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METHODS OF REMOTELY REMOVING THE BED FROM A SAND FILTER

C. O. Thornburg

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Unit Operations Section

Methods of Remotely Removing the Bed From a Sand Filter

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ABSTRACT

Three methods of remotely removing a highly contaminated sand bed from an isolated sand radiochemical filter were developed and tested: a water eductor method, a pressurized vessel method, and a steam jet method. The latter method appeared most reliable and practical, and special attention was given to determining optimum conditions for bed removal using a steam jet.

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1.0 INTRODUCTION

The sand filter tests were conducted in order to determine the practicality of using a sand bed filter in a radiochemical processing plant. A sand filter appears to be an attractive method of clarifying radioactive process streams, and since the sand will become highly contaminated, methods of remotely removing the sand bed are necessary(1).

2.0 SUMMARY

The water eductor methods (with one exception) were found to be inoperative. Except that it requires a closed vessel that can withstand slight pressure, the pressurized vessel method was found to be quite practical, requiring only 35 sec and approximately 2.5 gal of water to remove a 10-in. deep Ottawa sand (20-30 mesh) bed from a 6-in. diameter filter (the volume of water given here and in the following data does not include the water remaining in the filter vessel after the sand is removed). Of the three methods tested, the use of a steam jet is probably the most reliable and practical. The best operating procedure for removing the sand bed from a 12-in. diameter filter (see Figure 3) using a steam jet (Penberthy XL-96, Model No. 2A, 3/4 in.) was found to be:

1. Set backwash (rotameter no. 1) at 5-6 gpm.
2. Inject water into the suction tube (rotameter no. 2) at 1.5 gpm.
3. After 10 sec, apply 35 psig steam pressure to the jet.
4. When the liquid level in the filter begins to drop (at approximately 0.007 fps) removal is complete.

This procedure required 2-3 min and approximately 15 gal of water.

3.0 THE WATER EDUCTOR METHOD

The water eductor method of removing the sand bed from a filter was found to be either inoperative or impractical; however, it is possible that a practical system could be developed by using much higher flow rates. The water eductor method consisted of fluidizing the sand out through a tube by means of a high velocity stream of water injected into the inlet of the tube(2). The two types of filters on which this method was tested are shown in Figures 1 and 2. This method was found to be completely inoperative when applied to the filter shown in Figure 1. The sand could be removed from the filter shown in Figure 2 only if tube K were withdrawn 2-4 in. from the opening of tube T. This process required a minimum of

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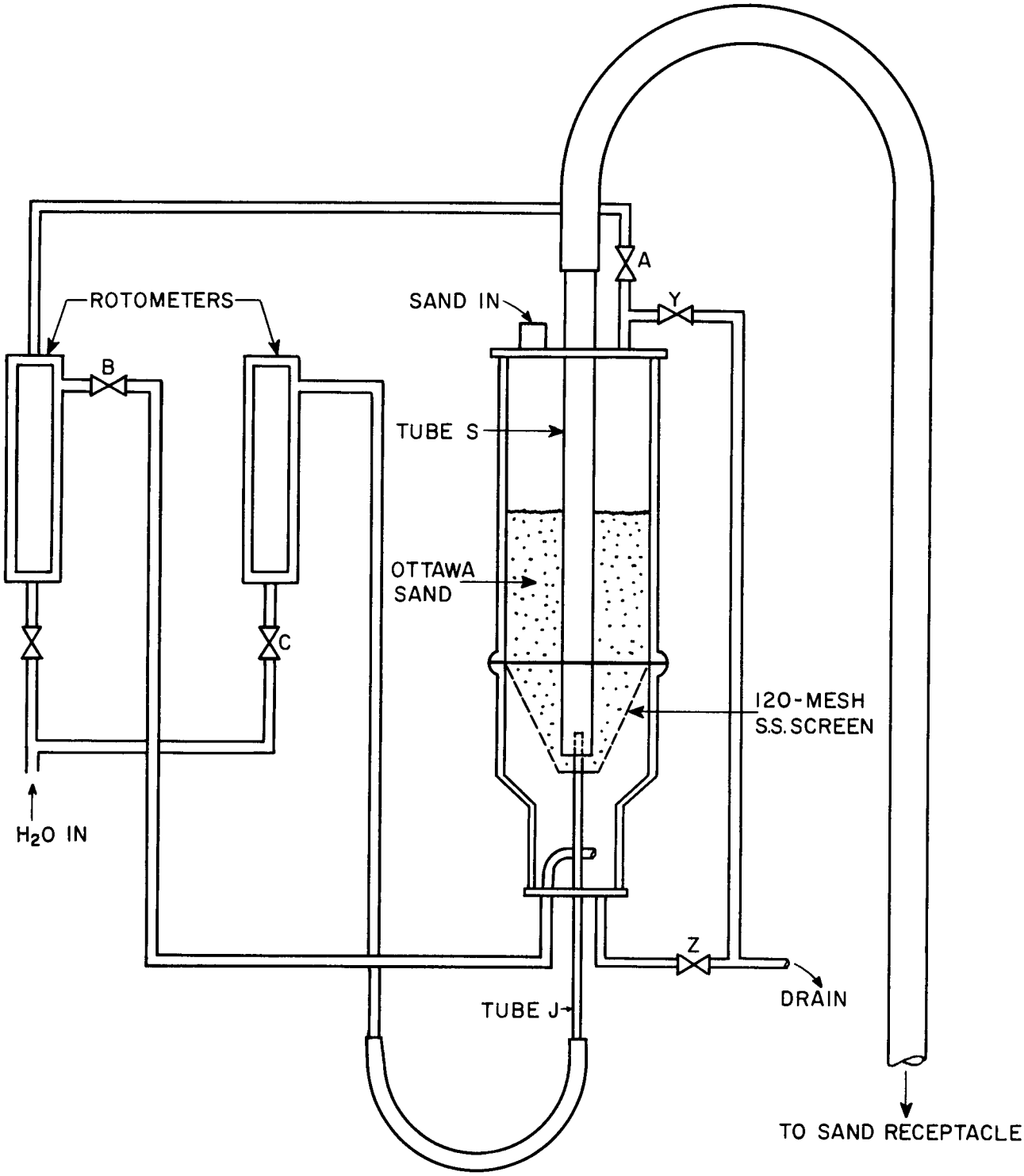

Fig. 1. The Apparatus for Testing the Conical-Screen Sand Filter.

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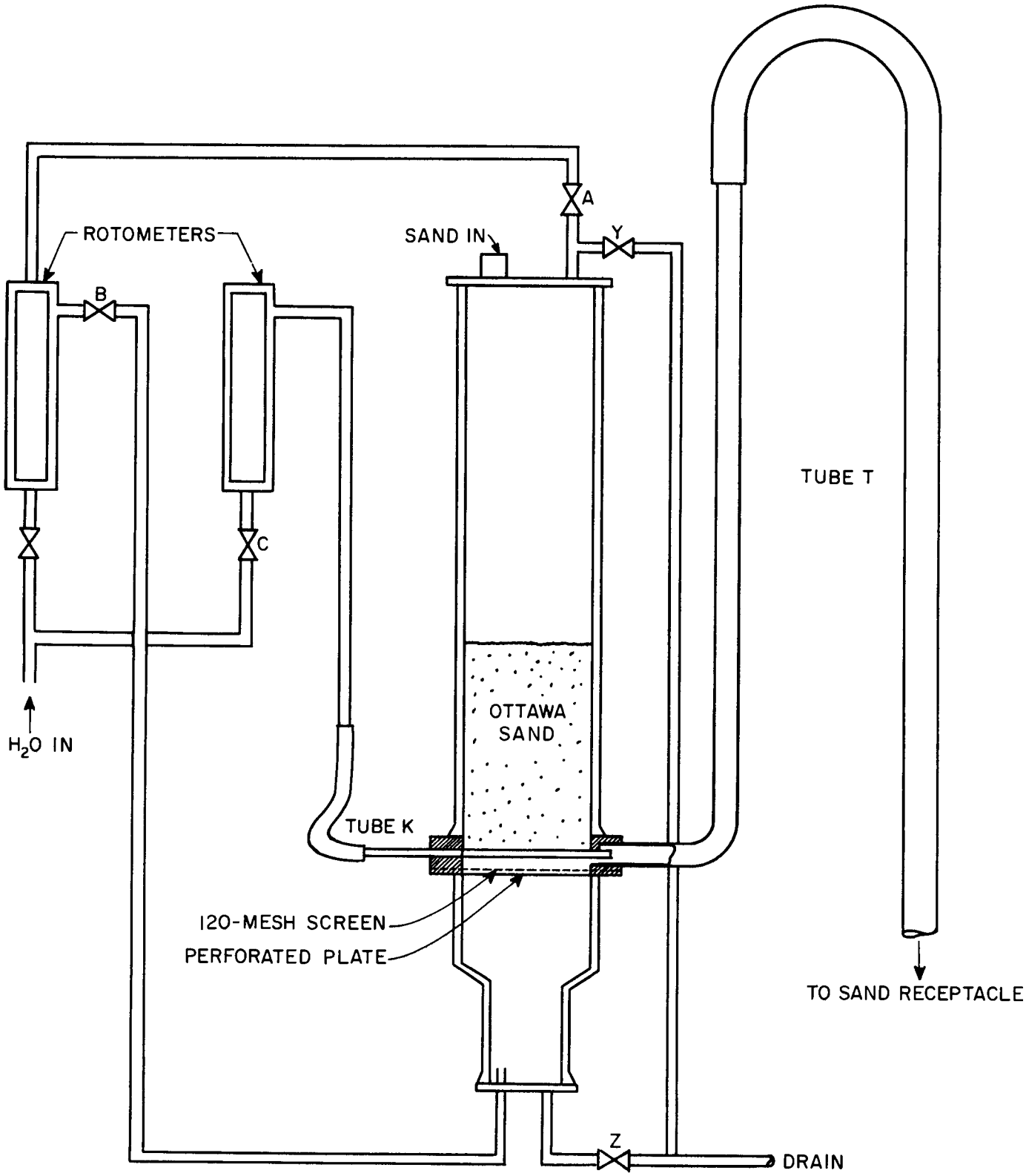

Fig. 2. The Apparatus for Testing the Flat-Screen, Side-Removal Sand Filter.

2 min and 25 gal of water to remove a 10-in. deep bed of Ottawa sand from a 6-in. diameter filter using a 3.42 gpm (0.04 fps) backwash and a flow rate of 9.6 gpm (2.8 fps) through tube K. For best results from a system of this type, the bed should be fluidized but not expanded, and the velocity of the water in tube K should be as high as possible. In no case could the sand be removed when tube K projected into the opening of tube T.

The water eductor method was inoperative except for the case cited, but even in that case it was impractical because of the large volume of water used. A 15 cu.in. heel of sand was left lying primarily against the side of the filter through which tube K enters; therefore, if the filter diameter were increased to 12 in., the heel would probably exceed the arbitrary limit of 10 per cent. If this method were used to remove the sand bed from a filter, the suggestions given in the preceding paragraph should be followed.

4.0 THE PRESSURIZED VESSEL METHOD

The pressurized vessel method of removing the sand bed from a filter was found to operate very well and required a minimum of water, but it has the disadvantage of requiring a closed vessel which can withstand slight pressure. This method consists of forcing the water-sand slurry out through a tube by means of pressure built up inside of the filter vessel by injecting water into the vessel which is closed except for the tube through which the sand is to be removed (tube S in Figure 1, for example). When this method was applied to the filter shown in Figure 1, the 6-10 in. deep bed of Ottawa sand was completely removed in 20 sec with about 1 gal of water when the water was introduced through valve A at approximately 3 gpm. A sand heel of approximately 5 cu. in. was left when the water was admitted through valve B. The removal of the 10-in.-deep bed of Ottawa sand from the filter shown in Figure 2 required 35 sec and approximately 2.5 gal of water leaving a sand heel of approximately 5 cu. in. when the water entered through valve C at approximately 4 gpm (tube K was withdrawn so that it did not project into the filter vessel); however, a sand heel of about 40 cu. in. was left when the water was admitted through valve A. The results obtained by applying this method to the filter shown in Figure 3 were similar to those obtained with the other filters. In all of the tests of this method, the pressure in the vessel did not exceed 5 psi.

This method of removing the sand can be made to require much less water than the other methods. Although little water is used in the method as described, this quantity could be decreased by filling the filter vessel with water to a depth of approximately 3 in. above the sand and using compressed air rather than water to force the water-sand slurry out through the tube. When using the pressurized vessel method, the water should be introduced into the filter in such a manner that it tends to wash the sand from the screen.

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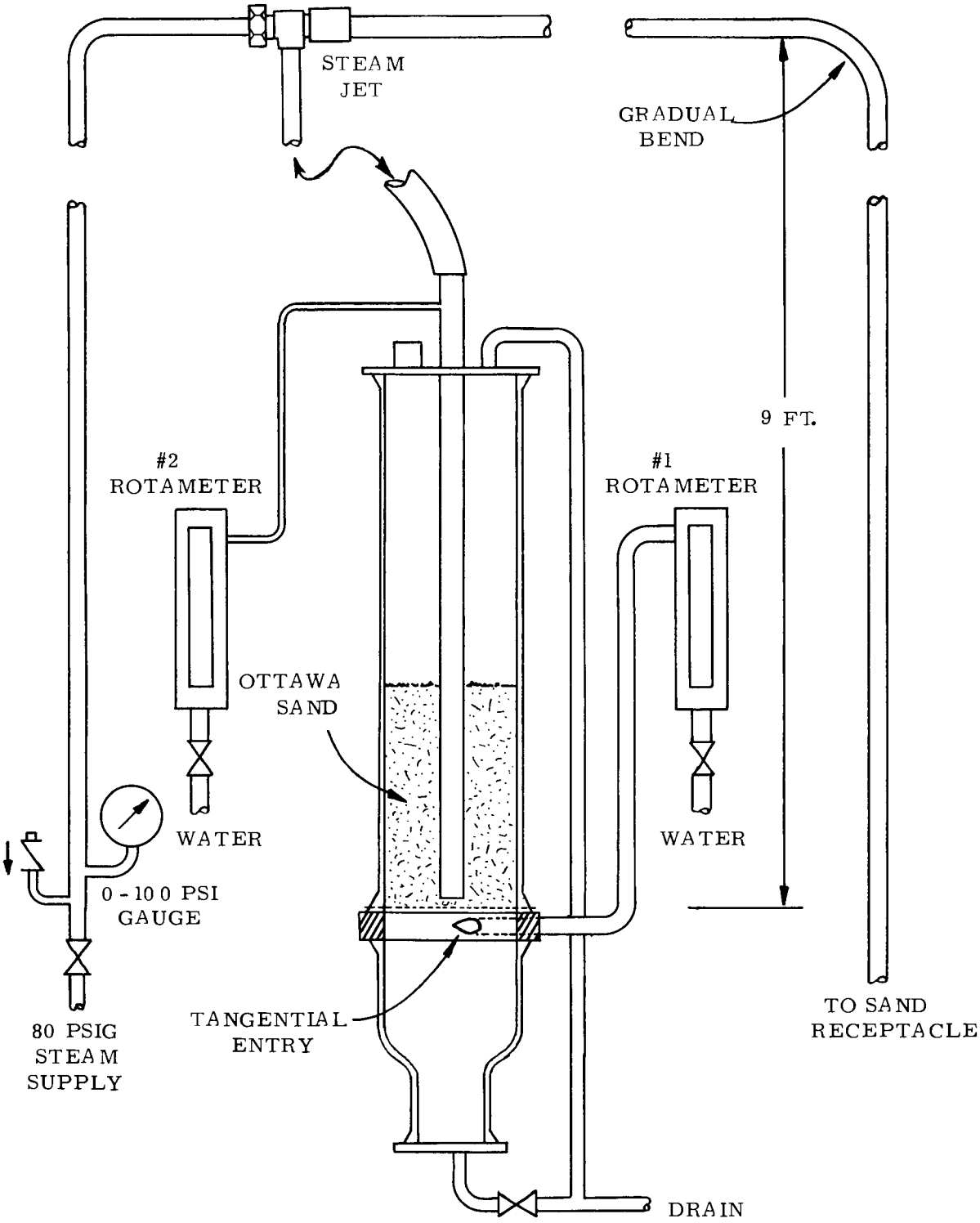

Fig. 3. Sand Removal by Means of a Steam Jet.

5.0 THE STEAM JET METHOD

The steam jet method of removing the bed from a sand filter is a practical and very reliable method. One big advantage of this method is that it does not require remotely operated valves in all process, service, and instrument lines into the filter as would be necessary with the pressurized vessel method. Such valves are expensive and subject to poor performance because of the high probability of sand lodging in seating surfaces. This method consists of pumping the water-sand slurry out of the filter by means of a steam jet. A Penberthy XL-96, Model No. 2A, 3/4 in. stainless steel jet pump was used in testing this method of sand removal. The steam jet method was first tested on the filter shown in Figure 2. The steam jet was installed 9 ft above the screen which supported the sand in the filter with the suction side of the jet connected to tube T. The process of removing the sand was intended to consist of (1) backwashing the bed and (2) passing steam through the jet to pump the water-sand slurry out into the sand receptacle. Upon trial this procedure proved inoperative. The constant sputtering, blowing of steam through the jet, and intermittent suction seemed to indicate that the steam jet was not receiving enough water. To remedy this, water was injected at 1.75 gpm into the tube connecting the filter to the suction side of the steam jet approximately 5 sec prior to, and during, the operation of the jet. When this procedure was followed, the 10-in. deep bed of sand was easily removed in approximately 35 sec leaving approximately 20 cu. in. of sand when no backwash was used and approximately 8 cu. in. when the bed was backwashed at 2.5 gpm (0.028 fps).

The injection of water into the suction tube makes the steam jet removal of the sand a very reliable method as is evidenced by 97 successful removals with no failures. After 20 cu. ft of sand had been transferred, there was no evidence of wear on the steam jet.

Good results were obtained by using the steam jet method with the filter shown in Figure 3. This design also appears attractive from the standpoint of symmetry and ease of construction. Of the variables to be determined, the steam pressure and the rate at which water is injected into the suction tube (i. e. the settling of rotameter no. 2) appear to be functions of the type and size of the steam jet and the size and length of the suction tube. In view of these considerations, a 6 in. diameter filter was used to determine these values. The data obtained for these variables are shown in Figures 4 and 5, respectively. The most efficient steam pressure was about 35 psi, and the most effective rate for injecting water into the suction tube was about 1.5 gpm. Water should be injected into the suction tube prior to jetting for such a length of time that the suction tube will be nearly full of water when the removal process is begun. For a flow rate of 1.5 gpm and the particular suction tube used (9 ft long and approximately 7/8 in. in diameter), this time was 10 sec. A 12.2-in.-diameter filter was used to determine the optimum distance from the suction tube to the screen supporting the sand. This information is plotted in Figure 6. Although this curve exhibits no minimum, this distance should

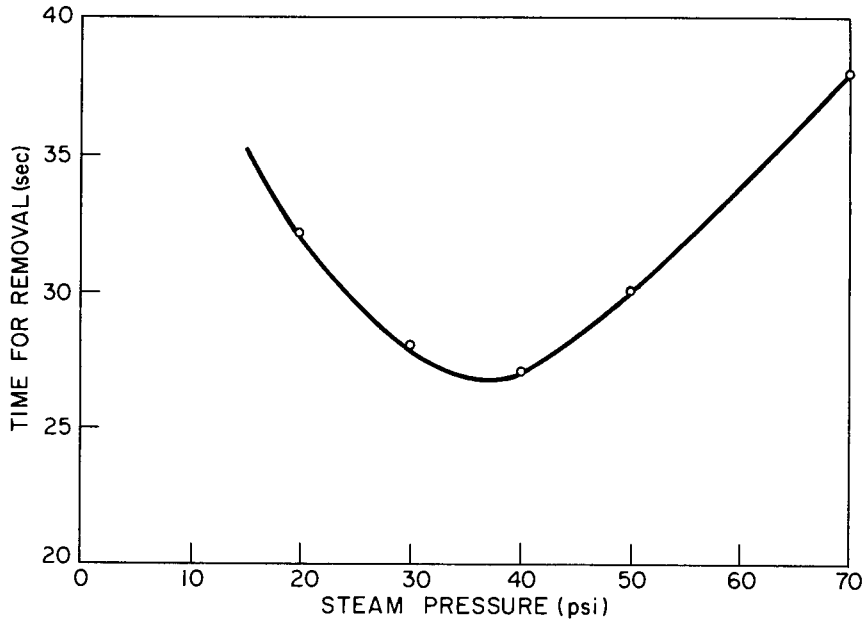

Fig. 4. Time Required for Sand to be Removed from 6-in.-dia Filter as a Function of Steam Pressure.

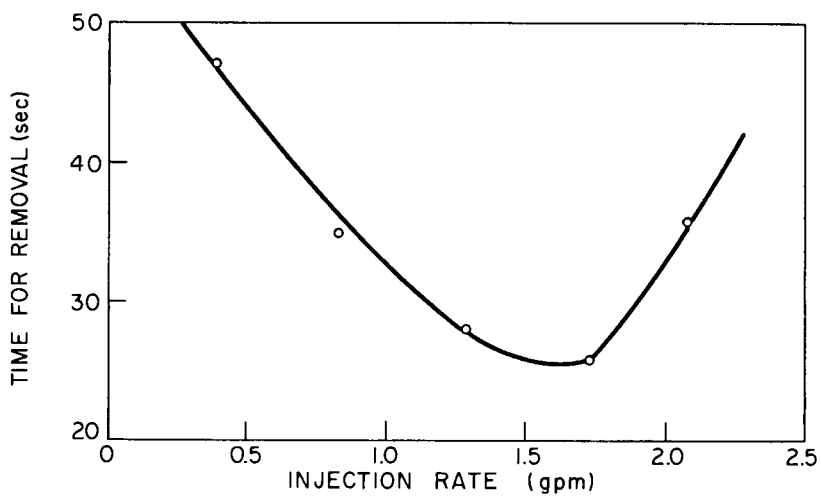

Fig. 5. Time Required for Sand to be Removed from the 6-in.-dia Filter as a Function of the Rate of Injection of Water into the Suction Tube.

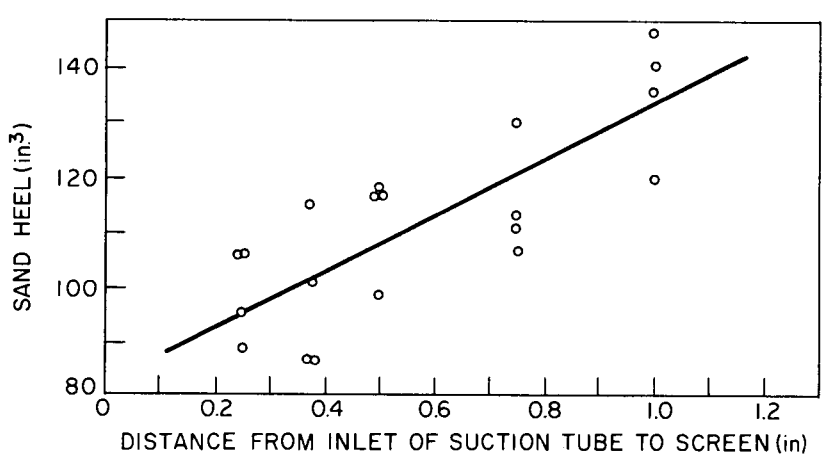

Fig. 6. Sand Heel as a Function of the Distance from the Suction Tube to the Screen in the 12.1-in-dia Filter

be 1/4 in. or more to prevent the steam jet from drawing water through the screen instead of removing the sand and also to reduce the danger of plugging.

Several factors enter into the determination of the optimum backwash rate. The most important of these factors is the quantity of sand that is left in the filter after the transfer (i. e., the sand heel). The data showing the relationship between the sand heel and the backwash rate are plotted in Figure 7. A 10-in.-deep bed of sand in a 12.2-in. diameter filter would have a total volume of 1160 cu. in.; therefore, all points of the curve (Figure 7) that lie below 116 cu. in. represent a sand removal of more than 90% of the total bed. Removal of at least 90% of the bed is a criterion that must be met before a method can be judged satisfactory. It can therefore be seen that the backwash rate must be greater than 4.25 gpm for a 12.2 in. filter. This is a linear velocity of 0.012 fps.

Another factor which determines the backwash rate pertains to the remote determination of when the sand has been removed from the filter vessel. The descent of the water level in the filter may be used to determine when all the sand (except the heel) has been removed from the filter. The principle used is that the steam jet pumps a water-sand slurry at a considerably slower rate than it pumps water; therefore, if the correct backwash rate is used, a slight amount of water will continue to flow out the overflow pipe, holding the water level constant during the removal process. As soon as the sand is removed, water is pumped through the jet at a considerably greater rate removing water from the filter vessel faster than it comes in thereby drawing the water level down. The falling water level, which may be remotely measured, indicates that the sand has been removed. The rate at which the water level descends is shown as a function of the backwash rate in Figure 8 (water was being injected into the suction tube at 1.5 gpm when these data were taken). From Figure 8 it can be seen that the backwash rate should be under 8 gpm in order to use this system to detect when the sand has been removed.

When all these data are considered, the optimum operating procedure may be outlined as follows:

1. Set backwash (rotameter no. 1) at 5-6 gpm.

2. Inject water into the suction tube (rotameter no. 2) at 1.5 gpm.

3. After 10 sec, apply 35 psig steam pressure to the jet.

4. When the liquid level in the filter begins to drop (at approximately 0.007 fps) removal is complete.

The reliability of the steam jet method is shown by the following ranges in which the system was found to operate:

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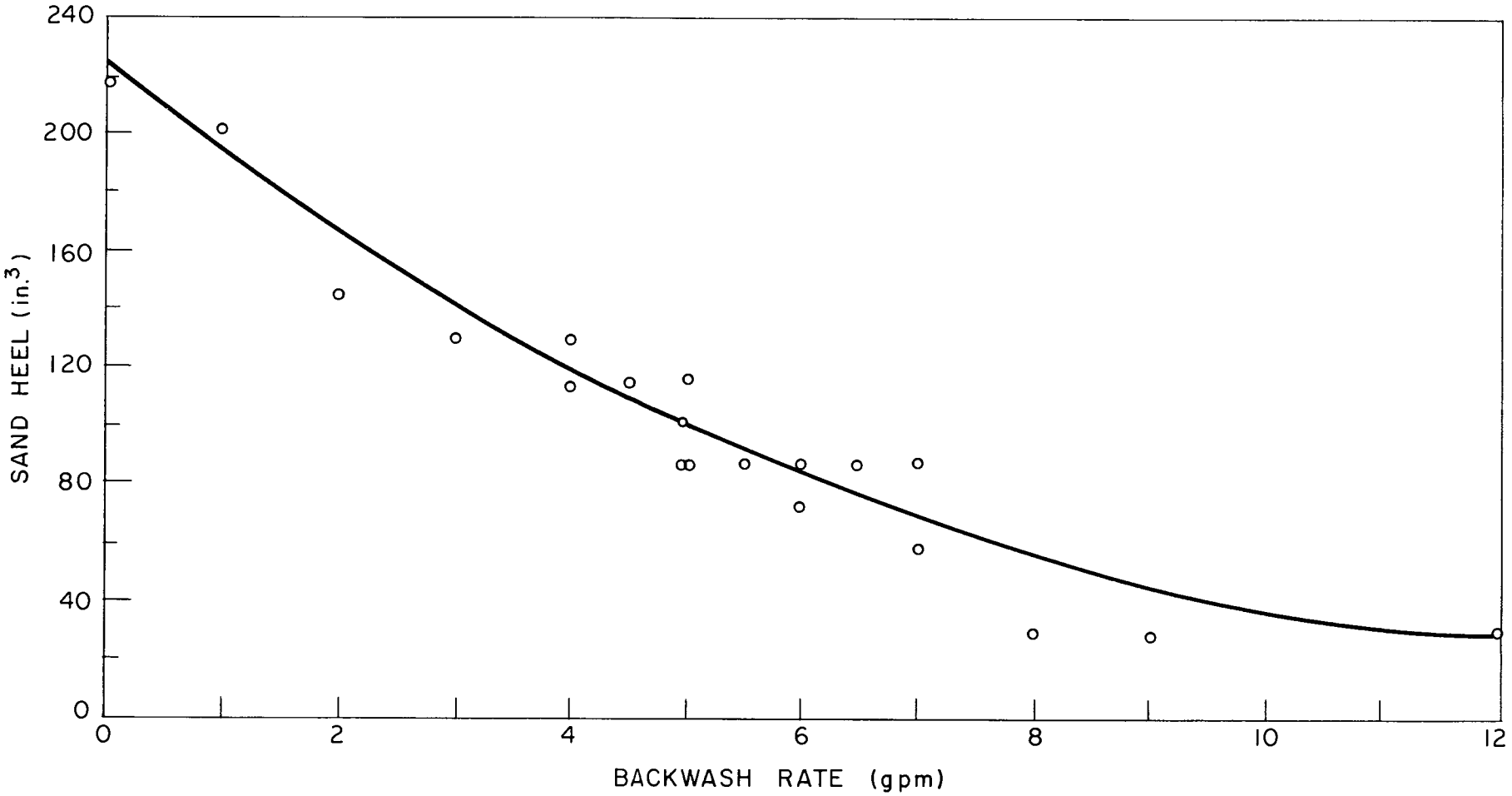

Fig. 7. Sand Heel as a Function of Backwash Rate in the 12.1-in-dia Filter.

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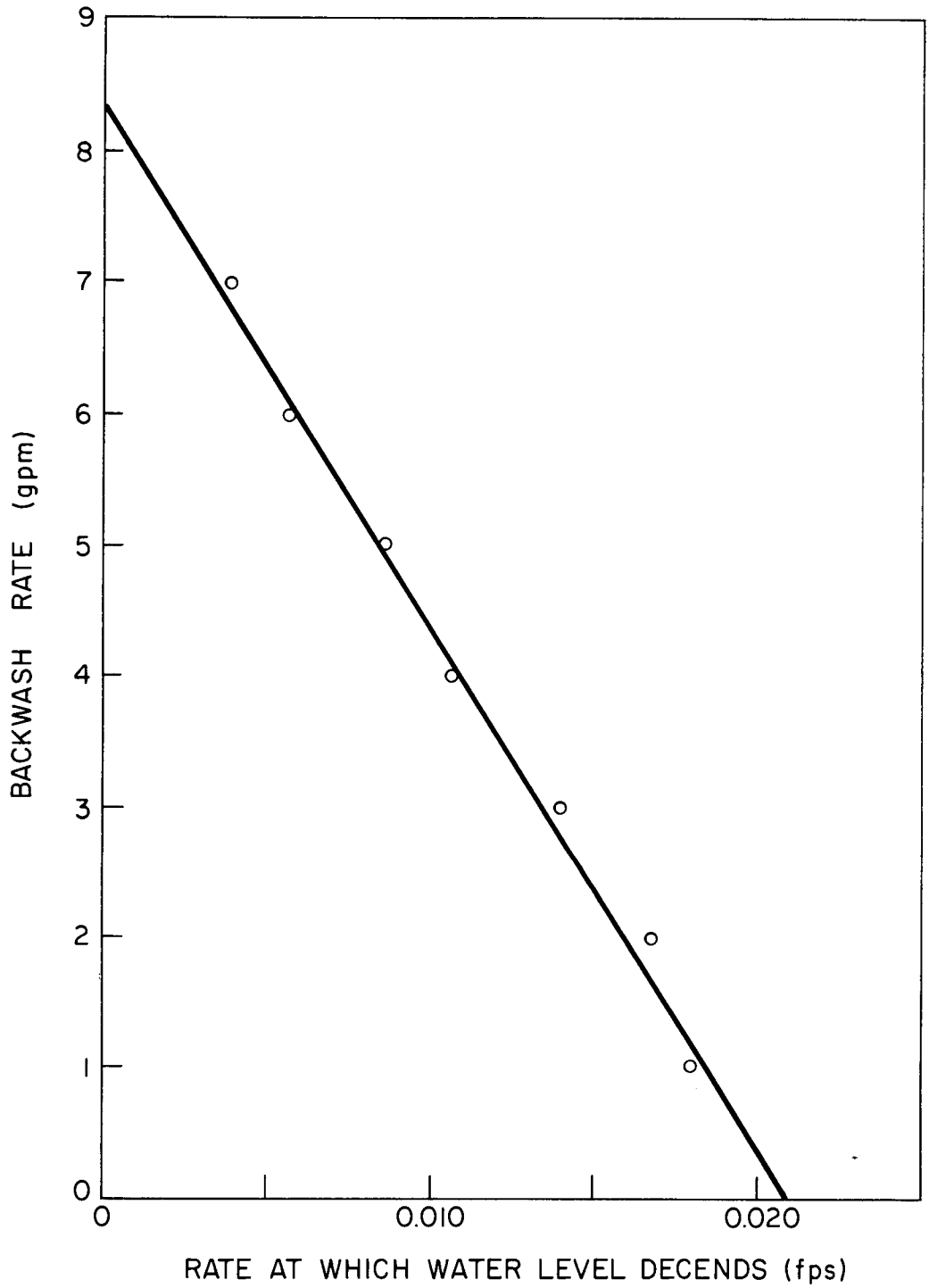

Fig. 8. Rate of Descent of Water Level in the 12.1-in-dia Filter Vessel (After the Sand is Removed) as a Function of Backwash Rate.

Backwash rate (rotameter no. 1)	0-15 gpm
Water injection rate (rotameter no. 2)	0.40-2 gpm
Steam pressure	20-70 psi
Distance from suction tube inlet to screen	1/4-3/4 in.

If it is desired that more than 90% of the sand be removed, the standard operating procedure should be followed except that when the liquid level begins to drop, the backwash rate should be increased to 10 gpm for 30 sec before shutting off the steam and water supply. This process leaves only 3% of the total sand bed as a heel. Water could be conserved in the steam jet method if the simultaneous backwash were omitted from all but the last 5 sec of the removal process. Of course, some other system of remotely detecting when the sand bed is removed would have to be devised. If a filter larger than 12 in. in diameter were required, an oval-shaped filter with 2 steam jets to remove the bed should be considered; even with relatively high backwash rates (0.03-0.045 fps) the sand heel was much thicker around the outer edge of the bed than near the center.

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