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To
OFFICE OF THE CHIEF OF ENGINEERS

Progress Report
to June 30, 1954

on

UNDERGROUND PIPE INSULATION

by

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Progress Report to June 30, 1954

Full Scale Trench Test

In order to conduct tests on Gilsulate insulation simulating actual use, a watertight box 4' x 4' x 12' long was constructed, as shown in the attached figure, along the longitudinal center line of which was placed a 4" I. P. S. test pipe. The box was filled with earth, which had previously been dried, to approximately mid-height of the box. At this point a wooden form was placed around the pipe and filled with Gilsulate in the form of a square about 12" on a side, simulating its application in a trench. After removing the form, the remainder of the box was then filled with earth. Both materials were tamped with an 8" x 8" steel tamper as they were added.

Five thermocouples were fastened to the top of the pipe at positions 23" apart starting at the center and extending in both directions. Also a thermocouple was fastened to the pipe at its entrance to and at its exit from the box. In addition, eleven thermocouples were located in the Gilsulate or the earth in each of three directions in a plane perpendicular to the steam pipe at its center. The thermocouples were spaced one at 1/2", four at 1", three at 2", and two at 4" separation in a downward, sideways, and upward direction from the pipe.

In order that the water table in the earth in the box might be adjusted and measured, six vertical 1/2" diameter pipes were equally spaced along each side of the box extending from the top to the bottom. A 100' length of rope was placed on the bottom of the box to provide distributing channels for water introduced

Full Scale Trench Test

In order to conduct tests on Giffels insulation simulation actual was a rectangular box 4' x 12' long was constructed, as shown in the attached figure, along the longitudinal center line of which was placed a 4" I. P. U. test pipe. The box was filled with earth, which had previously been dried, to approximately mid-height of the box. At this point a wooden form was placed around the pipe and filled with Giffels in the form of a square about 12" on a side, maintaining its application in a trench. After removing the form, the remainder of the box was then filled with earth. Both materials were tamped with an 8" x 8" steel tamper as they were added.

Five thermocouples were fastened to the top of the pipe at positions 12" apart starting at the center and extending in both directions. Also a thermocouple was fastened to the pipe at its entrance to and at its exit from the box. In addition, eleven thermocouples were located in the Giffels or the earth in each of three directions in a plane perpendicular to the steel pipe at its center. The thermocouples were spaced one at 1/2", four at 1", three at 2", and two at 4" separation in a downward, always, and upward direction from the pipe.

In order that the water table in the earth in the box might be adjusted and measured, six vertical 1/2" diameter pipes were equally spaced along each side of the box extending from the top to the bottom. A 100' length of rope was placed on the bottom of the box to provide distributed channels for water drainage.

through these vertical pipes. Two 1" diameter vertical pipes were placed 1' from the side and 1' from either end of the box to serve as wells for measuring the actual water table level.

The 12' steam pipe was divided into three sections by two internal half-moon dams set 4' apart isolating a "measuring section" at the middle of the pipe. Separate condensate drain lines were brought out from each section and connected to steam traps, float traps being used for the first two sections, and a bucket (air-venting) trap for the last section. In each case the condensate from the trap was arranged to pass through a water-cooled heat exchanger to cool it below 212°F so that the condensate could be collected in open weighing vessels and the rate of condensation in each section of the 12' pipe measured. An electrically-heated steam boiler capable of producing steam at the necessary pressure was constructed, installed and insulated. Its water level is maintained by a float control opening a solenoid valve in a line from a water supply tank maintained at a higher pressure than that of the boiler.

A first test run has been started, but sufficient data have not been obtained at the time of this report to yield significant results.

Laboratory Tests of the Properties of Gilsulate

Laboratory work was commenced for evaluation of the temperature-wise properties of "Gilsulate". The available literature

through these vertical pipes. The 1" diameter vertical pipes were placed 1' from the side wall of the tank and 1' from the bottom level. The 1/2" steel pipe was divided into three sections by two

horizontal 1/2" diameter pipes. The 1/2" diameter pipes were connected to a steam trap at the middle of the pipe. The 1/2" diameter pipes were brought out from each section and connected to a steam trap, the first trap being for the first two sections, and a second (air-venting) trap for the last section. In each case

the condensate from the trap was arranged to pass through a water-cooled heat exchanger to cool it below 212°F so that the condensate could be collected in open weighing vessels and the rate of condensation in each section of the 1/2" pipe measured.

An electrically-heated steam boiler capable of producing steam at the necessary pressure was constructed, installed and maintained. Its water level is maintained by a float control opening a solenoid valve in a line from a water supply tank maintained at a constant pressure from that of the boiler.

A float test was run and the following data

have not been obtained at the time of this report to yield

significant results.

Laboratory Tests of the Properties of Silicates
Laboratory work was arranged for evaluation of the structure-wise properties of "Silicates". The available literature

was reviewed and conferences held to determine the scope and magnitude of the work.

An apparatus for determining the temperature characteristics of the insulation at various pipe temperatures was designed and constructed. The apparatus consists of a 1-inch galvanized pipe with an electric heater wound on one end. Power to this heater is controlled by a thermostatic switch. Thermocouples are peened into the pipe at equal intervals along the pipe. The pipe is enclosed in a cement-asbestos board box which is used to contain a minimum of 4 inches of the insulating material radially around the pipe. In use, the temperature of the pipe decreases with distance from the hot end. Successive transverse sections of the surrounding insulation are thus subjected to different pipe temperatures in one test, the duration of which may be several days or weeks. Later examination of the condition of the insulation at different sections indicates the effect of different pipe temperatures, as shown below.

Five tests were completed with this apparatus and a sixth is under way. The results of the first test have been analyzed and conclusions drawn. The results of the other four tests are being analyzed.

The results of the first test are presented on the enclosed drawing and shown on the enclosed photograph. The conclusions based on this test were as follows:

1. Pipe temperatures greater than 444°F caused considerable

was reviewed and conference held to determine the scope and

magnitude of the work.

An apparatus for determining the temperature characteristics

of the insulation at various pipe temperatures was designed and

constructed. The apparatus consists of a 1-inch diameter pipe

with an electric heater wound on one end. Power to the heater

is controlled by a thermostat switch. Thermocouples are placed

into the pipe at equal intervals along the pipe. The pipe is

enclosed in a cement-asbestos board box which is used to contain

a minimum of 4 inches of the insulating material. Initially, around

the pipe. In use, the temperature of the pipe decreases with

distance from the hot end. Successive transverse sections of the

insulating material are thus subjected to different pipe

temperatures. In one test, the duration of which may be several

days or weeks. Later examination of the condition of the

material at different sections indicates the effect of different

pipe temperatures, as shown below.

Five tests were completed with this apparatus and a sixth is

under way. The results of the first test have been analyzed and

conclusions drawn. The results of the other four tests are being

analyzed.

The results of the first test are presented on the enclosed

drawing and shown on the enclosed graph. The conclusions

based on this test were as follows:

1. Pipe temperatures greater than 400°F cause considerable

slumping of the granular material, due to shrinkage as it consolidated or melted.

2. Estimated initial sintering temperature was about 193°F. Material that sintered at temperatures lower than 226°F was too weak to withstand gentle handling.
3. The minimum temperature of pipe for sintering to obtain moderate strength and cohesiveness of the sintered annulus was 226°F. This sintered material showed only slight fusion of particles.
4. "Glassy consolidation" occurred at temperatures higher than 371°F. This material is a uniform voidless "solidified liquid" when cool. In general the glassy material was found under the level of the pipe, as a result of plastic or liquid flow into this region from above. A thin layer of glassy material up to 1/2 inch thick was found on the top surface of the pipe where its temperature was between 371 and 491° F. At pipe temperatures higher than 491°F the material evidently became quite liquid and a void was formed above the pipe by melting out of material which flowed and collected under the pipe. The void was roofed by granular consolidated material with a skin of glassy fused material.
5. The sintered material under the pipe, between 300°F

and 371°F slumped away from the pipe slightly, leaving a gap into which a flow of plastic material entered from the hotter end. This flow persisted until it reached a temperature of 310°F.

6. It is concluded from this test that this particular material
 - a) sinters to a significant degree above 226°F.
 - b) consolidates at about 371°F.
 - c) is quite plastic, or liquid, above 455°F.
 - d) at pipe temperatures of 450°F and above, voids can be expected to develop over the pipe.
7. The "as received" density of the material was 39 lb/ft³ as determined in accordance with Federal Specification HH-I-521c.

An apparatus was designed for measuring the thermal conductivity of loose or granular fill materials. This apparatus will be used to make measurements on "Gilsulate" in the consolidated, sintered and unconsolidated conditions at appropriate ranges of temperature. Construction of the apparatus will commence upon receipt of ordered materials.

and the liquid was removed from the pipe slightly before
the fact which a flow of plastic material entered from
the lower end. This flow continued until it reached
a temperature of 210°F.

It is concluded from this test that this plasticizer

material

(1) starts to soften and deforms above 180°F.

(2) consolidates at about 210°F.

(3) is quite plastic, or liquid, above 220°F.

(4) at pipe temperatures of 200°F and above, will continue

expected to develop over the pipe.

The "as received" density of the material as 29 lb/cu

is determined in accordance with Federal Specification

BB-I-250.

An apparatus was devised for measuring the thermal conductivity

of loose or granular fill materials. This apparatus will be used

to make measurements of "granular" or "loose" materials, situated

and unconsolidated conditions at appropriate ranges of temperature.

Construction of the apparatus will commence upon receipt of ordered

materials.

... 217° ...
... flow of plastic material ...
... the hotter end ...
... temperature of 217° ...

It is concluded from this test that this particular

material

(a) yields to a significant degree above 217°

(b) consolidates at about 217°

(c) is quite plastic at liquid, above 217°

(d) at high temperatures of 400° and above, yields and is

expected to behave over the range

The "as received" quality of the material was 99 1/2%

as determined in accordance with Federal Specification

III-I-217c.

An apparatus was designed for measuring the thermal conductivity

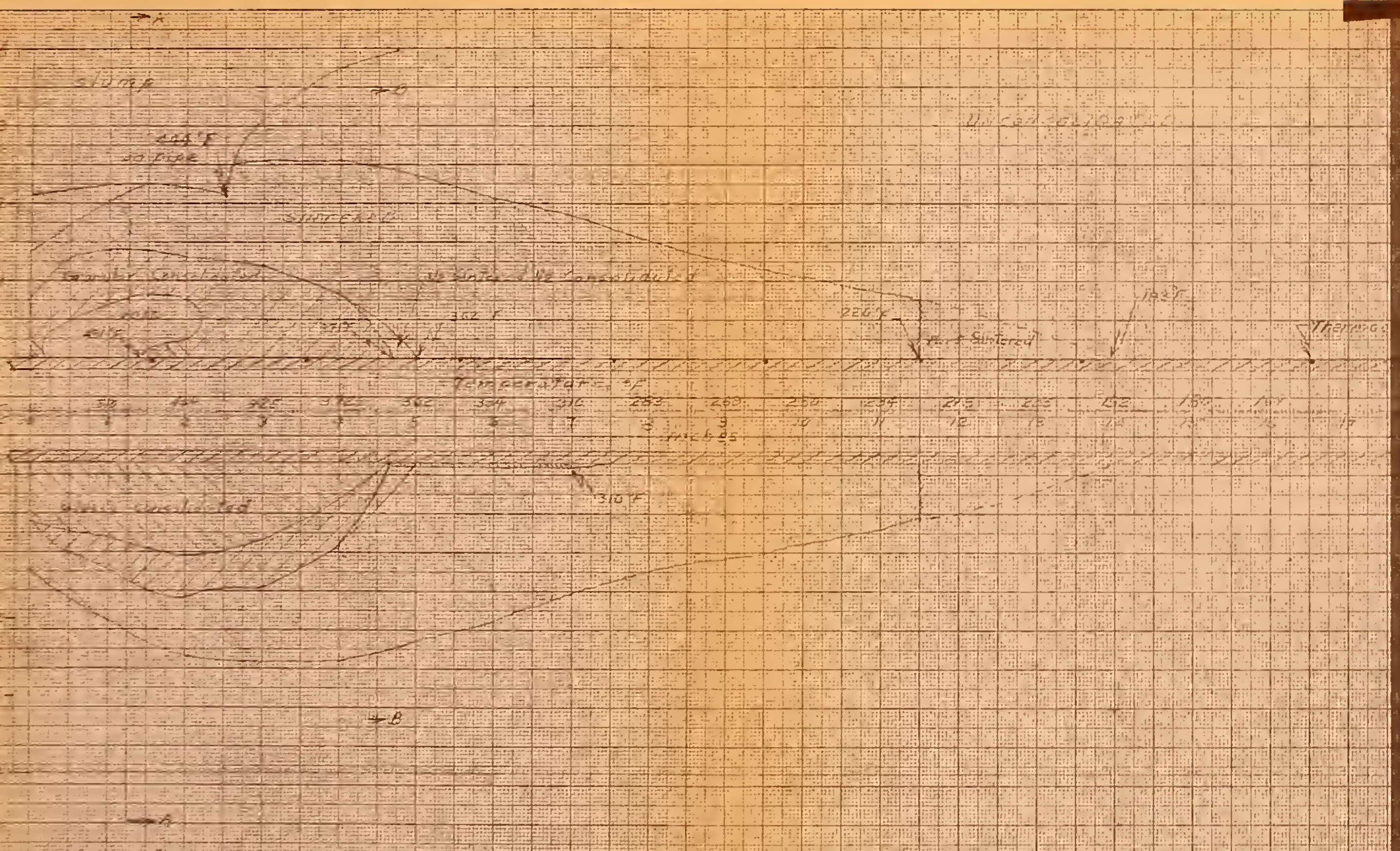
of loose or granular materials. This apparatus will be used

to make measurements on "silica" in the consolidated, sintered

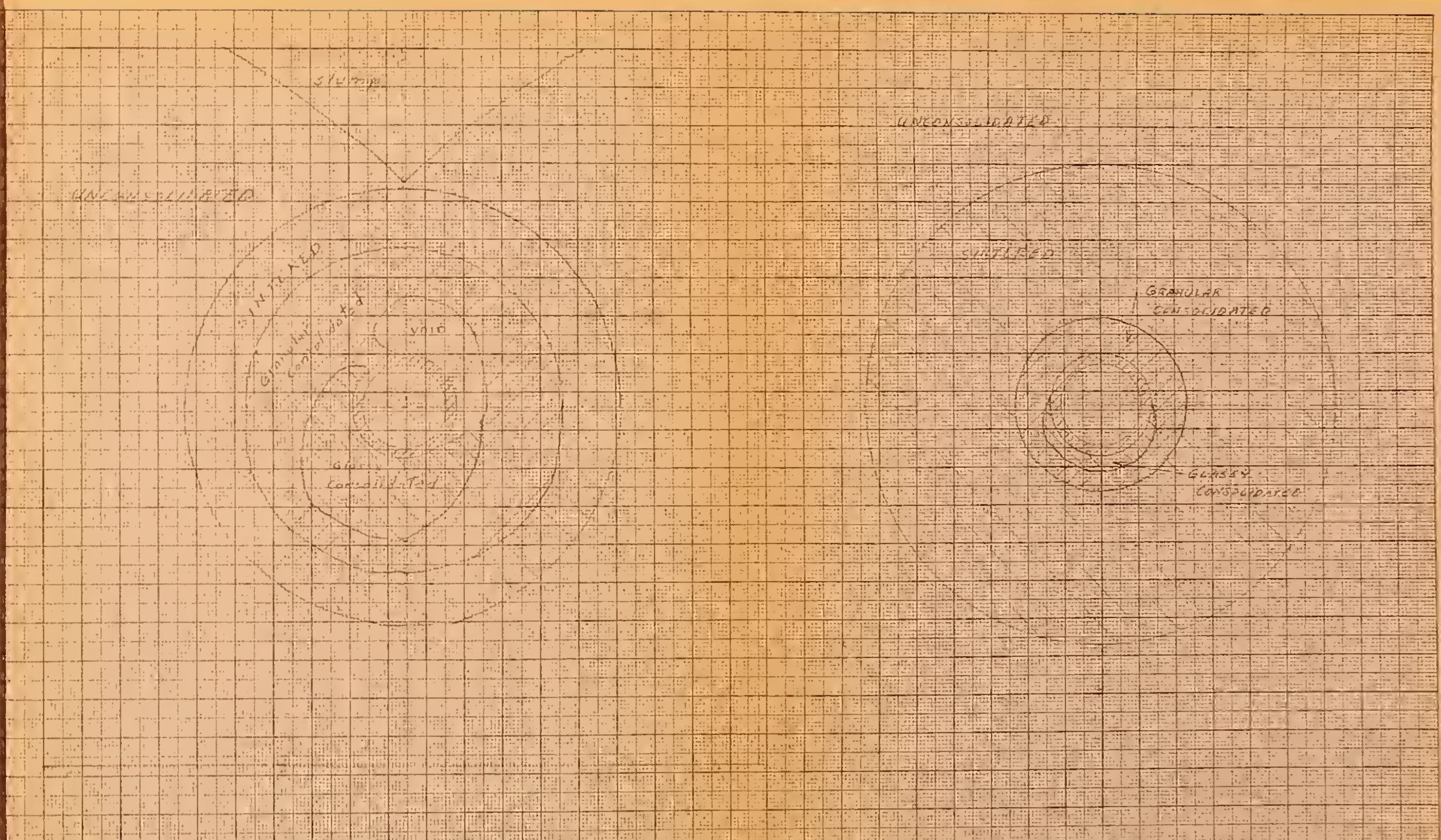
and unconsolidated conditions at appropriate ranges of temperature.

Construction of the apparatus will commence upon receipt of ordered

materials.



GIPSUM TYPE "B"



SECTION A-A
Pipe Terminal 400 ft

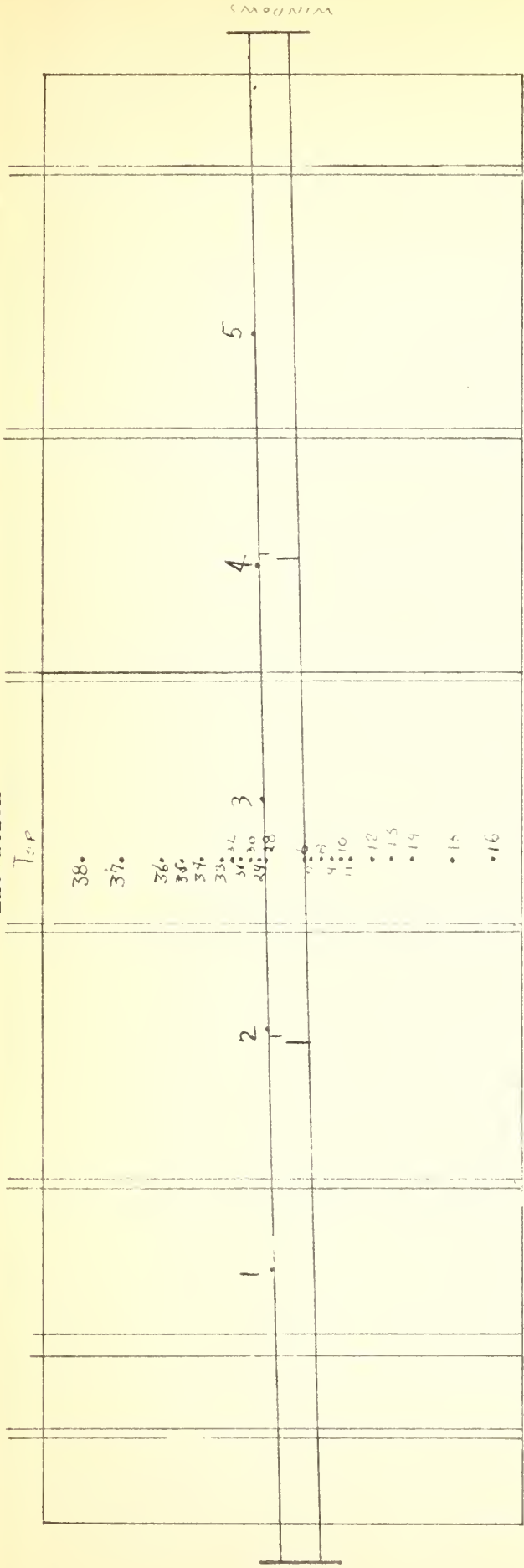
SECTION B-B
Pipe Terminal 300 ft





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Elevation



Plan

