compressor needs to be capable of handling the daily production of biogas in about 12 hours of running time.

If several makes or models of a suitable size are available, the choice should be made on their cost and reliability, and on the availability of servicing. Compressors may be three or four-stage types, but they should be fitted with stainless-steel piping. They must not have any copper piping or gaskets, because copper is rapidly attacked by both the sulphides in the raw gas and carbonic acid that is formed by any moisture in contact with the CO_2 in the compressed gas.

Provision should be made for bleeding gas from the compressor stages whenever it shuts down, so that it will not restart under load. Where the continuous running time is likely to exceed an hour, a timing device should be installed that will allow condensed moisture and oil contamination to be vented at about hourly intervals.

Lubricating and cooling: Whatever the compressor, it is important to use a synthetic oil, designed for use with methane — otherwise a chemical reaction between the oil and the methane can occur, causing the oil to degrade to a black sludge. Most compressors will be provided with a thermal sensor to detect a failure of the oil or the cooling system and some may have an oil-level warning indicator. Air-cooled compressors are simpler than the water-cooled models, but when the compressor is being operated in conjunction with a biogas plant, a water-cooled model allows the cooling water to be used for digester heating, enabling a more efficient utilisation of energy.

How many compressors: For smaller operations, it is more economic to use a single compressor for the scrubbing and the compressing — the capital costs are lower, the electrical installation is simpler and less costly, and there are fewer items to require regular maintenance. In larger plants however, it can be more economic to use a separate compressor for the scrubbing after which the gas is returned to a second, flexible storage bag that is fitted with limit switches to control the high-pressure compressor. The reduced volume of the scrubbed biogas (without the CO_2) allows the high-pressure compressor to be of smaller capacity than if it were used to scrub as well. This reduces its cost and can offset the added costs of the scrubbing compressor and the second gas bag with its electrical system.

Choosing the water pump

Once the compressor has been chosen, the scrubbing pressure and the gas-flow rate through the scrubber tower have been fixed. The only flexibility is in whether to direct gas to the scrubber from the first or from the second stage output of the compressor. The water pump must be able to work with water that is at or above the chosen scrubbing pressure — and at a suitable flow rate to clean the biogas to the desired degree of purity. (The choice of rate can be made from experience or, as described previously, by using a graph such as Fig. 3).

In order to provide for a possible increase in the scrubbing efficiency, it is wise to choose a pump whose flow rate does not depend too closely on the pressure — otherwise any attempt to increase the purity of the scrubbed gas by increasing the scrubbing pressure will be offset by a corresponding reduction in the flow rate from the pump. If the scrubbing system is to operate automatically, it is essential to have a pump that is easily maintained and reliable under extended usage. Water that contains dissolved CO_2 is acidic and thus corrosive to steel and copper — if the scrubbing water is to be re-used, a pump with a stainless-steel impeller or with rubber diaphragms is needed to avoid any possibility of corrosion.

Designing the scrubber tower

The scrubber tower is the vessel in which the raw biogas comes in contact with the scrubbing water. The taller the

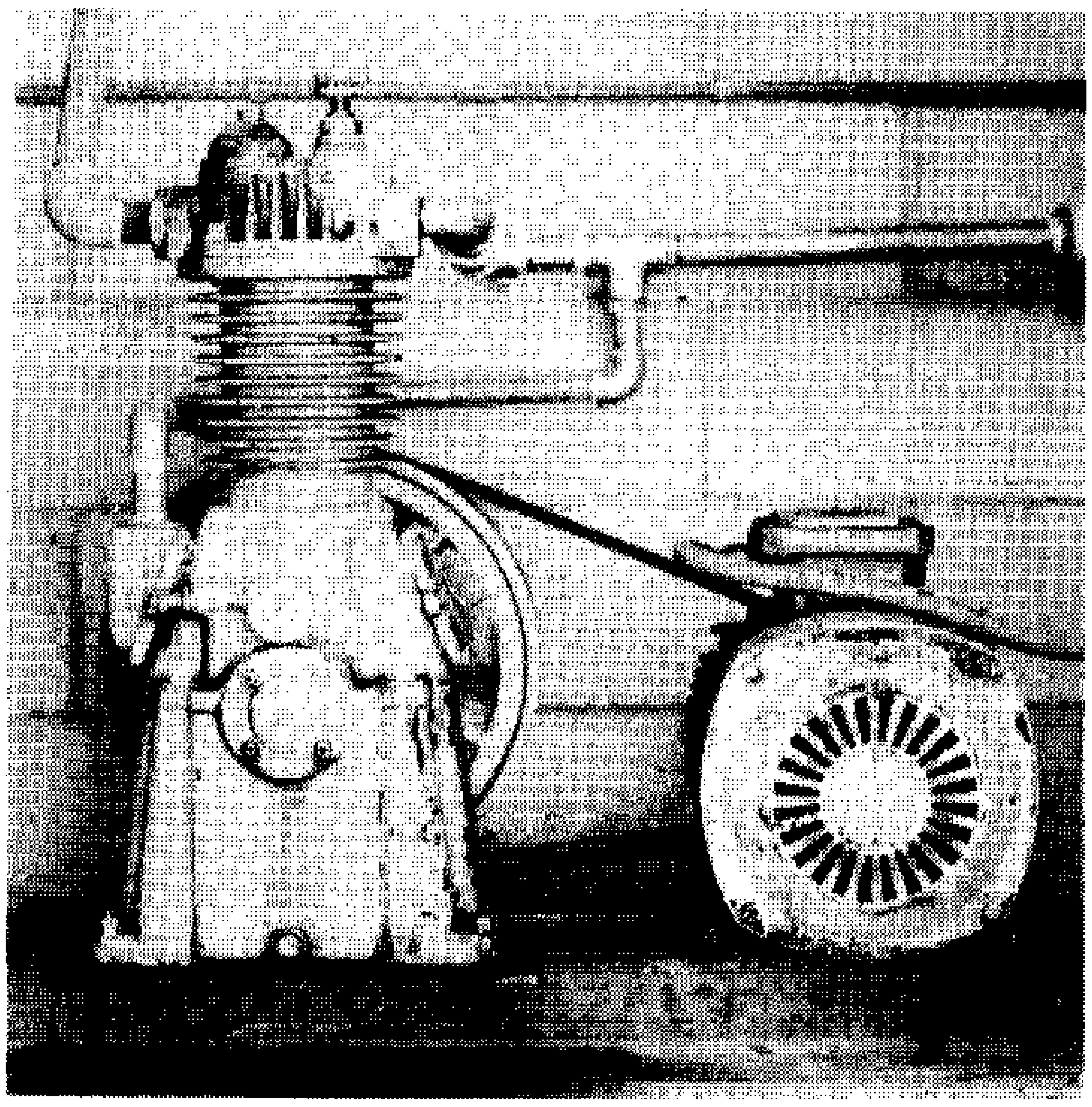

Fig. 4: A two-stage compressor (Kellogg 321 TV, marketed in New Zealand by Compair Ltd) being used to scrub biogas. A second compressor compresses the scrubbed gas.

vessel, the further the gas bubbles must travel through the water and the greater the efficiency of the gas washing. A vertical tower is therefore an appropriate shape for a scrubber.

Dimensions: The actual dimensions are not as important as are the water and gas flow-rates and pressure in determining the purity of the scrubbed gas. A 6 m length of 200 mm diameter pipe will make a scrubber tower able to handle as much as 2 000 m^3 of raw biogas per day if the other parameters are chosen correctly. A standard 6 m length of 200 mm diameter PVC irrigation pipe can be used to make an inexpensive and corrosion-free scrubber tower for smaller operations where the scrubbing pressure is below 1 200 kPa (174 psi), as shown in Fig. 6. Steel pipe must be used for higher pressure scrubbing.

Packing: The efficiency of scrubbing in any tower can be further improved by packing it with cascade minirings No. 1 (available in New Zealand from AHI Chemical Engineering Services, Private Bag, Auckland) or with nylon pot mitts, either of which will obstruct the gas flow and force it to

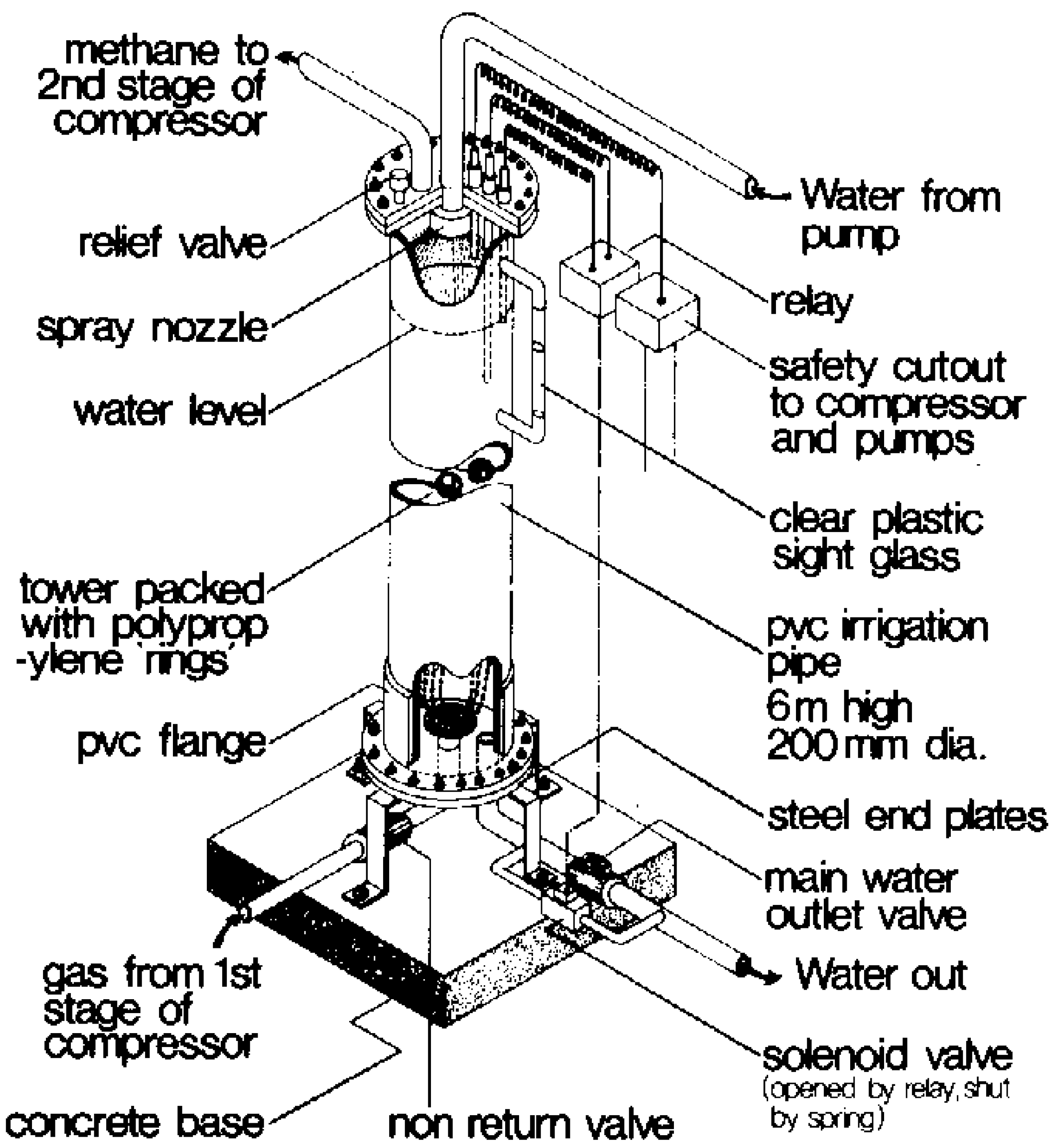

Fig. 5: Design of a water scrubber suitable for removing carbon dioxide and hydrogen sulphide from biogas.

travel further. Packing is very important in a tower that is operated as a spray tower with very little water in it – the contact between the gas and the water is made in the film on the surface of the packing. If a flooded tower almost filled with water is used, the nature of the packing is less critical.

All the information in this AgLink relates to flooded towers, which have a number of operational advantages over spray towers.

Water level: A device for controlling the level of the water in its tower is essential if the scrubber is to operate automatically. Without such a control, the water level could rise too high and water could flow through the gas outlet into the compressor. If the level dropped too low, the gas would not be scrubbed and might even escape through the water outlet.

There are a number of ways of monitoring and controlling the water level, but the least expensive and most robust is to use conductivity probes. These are two lengths of stainless-steel rod that either enter the tower through the top and descend to the desired water level, or are fitted in the walls of the tower at that level. If the tower is of steel the rods are insulated from it by an insulating seat. When the water level in the tower rises so that it covers both probes a current can travel between them through the water. It is used to operate a relay that opens a solenoid valve which releases more water from the tower.

The main water outlet valve is adjusted so that the water level will normally rise slowly during scrubbing, and the control maintains the level after it has reached the desired height. When the water is re-used, it could eventually become contaminated with solid particles and it is advisable to instal a water filter in front of the solenoid valve to ensure that its fine bleed holes do not become blocked.

As a further precaution, a third conductivity probe should be installed at the top of the scrubber tower so that if the water level does rise too far it will cause a current to flow between the upper and the lower probes and thus activate a safety shut-off of the water pump and compressor.

Water re-use: Some water-scrubbing systems use a second tower to assist the release of CO_2 from the water before it is re-used. However, this has not been found necessary with the scrubbers in use in New Zealand – so long as the water reservoir is large enough to allow sufficient time for the water to have lost most of its CO_2 content before it is used again. An open 13.6 m^3 (3 000 gal) concrete tank is suitable in most cases. It should be painted on the inside with a water-based epoxy paint to prevent erosion by the acidic content (carbon dioxide) of the water.

Electrical wiring

The operations of the scrubber are controlled by the limit switches on the biogas storage bag, which control the motor that drives the compressor and water pump. However, a number of other switches must be 'on' for the scrubbing and compression operation to take place (this is shown schematically in Fig. 7).

The high-pressure cut-out switch prevents overfilling of the high-pressure storage cylinders and also limits the operating pressure of the compressor. A gas-release valve is required to allow biogas to escape from the storage bag when this switch is 'off'. The vent-cycle timer may shut

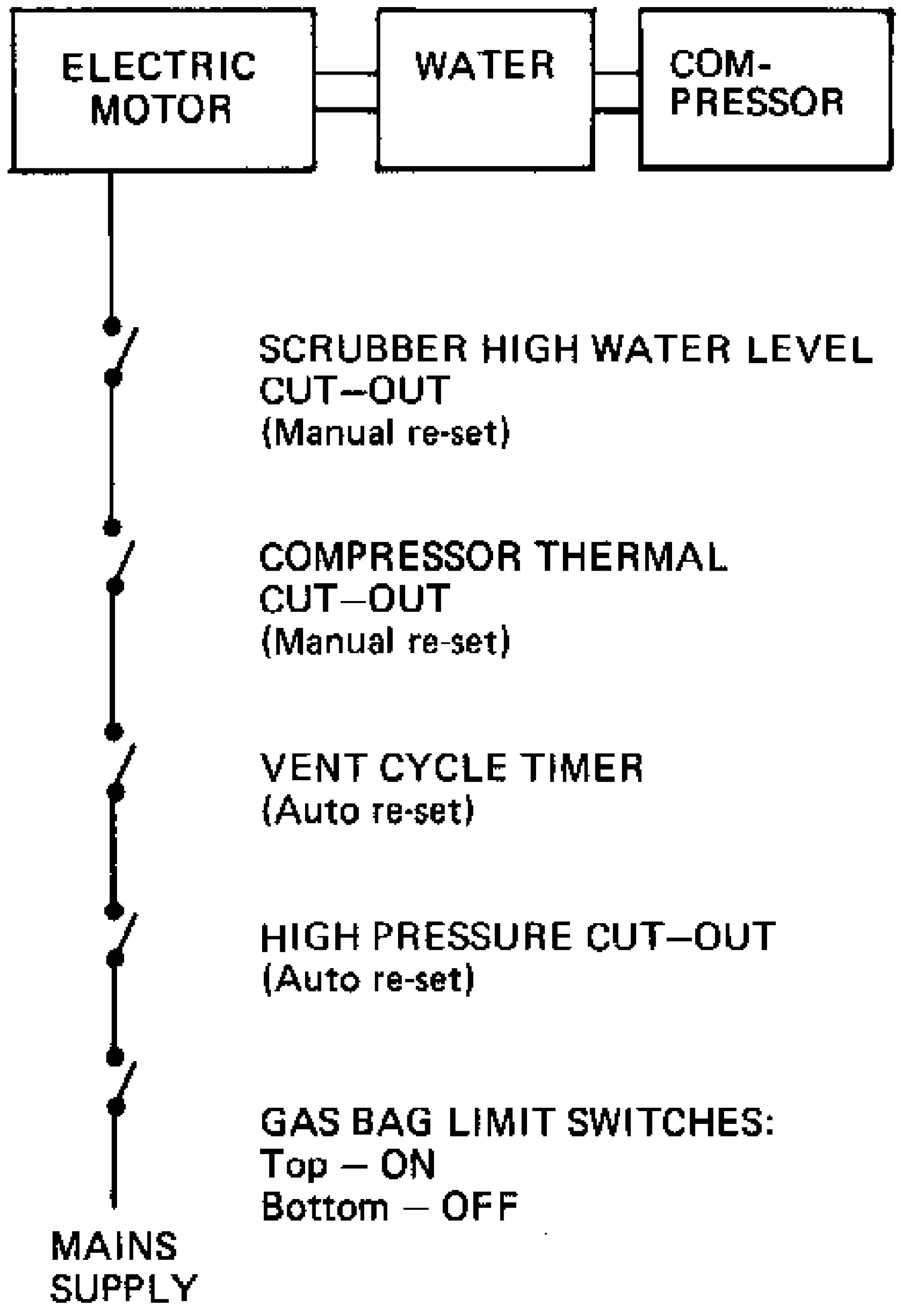

Fig. 6: Schematic electrical wiring of a scrubbing/compression system for biogas.

down the compressor for a short period to allow its normal shut-down bleed system to vent collected moisture and oil. Or, it may simply open the vent valve without stopping the compressor motor (if this valve is electrically operated).

The compressor thermal cut-out switch and the scrubber high-water-level switch are safety devices which must be re-set after the fault is corrected. When thrown to the 'off' position, they can also ring a warning bell to draw attention to the fault.

Insulation

In areas that are subject to freezing temperatures, it is essential to insulate any water pipes and valves that may freeze. Where extremely low temperatures are common this may necessitate locating the water pump, solenoid valve and even the bottom part of the scrubber tower, inside a building such as the biogas plant control shed.

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