hydraulic fluid or oil is forced over a supply passage **41** from the engine's crankcase by means of a continuously operating pump **42** through the solenoid valve to a control valve unit **43**. Fluid entering a passage **44** leading to the control valve unit slides a valve member **45** upwardly to communicate a high pressure line **14** through a check valve **46** with passage **44**. When this occurs, operating hydraulic fluid passes through the check valve to fill the high pressure line **14**. The latter is common to the upper end of a master piston cylinder **47** and to the clearance **15** above the work piston **11**. The latter may appropriately be called a slave of a master piston **48** operating in the master piston cylinder. A return spring **49** of the master piston is relatively weaker than spring **17** of the work piston; accordingly, the master piston is hydraulically moved by pressure of fluid in passage **14** over a normal slight clearance (not shown) and held in contact with an end of the usual fuel injector rocker arm **51** of the vehicle's engine or other suitably timed moving part. When a constantly rotating cam shaft **52** of the engine operates during a fuel intake stroke of the engine to pivot the injector rocker arm, the master piston **48** is forced upwardly. The hydraulic fluid imprisoned by check valve **46** in the high pressure line **14** is pressurized in the clearance **15** over the work piston **11** by this movement of the master piston. Whereupon this action, the work piston is forced down over a slight normal clearance **54** against the crosshead **55** of the exhaust valve unit **36** to force the latter to open condition. The exhaust valve unit is timely opened in this action at or near the end of the compression stroke of the related piston **38** to exhaust the gases of compression from the engine's cylinder. As the pressure of the cam shaft **52** upon the injector rocker arm relaxes, the work piston spring **17** returns the work piston to normal. As earlier mentioned, the trip valve **29** follows the reciprocating movement of the work piston **11**. In the normal reciprocating movement of the work piston during normal operation of the braking system, the work piston does not move over a range exceeding a distance corresponding to the normal spacing between the flange **32** of the trip valve and the retainer ring **33** (best shown in FIG. 1).

It can be seen that if for some reason, such as breaking of its return spring **17**, the work piston **11** did not fully return, further oil will flow through the check valve **46** to fill the void developing in the high pressure line **14** because of failure of the work piston to fully return while the master piston continues to retract. If this fault continued as the engine rapidly cycled, the work piston would be hydraulically locked, or "jacked" down further as additional oil accumulated in the high pressure line; and, unless this "jacking" action were timely stopped, the associated exhaust valve might be hydraulically locked in an open condition or projected harmfully into the path of the related reciprocating piston **38** of the engine. The trip valve **29** serves to prevent the work piston **11** from becoming hydraulically locked or moving down to a dangerous condition. The trip valve will limit upon the retainer ring **33** when the work piston moves beyond its prescribed range; and the work piston will separate from the trip valve and become disabled, as earlier explained, before it can be "jacked" down to a dangerous condition. Oil "dumped" through the spill-hole **34** will escape through the bottom **18** and slide slots **23** of the work piston to the crankcase. The operating deficiencies of the normal braking system will be readily sensed by the operator shortly after they develop. He will then stop his vehicle as soon as it is expedient to do so and will take steps to repair the fault. It is to be noted that the size of the clearance **54** may be selectively adjusted by making an axial adjustment of screw **24**, without affecting the constant tripping distance.

What is claimed is:

1. In an engine braking system of a gas compression relief type including a combustion engine piston reciprocable in a cylinder having an exhaust valve, a work piston cooperable on a work stroke with the exhaust valve at a predetermined time to open the exhaust valve, means for periodically applying hydraulic pressure fluid to a head end of the work piston to cause it to cooperate with the exhaust valve, and a spring arranged at the underside of the work piston adapted to move the work piston way from the exhaust valve after such cooperating action; safety valve means for automatically relieving the hydraulic pressure fluid from the head end of the work piston upon the latter moving beyond a predetermined distance relative to the exhaust valve on a work stroke, wherein

the safety valve means includes a valve housing selectively adjustable relative to the work piston to provide a stop limiting the starting position of the work piston.

2. In a system according to claim 1, wherein a trip valve is movable in the housing, and means is provided in the housing fixing the extent of such movement to a constant irrespective of any selected adjustment of the housing.

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