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Electric Drilling

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Dear Sir: WATER PUMP

This summary report describes the work done under Work Order No. IV, Task Order No. CC, during the period from November 18, 1958, through February 17, 1959. Under this program, an experimental pumping device was evolved that was capable of delivering 120 cc of water per minute at a pressure of from 10 to 30 psi, and also of supplying 96 cc per minute when pumping against a pressure of over 200 psi. However, the further development of this design has been discontinued in favor of a pump based on a mechanism used in a commercial paint sprayer; this effort is being conducted under Task Order No. II.

During 1956 and 1957, three programs had been undertaken to conduct research directed toward the development, modification, and preparation of portable drilling kits with which an operator could drill small holes through 30 inches of masonry-type building materials. Under these programs, namely, Research Order No. 30, Task Order No. O, and Work Order No. XI, Task Order No. A, drilling kits had been developed that consisted essentially of a motorized hand drilling unit, a CO_2 cylinder, a water tank with a hand-operated air pump, a water-and-dust collector, selected drills, and a carrying case.

Although this equipment has proved to be very useful, drilling operations could be significantly improved if the quantity of

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water in the supply vessel were not limited to approximately one quart and if the operator did not have to pressurize the tank by manually working the pump. Further, the operations would be facilitated if the water from the drill could be returned to the supply vessel where it could be filtered and reused. These benefits could be derived if a simple, inexpensive, constant-displacement, electrically powered pumping device were available to feed water from the supply vessel to the electric hand drilling unit. A research investigation directed toward the development of an experimental pumping device of this general type was undertaken on November 18, 1958, under Work Order No. IV, Task Order No. CC.

Engineering Activity

The effort under this program was concerned with the investigation of various types of small pumps and motors, the design and fabrication of an experimental pumping device, and the performance of evaluation tests on the experimental unit.

Pump Investigation

Gear Pumps. As stated in our proposal dated September 26, 1958, we had anticipated that a gear pump could be used for this application, and had cited a similar application where a pump with stamped gears was being used to pump oil through the moving parts of a commercial sewing machine. Another reason for our interest in gear pumps was that they do not involve intake or exhaust valves, and, consequently, are relatively simple units.

The initial effort in this program consisted of contacting 12 commercial gear-pump manufacturers and discussing our pumping problem with them. The results of these telephone calls quickly showed that there was no small, lightweight commercial pump available for pumping the small quantities of water involved in the device of interest. However, we did locate one company, the Mechanical Products Corporation, Chicago, Illinois, that manufactured a relatively small metering pump for soft-drink-dispensing machines. This pump was fabricated entirely from stainless steel and was capable of pumping the small quantities of liquid involved.

We purchased one pump of this type and conducted a preliminary evaluation. The tests showed that this unit could pump 500 cc of water per minute against a pressure of 0 psi and 130 cc per minute against a 30-psi pressure. We also found that the cut-off pressure was 68 psi.

Since no small commercial gear pumps were available that were capable of pumping at a pressure of 200 psi, it was decided to design a small compact unit using commercially available gears. After completing our preliminary design and making preliminary calculations, we found that, although a small gear pump could be prepared, the amount of precision machining required in producing a unit of this small size would result in the unit being too expensive; in order to achieve a maximum pressure of 200 psi with a flow rate of 30 cc per minute, the leak-back rate would have to be very small and tolerances for close fits would be required in all of the pump parts. We also found that if a pump, manufactured to reasonable tolerances, were capable of handling 30 cc per minute at a pressure of 200 psi, the unit would have a capacity of approximately 600 cc per minute at 10 psi. This was considerably more than the desired capacity, and would have necessitated the incorporation of a metering-type valve for use in the lower pressure portions of the drilling operation.

Since our design calculations and preliminary evaluation effort showed that a gear pump was not feasible for the proposed application, it was decided to investigate other types of constant-displacement pumps. Our next choice was a diaphragm pump.

Diaphragm Pump. Although this type of pump required the use of inlet and exhaust valves, we felt that a diaphragm pump would probably be more satisfactory than a piston pump because no pistons or cylinders, which could be affected by wear or contamination, would be involved.

After studying the requirements as to size, displacement, and thickness of material which would be required in connection with the diaphragm, we decided to use a bellows type of diaphragm rather than a disk type, in order to keep the over-all size of the pump to a minimum. A small four-sectioned bellows, approximately 1-1/4 inches in diameter and 3/4 inch long, was procured for use in an experimental pump. A cam-driven mechanism was employed to drive the bellows, and a set of ball check valves was fabricated and incorporated in the experimental unit. Evaluation tests with this experimental diaphragm pump showed that the unit was capable of pumping against a pressure

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of 200 psi; however, the flow rate at these pressures was very low because the bellows deflected and reduced the effective displacement of the pump.

Because of these problems with the diaphragm pump, we decided that a piston pump should be investigated.

Piston Pump. In the design of the piston pump, two possible sources of difficulty were considered. The first was the problem associated with the operation of valves at high speed, and the second involved the excessive wear of the cylinder and/or piston as a result of contamination of the water. In order to handle these two problems, we decided to build a low-speed, large-displacement, short-stroking piston pump. Preliminary calculations were made and it appeared that a pump with a 7/8-inch bore and 1/8-inch stroke operating at a speed of 85 rpm would provide a unit in which the above-indicated problems would be minimized. By using an O-ring seal on the piston and allowing it to roll instead of slide during the short stroke, we felt that cylinder wear would be substantially eliminated.

In order to permit checking the calculations, we fabricated a piston pump using ball check valves for the inlet and outlet ports, and also the same cam-driving mechanism which had previously been employed in the diaphragm pump. A 1/15-horsepower variable-speed motor was connected to the experimental unit for the evaluation tests.

The preliminary evaluation results showed that the pump would probably deliver the amount of water required and would pump at a pressure in excess of 200 psi. However, we could not check the actual pumping rate and pressures at the design speed because the variable-drive unit on the motor did not operate over a wide enough range.

Motor Investigation

Since the objective of this program was to develop a complete pumping unit, a small motor had to be selected to drive the pump. As was stated in the proposal, an appropriate motor was a unit which was lightweight, quiet, and operable on standard house current.

A number of motor manufacturers were contacted to determine if there were any available motors that would meet the requirements. It was found that the Lamb Electric Company, Kent, Ohio, manufactured a small gearhead-type series-universal cash-register motor that weighed 1 pound 2 ounces; had a full-load output speed of 82 rpm; and operated on 115-volt a-c or d-c. One of these motors was purchased and connected to the experimental piston pump.

Evaluation of Experimental-Piston Pump

A number of pressure and flow measurements were made on the experimental piston pump. It was found that the unit was capable of supplying approximately 140 cc per minute at 10-psi pressure and approximately 105 cc per minute at 200-psi pressure. However, the flow measurements were not consistent, because the ball check valves did not operate properly.

In order to correct the valve problem, we purchased special small piston-type check valves and installed them in the experimental pump. It was subsequently found that the flow increased considerably; in order to reduce the output of the pump to the desired values, a Variac was connected to the input of the motor, to facilitate reducing the input voltage to approximately 60 volts. Although this reduction in the input voltage to the motor, decreased the noise level of the operating experimental unit, the noise was still considerably higher than that of the operating electric hand drilling unit.

Since it was desirable that the pump of interest operate quietly, a sound-silencing study was made on the experimental pumping device. The study showed that, by encasing the motor in a metal box and wrapping the outside of the box with approximately 1/2-inch-thick Fiberglas insulation, the sound level of the operating experimental pumping device could be reduced to a level below that of the operating electric hand drilling unit. We did, however, find that it was necessary to add cooling coils to the outside of the motor and thus provide for water cooling, in order to prevent the encased motor from overheating during operation.

Subsequently, the experimental piston-pump unit was transmitted to you for further evaluation.

Future Work

On February 17, 1959, a meeting was held with you to discuss the experimental piston-pump design. At that time, you brought with you a commercial paint sprayer which incorporated a small vibrator-powered piston pump. This pump had a bore of approximately 1/8 inch and a stroke of 3/32 inch, and preliminary tests showed that it was capable of supplying 120 cc of water against a 10-psi pressure and 96 cc of water against a 200-psi pressure. An added feature of this pump was that it involved only one valve; no inlet valve was used, and the exhaust valve was a self-cleaning disk-type unit. Since the size of this pump was considerably smaller than that of the above-described experimental device, you suggested that we consider the adaptation of this vibrator-driven pump to an electric-motor drive, in an additional program of research directed toward developing a suitable pump. Subsequently, this additional effort was initiated under Task Order No. II.

We would appreciate any comments that you or your associates might care to make with regard to the activity under Work Order No. IV.

Sincerely,

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In Triplicate