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A PIPE BEND FLOW METER FOR MEASURING THE FLOW OF WATER FROM A WELL

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PIPE BENDS AS FLOW METERS FOR WELLS

Proper management of any water resource requires that the quantity of water delivered by the system be known. The challenge is to utilize methods of measurement that are sufficiently accurate yet low enough in cost to permit installation of the required measuring devices.

The pipe-bend flow meter is both economical and accurate. Such a meter can be installed by placing a 90-degree elbow at the end of the discharge pipe of the pump. For free-flowing conditions, the pumping lift will be reduced by attaching a short vertical section of pipe to the elbow so that the water will be discharged at or near the water surface in the conveyance system. The reduction in pumping lift, which will result in lowered power costs, will pay for the installation of the elbow meter and pipe in a short period of time.

LOWERING THE DISCHARGE OUTLET

Most wells are constructed so that the water discharges horizontally from an open pipe into a box, ditch, or canal. Frequently, the outlet consists of a short section of pipe attached directly to the outlet of the pump. Usually the outlet of the pipe is several feet above the water surface in the ditch or canal. A difference in elevation between the water level in the ditch or canal and the outlet of the pipe represents wasted pump energy. For example, consider a well which discharges water three feet above the water level in the canal when pumping water from a level 97 feet below the canal water surface. If the outlet of the well could be lowered to the water level in the canal, a reduction of approximately 3 percent in pumping costs would result. Usually the reduction in cost of

pumping over two or three years will pay for the cost of lowering the outlet.

One of the simplest ways of lowering the outlet is to put a 90-degree bend on the end of the pipe leading from the well and attach a short section of pipe to the end of the elbow so that the outlet is at or near the normal water surface in the ditch or canal. When economics justify, a flaring of pipe can be connected to the bend to reduce the velocity at exit and thus reduce the amount of kinetic energy that is lost as the water flows from the pipe. The lift is thus reduced with a consequent saving in power cost or an increase in flow, and an elbow is provided which can be used as a water measuring device.

DESCRIPTION OF METER

The pipe-bend flow meter, often called an elbow meter, is simply a standard 90-degree pipe bend. The bend is welded, threaded, or bolted onto the outlet of the well. The bend should be attached to the pipe so as to direct the flow downward. A short section of pipe should be attached to the bend to bring the outlet near the water level in the open ditch or canal into which the pump discharges the water. (Figure 1 shows the general arrangement).

Piezometers should be attached to both the inside and the outside of the bend as shown in Figure 2. Piezometers consist of small openings in the pipe wells to which transparent tubes are attached. The vertical difference between the water levels in the two tubes leading from the piezometers is a measure of the flow occuring in the pipe.

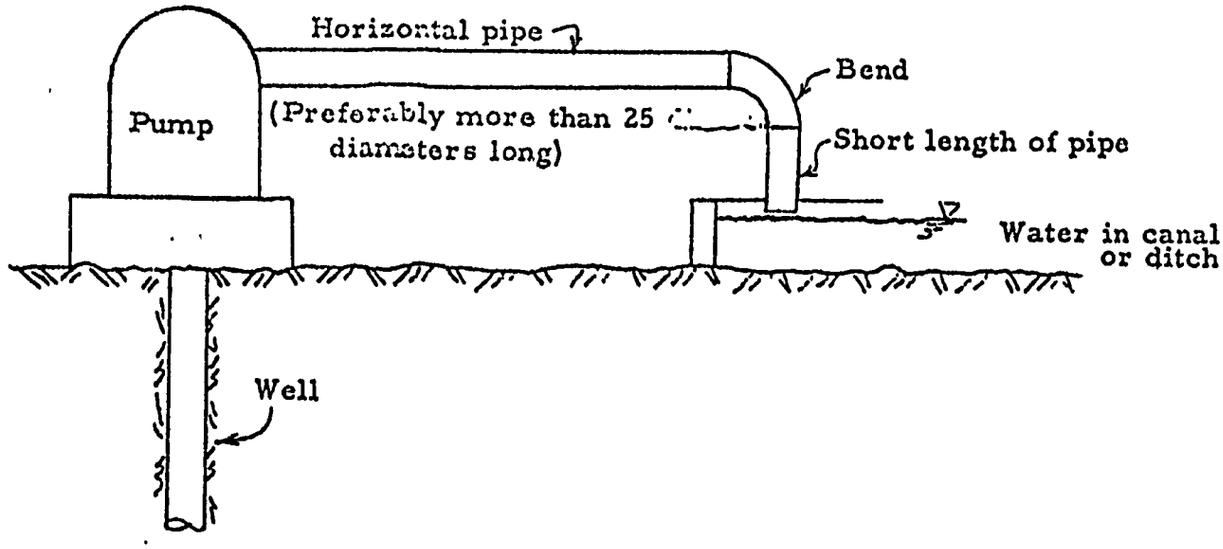


Figure 1. Profile of typical well, showing position of bend used for water measurement.

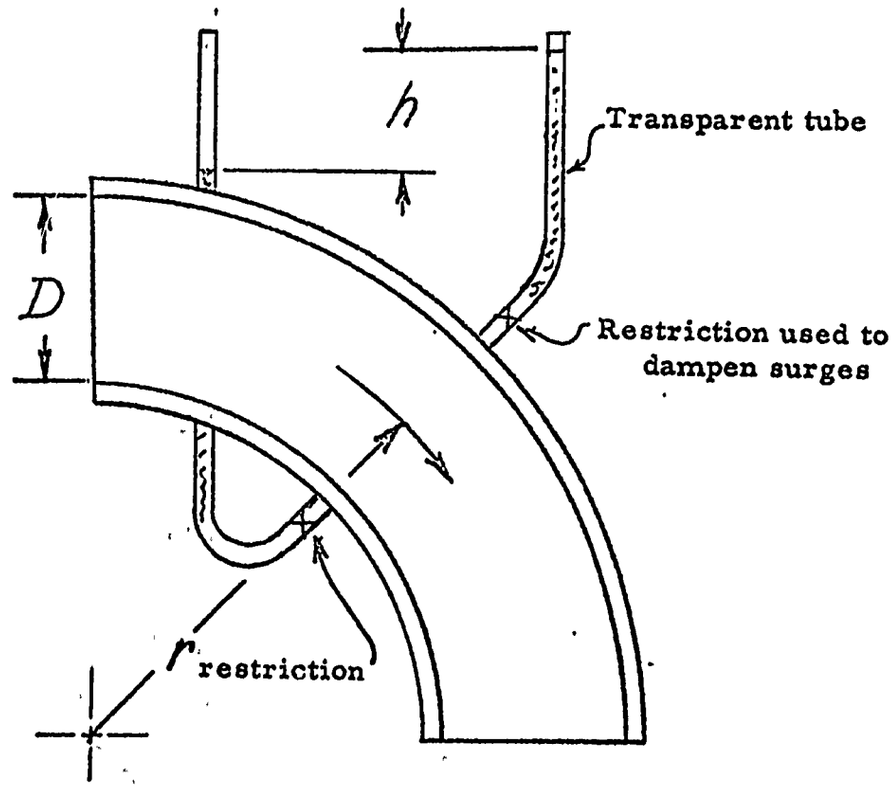


Figure 2. Pipe bend with piezometers attached.

CONSTRUCTION OF PIEZOMETERS

Piezometer outlets can be constructed by the method that is most convenient with the materials at hand. However, several precautions should be taken. Piezometer outlets must be perpendicular to the pipe well. Any inclination toward or against the direction of flow will cause false readings. The opening in the pipe must be free of irregularities. All burrs caused by drilling should be removed, and the piezometer tap should not extend beyond the inside wall of the pipe. The openings should have a diameter not greater than onehalf of the thickness of the wall of the pipe. Connections illustrated in C and D of Figure 3, are preferred. Connections shown in A and B would not be acceptable.

When the bend is near the pump or when valves or other obstructions are located immediately upstream from the bend, excessive surging will occur in the piezometers. Surging can be minimized by restricting the flow from the piezometer opening to the transparent tube in which the measurement is taken as shown in Figure 4. However, special precaution must be taken to insure symmetrical restriction. That is, the flow must encounter the same resistance when flowing from left to right as when flowing from right to left through the restriction, other wise a differential pressure head will occur across the restriction. The restriction or damping device should essentially eliminate surging, but the opening should be sufficiently large to assure that the pressure in the pipe bend is transmitted across the restriction. Also, the hazard of the opening clogging is more serious with the smaller openings. Therefore it is necessary to have a practical balance between the criteria for eliminating surging and preventing clogging in the piezometer.tube.

Three methods of damping piezometers are widely used:

1) Symmetrical valve (Figure 4A) The valve is closed gradually until the pulsations are reduced sufficiently.

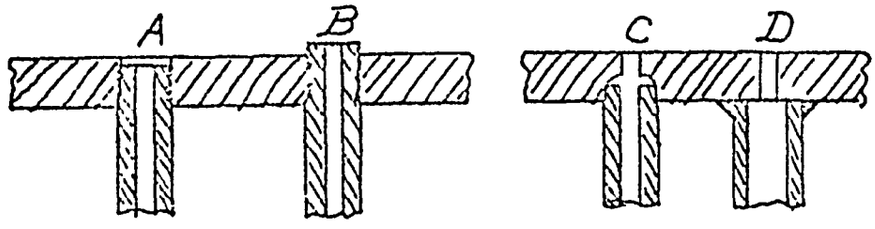
2) Capillary tube (Figure 4B) A capillary tube is placed in the transparent tube, providing a damping effect in the tube.

3) Crimping (Figure 4C) A restriction is created in the pipe - leading from the piezometer tap to the transparent tube. This restriction is usually constructed by crimping the pipe.

The symmetrical valve method is excellent for laboratory use but may not be properly operated in the field. Use of the capillary tube is a reliable method, but capillary tubing may be broken in the field. A symmetrical indentation in copper tubing is a permanent and inexpensive damping device for field installations.

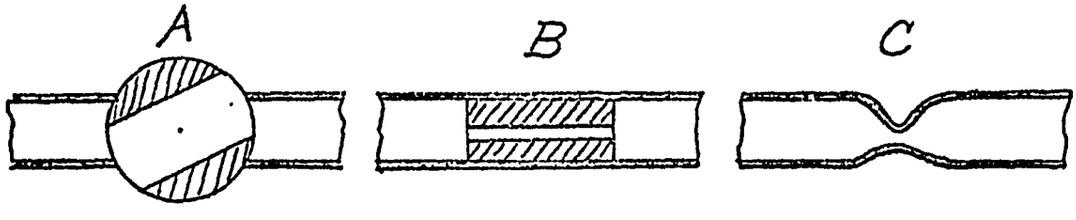
The difference in water pressure in the piezometers attached to the inside and outside surfaces of a pipe bend are measured by noting the difference in water level in the vertical transparent rubes attached to the piezometers. Plastic tubes are more durable than glass tubes for field use. A large diameter is preferred, since the larger the diameter the smaller the oscillation in the water level as a result of surging within the pipel A ½-inch tube will probably be satisfactory. In order to obtain an indication of how much restriction should be placed in the piezometers and how large the transparent tubes should be to minimize water level fluctuations, it would be helpful to experiment until surging is minimized.

Differences in water levels can be read from a scale placed behind the plastic tubes. A bracket should be welded to the bend to support the transparent tubes in a vertical position.



Not satisfactory Satisfactory

Figure 3. Piezometric connections to the wall of a bend, illustrating desirable features.



Symmetrical valve Capillary tube Crimped tube

Figure 4. Methods of dampening surges in piezometers. Restriction must be symmetrical.

CALIBRATION

Bends are now recognized in hydraulic literature as useful water - measuring devices. Under normal conditions, standard curves and formulas can be expected to indicate the discharge with an accuracy of - 10 percent. When greater accuracy is desire or where adverse site conditions exists, - each bend meter should be individually calibrated. The necessity for calibration is not any greater when a bend is used than when other divices, wich as Venturi meters, are used for water measurement.

The care taken in the installation will affect, to a large extend, the degree of accuracy that will be attained. For example, the length of straight pipe ahead of the pipe bend will greatly influence the accuracy of the meter. Although a length equal to ten times the pipe diameter may be used, a straight pipe of twenty-five times the diameter is preferable. The closer the elbow is to the pump the greater the surging and the more the velocity distribution will depart from normal. Also, the type of pipe and the method of attaching the bend to the pipe will affect the velocity distribution. Any irregulations in the piezometer connections, such as the piezometer opening not being perpendicular to the surface, a burr, or a restriction that is not symmetrical will affect the differential water level in the piezometers.

The amount of water flowing in the pipe can be calculated from the equation:

$$Q = \frac{r}{2D} \times a \; 2gh \quad . \quad . \quad . \quad (1)$$

not complete

h) difference in piezometric head between the outside and the inside of the bend of midsection.

D) The diameter of the pipe

r) Centerline radius of the elbow (see figure 2)

Equation (1) has been used to develop the graphs of differential head versus discharge for commercal 90-degree elbows given in Figure 5 thru 12. These plots can be expected to give dicharge readings that will be within 10% of the true discharge.

Discharge measurements can be checked and/or imporved by fuether calibrating the pipe bend in the field. A portable pershall flum can be temporarily installed in the canal differential head and discharge measurements taken. This data can then be plotted on graph paper to obtain a curve similar to those shown in figures 5 thru 12. If the discharge from the pump can not be varied (changed) or precise measurements are not necessary Figure 5 thru 12 can be used.

ADVANTAGES OF A PIPE BEND FLOW METER

1) No additional expense is involved except for the installation of the piezometers, assuming the bend and a short lenght of pipe are installed to lower the water outlet and are thus paid for by a reduction of pumping costs.

2) After the meter is calibrated, it will give reliable service over a long period of time with a minimum of maintenance.

3) Computation of the discharge is very simple.

Fig. 5 Discharge of Comerical Standard steel Elbos for various Differential Piezometric Heads r/D = 1.0

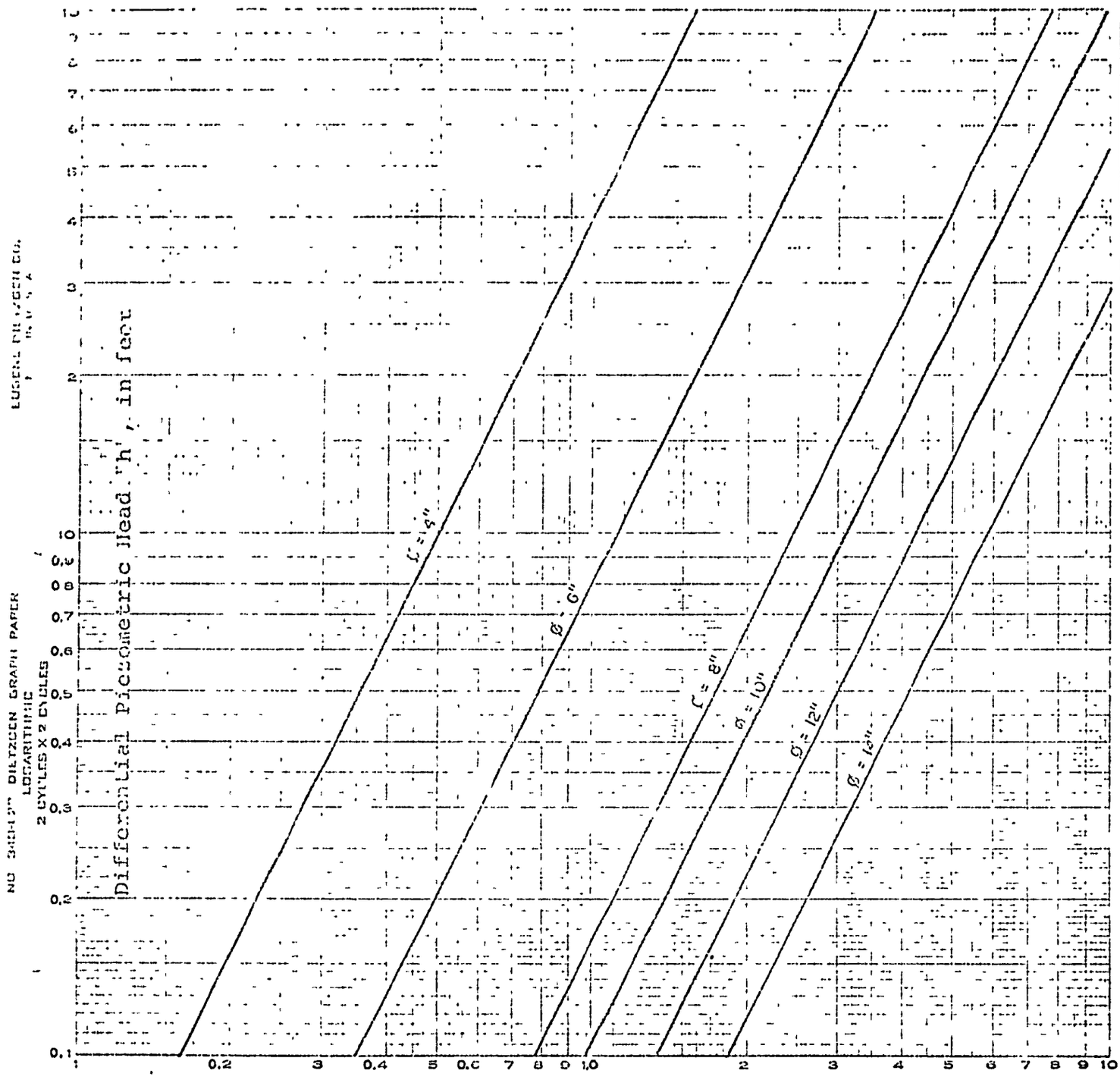


Fig. 6. Discharge of Commerical Standard steel Elbows for various Differential Piezometric Heads r/D = 1.0

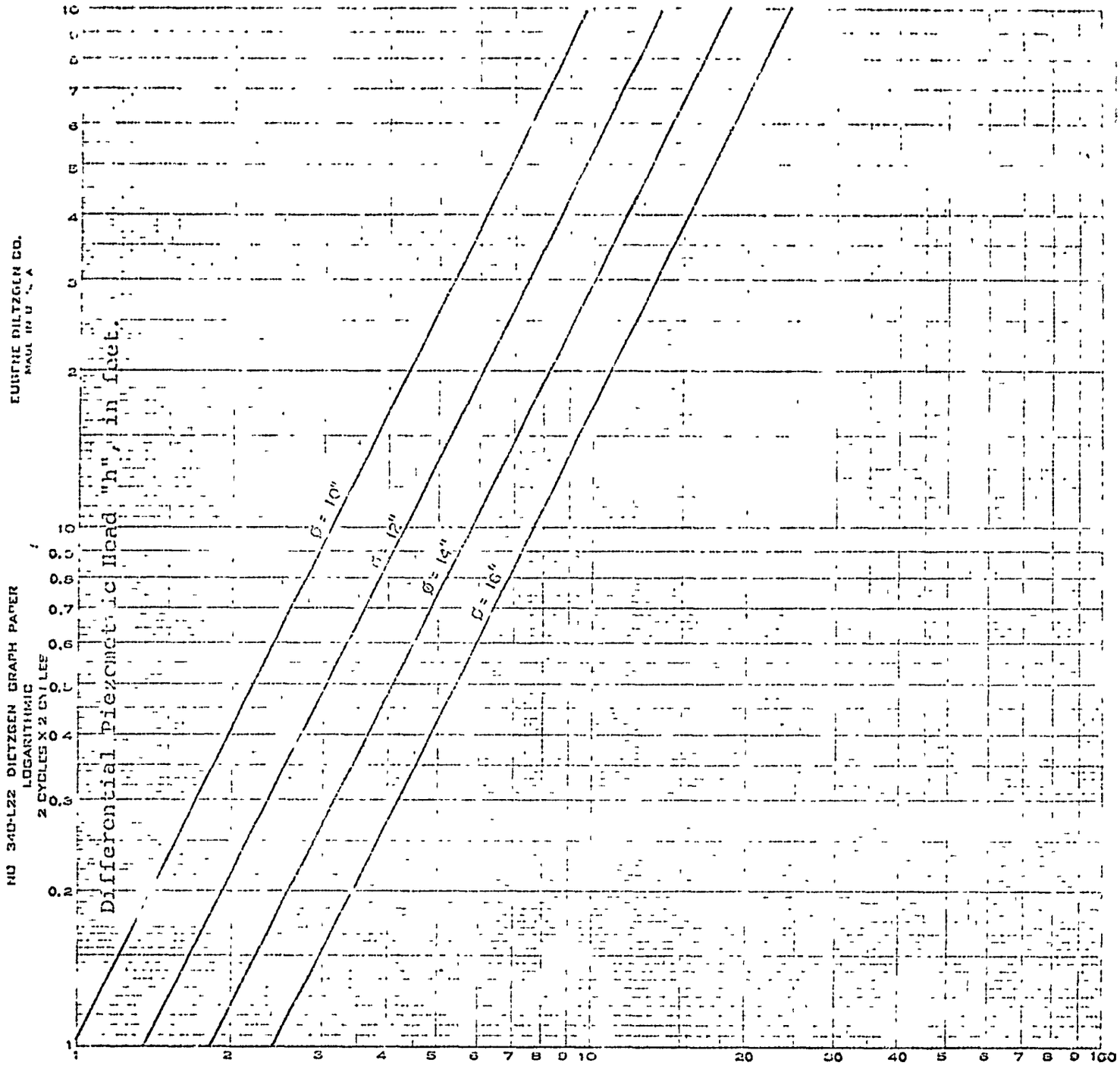


Fig. 7 Discharge of Commerical Standard steel Elbows for various Differential Piezometric Heads r/D = 1.5

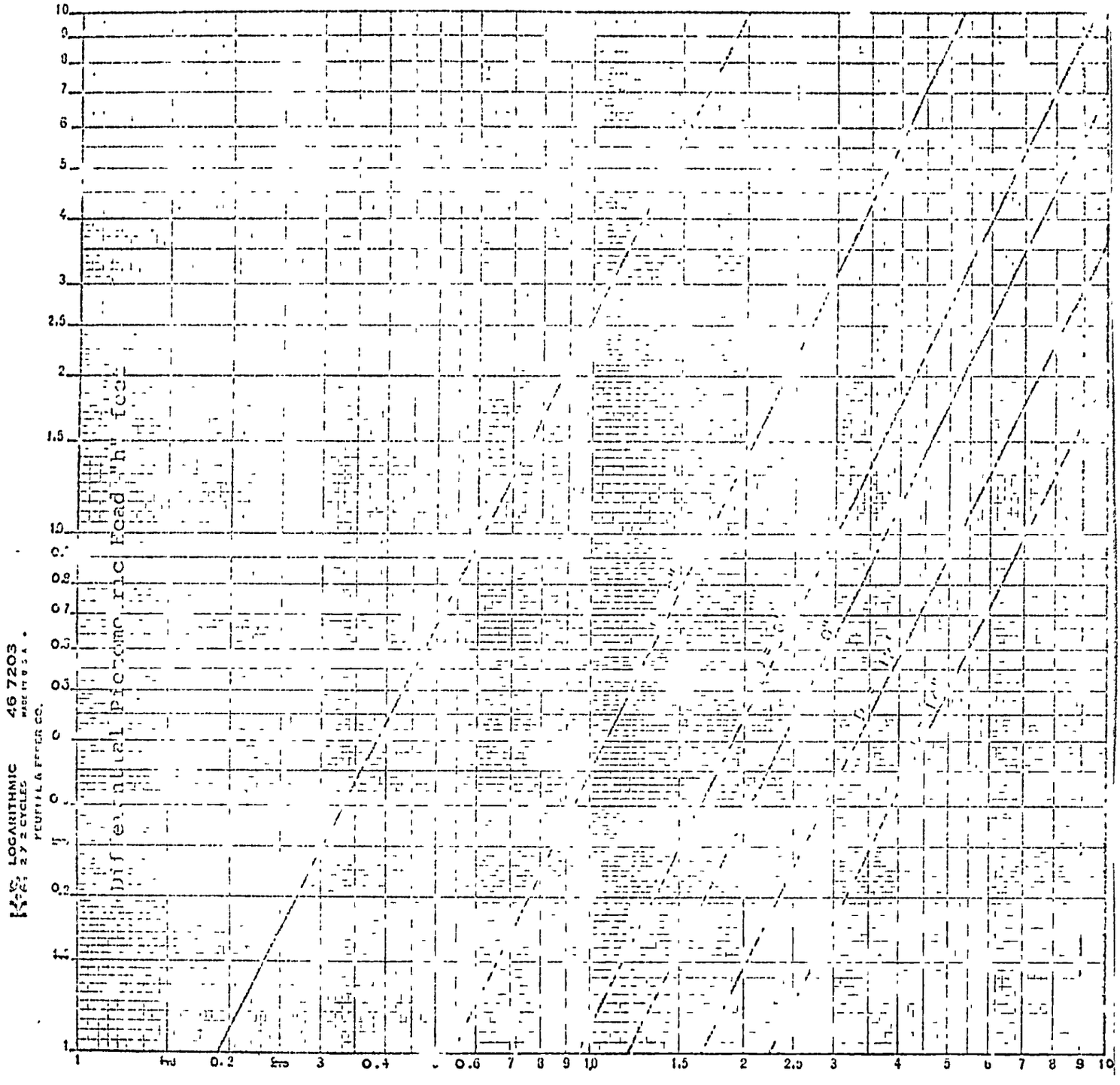
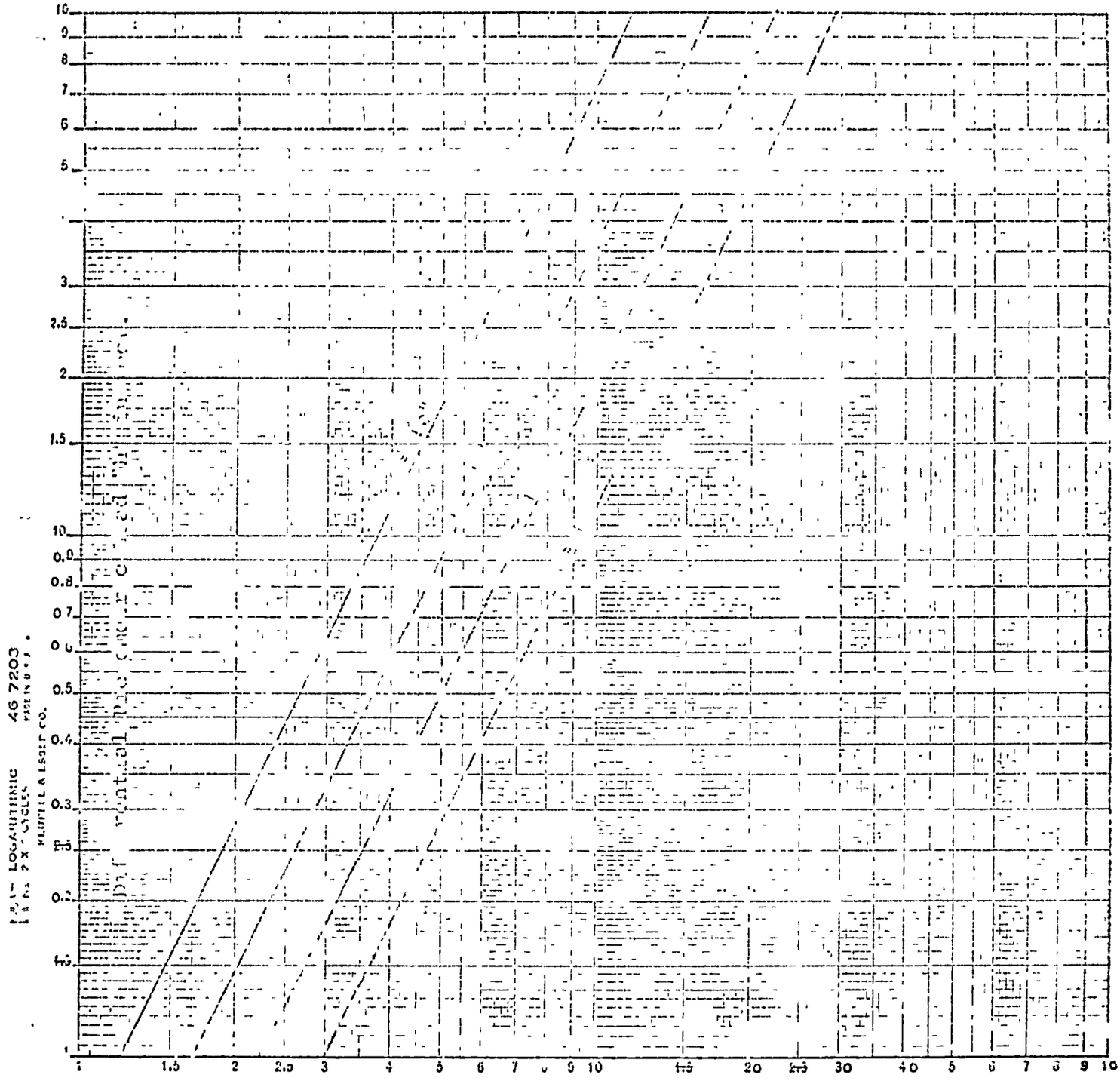
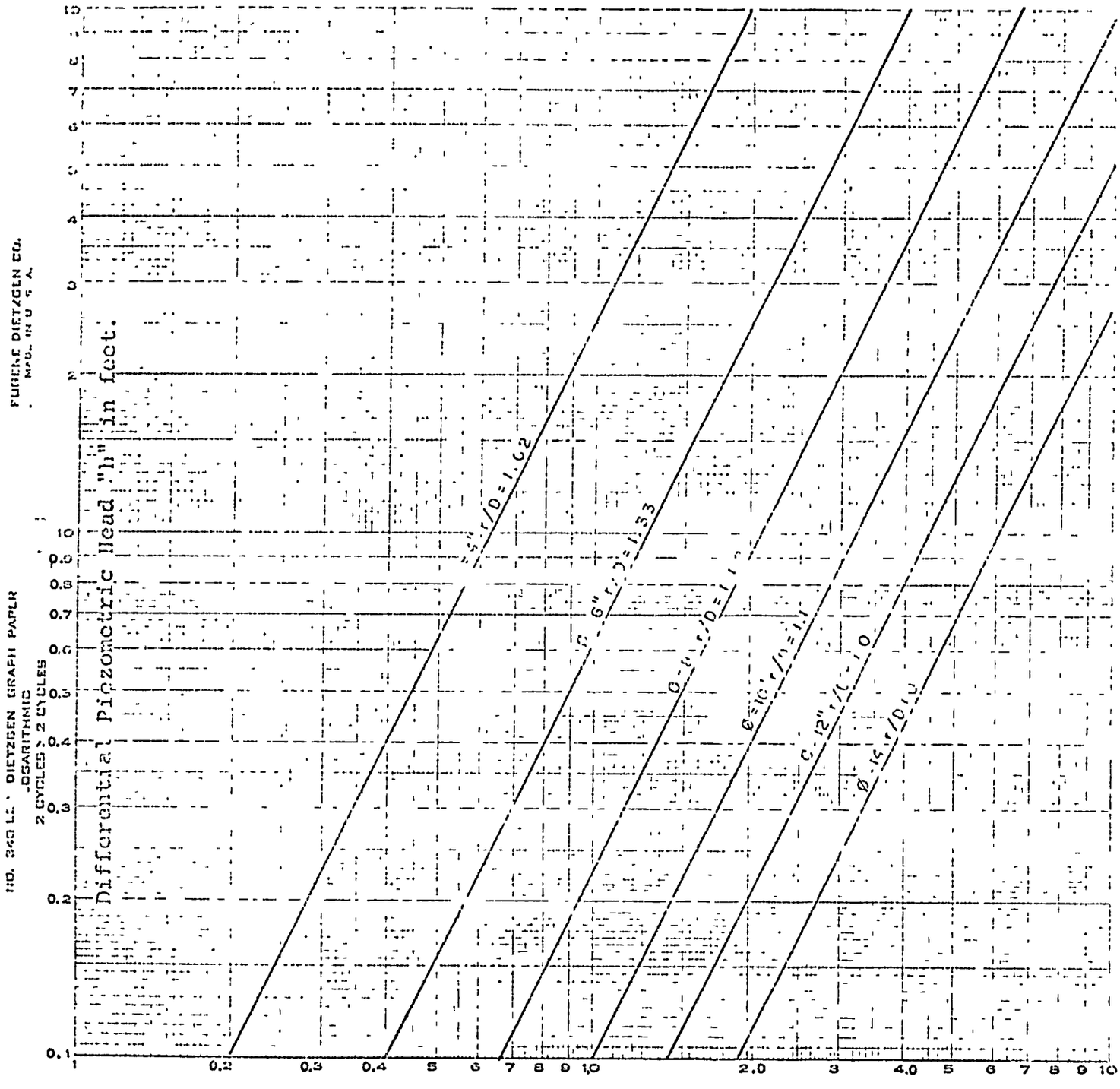


Fig. 8 Discharge of Commerical Standard Steel Elbows for various Differential Piezometric Heads. r/D = 1.5



Discharge Q in c.f.s.

Fig. 9. Discharge of Commerical Standard Cast Iron Elbows for various Differential Piezometric Heads.



Discharge Q in c.f.s.

Fig. 10. Discharge of Commerical Standard Cast Iron Elbows for various Differential Piezometric Heads.

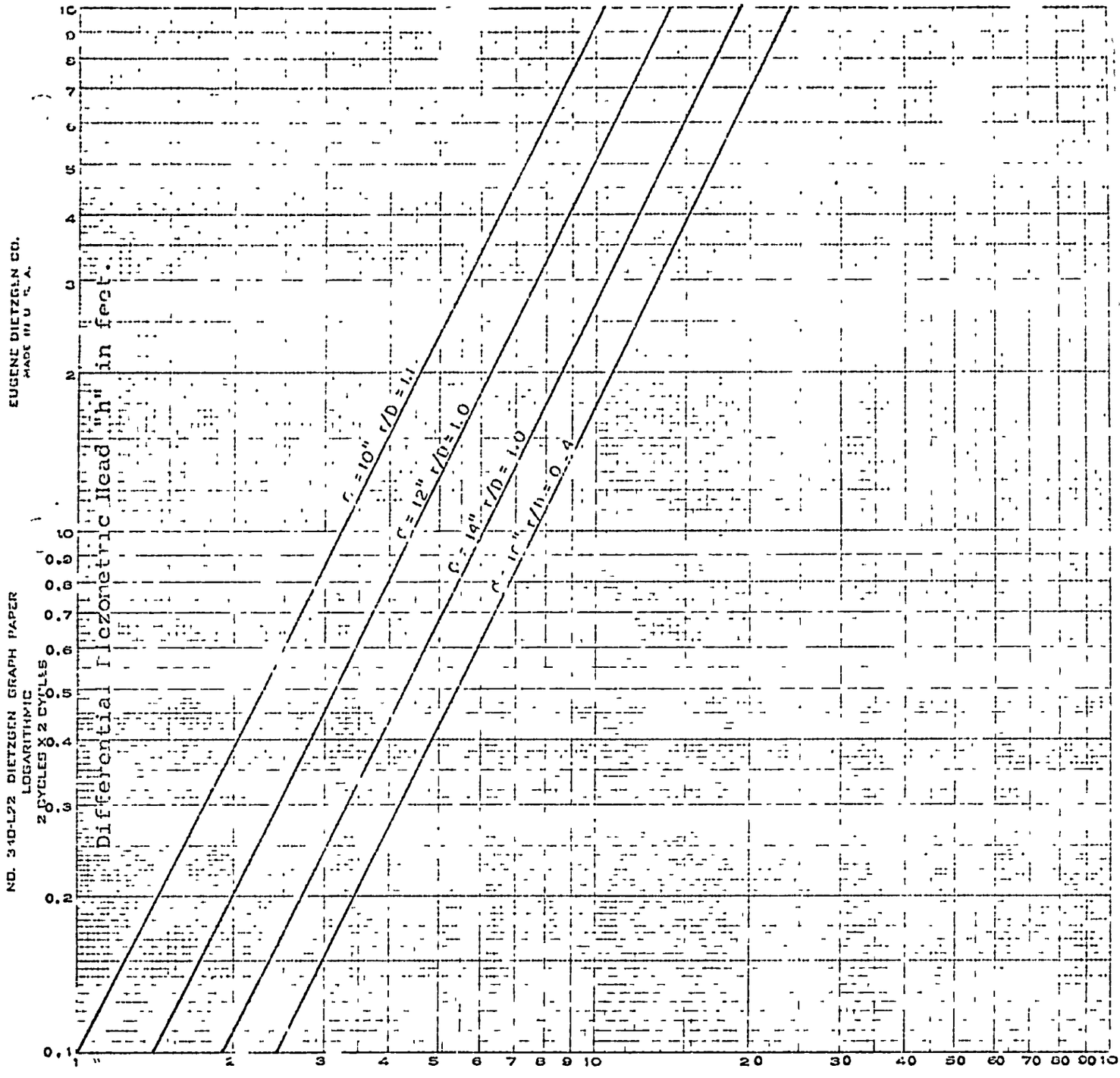


Fig. 11. Discharge of Commerical Standard Cast Iron Elbows for various Differential Piezometric Heads.

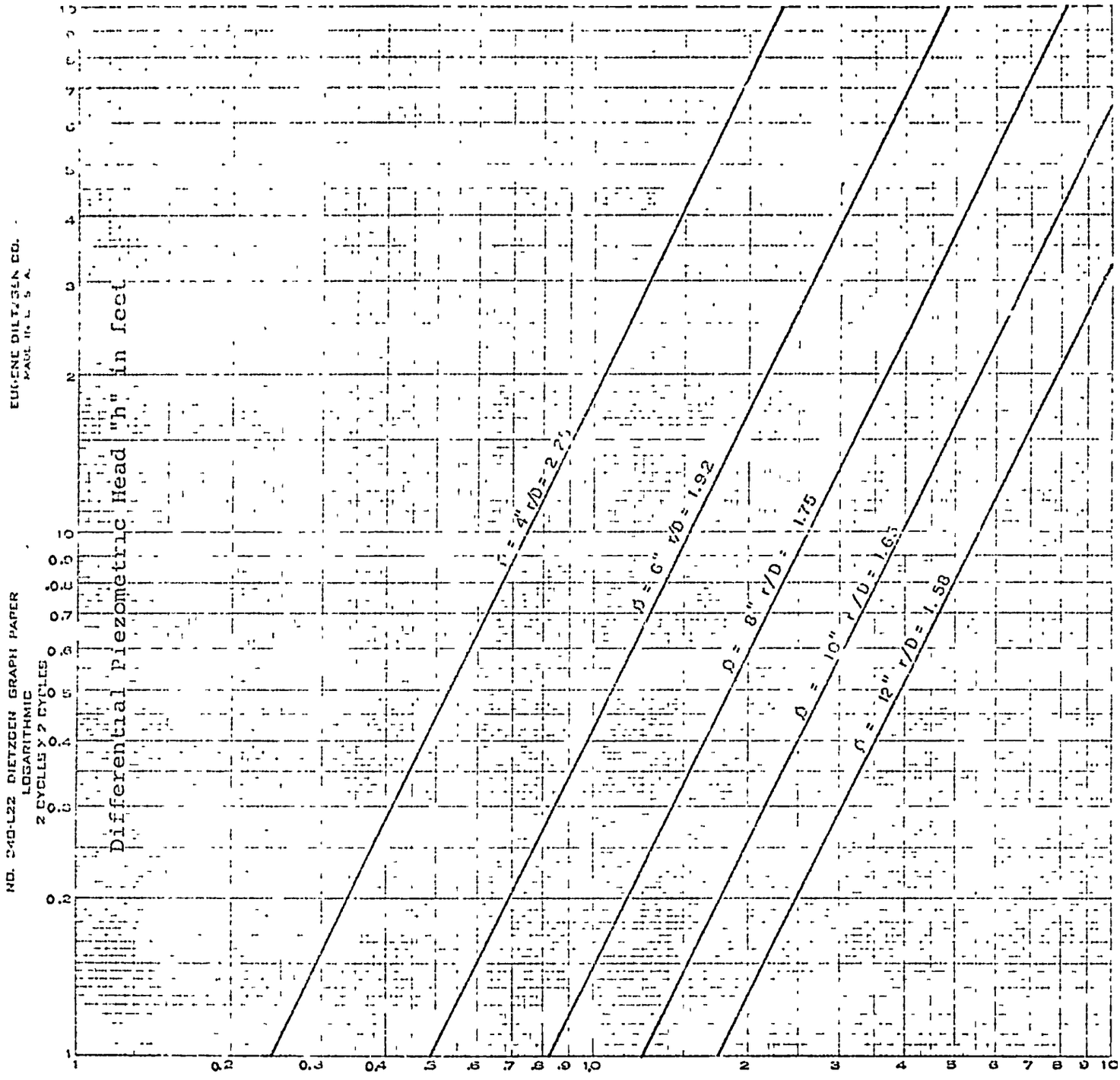


Fig. 12. Discharge of Commerical Standard Cast Iron Elbows for various Differential Piezometric Heads.

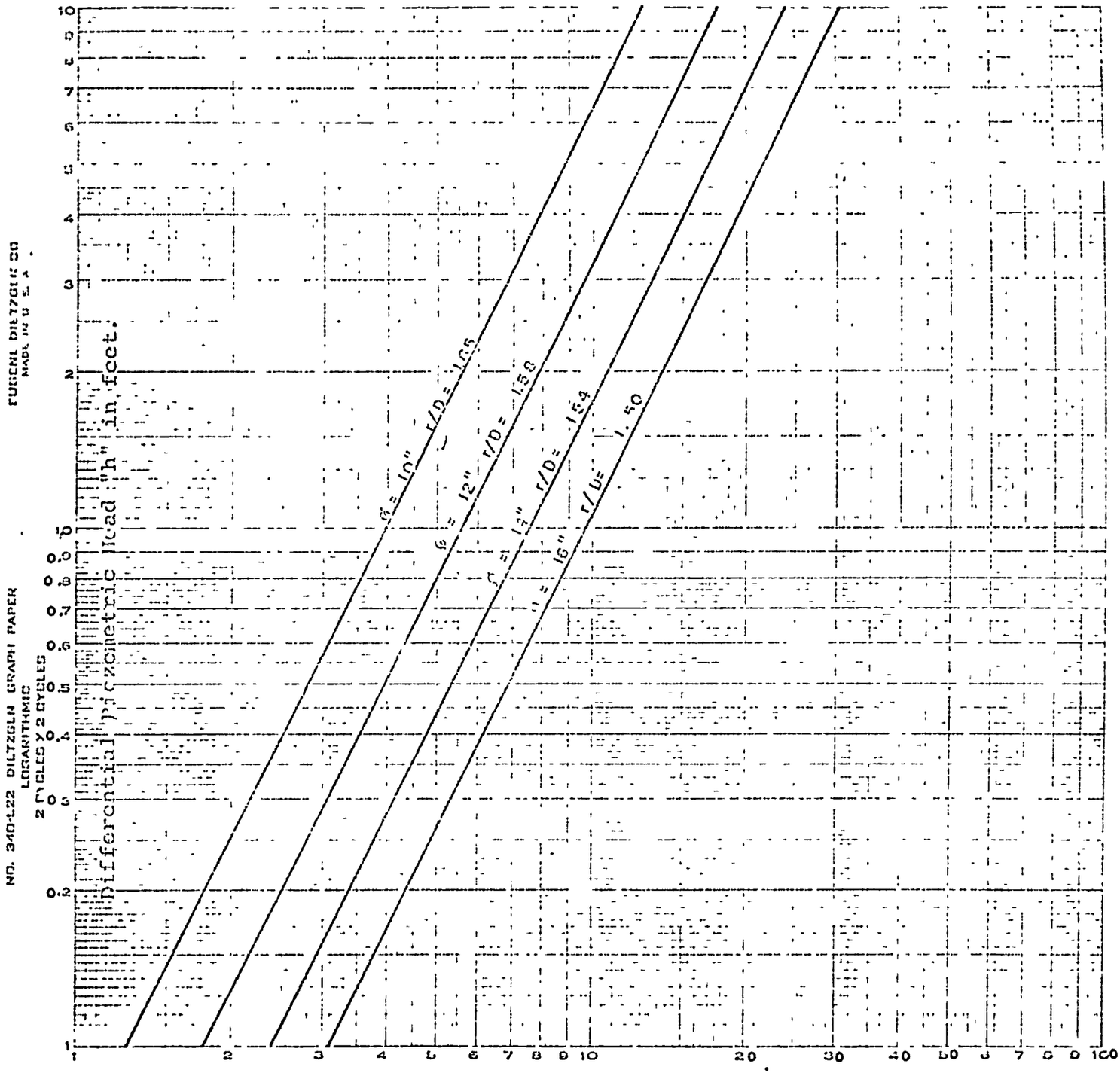
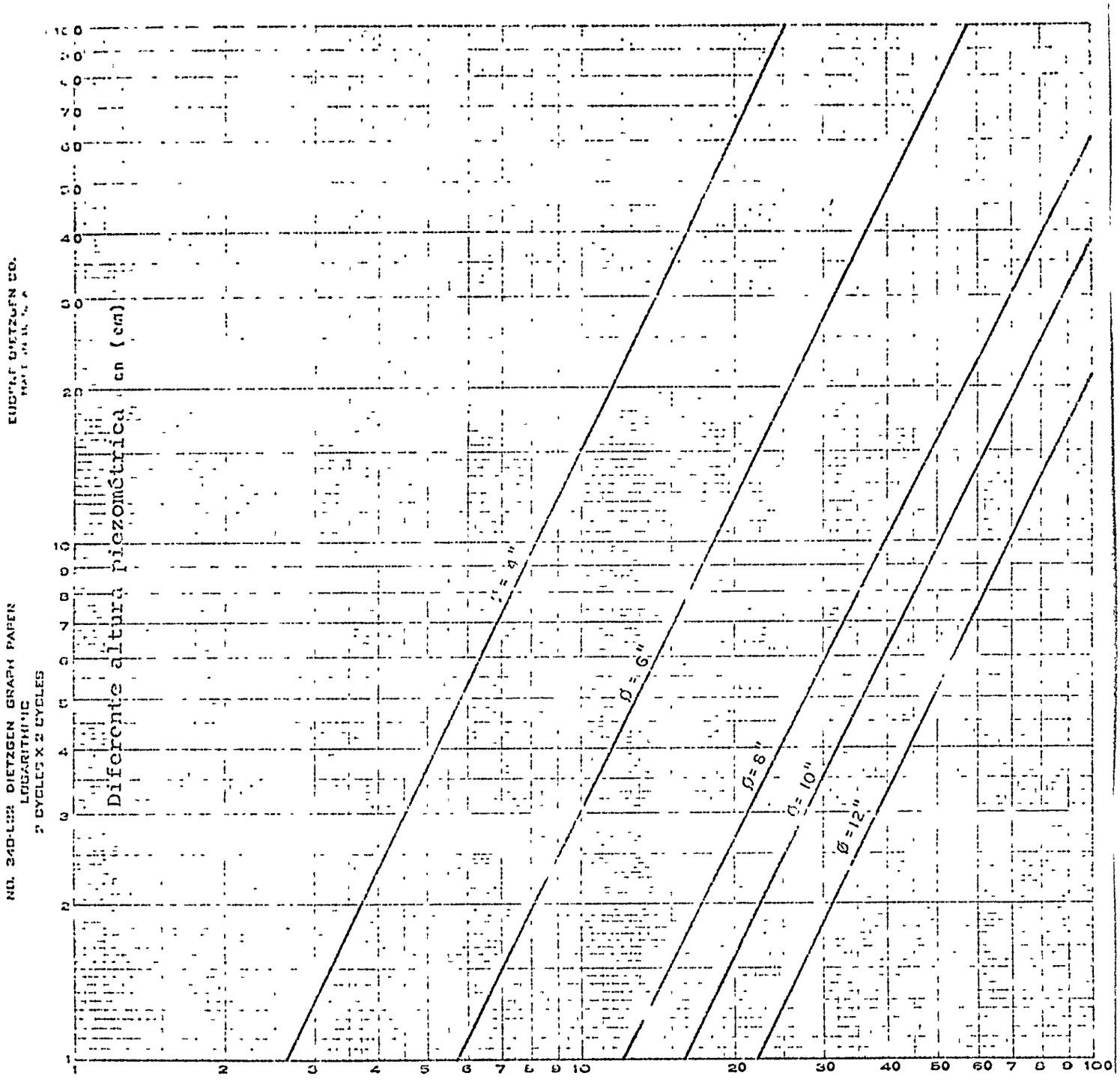
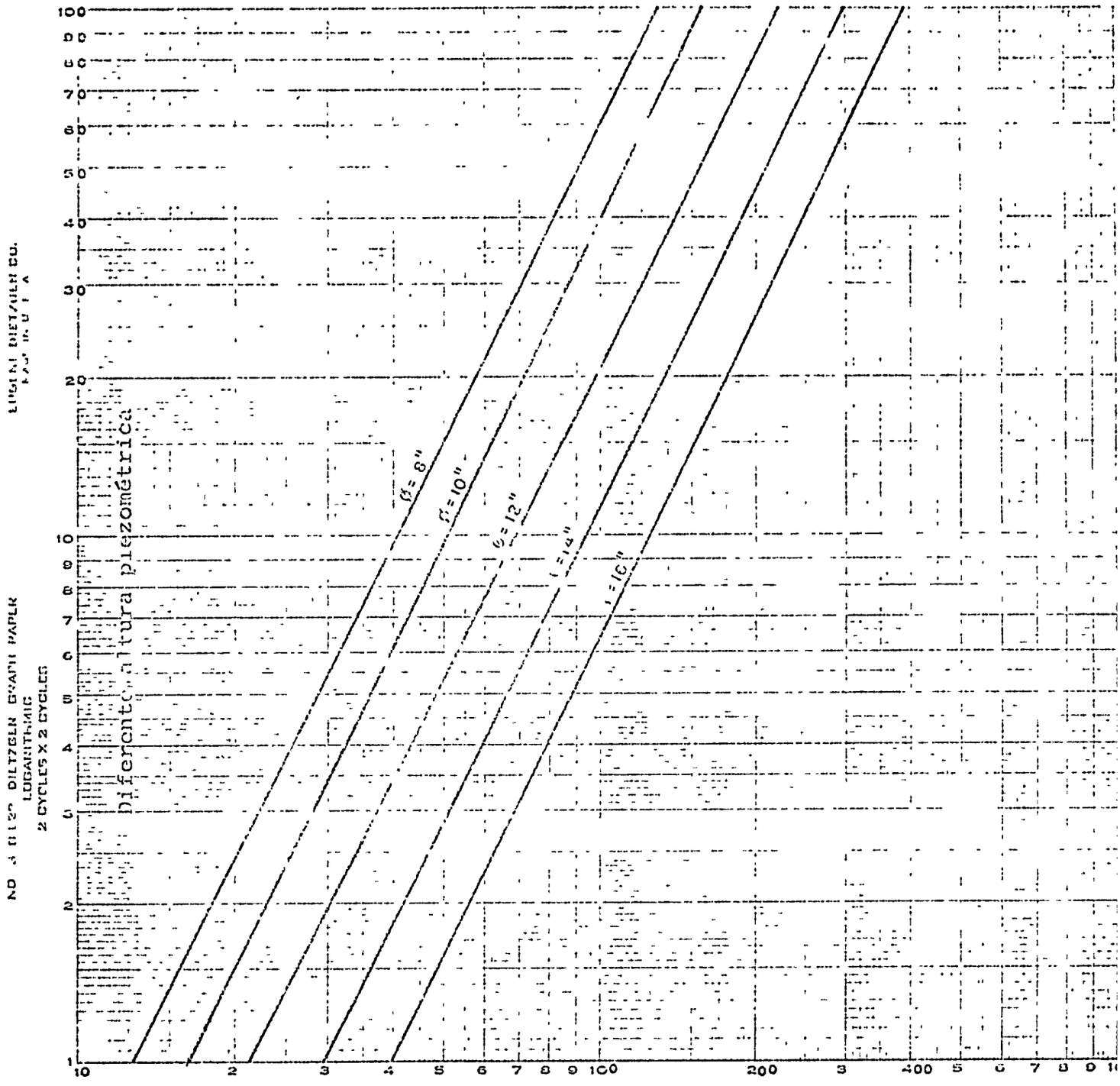


Fig. 5 . Cantidad de la corriente de agua, codo de 90°de acero "standard" para diferentes alturas piezométricas (r/D = 1.0)



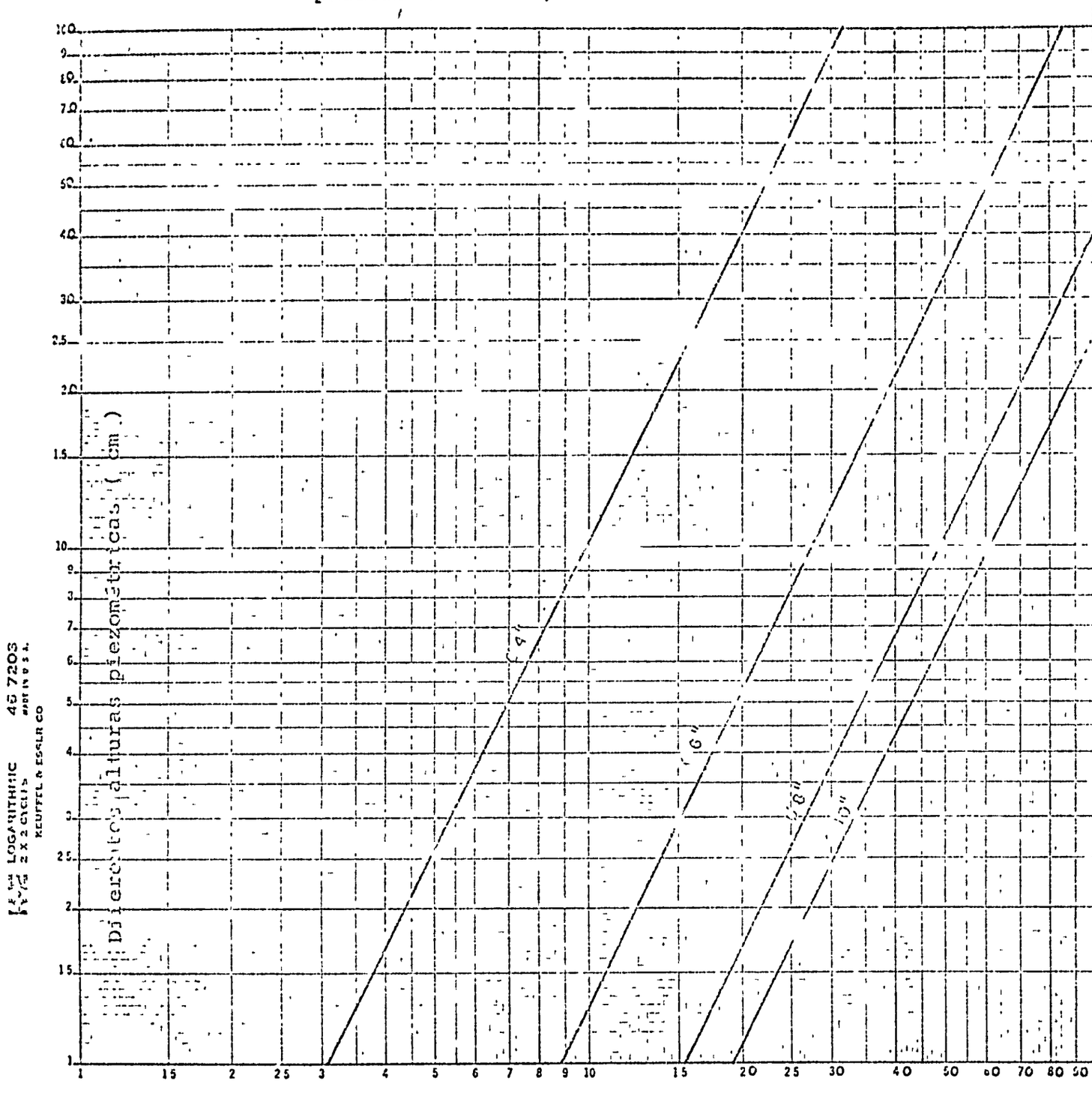
Cantidad en litros por segundo

Fig. 6 Cantidad de la corriente de agua, codo de 90° de acero "standard" para diferentes alturas piezométricas (r/D = 1.0)



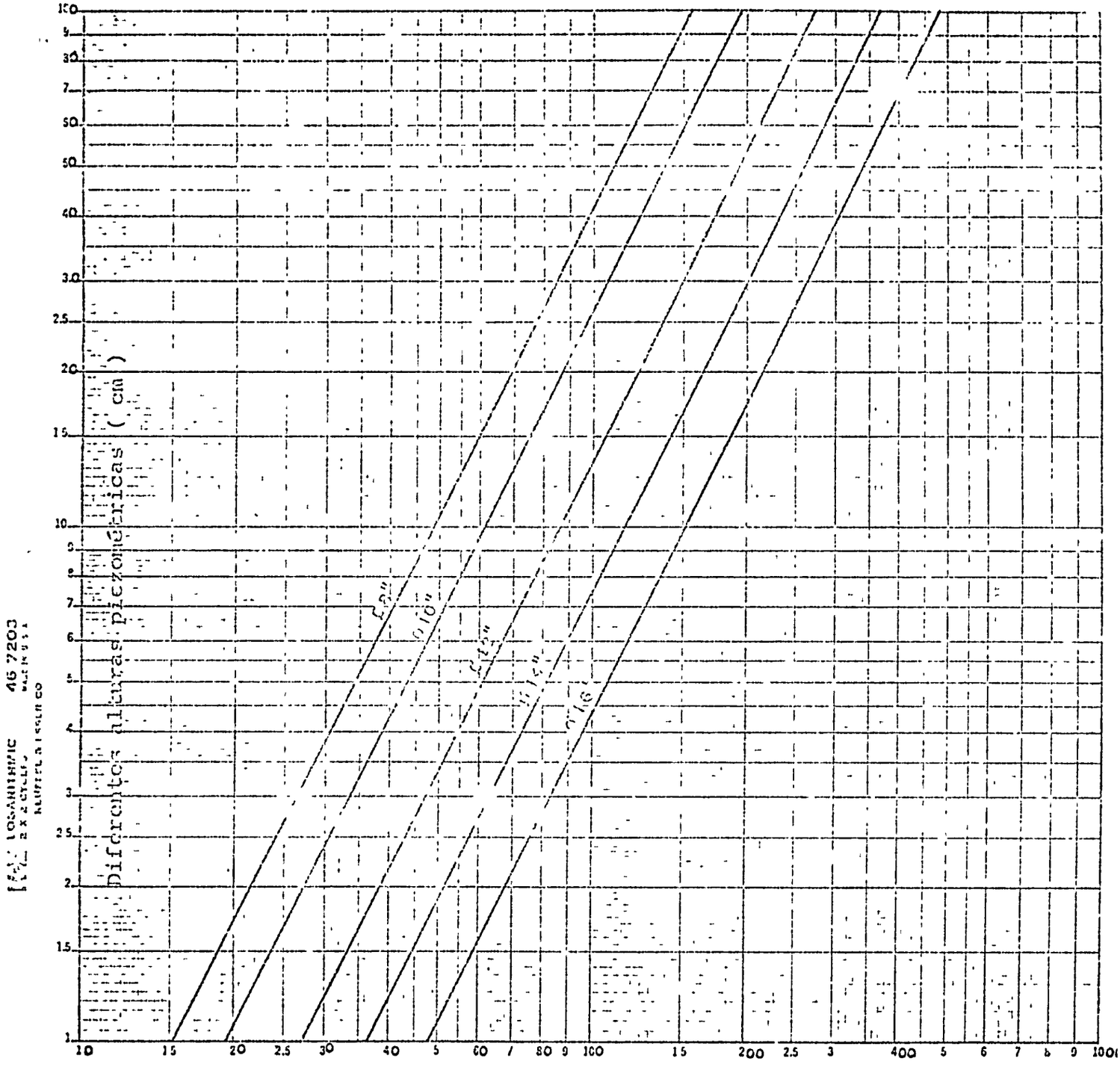
Cantidad en litros por segundo

Fig. 7 Cantidad de la corriente de agua, codo de 90°de acero "Standard" para diferentes alturas piezométricas r/D = 1.5



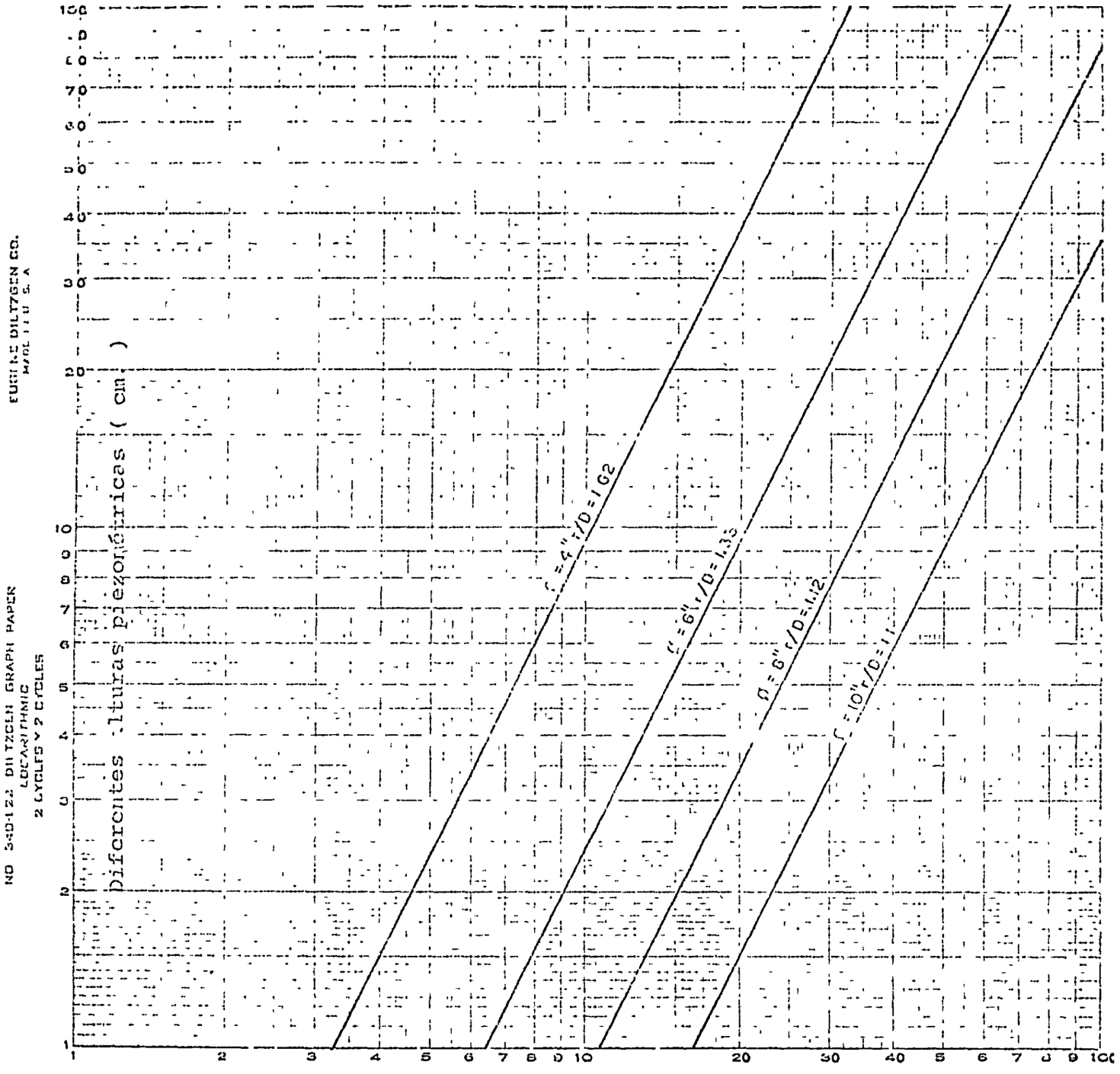
Cantidad en litros por segundo.

Fig. 8 Cantidad de la corriente de agua, codo de 90°de acero "standard" para diferentes alturas piezométricas r/D = 1.5



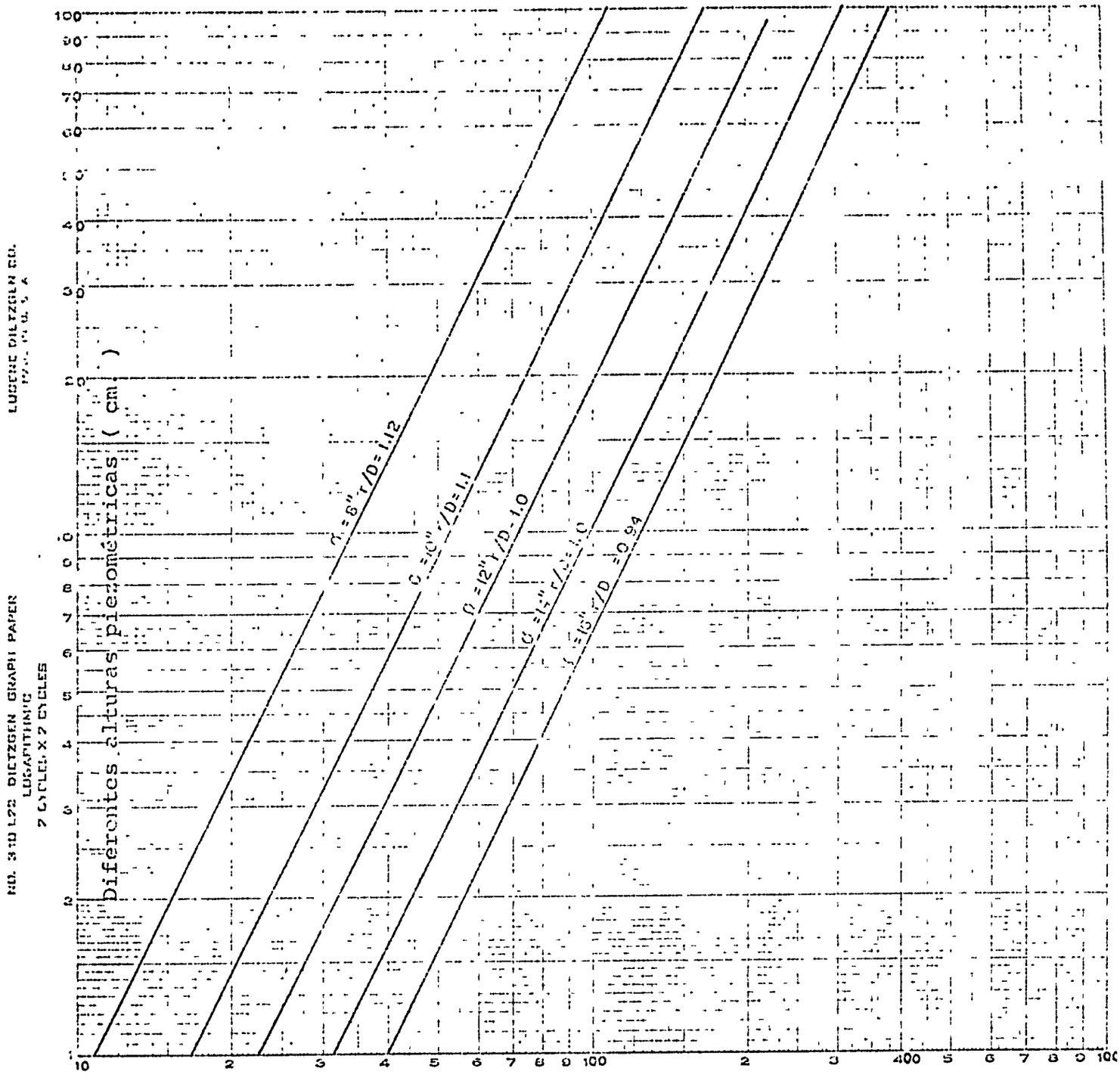
Cantidad en litros por segundo.

Fig. 9 Cantidad de la corriente de agua, codo de 90°de hierro colado para diferentes alturas piezométricas.



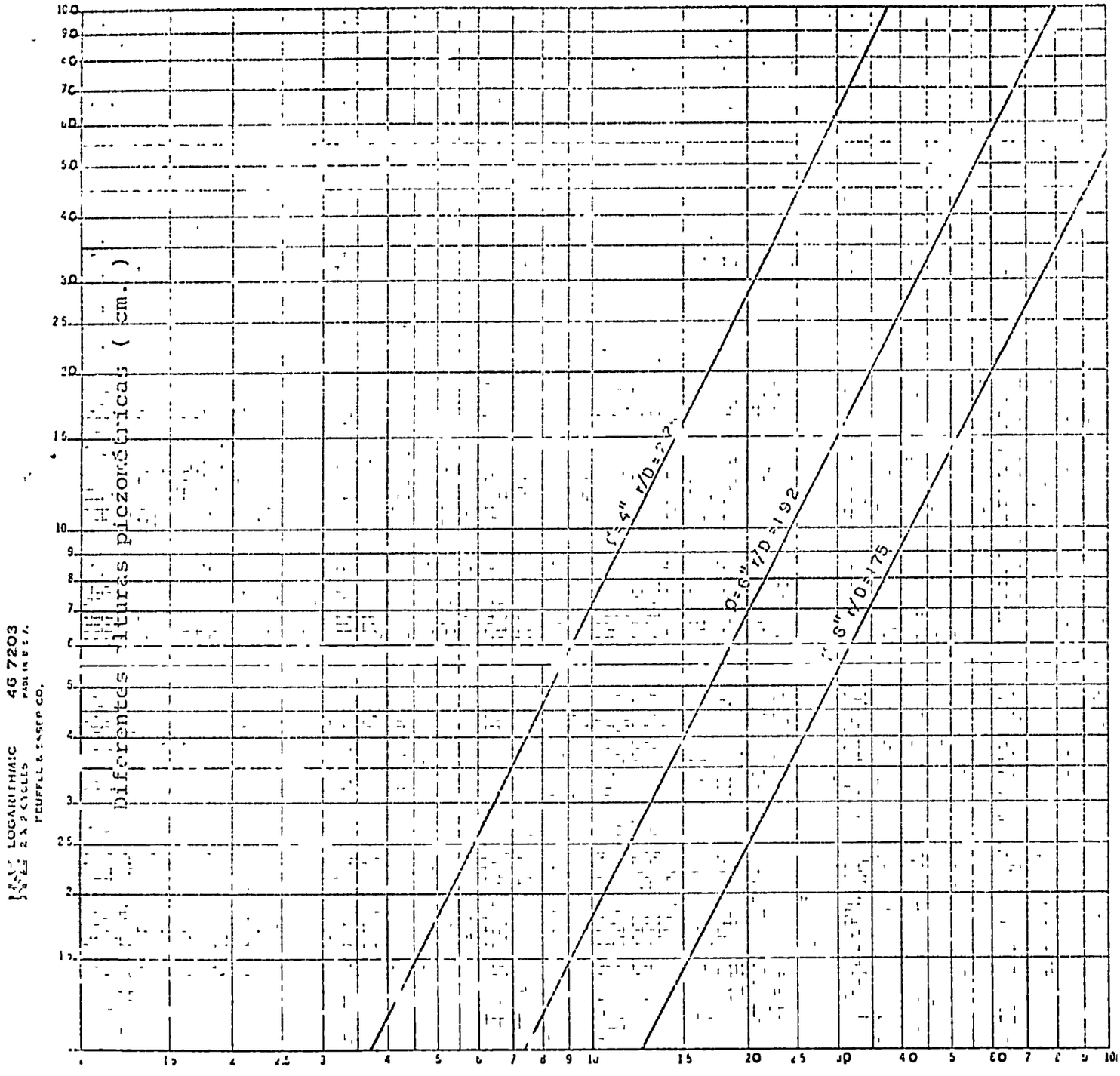
Cantidad en litros por segundo.

Fig. 10 Cantidad de la corriente de agua, codo de 90°de hierro colado para diferentes alturas piezométricas.



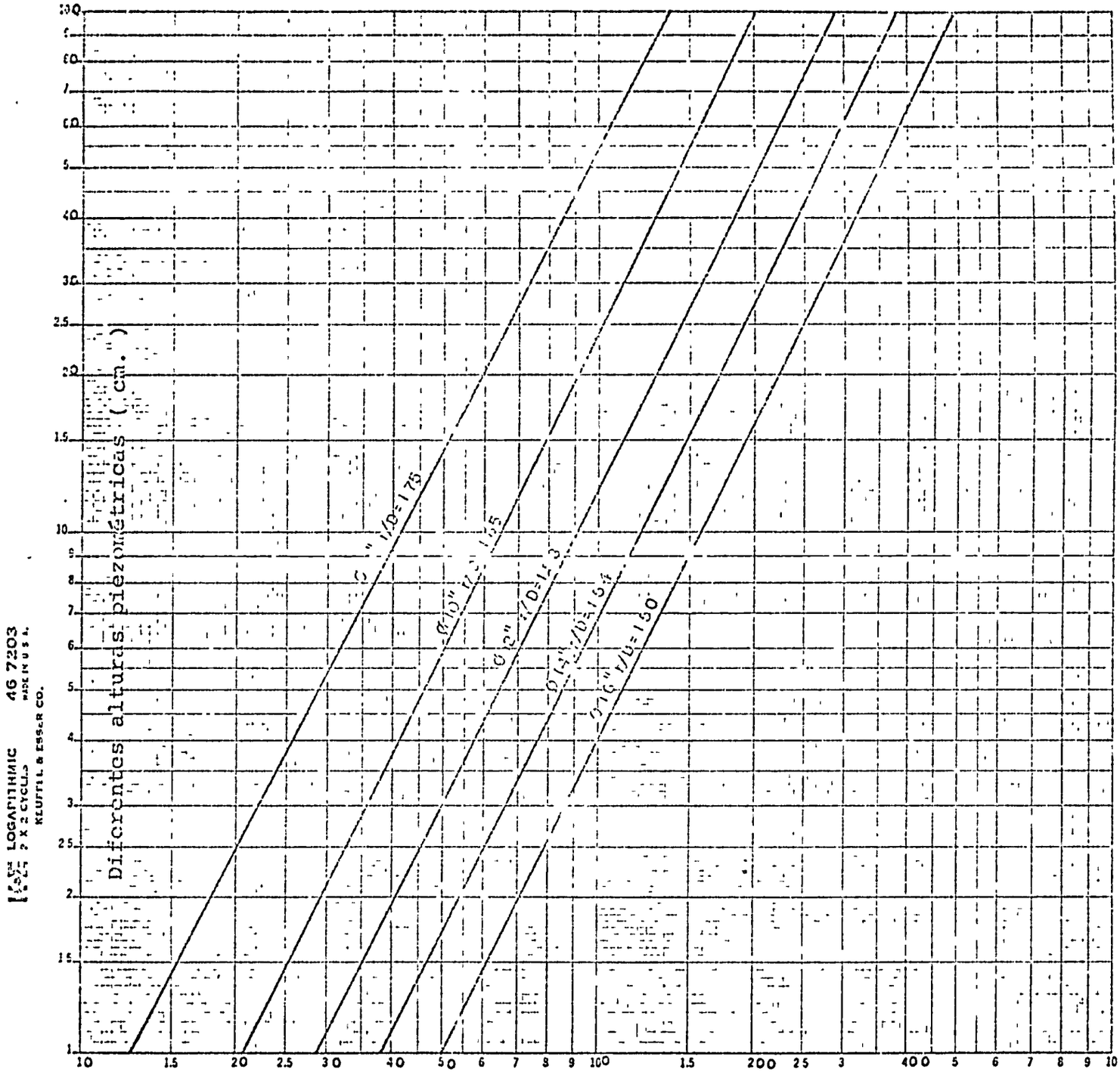
Cantidad en litros por segundo.

Fig. 11 Cantidad de la corriente de agua, codo de 90°de hierro colado para diferentes alturas piezométricas.



Cantidad en litros por segundo.

Fig. 12 Cantidad de la corriente de agua, codo de 90°de hierro colado para diferentes alturas piezométricas.



Cantidad en litros por segundo.