FAILSAFE BRAKES ON FARM TRACTOR-DRAWN CANE HAULAGE TRAILERS

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Abstract

Failsafe brakes have been confined mainly to air operated braking systems such as those found on trucks and heavy duty trailers used to transport sugarcane and timber. The Experiment Station undertook to investigate various systems by which efficient and inexpensive failsafe braking could be achieved on conventional farm trailers using the principle of spring pressure to apply the brakes, and hydraulic pressure to release them. If a hose bursts the springs will automatically apply the brakes, bringing the tractor and trailer to a halt until repairs are made. Several systems were built and tested for tractors equipped with both variable and fixed displacement pumps, and those that have merit are described.

Introduction

A survey conducted in 1986 indicated that growers showed such lack of interest in brakes on farm cane trailers that some preferred not to have brakes fitted at all. The rationale was that on steep gradients the tractor driver would be forced to use the gears to slow the tractor-trailer rig. The driver might otherwise drive downhill at a much higher speed using only the trailer brakes to slow the rig. This concept leaves no leeway for complete braking if an emergency situation suddenly developed.

Another argument against the use of trailer brakes is that road conditions on flat country do not require more braking effort than that supplied by the tractor. In this case, however, there is the potential hazard of the trailer 'jack-knifing' against the tractor and possibly overturning.

Most trailer manufacturers fit brakes to their trailers, but some fit them only on request. The cost of fitting brakes to a trailer is minimal when compared with the cost of damage to expensive transport equipment, or with injuries sustained in the event of an accident.

The Machinery and Occupational Safety Act (Act 6 of 1983) requires that reasonable precautions be taken by the employer to protect his employees. In the event of an accident on the farm involving injury or loss of life, the extent of culpability of the employer and the employee would depend on their compliance with the Act. If the case devolves on the use of trailer brakes, the extent of care with which the farmer has installed and maintained them may mean the difference between exoneration and proven culpability. If, however, trailer brakes are not fitted, such action may be construed as grossly negligent.

Method

Four failsafe braking systems were built and tested for both variable and fixed displacement pumps, and one commercially available system is described.

The brake springs and hydraulic cylinders were mounted on a reconditioned trailer axle with 'S' cam brake assemblies. Conventional 38 mm diameter single acting hydraulic cylinders were used with springs and retaining brackets, which were designed and manufactured to meet the general criteria outlined in Appendix A. Commercially available hydraulic components were used and an hydraulic test rig was used to power the various systems.

Following the satisfactory results obtained from the tests, the components used in System 2 were fitted to a Ford 5610 tractor and a 6 ton Experiment Station design basket trailer, used for cane haulage on the Experiment Station La Mercy farm. The system was tested during the 1990/91 season. The only problem experienced to date was a small leak in one of the brake cylinder seals. Midway through the season it became necessary to fit the original brake and tip kit so that other trailers which have conventional hydraulic systems could be used. The refitting necessitated the addition of a selector valve, so that either the failsafe or the conventional brake and tip system could be selected.

Results

System 1

System 1 is similar to the Jacobyl design (Figure 1) which is available commercially (Manly, W personal communication) and operates as follows:

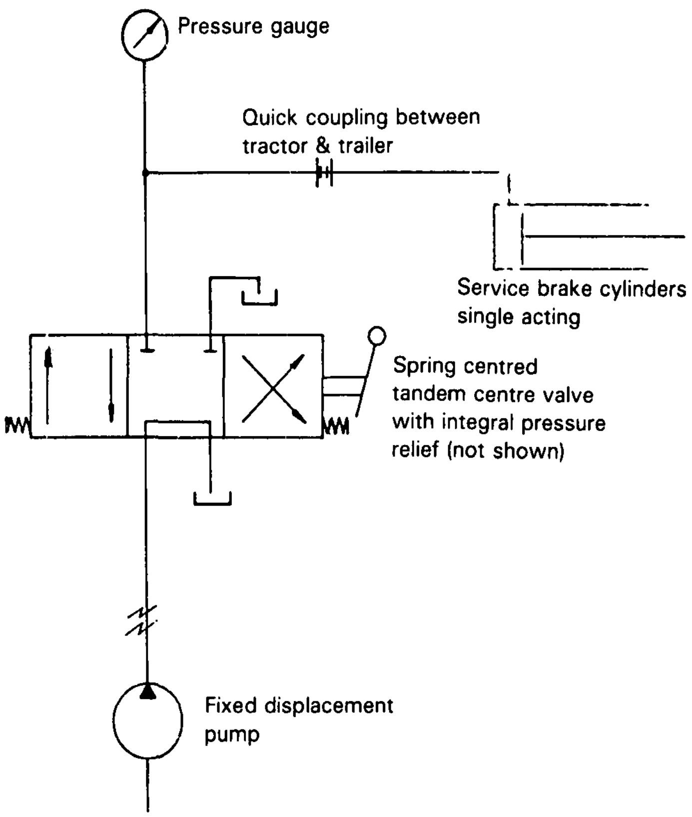

FIGURE 1 The Jacobyl designed failsafe brakes.

A spool valve is coupled between the pump output and the brake line as in conventional brake and tip kits. System pressure is limited by the integral pressure relief valve. By moving the spool lever in one direction oil is fed to the brake cylinders through the 'A' port. The 'B' port and tank ports are coupled and return the oil to the reservoir (tractor gearbox). Pressure from the pump extends the cylinders, releasing the brakes. When the lever is moved to the centre position, oil from the pump is returned to tank and the 'A' and 'B' ports are blocked, holding the brake cylinders at system pressure. When the valve lever is moved the opposite way, pressure is released from the brake cylinders back to the reservoir and the springs pull the brakes on.

The advantage of System 1 is that it uses only one double acting tandem centre spool valve to achieve failsafe braking. A disadvantage is that a small amount of oil will leak past the valve spool while it is held pressurised in the centre position. This causes the cylinders to lose pressure after a few minutes, and the brakes will apply gradually unless the driver notices this effect and recharges the system (Bodasing, P personal communication). It is advisable to mount a pressure gauge in a conspicuous place so that the driver may notice any drop in pressure before the brakes start binding and cause unnecessary wear to the brake linings.

System 2

System 2 is essentially an accumulator charging circuit that uses an externally sourced, pilot-operated overcentre valve to maintain pressure in the brake circuit (Figure 2), at the same time return oil at low pressure to the reservoir. Initially oil at system pressure is fed directly to the cylinders through a check valve. An overcentre valve is coupled in reverse mode so that the integral check valve is disabled. The vent hole through the main spool is closed off with a spot of brazing, and is machined flush with the plug face. A slot must be cut in the main spool to allow oil trapped behind it to be evacuated.

The overcentre valve is then teed into the high pressure side of the line before the check valve. Pilot pressure is taken beyond the check valve, as is the line to the directional valve. As the pilot line is filled pressure on the pilot spool in the overcentre valve increases until it overrides the preset spring pressure holding the main spool closed. The two chambers are then opened and oil is vented to tank. The directional valve which is mounted above the tractor brake pedals is offset with a spring to open the 'A' port to tank when the pedal is depressed. The spring's tension value should be such that the foot pressure required to compress it is slightly less than or equal to the pressure required to apply the tractor brakes so that progressive braking between the trailer and the tractor is achieved.

Pressure beyond the check valve is held at the level to which the spring in the overcentre valve is set, nominally 5 MPa. Pressure before the check valve drops toward zero as the main spool opens, allowing oil to flow back to tank.

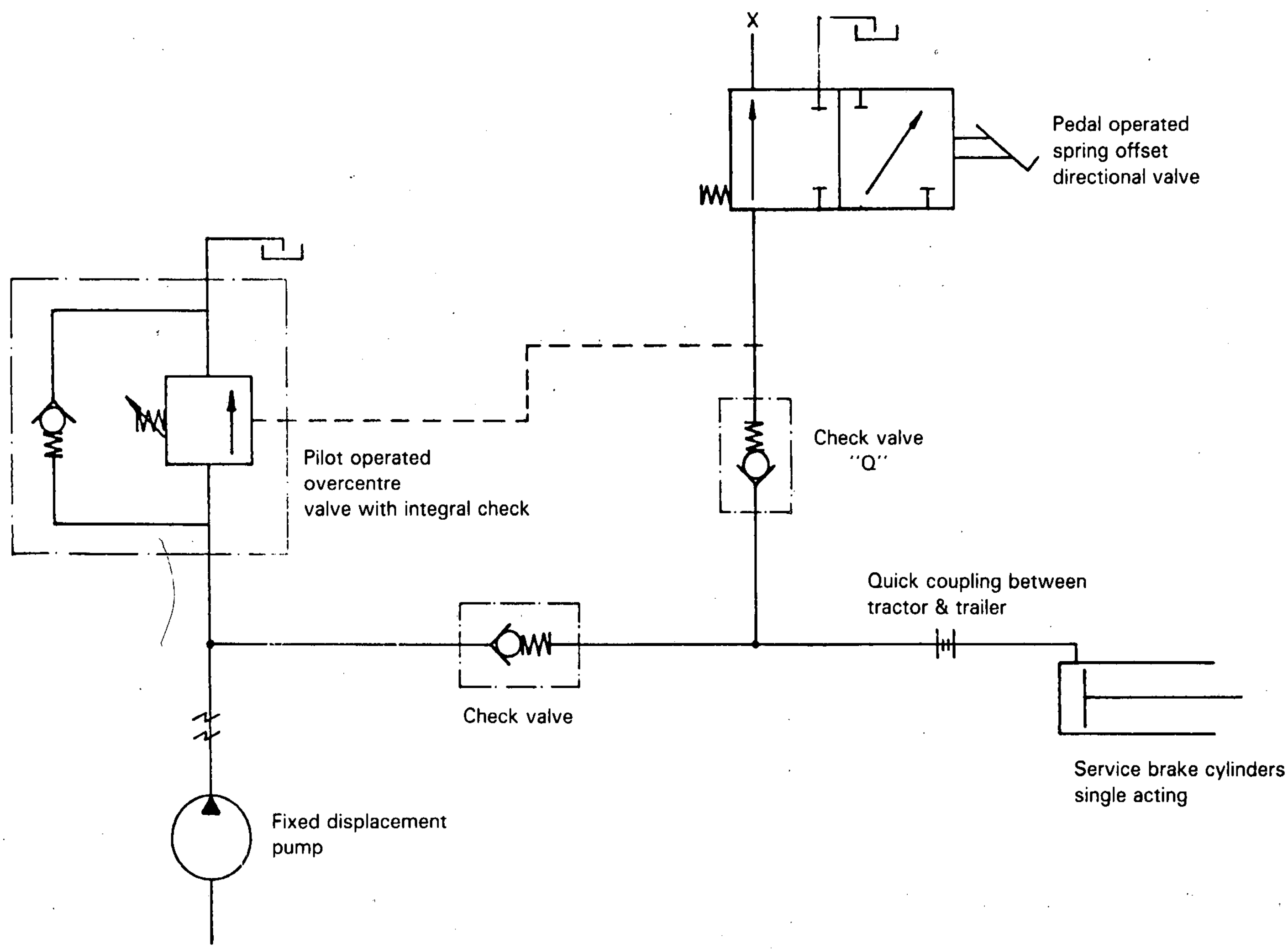

FIGURE 2 The failsafe braking circuit fitted to the SASA Experiment Station tractor and trailer.

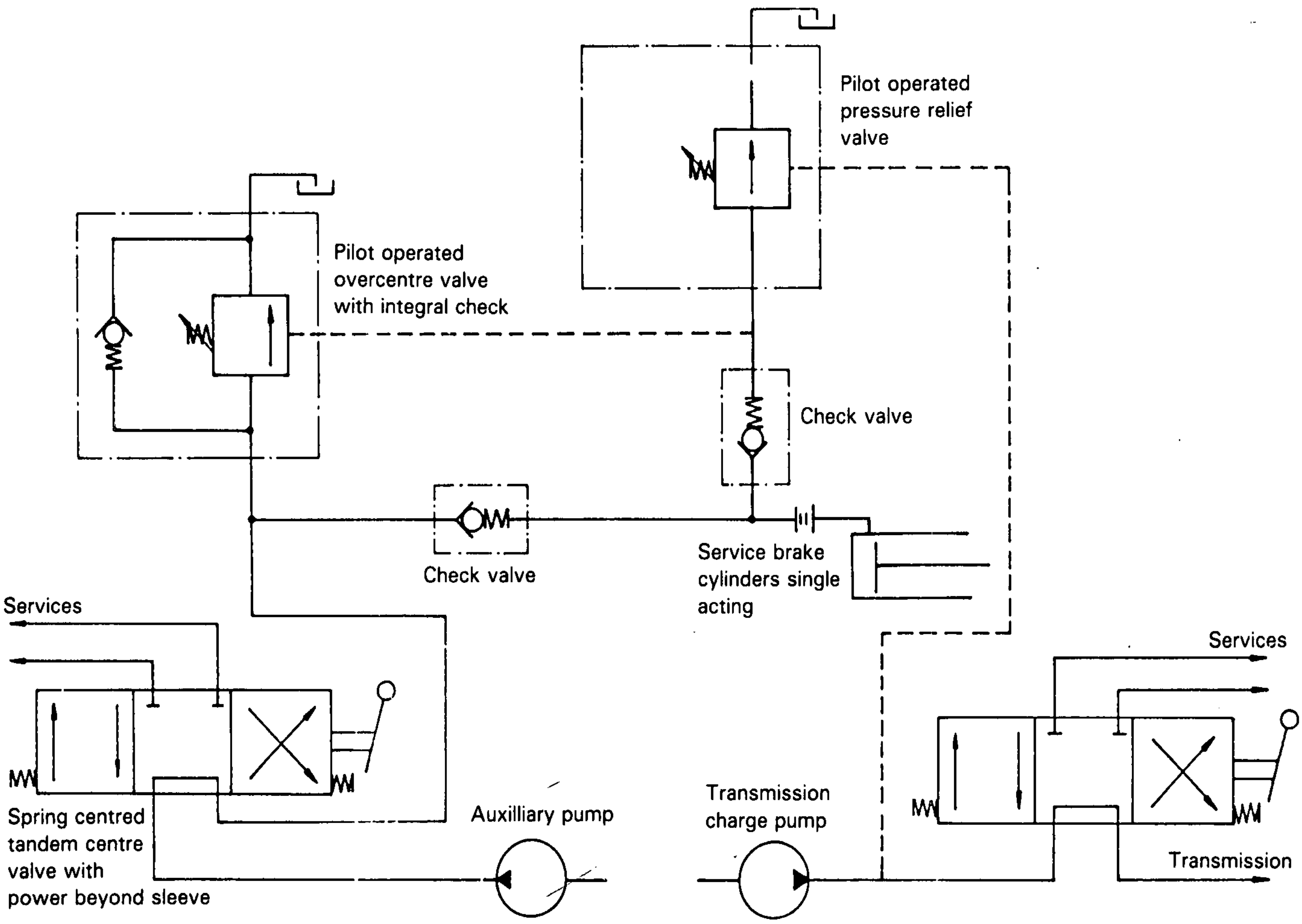

FIGURE 3 The failsafe braking circuit fitted to the Bell loader at La Mercy farm.

Opening the directional valve releases the oil trapped beyond the check valve and the pilot line, allowing the brake springs to apply the brakes. Removing foot pressure from the directional valve repeats the process.

The advantage of this system is that it will automatically recharge if there is a drop in pressure in the brake line. To prevent oil being lost in the event of a hose burst, pilot pressure is maintained by inserting another check valve ('Q' in Figure 2) between the pilot line and directional valve junction and the main brake line, so that oil at system pressure is maintained, thus holding the overcentre spool open to tank.

System 3

The inclusion of a pilot operated pressure relief valve, which replaces the pedal operated directional valve, will enable this system to operate the brakes of vehicles equipped with hydrostatic transmissions such as the SASA Experiment Station 'Twiga' crane and the Bell loader, provided they are fitted with external lever actuated brakes (Figure 3).

Before the 1990 season, a failsafe braking system was fitted to the SASA La Mercy farm Bell loader. The parts used were those available at the time and included two 50 mm agricultural hydraulic cylinders and the brake spring assemblies from a dismantled experimental machine. During the 1990 season, pilot operated pressure relief and overcentre valves were included in the system so that full braking would be automatically achieved if the engine stalled for any reason.

On starting the engine, pressure from the tank port of the service valve (which must be equipped with a power beyond sleeve) is supplied from the auxiliary pump which charges the brake line, releasing the brakes as in System 2. Pilot pressure then opens the overcentre valve spool, releasing the oil to flow back to tank. The pilot line and the line to the overcentre valve are fed from a common connection between the check valve and the brake cylinders. Pilot pressure to close the pressure relief spool is taken from a line coupled between the transmission charge pump and the transmission or the first service valve in the line. The back-pressure in this line is created by the transmission demand setting and is generally about 1 MPa, which is sufficient to hold the pressure relief valve closed.

When the engine is stopped, the pressure in the charge pump line and on the pressure relief valve spool drops to zero, allowing the release of oil from the brake cylinders back to tank, and the springs apply the brakes.

System 4

System 4 pertains to tractors which are equipped with pressure compensated variable displacement pumps such as those found on John Deere tractors. These pumps are designed to destroke at their maximum preset pressure. They therefore require a different type of valve to charge the brake cylinders and then destroke the pump by allowing the compensator to build up pressure.

This problem can be overcome in two ways. Firstly, by using a remote pilot operated pressure relief valve (Figure

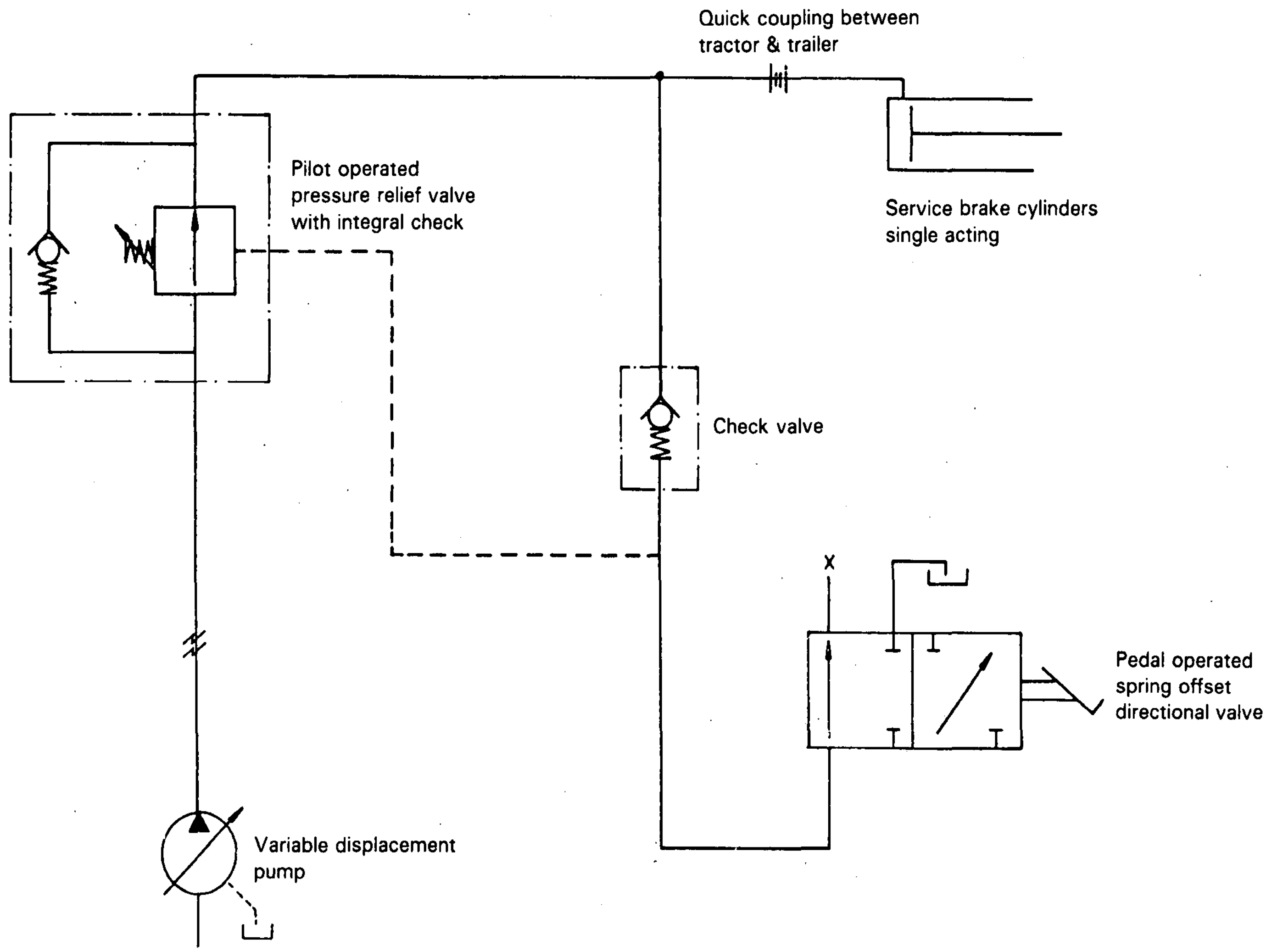

FIGURE 4 Failsafe braking circuit for a tractor fitted with a variable displacement pump.

4), to which is added a check valve and a spring-offset directional valve (as in System 2) to apply the brakes. In the event of a hose burst the valve spool will be held closed by pilot pressure, which is charged to a pressure determined by the preload on the adjustable spring (typically 5 MPa) and held there by the operation of the check valve, even though the pressure on the brake line side has dropped to zero by releasing oil through the fracture. Oil in the pilot line can be released only through the directional valve.

Secondly, by using a closed centre bi-directional valve (Figure 5) to charge the brake line, and a simple pressure relief valve to maintain a nominal pressure of 5 MPa, the brakes will be released by moving the lever to one position. In the centre position all the ports are blocked, and the oil pressure trapped between the valve and the cylinders holds the brakes off. Oil at high pressure between the valve and the pump then destrokes the pump. When the lever is moved the opposite way the oil between the valve and the brake cylinders is released to tank thus applying the brakes, while the oil beyond the pump is held at destroke pressure against the 'B' port plug. The effect of the brakes being applied through oil leakage, in a manner similar to System 1, necessitates the inclusion of a pressure gauge so that the driver may notice a drop in brake cylinder pressure.

System 5

System 5 is commercially available. Failsafe as well as conventional brakes using many of the same parts are also available. The spring and cylinder components by which the brakes are applied are manufactured as an integral unit. The control valve has four pressure settings which enable the operator to choose the pressure and thus the braking effort to suit a particular situation. Figure 6 illustrates a typical failsafe circuit which may be applied to conventional tractor drawn cane trailers (after SB Systems information leaflets).

Conclusions

The fitting of hydraulic over spring failsafe brakes to cane trailers is the only reasonable solution, in terms of cost and effectiveness, to ensure that the safety standards and legal requirements pertaining to braking systems are met. The hydraulic components used to construct Systems 1 to 4 are commercially available and require no particular skill to assemble. The inherent safety features ensure that a failsafe braking system must be functioning and in good order and any failure in the system will automatically apply the brakes. Brake hoses must be coupled before the trailer can be moved.

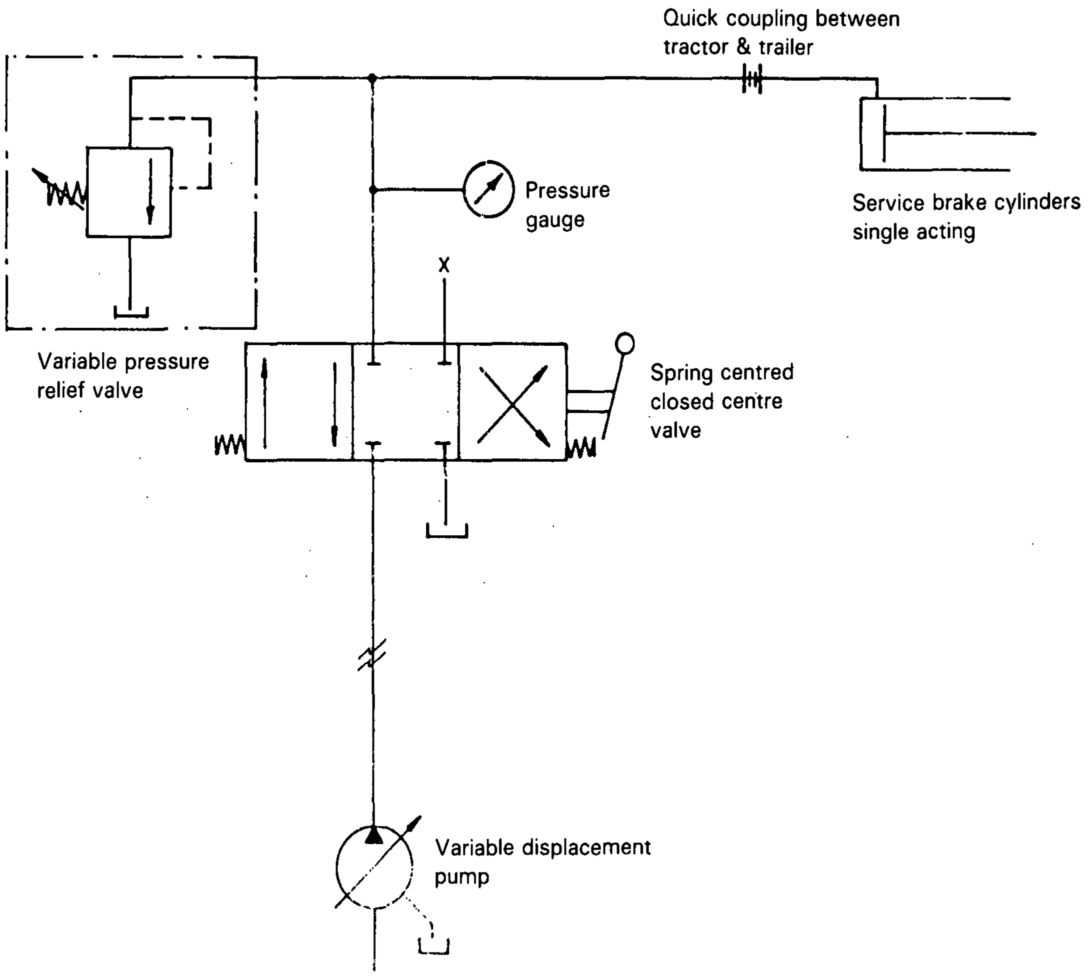

FIGURE 5 Alternative failsafe braking circuit for a tractor fitted with a variable displacement pump.

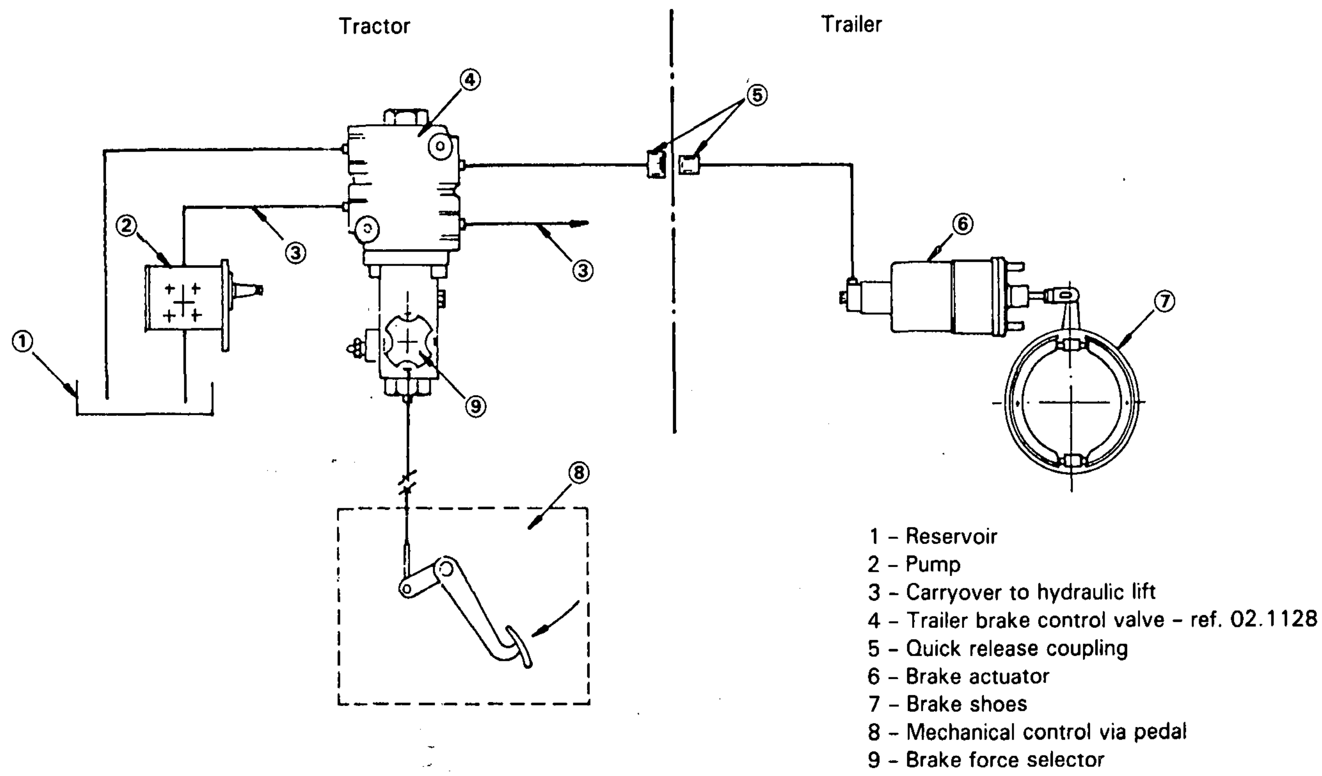

FIGURE 6 Failsafe braking circuit incorporating parts from a commercial company.

REFERENCES

Anon: S.A Bureau of Standards. Specifications for braking (motor and towed vehicles, designed for low speed or for use off public roads). Specification no. 1447 Part II p 12. 1986

APPENDIX A

When tractors and trailers are driven on public roads the specifications for braking systems laid down by the Road Traffic Ordinance apply. It has been proposed by the South African Bureau of Standards (Anon: SA Bureau of Standards) that Category B and C trailers (which applies to most tractor drawn cane trailers) should be fitted with both parking and service brakes which meet specifications.

General specifications for such braking systems include the following:

1. The trailer must be held stationary by a parking brake on slopes of up to 18%. In the case of failsafe brakes the automatic braking capabilities should meet this requirement.
2. The braking force applied by the driver using a supplementary power source (hydraulic) should bring the tractor and trailer to a standstill at the rate of 2,4 metres per second^2 (Anon: SA Bureau of Standards), i.e. tractor and laden trailer travelling at speed must stop within a distance according to the formula:

$$D = 0{,}208 \times U^2 \quad \text{where}: D = \text{distance in m}, \; U = \text{speed in m/s}$$

Table 1 gives a range of speeds and corresponding stopping distances calculated from the above formula for Category B and C tractor drawn trailers.

Table 1

Stopping distance for a corresponding range of speeds

Speed (kph)	Stopping distance (m)
10	1,6
15	3,6
20	6,4
25	10,0
30	14,4
35	19,7