PERMEABILITY OF BITUMINOUS CONCRETE SURFACE COURSE MIXES

Report R72-2

February 1972

VERMONT DEPARTMENT OF HIGHWAYS

J. T. Gray, Commissioner

R. H. Arnold, Chief Engineer

A. W. Lane, Materials Engineer

Report Prepared By

Bituminous Concrete Section

INTRODUCTION

In past years there have been varied opinions concerning permeability of different types of pavement. During this past construction year, investigations of various bridge decks with membrane systems on the interstate uncovered deterioration of the concrete decks (1). This deterioration has been attributed to the presence of salt in the surface of the bridge deck. The question that inevitably arose was, how did it get there? Most people involved were of two opinions. Some maintained that the salt was carried down through the pavement and membrane as part of a brine. This would mean the pavement and membrane would have to be porous enough to let water through it. Other persons felt that the pavement was not permeable and the salt water (or brine) worked its way between the edge of the pavement and the curb on the bridge, eventually spreading toward the middle of the bridge between the pavement and membrane system and the concrete of the bridge deck.

In order to determine the degree that pavements are water permeable, other agencies' work in this area was researched. After some study, the AASHO method T 215-66 of testing the permeability of soils was adopted for use as a guide line. In some reports (2, 3, 4) written on the topic, it has been shown that a bituminous concrete pavement has various degrees of permeability depending on the gradation as well as the asphalt cement and void content.

Our purpose in the following research and report is to determine the permeability of various pavements having varied percentages of air voids.

PROCEDURE

From the information gathered and the results desired it was decided that the two things needed most, were an apparatus that would hold the sample, and a sealing agent to guarantee water tightness between the sample and the apparatus. After the sample of pavement was in place and sealed, a static head of water at an arbitrary height would be exposed to the sample surface. The amount of time it would take the water, under pressure of a constant head, to permeate the sample would be recorded. The basic diagram of apparatus and sealer originally intended for use is shown in Figure 6. In the AASHO Method of testing the permeability of soils, a mold measuring 4½" by 4" in diameter is used. In order to use this piece of apparatus, a sample considerably smaller than these dimensions would have to be made.

Types II, III, & IV mixes, designed according to the Marshall Method and reported in Procedures for Recovery of Asphalt Cement (#72-1) were used in making the Marshall briquettes for this experiment. The Marshall briquettes, however, were too large for the mold used in soils. If the sides of the briquettes were not sealed with wax and forced into the mold, the seal was not water tight. (See Figures #1 & 2). If the briquette was put into the mold and the sealer poured between the mold and the briquette there was too little space available and the sides of the briquette were not coated, allowing water leakage. Instead of flowing through the sample or not permeating at all, the distilled, de-aired, dyed water seeped part way into the sample and then flowed between the mold and the sample (Figure #2). As a result, the times obtained for permeability of the 2½" thick sample were not realistic, or accurate. It was clear that if the present apparatus was to be used, a smaller diameter sample would have to be found. A roadway core measuring 3 11/16" was tried in place of the Marshall briquette. Being smaller in diameter, the core could be easily coated with wax and placed into the top half of a Marshall mold. The mold and core sealed inside were then placed in the bracket originally intended for the soils mold with the top portion of the core exposed to the specially prepared water used. This still was not the solution to the leakage problem. This time the water forced its way down the sides of the core under the bees wax used for coating. It was decided that a new sealing agent might be the solution to the leakage problems. First, asphalt cement was tried and then a mixture of hot lead and sulfur as new sealing agents. The leakage still occurred. Acting on a suggestion made by the Assistant Materials Engineer, an epoxy compound was tried. The results were acceptable with no leakage occurring. The epoxy, however, took three days to harden which was felt to be too long a preparation time to be practical. The last sealing agent tried was bathtub caulking which also allowed water to escape through leakage. It was clear that a new approach must be made to the problem.

A suggestion was made that a container of some sort be used that would have a smaller diameter than the sample briquette. This container would be placed on top of the sample so as to prevent leakage of the water down the sides of the briquette (Figure 5).

As can be seen from Figure #5, water still managed to make its way to the sides of the sample and run out. The only solution was to try and seal the sides of the sample with bees wax again. This time, however, it would be much easier to make sure that the sides were well covered vecause they would be exposed to view. With the sealing problem resolved, a permeability container was designed and constructed which would hold a constant static water head. A system was also designed and calibrated so that the rate of permeation could be recorded as it occurred. (See Figure #6). The distance from the surface of the sample to the overflow pipe of the container was exactly 2.0 ft. The container itself was brass and had an inside diameter of 2 13/16". With the system in operation, a regulated flow of the prepared water from the reservoir through to the overflow of the container insured a constant head and pressure above the sample. The rate of flow was set at 6 ml./minute into the brass container. Any discrepancy in the rate of overflow would indicate the amount of water permeating the sample.

RESULTS AND DISCUSSION

Only one problem was encountered with the established procedure. The force of the water upheaved the sealing agent around the bottom of the container and eventually a weaker part of the seal would erupt and leakage occur. It was decided that use of a large container was only practical if speedy results were desired. A sealing agent that was dependable 100% of the time was not found.

All of the cores used for permeability tests had an air void content of more than 5% and the treated water permeated them all. After the samples were tested, the cores were broken apart and the dye that had been used in the water had dried and showed up very clearly in the places where the water had permeated.

A suitable means of removing the bees wax or the sulfur-lead sealants was not found. As sealants were removed, damage to the sample occurred. If any of the sealing material was left on the briquettes, the proper figure for aid voids could not be calculated. The easiest sealant to remove was the hot bees wax that was allowed to cool overnight after being applied to the surface of the Marshall. When it came time to remove the bees wax, it was scraped off with the use of hot wire and a stiff bristled brush.

The method for sealing the samples was effective only about half the time. Every core that was split showed evidence of leakage down the sides.

The information gained through the few successful Marshall samples we had, indicated that pavements with air voids greater than 5.0% do in most cases allow water to pass through them. On the other hand, pavements with air voids of 5.0% or less are not nearly as likely to allow water to permeate through them as evidenced by one sample that held a static head of 2.0 ft. for over 2 days. With the amount of pressure exerted by this depth of water, it is improbable that pavements on bridge decks of the same consistency will allow water to permeate these depths. It would appear that the ability of pavements to remain impermeable to water varies in relation to the percent air voids in a given pavement.

CONCLUSION

The investigation conducted by the Bituminous Concrete Section of the Materials Division, has indicated that some bituminous concrete pavements are water permeable and some are not. Further study and development of a suitable sealing process for samples will aid in future investigations.

The percentage of air voids allowing permeability in various types of mixes was not established in this study due to the sealing difficulties encountered.

REFERENCES

1. "Investigation of Protective Membranes Used on Four Vermont Bridge Decks"
2. HRB Special Report 98 "Effect of Water on Bitumen - Aggregate Mixtures"
3. ASTM STP #240 "Effect of Water on Bituminous Paving Mixtures"
4. HRB Vol 34 "Permeability, Void Content and Durability of Bituminous Concrete"

Fig #1

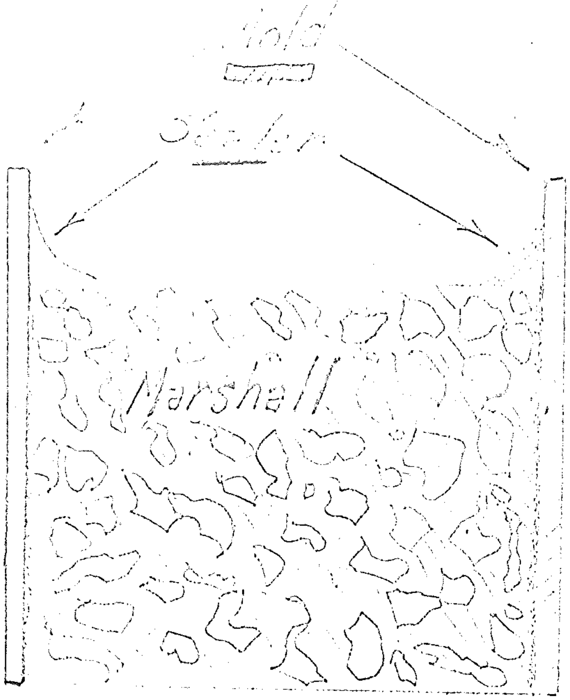
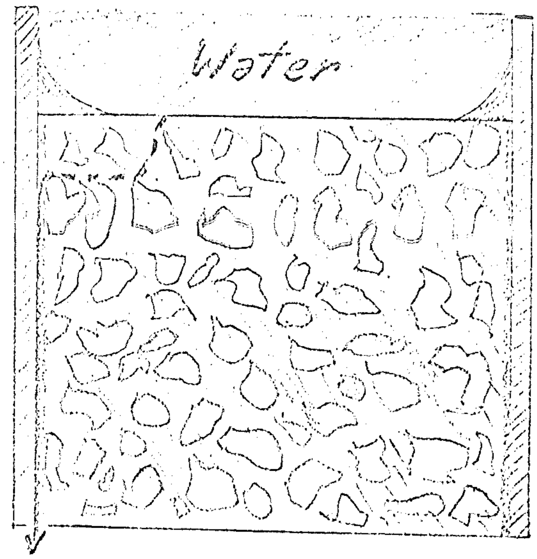


Fig #2



Path of
Water Seepage ----→

Fig. #3

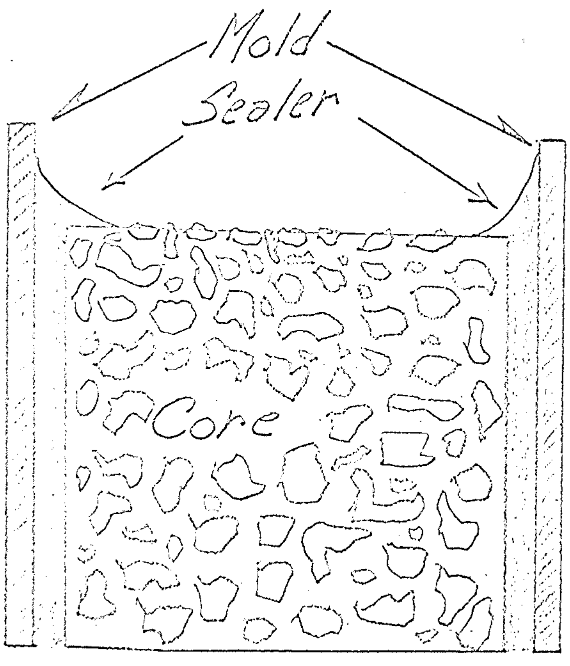


Fig. #4

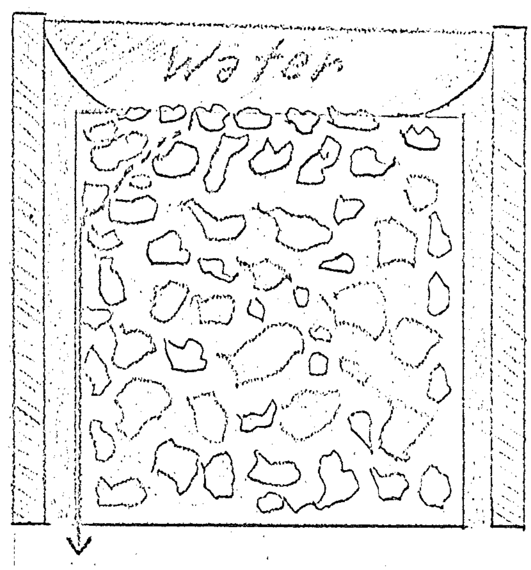
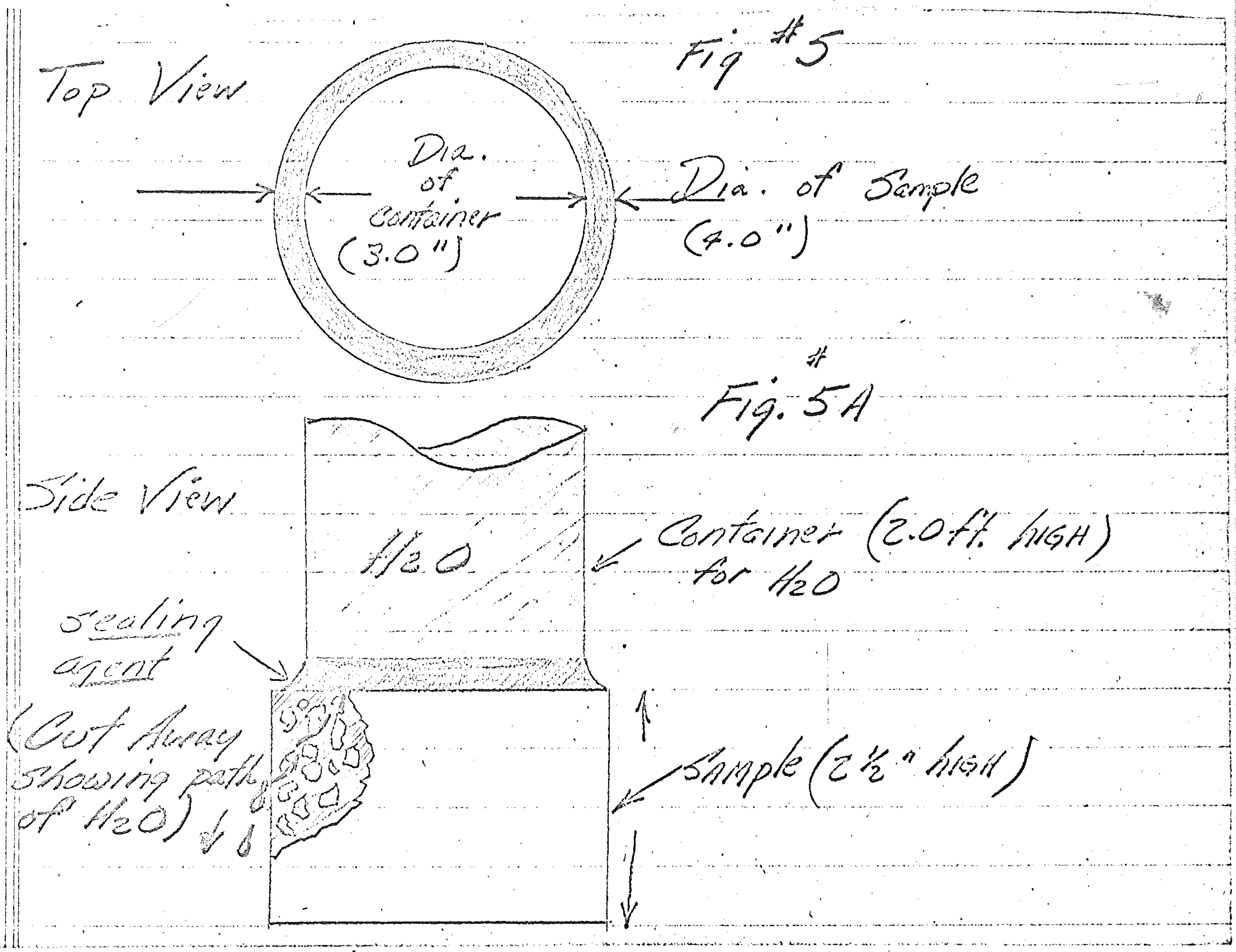
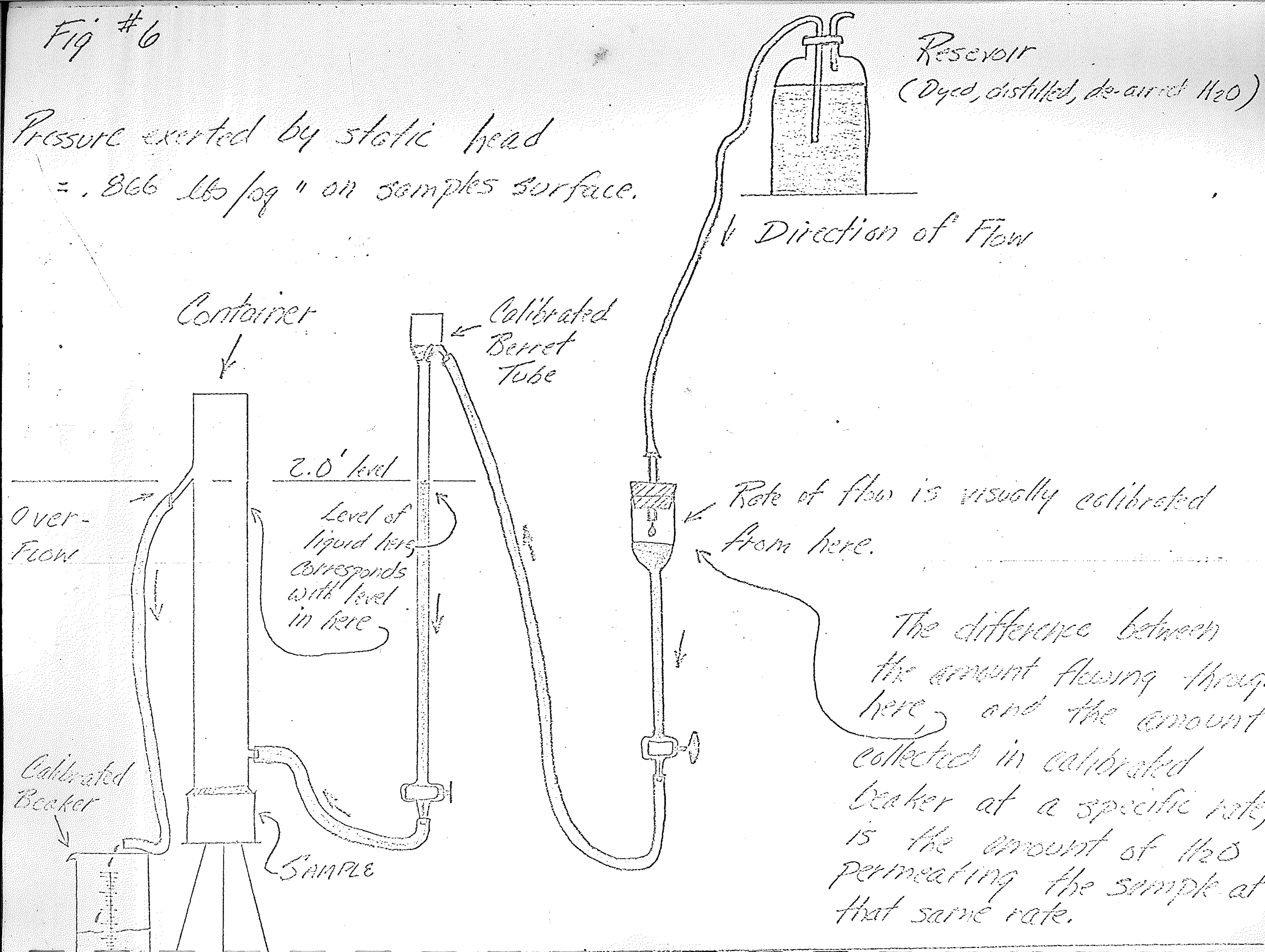


Fig #5



Top View
Fig #5
Dia. of Container (3.0")
Dia. of Sample (4.0")
Fig. #5A
Side View
H_2O
Container (2.0 ft. HIGH) for H_2O
Sealing agent
(Cut Away showing path of H_2O)
Sample (2½" HIGH)

Fig #6


Reservoir
(Dyed, distilled, de-aired H_2O)
Pressure exerted by static head
= .866 lbs/sq" on samples surface.
Direction of Flow
Container
Calibrated
Berret
Tube
2.0' level
Over-
Flow
Level of
liquid here
corresponds
with level
in here
Rate of flow is visually calibrated
from here.
The difference between
the amount flowing through
here, and the amount
collected in calibrated
beaker at a specific rate,
is the amount of H_2O
permeating the sample at
that same rate.
Calibrated
Beaker
SAMPLE