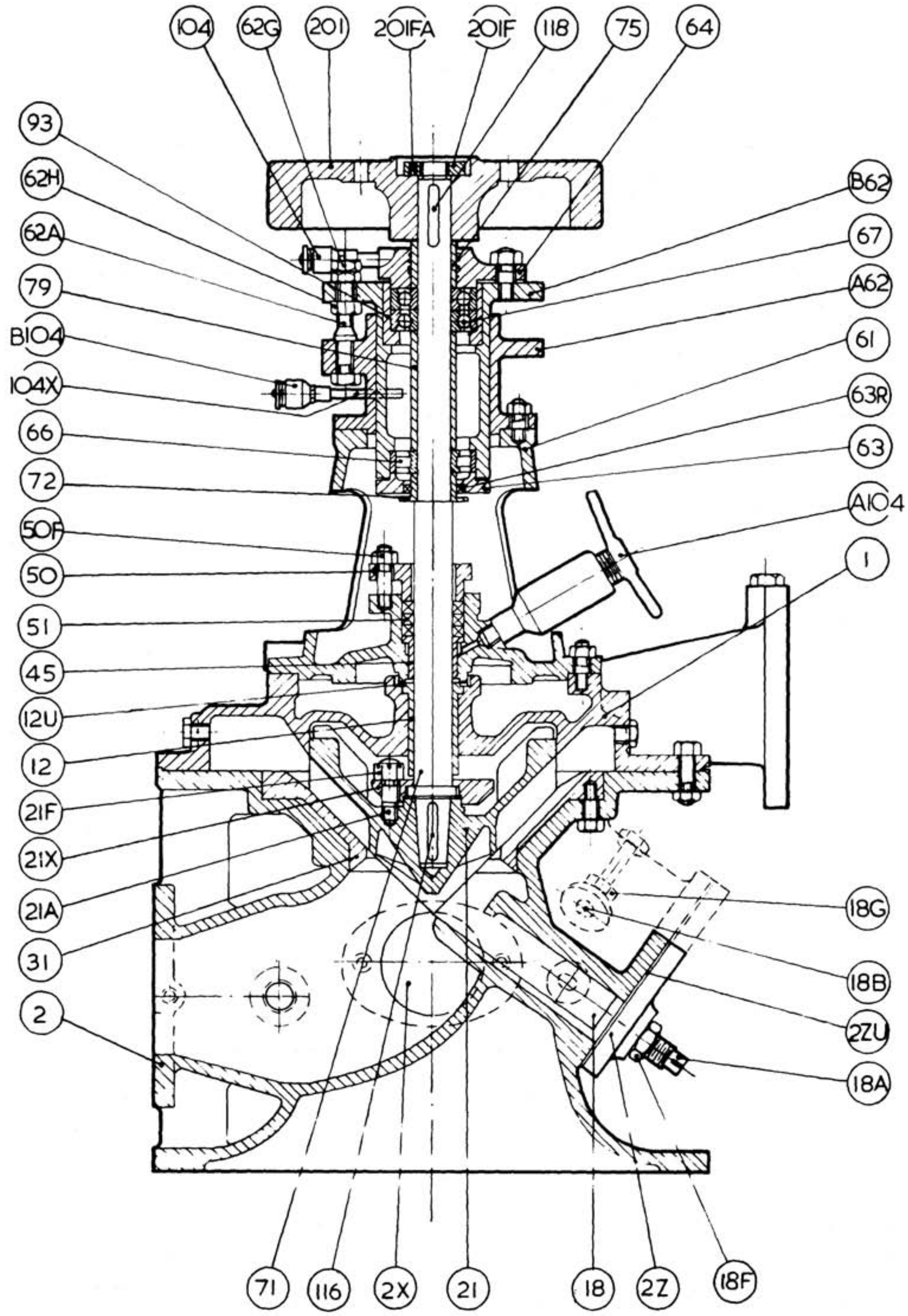

Fig. 14.1. *Disintegrating pump (by courtesy of Sigmund Pulsometer Pumps Ltd—see their Data Sheet No.* 43.7 *(V) for references).*

DISINTEGRATING PUMPS

Various forms of self-clearing centrifugal pumps are available in which a cutting knife (or knives) works in conjunction with the impeller. The unit acts as both a disintegrator and a pump. The manufacturers claim that in addition to faecal matter, these pumps will deal with rags, pieces of wood and other hard materials. A typical cross-section of one version of this pump is shown at Fig. 14.1.

This type of pump is suitable for isolated pumping stations or where screening at the inlet would not be convenient. It is particularly suitable for coastal towns when crude sewage is to be discharged direct to the sea. Where these pumps are

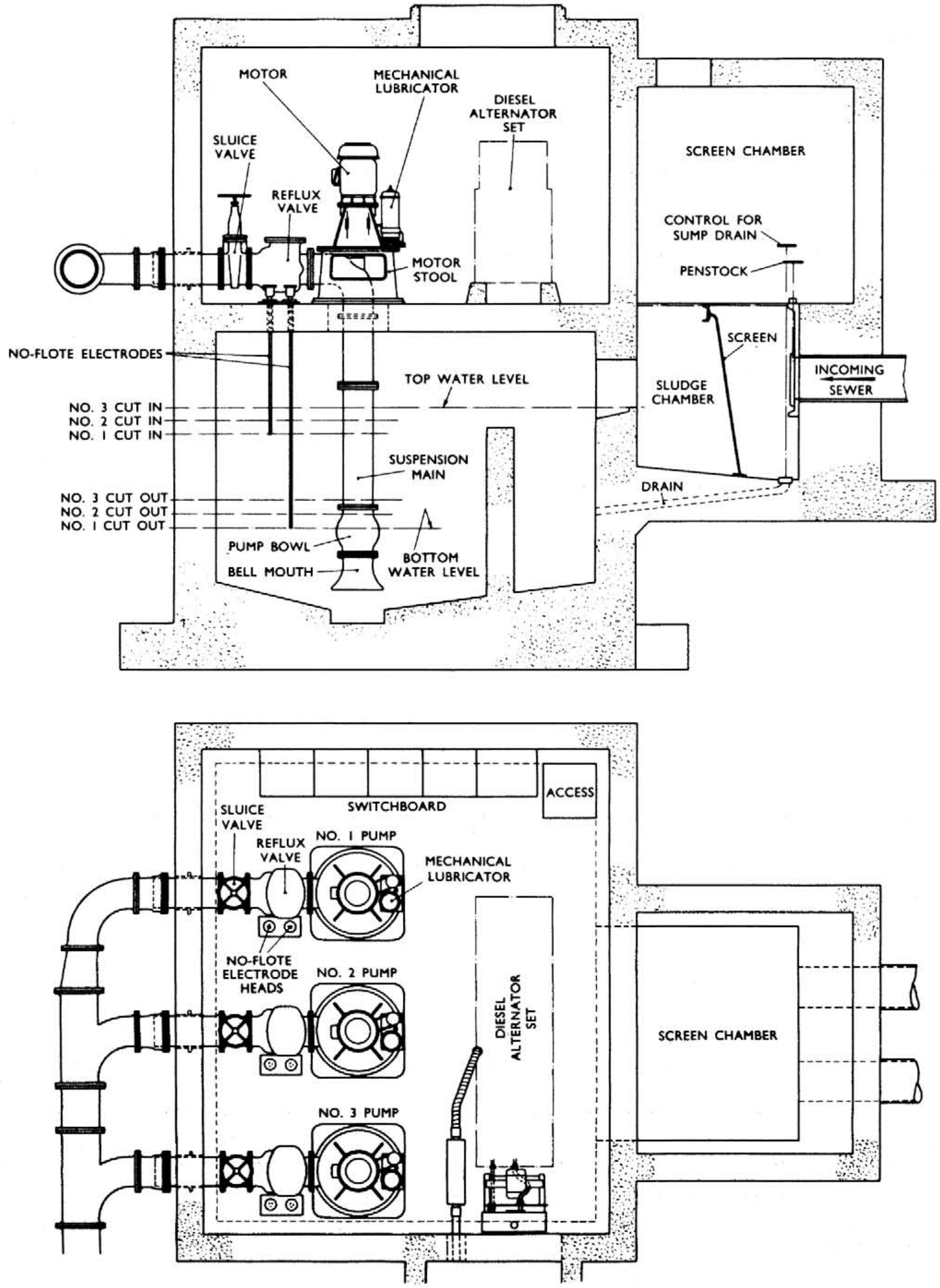

Fig. 14.2. *A typical extended spindle pumping installation with suspended mixed-flow bowl pumps (by courtesy of A.P.E.— Allen Ltd).*

installed on a 'combined' sewerage system, the wear due to the grit in the sewage may be high and the extra cost of overheads and servicing should be considered.

The efficiency of the disintegrating pump is good within its recommended ranges of capacities up to 500 m^3/h or over, and at heads of up to 30 or 40 m.

EXTENDED SPINDLE PUMPS

These pumps are used to some extent for pumping sewage as the omission of a separate dry well reduces the size and cost of a pumping station, while at the same time the installation of the pumps below liquid level ensures that they are always fully primed for automatic action. These pumps are normally of the mixed-flow type and are suitable for storm sewage duties,

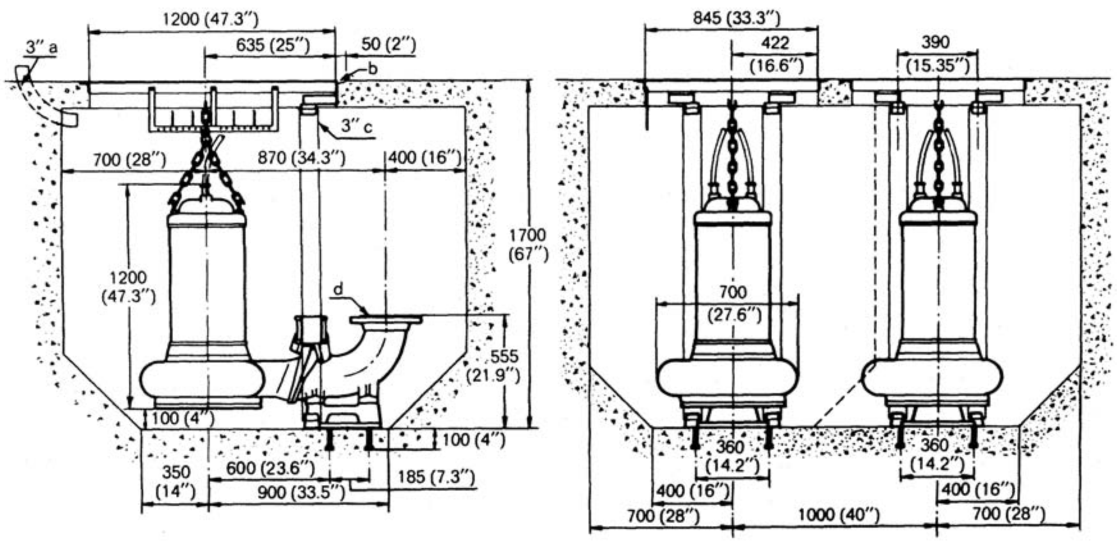

Fig. 14.3. *Submersible pumps, Minimum dimensions for an installation of two pumps, capacity of each up to* 600 *m*^{3}*/h (by courtesy of Flygt Pumps Ltd).*

when the pumps do not normally run for long periods and maintenance is therefore less frequent. Generally, they are more expensive than unchokable pumps installed in a conventional dry well, and maintenance is more difficult, as the unit must be completely withdrawn from the wet well before any work can be carried out. A typical layout of this type of pumping installation is illustrated in Fig. 14.2.

SUBMERSIBLE PUMPS

Completely submersible pump/motor units have now become very popular. There are two basic categories of pumps available, namely sewage and solids handling pumps or clean water pumps.

The sewage pumps are available either as transportable or permanently installed units and are capable of discharging up to 1400 litres/s and of achieving heads in excess of 50m. A typical installation is shown in Fig. 14.3.

The clean water pumps are used extensively on construction sites for general dewatering purposes. The advantages of this type of pump unit have been recognized and they are now being used for specialist applications throughout industry, e.g. fish farming, oil rigs, food industry, vegetable processing, etc.

In addition to these two main groups, developments have been made into specialist areas and pumps are now available, manufactured in stainless steel, for chemical applications. Units are also available certified for use in flammable atmospheres, thus making them suitable for use in coal mines, etc.

EJECTORS

Compressed-air ejectors are available for flows between about 3 m^3/h (0–001 cumec) and 30m^3/h (0.01 cumec) and can therefore be used to deal with isolated properties or with groups of up to 100 or more houses. Efficiencies may be as low as 20 % and are rarely over 50 %, but ejectors are very reliable, and as no sump or screens are needed they are often more suitable than small-capacity pumps for low flows. The actual rate of discharge is usually considerably greater than the nominal capacity of the ejector, and this should be taken into account when calculating the diameter of, and the velocity in, the rising main.

Compressed-air ejectors can be installed in a chamber built below the invert of the incoming sewer, and fed by gravity, or they can be of the ‘lift-and-force’ type, in which case the machinery is installed above ground level. An example of the latter type of installation is given in Fig. 14.4. Lift-and-force ejectors are more easily maintained, but there are situations in which a gravity-fed system may be preferable. Two small gravity-fed ejectors can be installed in an underground chamber about 2.5 by 2.0 m, while a larger pair would require about 3.0 by 2.5 m. A pair of small lift-and-force ejectors can be housed in a building about 3.0 by 3.0m by about 2.3 m high.

Compressed air can be provided by a compressor at each ejector station, or it is possible to arrange for a number of stations to be fed from a central compressor station. In the low-lying, flat district of Rangoon, Burma, twenty-two ejectors were commissioned in about 1890, all served from one central compressor station. Installations of that type are not common, and it

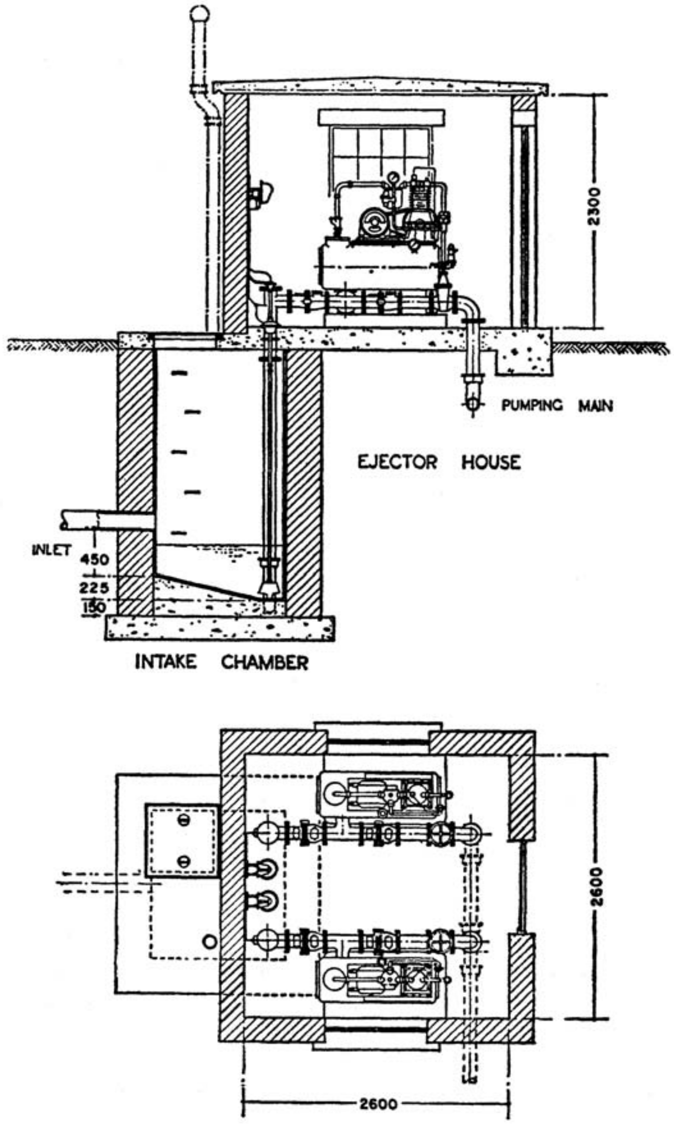

Fig. 14.4. *An ejector station (by courtesy of Tuke and Bell Ltd).*

is now more normal for each ejector station to be self-contained. Ejectors are usually installed in pairs, and where a breakdown would have serious results duplicate air compressors should be provided.

SPECIAL INSTALLATIONS FOR SMALL FLOWS

In more recent years other types of installation have been developed for pumping small quantities of unscreened sewage without the use of compressed air. These include the Sigmund Pulsometer 'Solids Diverter' (see Fig. 14.5) and the Mono 'Mutrator'. They are suitable for flows from about 2 to 55 m^3/h. The 'Solids Diverter' consists of a mild-steel sewage receiver, twin electrically driven pumps (one duty and one standby) and a system of non-return valves. As only the liquid part of the sewage passes through the pumps (the solids are diverted) the efficiency is relatively high (up to 60%); no further standby is necessary; and heads of up to 35m are acceptable. The 'Mutrator' includes a macerator for the solids, is self-priming, can be installed at ground level with a suction lift of between 4.5 and 6.0 m and can be used with a small bore rising main (see Fig. 14.6).

Taking 100mm as a minimum diameter for the rising main, and with a minimum velocity of 0.75 m/s, it will be apparent that the minimum pump output should be about 20 m^3/h.

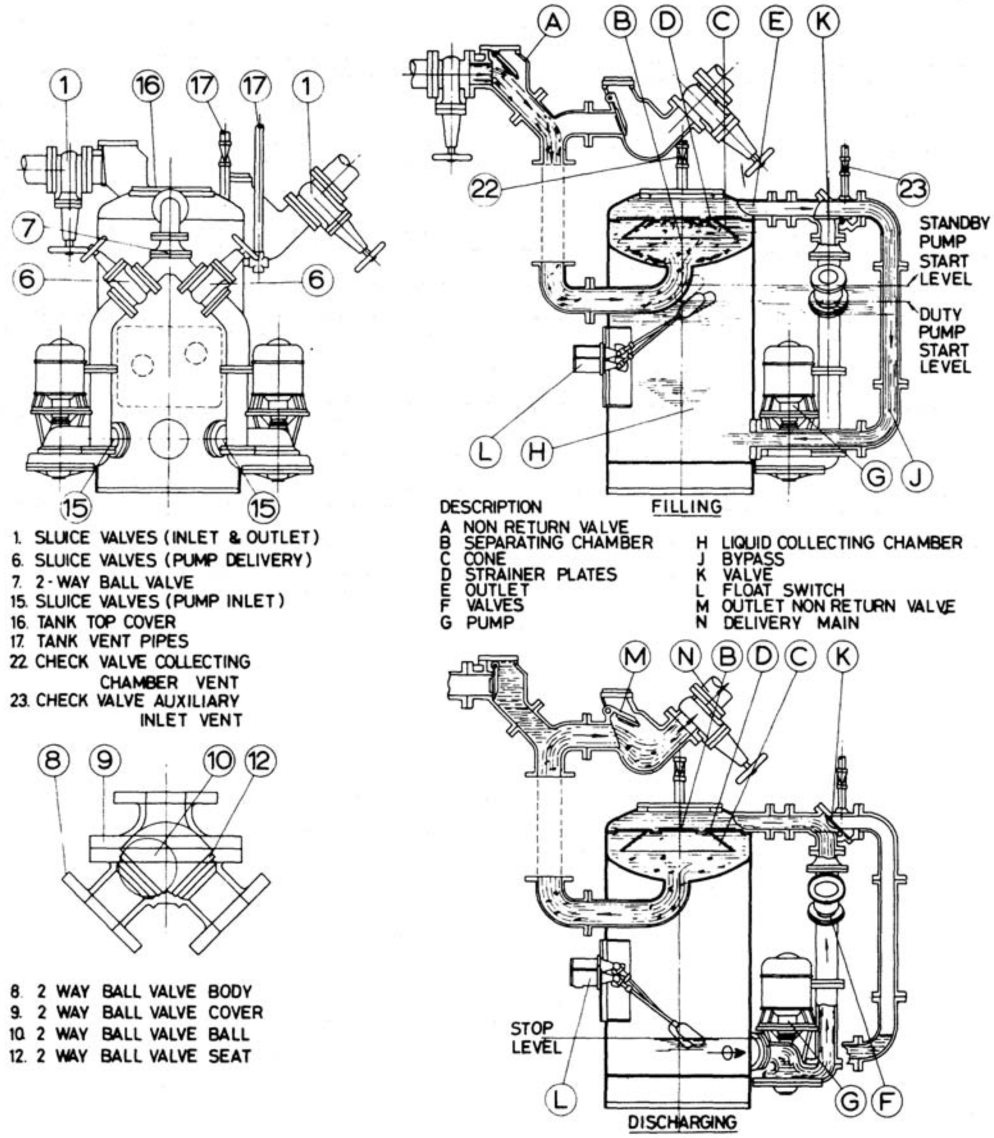

Fig. 14.5. *Solids diverter (by courtesy of Sigmund Pulsometer Pumps Ltd).*

SELF-CONTAINED 'PACKAGED' PUMPING STATIONS

A recent development intended for isolated housing estates and similar conditions, the self-contained packaged station houses the pumps and motors (with a wet well if required), together with all valves and switchgear in one factory-built unit. This type of unit can now be supplied by a number of manufacturers, and is suitable for flows up to about 200 m^3/h. One type of packaged unit is illustrated in Fig. 14.7.

SCREW PUMPS

Screw pumps have been developed during recent years for lifting liquids through heads up to about 10m (see Fig. 14.8). They are a modern development of the Archimedes screw, rotating slowly in an inclined trough. Screw pumps are available with capacities up to 25 000 m^3/h, and are claimed to have efficiencies of between 65 % and 70 %.

The design of this type of pump makes it completely unchokable, and the manufacturers claim that the screw action and the low speed (between 20 and 90 revolutions per minute), are ideal for lifting activated sludge, as the floc is not damaged. Screw pumps are available for a wide range of flows, and can be used for pumping both crude sewage and storm water.

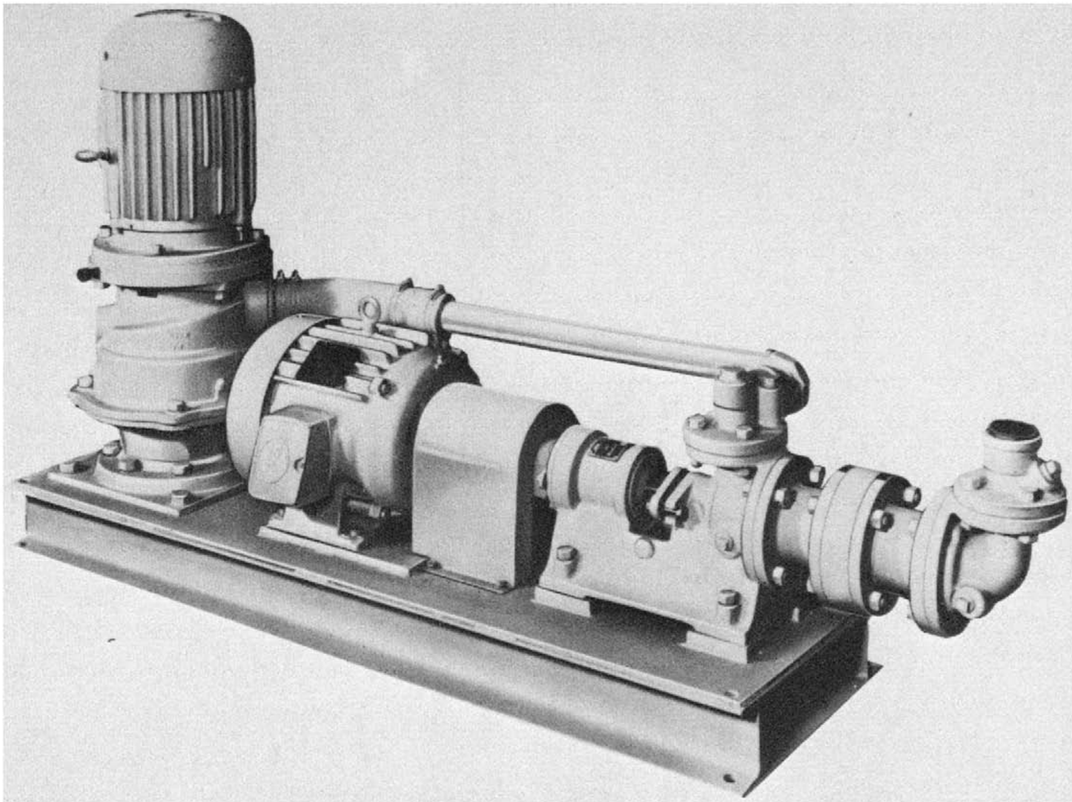

Fig. 14.6. *The mono mutrator (by courtesy of Mono Pumps Engineering Ltd).*

A *Handbuch der Wasserforderschnecken,* by Messrs. Ritz-Pumpenfabrik OHG of West Germany (associated with New Haden Pumps Ltd) contains very full details on the design and installation of these pumps.

PUMP CAPACITIES

The pumps in a sewage pumping station must be suitable for a wide range of flows, from low (night) flows to peak daytime flows. If the sewage is stored in the pump well for long periods of time it will turn septic, resulting in the generation of hydrogen sulphide, with its objectionable smell, and making the sewage difficult to treat at the works. Except in small installations, it is therefore usual to install more than one duty pump, so that one pump will deal with low flows and further pumps will come into operation as the flow increases. If the rising main will discharge at or near the treatment works, special consideration must be given to the effect of pumped flows on the operation of the works. Pump capacities should be chosen to even out the surges as far as possible. The use of variable-speed motors will overcome surge problems to a great extent, but they are, of course, more expensive and more complicated to maintain than single-speed motors.

Some designers prefer to have several sizes of pump to cater for variations in flow, with each pump cutting out in succession as the next larger pump starts up. This is not generally considered good practice, and, as each motor must be electrically interconnected, a fault in the relay system could result in the whole station being out of action. It is better to have only one (or at the most two) sizes of pump in a station. In this way, the ‘duty pump’ can be changed regularly to avoid excessive wear on one pump, spares are more easily available, and the wet well and rising main can be designed more accurately.

To be truly interchangeable, the pumps and motors should be similar in all details, including the ‘hand’ of the pump. A pump is ‘left-hand’ when the direction of rotation is anti-clockwise when viewed from the inlet branch (i.e. when viewed from *below* if a vertical-spindle pump). Right-hand pumps are available, but are not so common.

Standby pumping capacity must always be provided. A small station will have one duty pump and one standby, while larger stations must have sufficient installed capacity to cope with the flow if one of the larger pumps is out of action.

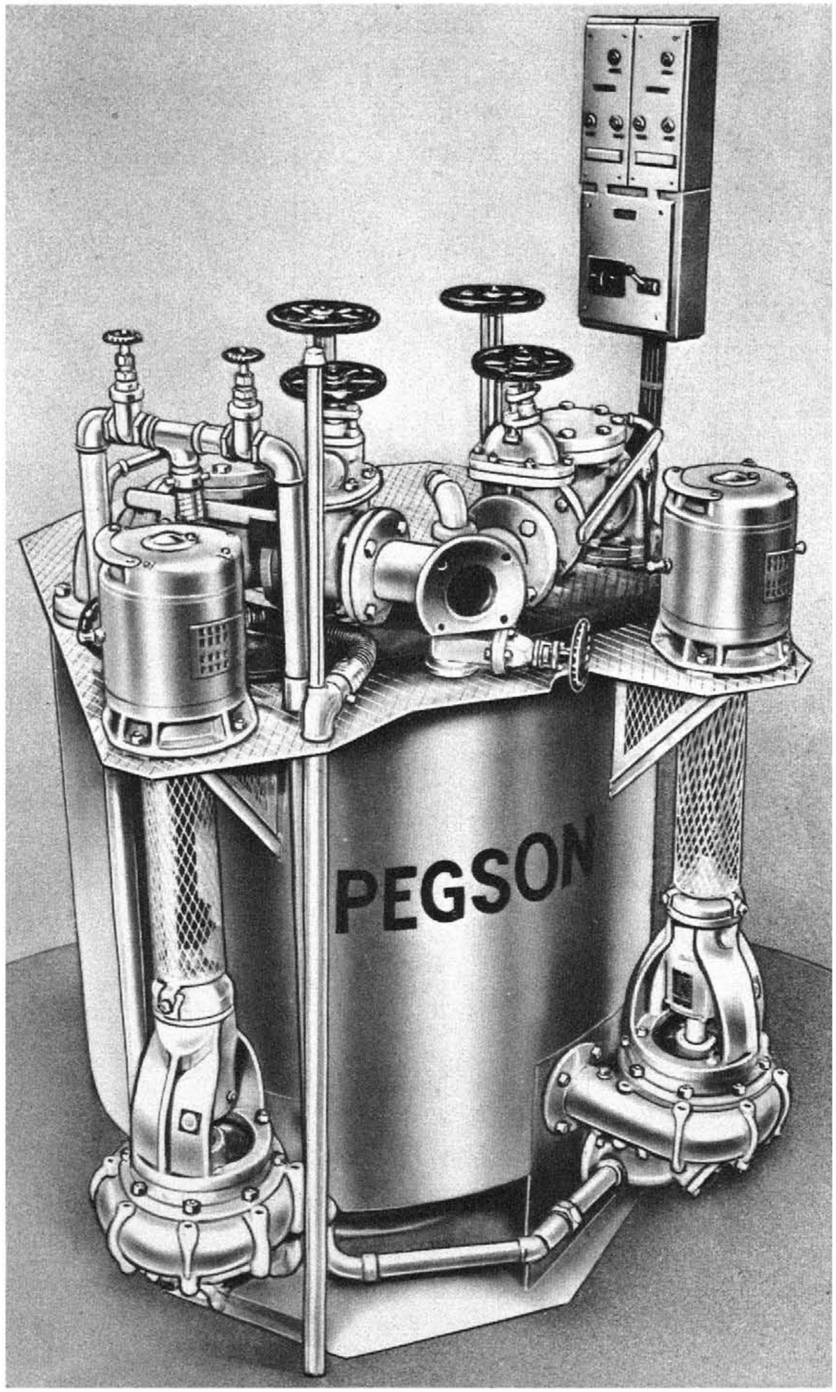

Fig. 14.7. *A packaged-type pumping unit (by courtesy of Pegson Ltd).*

CALCULATIONS

Although the sewers of a 'separate' system may occasionally be designed for a maximum flow of 4 d.w.f., it is usual to install pumping capacity for up to about 6 d.w.f. If it is intended to install two sizes of pump, and the d.w.f. is, say, 0.125 cumec (450 m^3/h), the pump duties could then be divided as follows:

One pump type 'A'	500m^3/h	1.1 d.w.f.
Two pumps together (type 'A')	950m^3/h	2.1 d.w.f.
Three pumps together (type 'A')	1350m^3/h	3.0 d.w.f.
One pump type 'B'	1 600m^3/h	3.6 d.w.f.

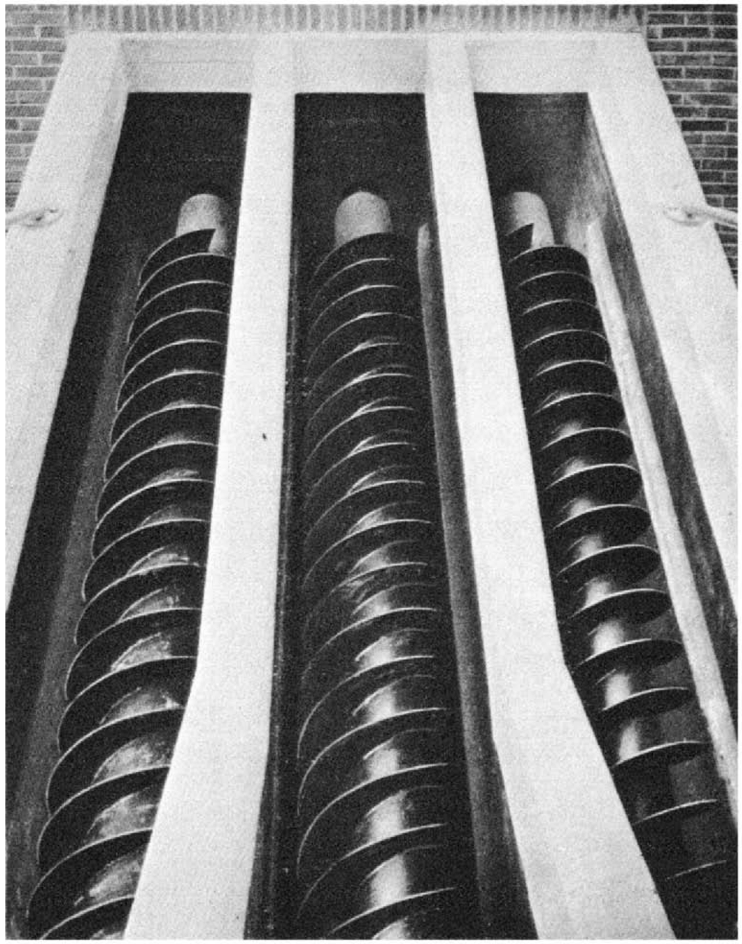

Fig. 14.8. *Screw pumps (by courtesy of Simon-Hartley Ltd).*

Two pumps together (type 'B')	2800m^3/h	6.2 d.w.f.

It is well known that the maximum load on the motor starters (in terms of the number of starts per hour) occurs when the inflow to the station is 50 % of the outflow. It can be shown that under those conditions:

$$Q = \frac{D \times t}{240}$$ **Formula 14.2**

where

Q is the storage capacity in m^3

D is the discharge in m^3/h

t is the total time in minutes to empty and refill the sump

If the starter capacity is limited to 15 starts per hour (BSS 587, 'lntermittent Duty'), then t must be not less than 4 min, so that:

$$Q = \frac{D}{60}$$ **Formula 14.3**

As D is the discharge per hour, the suction well must then have a capacity of at least 1 min discharge of the pump, the capacity being measured between the cut-in and cut-out levels of each individual pump. The length of the sump will normally be fixed by the plant layout, and as the depth of liquid between cut-in and cut-out levels of each pump should normally be between 450 and 600 mm, it is then comparatively simple to calculate the required width of the wet well. While the design of the pumping station is usually based on the use of 'intermittent duty' starters, many engineers allow a further factor of safety by specifying 'frequent duty' starters, suitable for up to 40 starts per hour.

Having established suitable pump outputs for the particular installation, the rising main should then be designed so that pumps of high efficiency can be chosen for the total head (static lift plus friction head), and so that the velocity in the main and the total head on the pumps are kept within accepted limits (see Chapter 15). The maximum possible static lift will be the suction lift from the lowest water level, plus the delivery head to the highest point of discharge. It may, however, be preferable to design the pumps so that their maximum efficiency occurs at a head less than this. The suction lift itself should be considered to avoid cavitation caused by the vaporizing of the liquid under partial vacuum when pumping against an excessive suction head.

When the output and total manometric head have been calculated, the pump power expressed in kilowatts can be found from the following formula:

$$P = \frac{Q + H}{3{\cdot}67\, r}\,\text{kW}$$ **Formula 14.4**

where

Q is the output in m^3/h

His the total manometric head in metres

r is the efficiency expressed as percentage

If the total head on one of the type ‘A’ (500 m^3/h) pumps referred to above is 21 -4 m and the pump efficiency is 40 %, then the power of the required pump is:

$$P = \frac{500 \times 21{\cdot}4}{3{\cdot}67 \times 40}\,\text{kW}$$

$$= 73\,\text{kW}$$

To calculate the required size of motor, further allowance must then be made for the efficiency of the motor. If this is, say, 85% in the above example, then the motor power must be:

$$73 \times \frac{100}{85} = 86\,\text{kW}$$

MOTORS

While pumps may be driven by petrol motors, or oil and gas engines, the most usual prime mover for a sewage pump is the electric motor. Those used to drive vertical spindle pumps in the conventional station with wet and dry wells are normally of the ‘drip-proof’ type, although in some installations it may be preferable to use the more expensive ‘totally enclosed’ motors.

Most sewage pumps are driven by fixed-speed motors, although variable-speed motors may be used for special conditions. When the electricity supply is alternating current, motors may be either of the squirrel-cage or the slip-ring type.

Squirrel-cage motors are cheaper and are usually satisfactory in small installations and when a high starting current is acceptable. For direct-on-line starting, this current may be up to six times the full load current; this will be less with star-delta or auto-transformer starters.

Slip-ring motors, with stator-rotor starters, take about 1.25 times full load current for starting. Most electricity charges are now based on a kW charge for current used, plus a kVA charge which takes into account the magnitude of the starting load, and for anything except very small installations the use of slip-ring motors and stator-rotor starters is fairly common.

In installations where a variable output is required, it is possible to install pumps with variable-pitch impellers, or the motors can be of the variable-speed type. The latter can be achieved with either a slip-ring motor with rotor-resistance control, or by using a commutator machine with an induction regulator.

The ‘power factor’ of the motors will depend on their power and the load, and may vary from about 65% to over 90%. These figures can be improved by using power-factor correction condensers. The capital cost of these condensers can often be recovered very quickly by the saving in kVA charges.

CONTROLS

Recommendations for standards of control gear are set out in BSCP 2005. As the majority of sewage pumping stations incorporate electric motors using 50 Hz, 3-phase, 415-volt, A.C. current, this is the only type of installation considered here.

It is usual to arrange for the automatic starting and stopping of pumps, either by floats or with floatless control gear (electrode or pneumatic), operated by the level of the sewage in the wet well, so that the higher the level of sewage in the well, the greater the pumping capacity in operation. To allow the ‘duty’ pump to be changed at regular intervals, it is normal