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PUMPING SYSTEM

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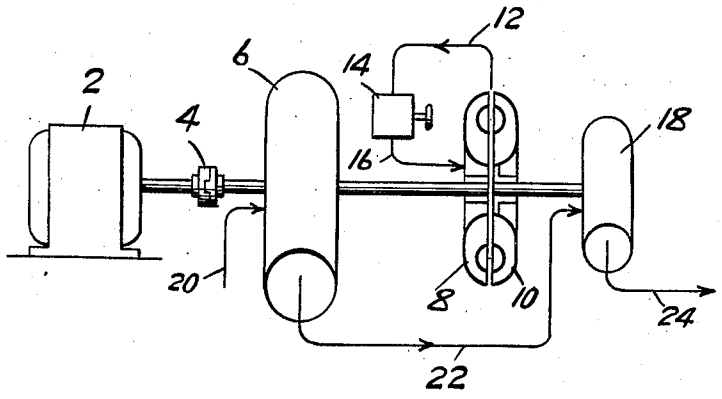


FIG. 1.

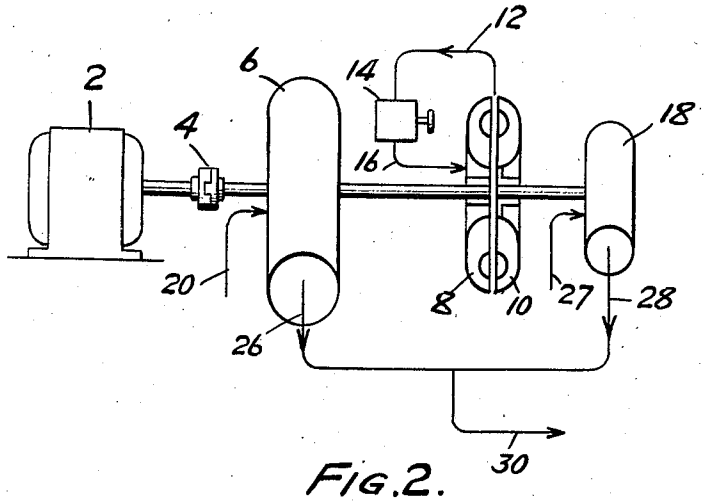


FIG. 2.

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PUMPING SYSTEM

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3 Claims. (Cl. 103—11)

This invention relates to a pumping system and has particular reference to the efficient operation of centrifugal pumps, blowers and compressors to supply varying demands.

When selecting pumping, compressor, or similar equipment, consideration must always be given to peak requirements; in other words, the unit or units must be large enough to take care of maximum demands. Under normal service conditions, therefore, operation takes place at reduced capacities and pressures. If the driver of a centrifugal pump or compressor, for example, is of a variable speed type such as a steam turbine, efficient operation will be realized not only at maximum demand, but also under normal operating conditions.

However, if the speed of the driver cannot be varied, such as in the case of certain kinds of electric motors, as those of synchronous type, reduced capacity and pressure can only be obtained in either of two fashions. The first is by throttling the delivery, which action generally results in a considerable waste of power. The alternative, which makes possible more efficient operation at partial capacities and pressures with constant speed drivers, involves the use of a variable speed coupling between the driver and the pump or compressor. Hydraulic couplings of the well known Fottinger type have been found particularly desirable in this use. However, other types of efficient variable speed couplings may also be used.

It is the object of the present invention to provide a more effective pumping system in which a constant speed driver such as a synchronous motor may be used to drive a pump to supply a variable demand. It will be understood hereafter that where reference is made to a centrifugal pump the term may be considered as including not only liquid pumps, but also pumps, blowers and compressors for elastic fluids, the invention being applicable generally to the delivery of fluids to supply variable demands by the use of apparatus the speed of which must be varied to suit the demand.

The above general object, and more specific objects of the invention, particularly relating to details, will be apparent from the following description, read in conjunction with the accompanying drawing, in which:

Figure 1 is a diagrammatic illustration of a pumping system in which a plurality of pumps are connected in series to provide successive stages for the handling of fluid; and

Figure 2 is a similar diagram but showing a plurality of pumps arranged in parallel.

Referring first particularly to the series arrangement of Figure 1, such an arrangement is particularly applicable in pumping plants in which the pressure requirements are such that multistage pumps are required. Such pumps have been provided either with all the impellers operating in series in one casing or having separate casings with one or more impellers in each casing, the pump casings being connected in series in order to obtain the required pressure.

Heretofore, a variable speed coupling has been applied between the electric motor and the single multistage pump or all of the pumps of a series providing a plurality of stages. What is proposed in accordance with the present invention is to apply the coupling in such fashion that part of the pumping unit operates at constant speed and another part at variable speed through the medium of a coupling such as a hydraulic coupling having an adjustable slip. This results in additional saving in power of considerable magnitude and also in reduced cost of coupling used; in other words, increased operating efficiency is obtained consistent with reduction in the original investment, which is an unusual condition, the opposite generally being true.

In the diagram of Figure 1, there is illustrated at 2 an electric motor which, for purposes of illustration, may be considered as of a synchronous, and accordingly constant speed, type. The invention, however, is applicable even in the case of variable speed motors such as induction motors, which operate most efficiently at some optimum speed and which involve considerable reduction of efficiency with drop of speed. If an induction motor is used, for example, it may be operated with a minimum of slip, even though the pumping requirements vary greatly.

The motor 2 is illustrated as connected through a fixed coupling 4 to a centrifugal pump 6 the shaft of which is in turn connected to the impeller member 8 of a hydraulic coupling, which may be, for example, of the Fottinger type. The runner member 10 of this coupling serves to drive a second pump 18.

The Fottinger coupling is well known, and its operation need be illustrated only diagrammatically. Essentially, this type of coupling involves continuous leakage of driving liquid through a passage such as 12 to a variable pumping means indicated at 14 by which it is returned through a passage 16 to the coupling. By so controlling the recirculation of the liquid, the

coupling may be operated containing varying quantities of liquid, with the result that the slip of the two parts may be very small, or may be quite large. These couplings will operate stably even if the runner operates at only about twenty per cent. of the impeller speed.

The supply of liquid to the pump 6 is indicated at 20. This first stage pump 6 delivers through a passage indicated at 22 to the second stage pump 18, which in turn delivers its liquid as indicated at 24.

The advantage of the arrangement illustrated in Figure 1 will be readily understood. The design of the arrangement will have to be such that, with the pump 18 operating at full speed and the pump 6 at its constant speed, the maximum demand will be met. The pump 18 in relationship to the pump 6 may also be such that with the pump 18 operating at minimum speed consistent with proper operation of the variable coupling the minimum demand will be supplied. Taking these two requirements into consideration, there can be arrived at the minimum size of the pump 18, from which will follow the proper size for the pump 6.

If this design is used, it will be obvious that both investment and operating advantages will be secured.

First, as contrasted with an installation in which a multiple stage pump or a plurality of pumps are all driven through a variable speed coupling, the coupling need not be sufficient in size to transmit the entire pumping power, but need only be sufficient to supply power to the small pump 18, which, as pointed out, need only be sufficient in size so that its variable speed will take care of the varying demand in efficient fashion. Usually, the pump 18 would not be required to be any larger than pump 6 and more generally it might be considerably smaller. Thus, the coupling used need only be of sufficient size to transmit one-half or less of the power delivered by the driver. Not only the coupling, but its auxiliaries as well, for example, the recirculating pump, will be reduced in size. Thus the investment may be cut to a fraction of that required in a coupling designed to transmit the entire required power.

Additionally, there is involved a very substantial saving in driving power. Any variable speed coupling of the hydraulic or any other type involves some power loss. The efficiency of a coupling is only slightly dependent on its size, and the entire power loss in the coupling is, therefore, substantially proportional to the power which it is required to transmit. Suppose, for example, that each pump in the illustration is developing the same pressure. With the coupling between the two pumps as illustrated, the coupling would only have to transmit one-half the power and would be subject, therefore, to only about one-half the loss as compared with a coupling which would be used to drive both stages. An example will best illustrate what the coupling between the pumps will accomplish. Assume a unit designed for a maximum demand of 11,100 gallons per minute against a 350 foot head. Normal requirements may call for operation at 325 foot head and a capacity range from 5550 to 11,800 gallons per minute. At maximum demand, the pumps require 1105 brake horse power and with the normal slip in the coupling its efficiency would be about ninety-six per cent., so that the output from the motor would have to be 1150 horse power corresponding to a loss in the coupling of 45 horse power if both pumps were driven through the coupling.

As contrasted with the above, and considering the same demands, if only one of two equal size pumps were driven through the coupling and the other driven directly by the motor, the loss would be only 22.5 horse power and the output required of the motor 1127.5 horse power. Furthermore, the coupling would have to transmit only 552.5 horse power as compared with 1105 horse power in the former case. The cost of a coupling and its auxiliaries is a function of the power required to be delivered and thus, it will be seen, that in the example just indicated the cost of the coupling would be materially reduced. It will be obvious that still greater saving in power and cost of the coupling would be accomplished by designing the pump which is driven through the coupling for less than one-half the maximum specified load. This could be done if the speed variation requirements of the smaller pump could be attained without great loss of efficiency.

It will be obvious that the invention may be embodied in various modifications. For example, the driving motor may well be between the constant speed pump and the combination of variable speed coupling and another pump. The variable speed pump may constitute the first rather than a last stage, or, if more than two stages are used, the variable speed pump may be any one of the pumps. In general, the arrangement will depend upon space requirements, etc., but it will be evident that because of the reduced size of the coupling reduction in the space required by the installation will generally result. In fact, by the use of a nested shafting arrangement, it is possible that impellers constituting different stages may be driven at different speeds, one constant and one variable, within the same casing.

Furthermore, either or both of a plurality of pumps provided in accordance with the present invention may of itself be a multiple stage pump.

Saving in power under certain operating conditions may be accomplished when two or more pumps are connected in parallel with one of the pumps driven at constant speed and the other at variable speed through a variable speed coupling. Such an arrangement is illustrated, for example, in Figure 2, in which the constant speed pump 6 and variable speed pump 18 are connected in parallel, as indicated by the passages 26 and 28 delivering to a common conduit 30.

It will be obvious that various other modifications of the invention may be adopted. In general it may be said that the invention is related to having the variable speed confined to a pumping unit which will be as small as possible so that the power to be transmitted through a variable speed coupling will be a minimum.

What I claim and desire to protect by Letters Patent is:

1. In combination, a motor of substantially constant speed type, a plurality of pumps arranged to supply conjointly a variable fluid demand, means connecting one of said pumps to the motor for substantially constant speed operation thereby, and means connecting another of said pumps to the motor to be driven thereby at variable speed, the last named means including a clutch of variable slip type.

2. In combination, a motor of substantially constant speed type, a plurality of pumps connected in series to supply a variable fluid demand, means connecting one of said pumps to the motor for substantially constant speed operation there-

by, and means connecting another of said pumps to the motor to be driven thereby at variable speed, the last named means including a clutch of variable slip type.

3. In combination, a motor of substantially constant speed type, a plurality of pumps connected in series to supply a variable fluid demand, means connecting one of said pumps to the motor for substantially constant speed operation thereby, and means connecting the last pump of the series to the motor to be driven thereby at variable speed, the last named means including a clutch of variable slip type.

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