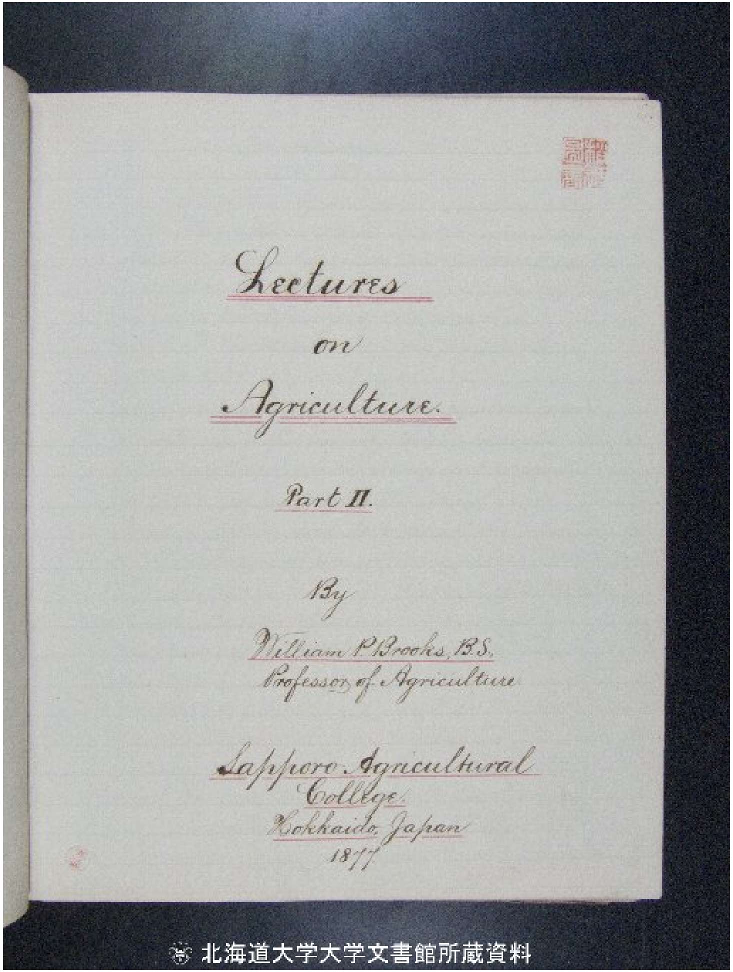


Lectures

on

Agriculture

Part II.

By

William P. Brooks, B. S.

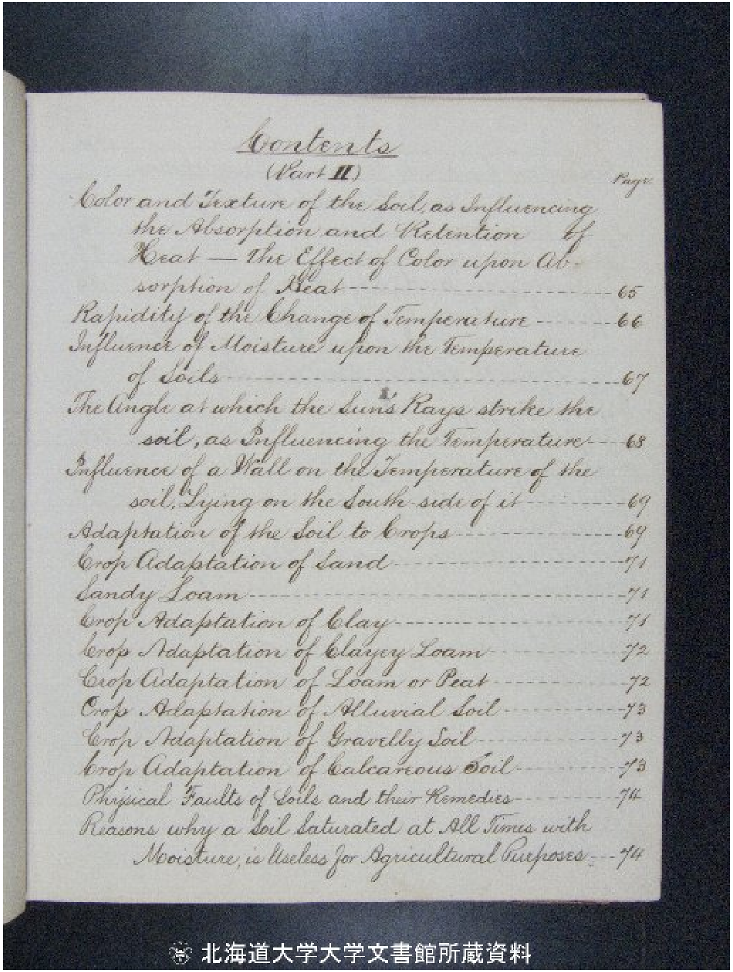
Professor of Agriculture

Sapporo Agricultural

College,

Hokkaido, Japan

1877.



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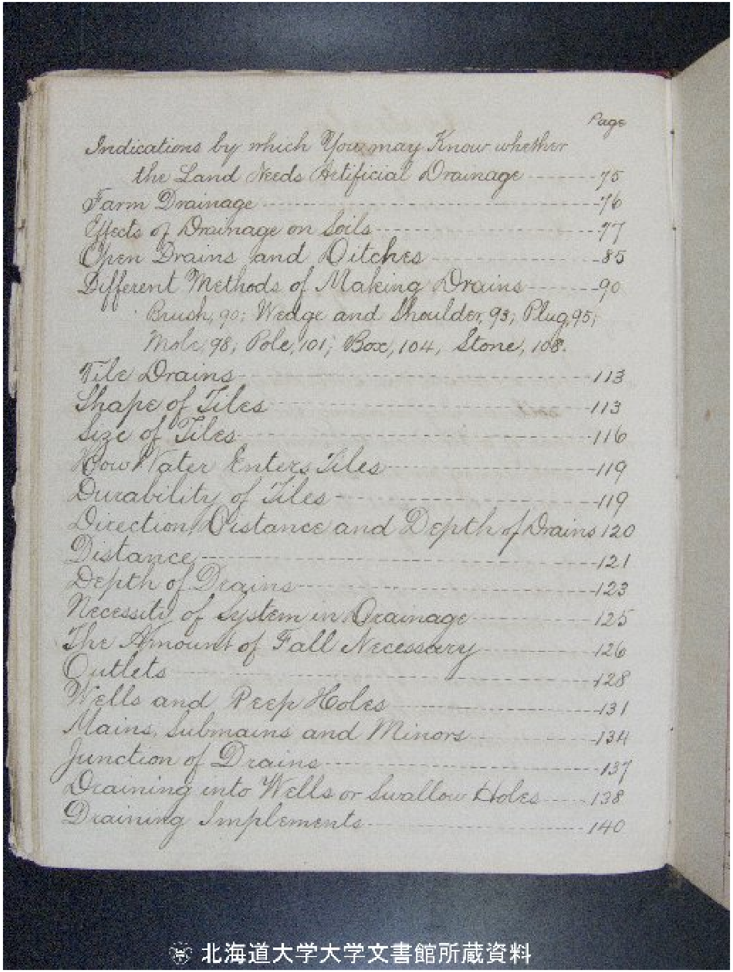
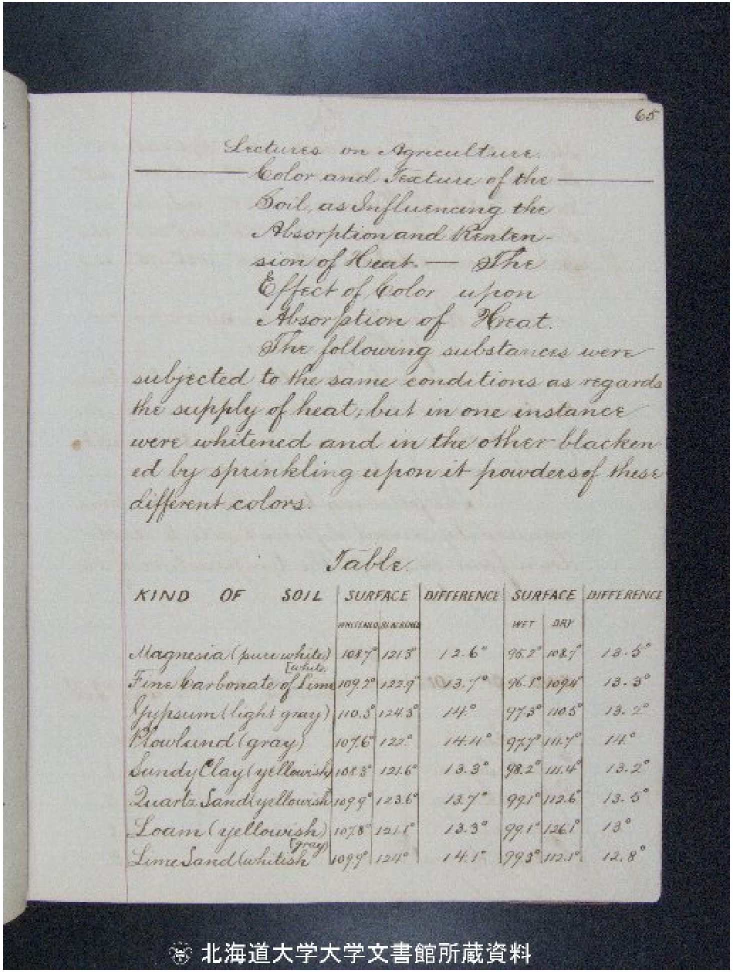
(Part II)





Lectures on Agriculture

——— Color and Texture of the ———

Soil, as Influencing the

Absorption and Rentension

of Heat. —The

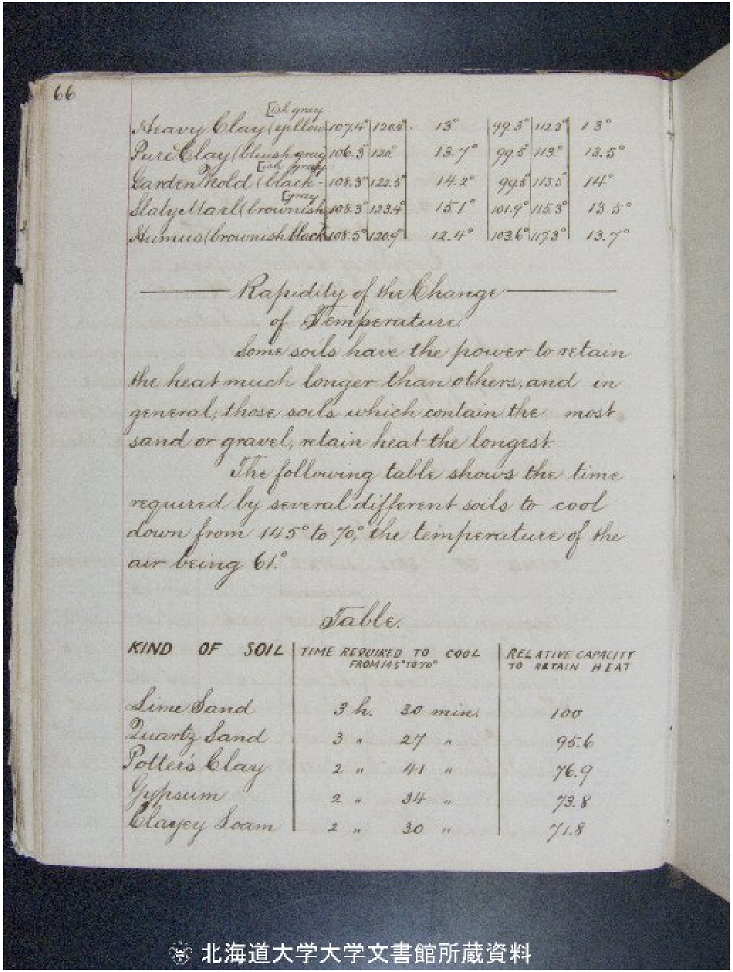
Effect of Color upon

Absorption of Heat.

Thee following substances were subjected to the same conditions as regards the supply of heat; but in one instance were whitened and in the other blackened by sprinkling upon it powders of these different colors.

Table

KIND OF SOIL	SURFACE		DIFFRENCE	SURFACE		DIFFERENCE
	WHITENEO	BLACKNEO		WET	DRY	
Magnesia (pure white)	108.7°	121.3°	12.6°	95.2°	108.7°	13.5°
Fine Carbonate of Lime (white)	109.2°	122.9°	13.7°	96.1°	109.4°	13.3°
Gypsum (light gray)	110.3°	124.3°	14°	97.3°	110.5°	13.2°
Howland (gray)	107.6°	122°	14.4°	97.7°	111.9°	14°
Sandy Clay (yellowish)	108.3°	121.6°	13.3°	98.2°	111.4°	13.2°
Quarts Sand (yellowish)	109.9°	123.6°	13.7°	99.1°	112.6°	13.5°
Loam (yellowish)	107.8°	121.1°	13.3°	99.1°	126.1°	13°
Lime Sand (whitish gray)	109.9°	124°	14.1°	99.3°	112.1°	12.8°



Heavy Clay (yellowish gray)	107.4°	120.4°	13°	99.3°	112.3°	13°
Pure Clay (bluish gray)	106.3°	120.°	13.7°	99.5°	113°	13.5°
Garden Mold (blackish gray)	108.3°	122.5°	14.2°	99.5°	113.5°	14°
Slaty Marl (brownish gray)	108.3°	123.4°	15.1°	101.9°	115.3°	13.5°
Humus (brownish black)	108.5°	120.9°	12.4°	103.6°	117.3°	13.7°

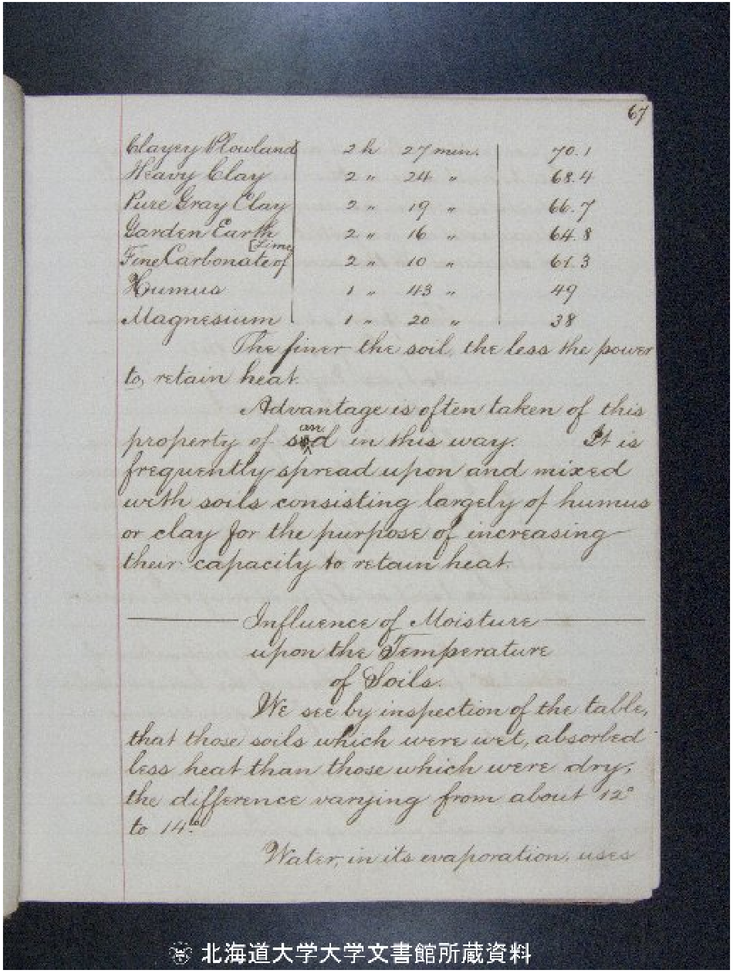
Rapidity of the Change of Temperature

Some soils have the power to retain the heat much longer than others, and in general, those soils which contain the most sand or gravel, retain heat the longest.

The following table shows the time required by several different soils to cool down from 14.5°to 70,°the temperature of the our being 61.°

Table

KIND OF SOIL	TIME REQURED TO COOL FROM 145°TO 70°	RELATIVE CAPACITY TO RETAIN HEAT
Lime Sand	3h. 30 min.	100
Quartz Sand	3〃 27〃	95.6
Potter's Clay	2〃 41〃	76.9
Gypsum	2〃 34〃	73.8
Clayey Loam	2〃 30〃	71.8



Clayey Howland	2h. 27min.	70.1
Heavy Clay	2〃 24〃	68.4
Pure Gray Clay	2〃 19〃	66.7
Garden Earth	2〃 16〃	64.8
Fine Carbonate of Lime	2〃 10〃	61.3
Humus	1〃 43〃	49
Magnesium	1〃 20〃	38

The finer the soil, the less the power to retain heat.

Advantage is often taken of this property of sand in this way. It is frequently spread upon and mixed with soils consisting largely of humus or clay for the purpose of increasing their capacity to retain heat.

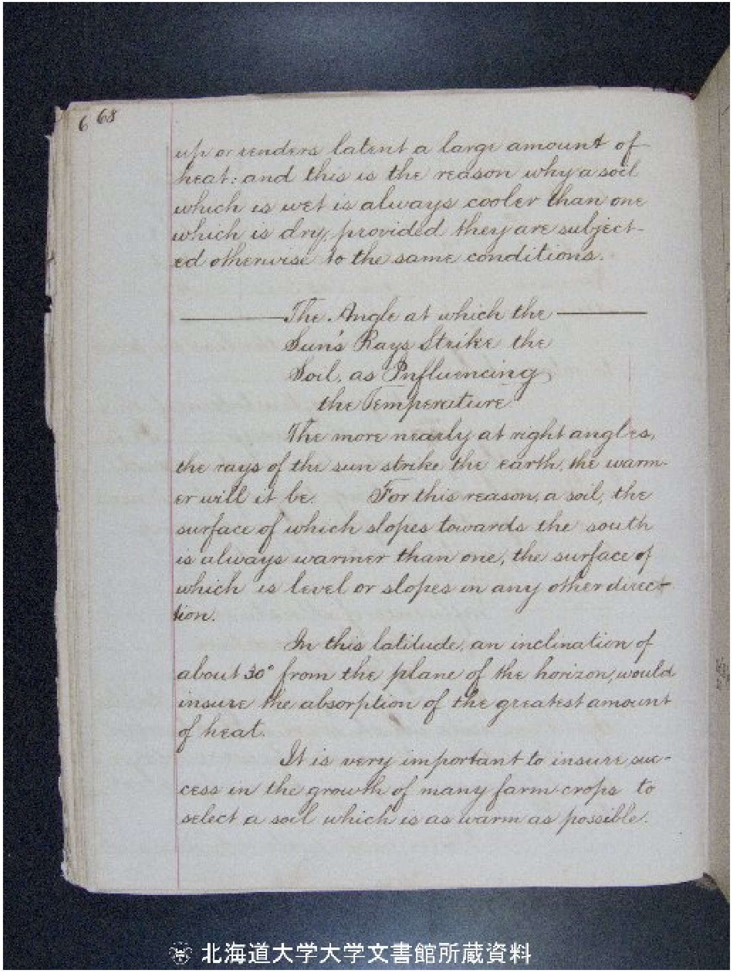
——— Influence of Moisture ———

upon the Temperature

of Soils

We see by inspection of the table, that those soils which were wet, absorbed less heat than those which were dry, the difference varying from about 12°to 14.°

Water, in its evaporations uses



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up or renders latent a large amount of heat: and this is the reason why a soil which is wet is always cooler than one which is dry, provided they are subjected otherwise to the same conditions.

The Angle at which the Sun's Rays Strike the Soil, as Influencing the Temperature

The more nearly at right angles, the rays of the sun strike the earth, the warmer will it be. For this reason, a soil, the surface of which slopes towards the south is always warmer than one, the surface of which is level or slopes in any other direction.

In this latitude, an inclination of about 30° from the plane of the horizon, would insure the absorption of the greatest amount of heat.

It is very important to insure success in the growth of many farm crops to select a soil which is as warm as possible.

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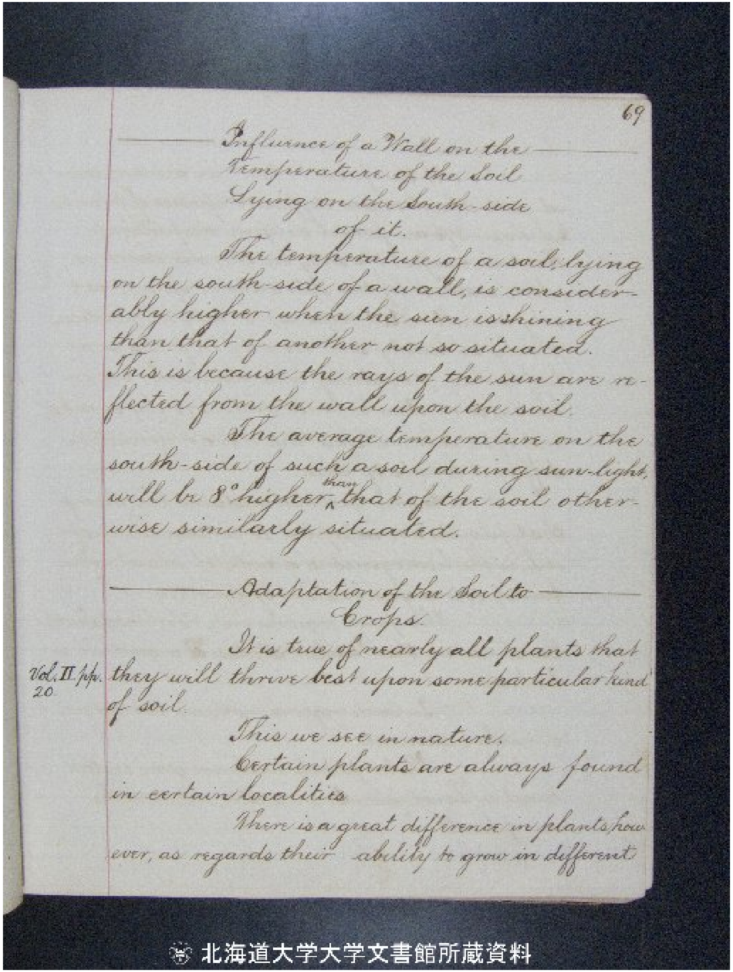
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Influence of a Wall on the
Temperature of the Soil
Lying on the South-side
of it.

The temperature of a soil, lying on the south-side of a wall, is considerably higher when the sun is shining than that of another not so situated. This is because the rays of the sun are reflected from the wall upon the soil

The average temperature on the south-side of such a soil during sun-light, will be 8° higher than that of the soil otherwise similarly situated.

Adaptation of the Soil to
Crops

Vol. II pp. 20 It is true of nearly all plants that they will thrive best upon some particular kind of soil

This we see in nature.

Certain plants are always found in certain localities

There is a great difference in plants however, as regards their ability to grow in different

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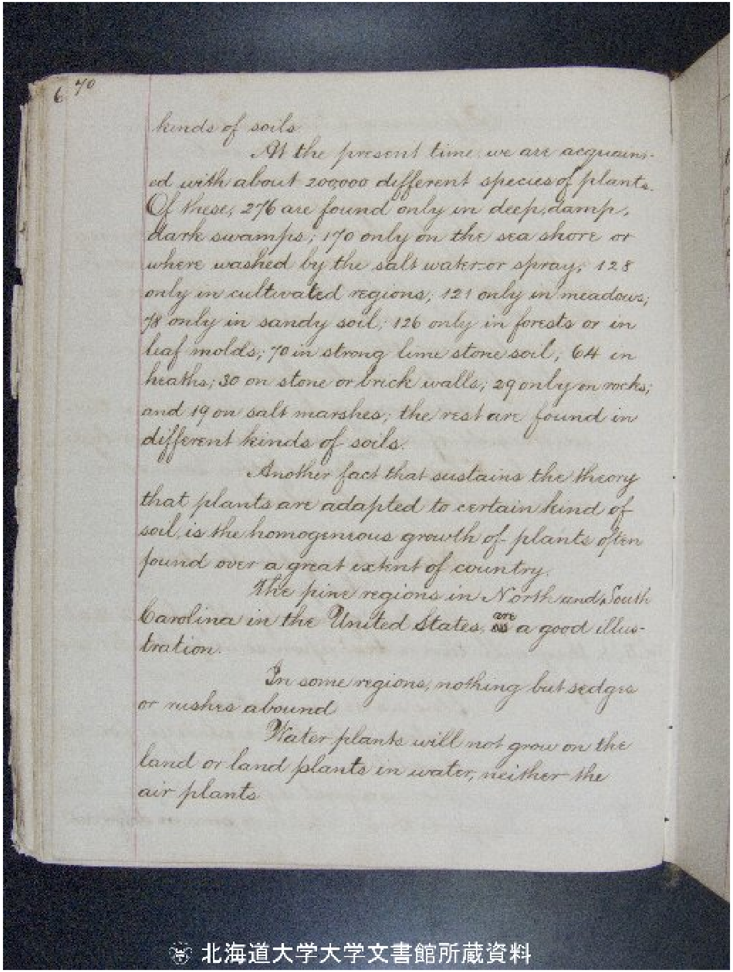
6 70

kinds of soils.

At the present time we are acquainted with about 200000 different species of plants. Of these, 276 are found only in deep, damp, dark swamps; 170 only on the sea shore or where washed by the salt water or spray, 128 only in cultivated regions; 121 only in meadows; 78 only in sandy soil, 126 only in forests or in leaf molds; 70 in strong lime stone soil, 64 in heaths; 30 on stone or brick walls; 29 only on rocks; and 19 on salt marshes; the rest are found in different kinds of soils.

Another fact that sustains the theory that plants are adapted to certain kind of soil is the homogenious growth of plants often found over a great extent of country.

The pine regions in North and South Carolina in the United States are a good illustration.

In some regions, nothing but sedges or rushes abound.

Water plants will not grow on the land or land plants in water, neither the air plants.

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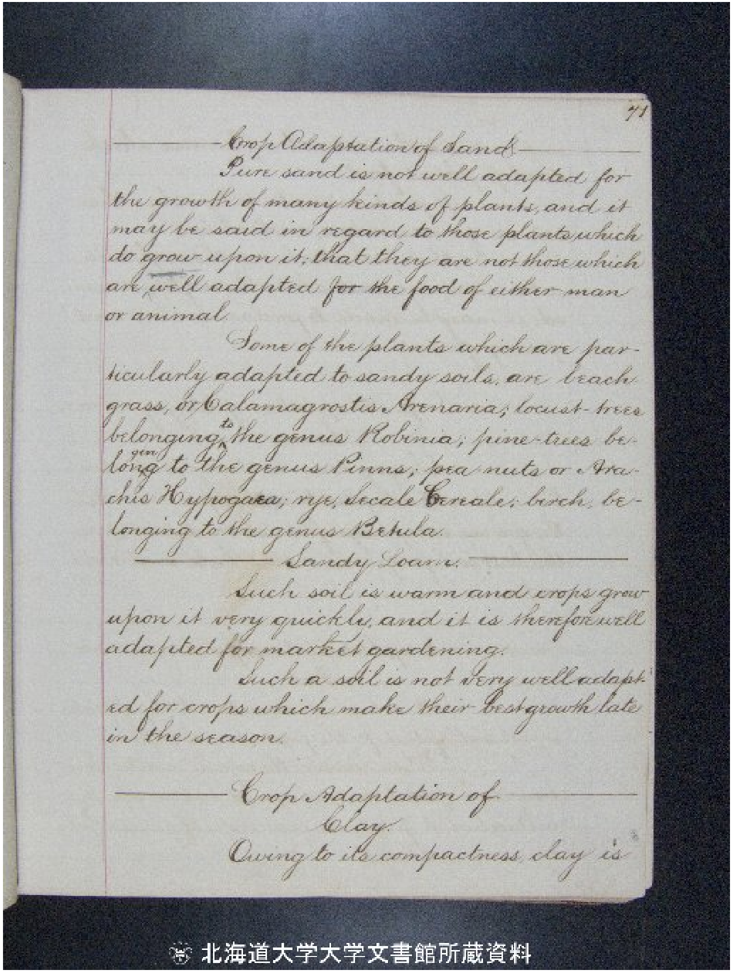

Crop Adaptation of Sand

Pure sand is not well adapted for the growth of many kinds of plants, and it may be said in regard to those plants which do grow upon it, that they are not those which are well adapted for the food of either man or animal.

Some of the plants which are particularly adapted to sandy soils, are beach grass, or Calamagrostis Arenaria; locust-trees belonging to the genus Robinia; pine-trees belong to the genus Pinns; pea nuts or Arachis Hypogaea; rye, Secale Cereale; birch, belonging to the genus Betula.

Sandy Loam.

Such soil is warm and crops grow upon it very quickly, and it is therefore well adapted for market gardening.

Such a soil is not very well adapted for crops which make their best growth late in the season.

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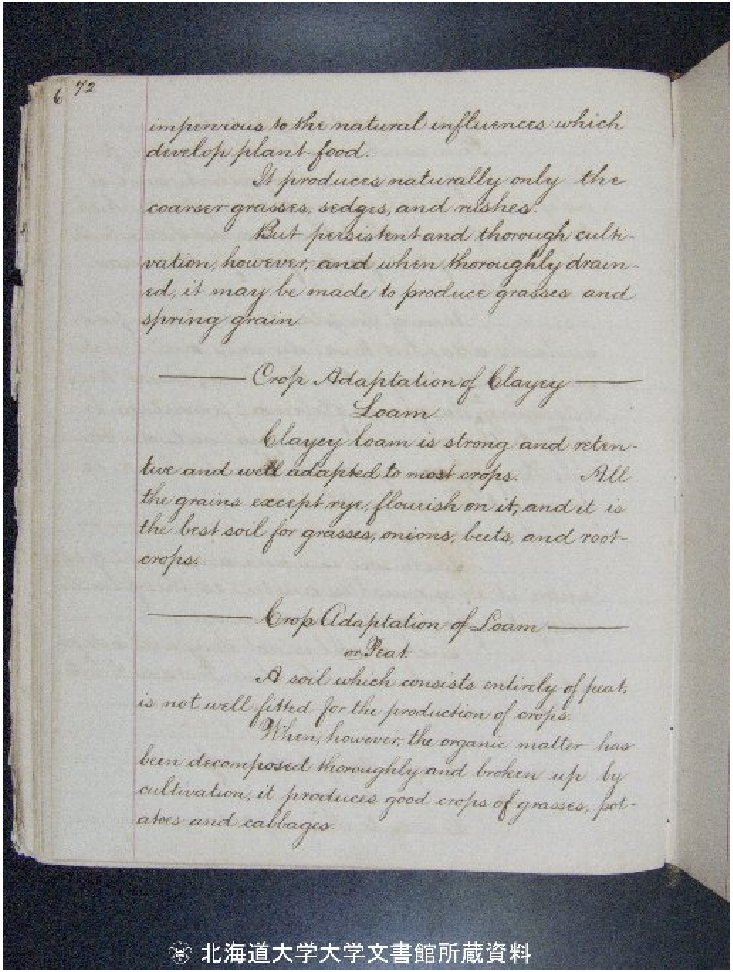
6 72

impervious to the natural influences which develop plant-food.

It produces naturally only the coarser grasses, sedges, and rushes.

But persistent and thorough cultivation, however, and when thoroughly drained, it may be made to produce grasses and spring grain.

—— Crop Adaptation of Clayey ——
Loam

Clayey loam is strong and retentive and well adapted to most crops. All the grains except rye, flourish on it, and it is the best soil for grasses, onions, beets, and root-crops.

—— Crop Adaptation of Loam ——
or Peat

A soil which consists entirely of peat, is not well fitted for the production of crops.

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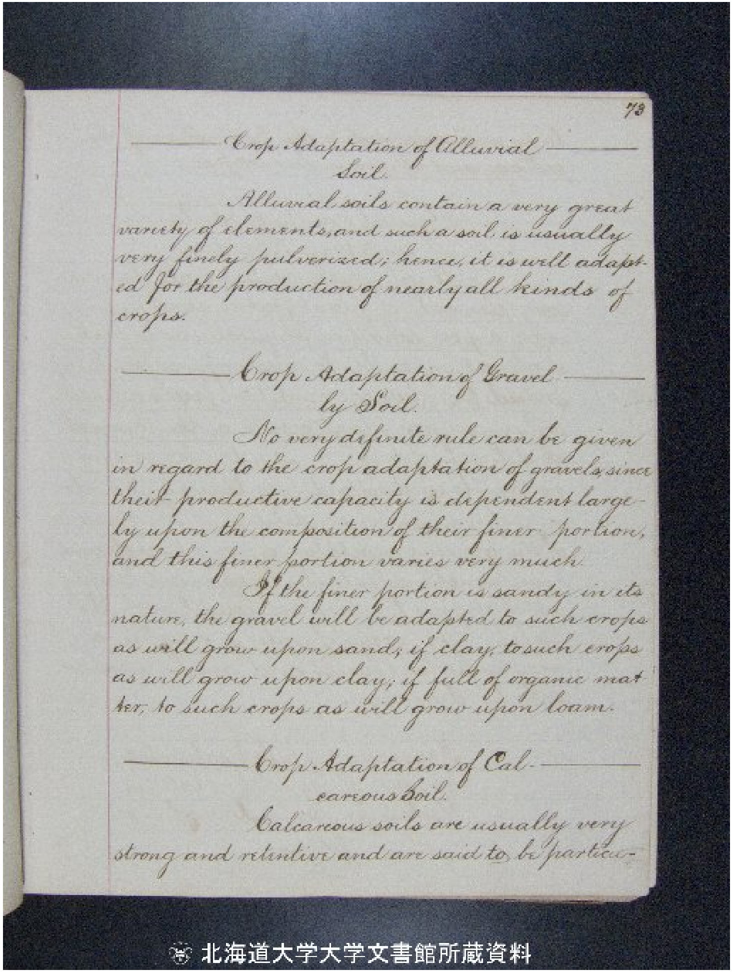

Crop Adaptation of Alluvial Soil.

Alluvial soils contain a very great variety of elements, and such a soil is usually very finely pulverized; hence, it is well adapted for the production of nearly all kinds of crops.

Crop Adaptation of Gravelly Soil.

No very definite rule can be given in regard to the crop adaptation of gravels, since their productive capacity is dependent largely upon the composition of their finer portion, and this finer portion varies very much.

If the finer portion is sandy in its nature, the gravel will be adapted to such crops as will grow upon sand; if clay, to such crops as will grow upon clay; if full of organic matter, to such crops as will grow upon loam.

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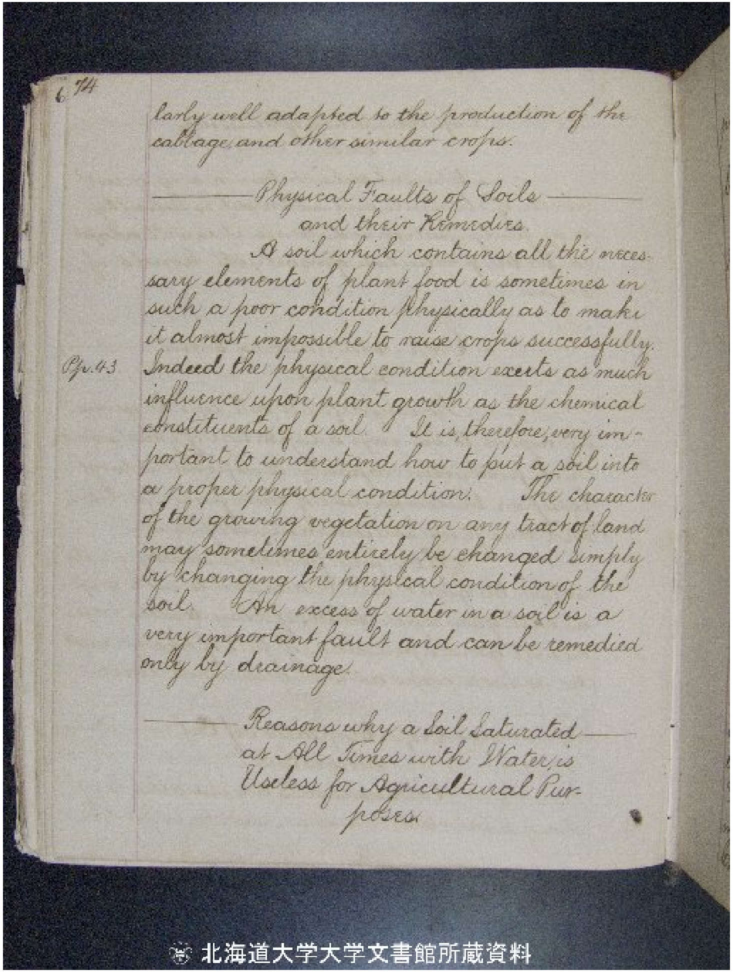

6 74

larly well adapted to the production of the cabbage and other similar crops.

Physical Faults of Soils
and their Remedies.

A soil which contains all the necessary elements of plant food is sometimes in such a poor condition physically as to make it almost impossible to raise crops successfully. Pp.43 Indeed the physical condition exerts as much influence upon plant growth as the chemical constituents of a soil. It is, therefore, very important to understand how to put a soil into a proper physical condition. The character of the growing vegetation on any tract of land may sometimes entirely be changed simply by changing the physical condition of the soil. An excess of water in a soil is a very important fault and can be remedied only by drainage.

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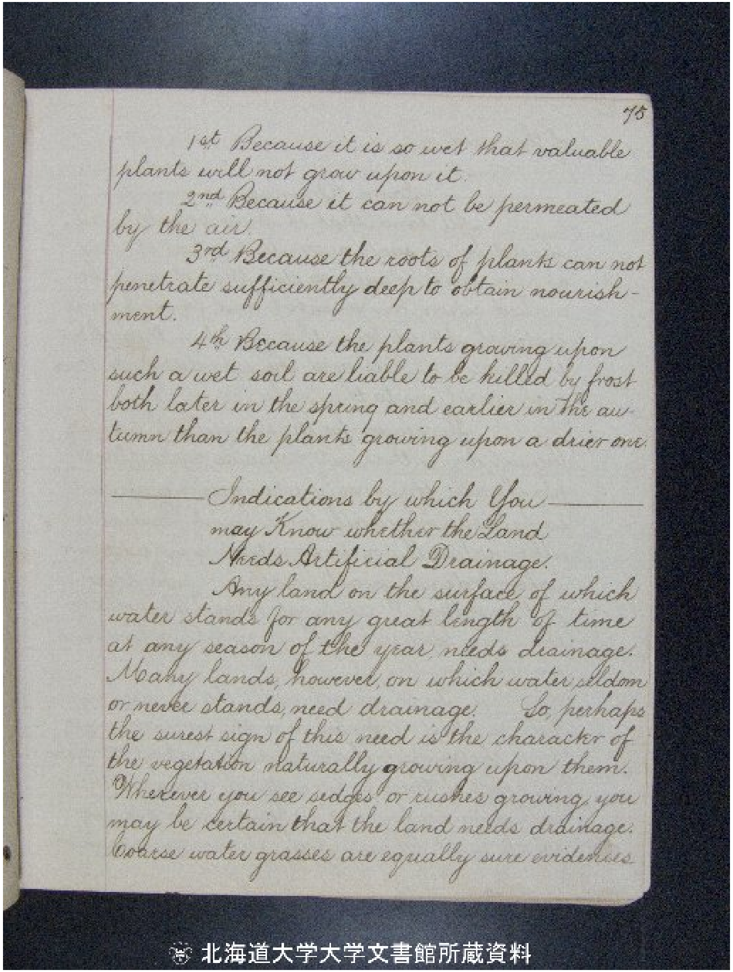

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1st Because it is so wet that valuable plants will not grow upon it.

2nd Because it can not be permeated by the air.

3rd Because the roots of plants can not penetrate sufficiently deep to obtain nourishment.

4th Because the plants growing upon such a wet soil are liable to be killed by frost both later in the spring and earlier in the autumn than the plants growing upon a drier one.

Indications by which You may Know whether the Land Needs Artificial Drainage.

Any land on the surface of which water stands for any great length of time at any season of the year needs drainage. Many lands, however, on which water seldom or never stands, need drainage. So, perhaps the surest sign of this need is the character of the vegetation naturally growing upon them. Wherever you see sedges or rushes growing, you may be certain that the land needs drainage. Coarse water grasses are equally sure evidences

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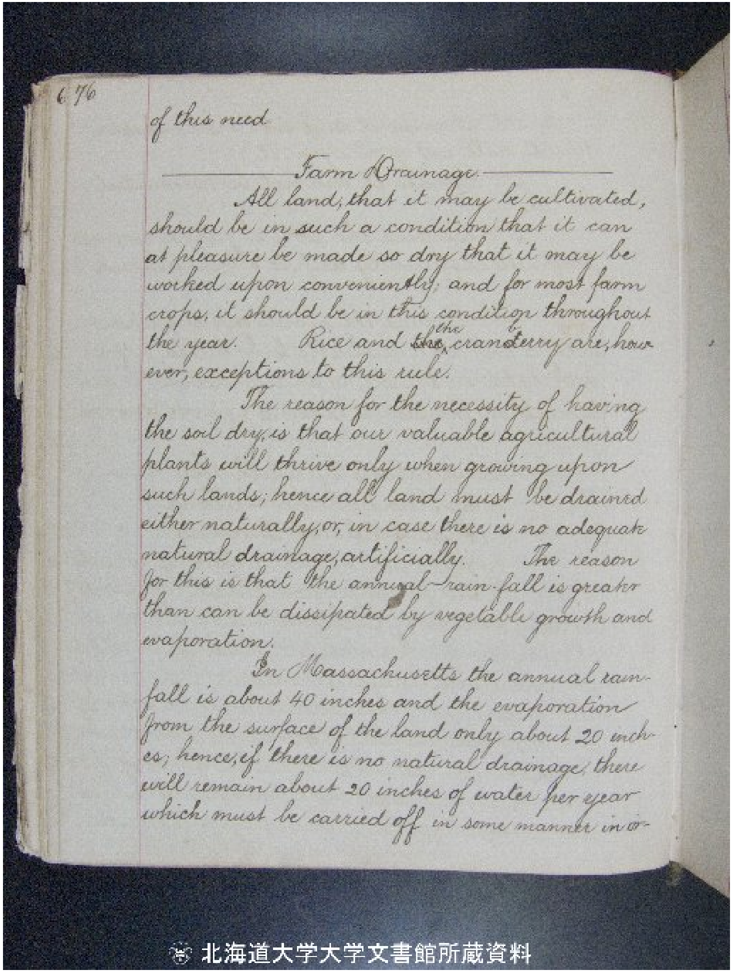

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Farm Drainage

All land, that it may be cultivated, should be in such a condition that it can at pleasure be made so dry that it may be worked upon conveniently; and for most farm crops, it should be in this condition throughout the year. Rice and the cranberry are, how ever, exceptions to this rule.

The reason for the necessity of having the soil dry, is that our valuable agricultural plants will thrive only when growing upon such lands; hence all land must be drained either naturally, or, in case there is no adequate natural drainage, artificially. The reason for this is that the annual rain-fall is greater than can be dissipated by vegetable growth and evaporation.

In Massachusetts the annual rain-fall is about 40 inches and the evaporation from the surface of the land only about 20 inches; hence, if there is no natural drainage there will remain about 20 inches of water per year which must be carried off in some manner in or-

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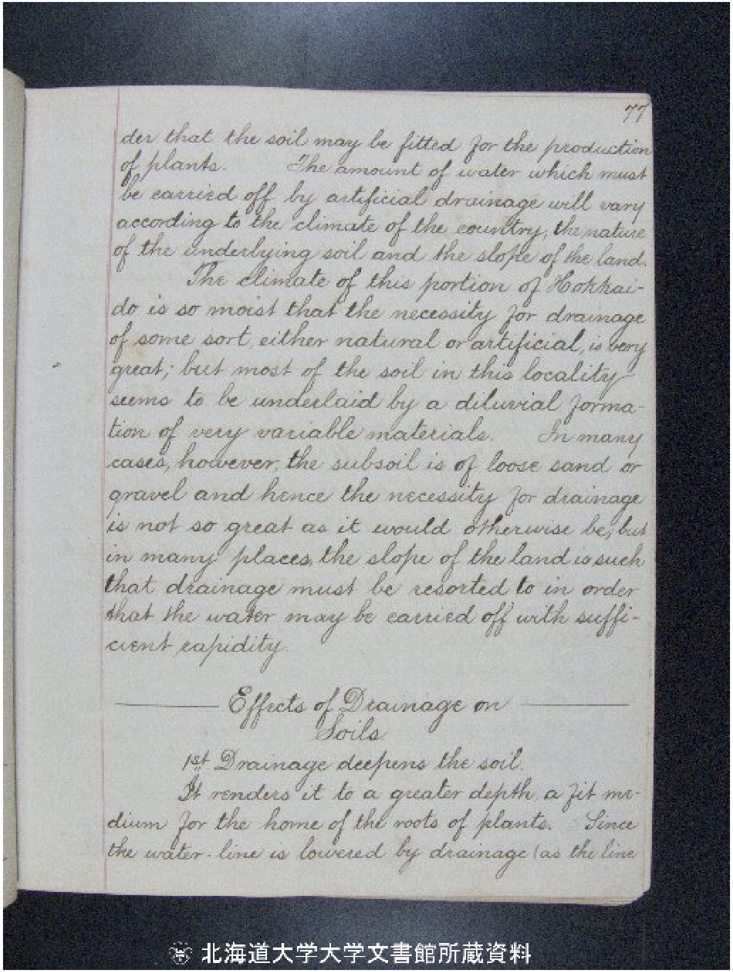

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The climate of this portion of Hokkaido is so moist that the necessity for drainage of some sort, either natural or artificial, is very great; but most of the soil in this locality seems to be underlaid by a diluvial formation of very variable materials. In many cases, however, the subsoil is of loose sand or gravel and hence the necessity for drainage is not so great as it would otherwise be, but in many places, the slope of the land is such that drainage must be resorted to in order that the water may be carried off with sufficient rapidity.

Effects of Drainage on Soils

1st Drainage deepens the soil.

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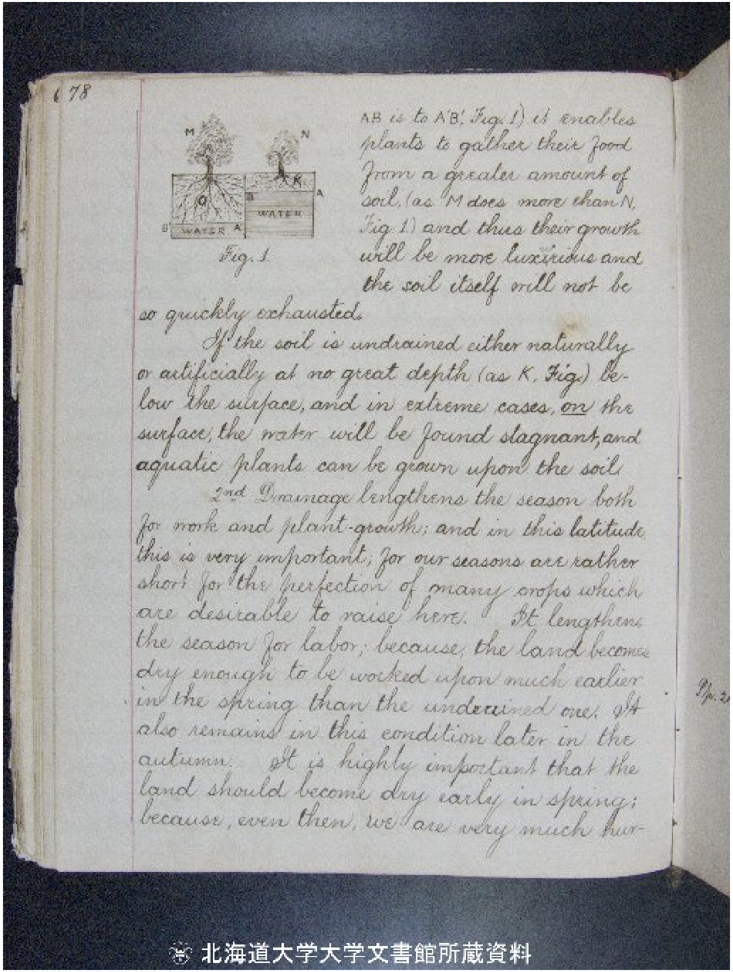
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AB is to A'B', Fig. 1) it enables plants to gather their food from a greater amount of soil, (as M does more than N, Fig. 1) and thus their growth will be more luxurious and the soil itself will not be so quickly exhausted.

If the soil is undrained either naturally or artificially at no great depth (as K, Fig.) below the surface, and in extreme cases, on the surface, the water will be found stagnant, and aquatic plants can be grown upon the soil.

2nd Drainage lengthens the season both for work and plant-growth; and in this latitude this is very important; for our seasons are rather short for the perfection of many crops which are desirable to raise here. It lengthens the season for labor; because, the land becomes dry enough to be worked upon much earlier in the spring than the undrained one. It also remains in this condition later in the autumn. It is highly important that the land should become dry early in spring; because, even then, we are very much hur-

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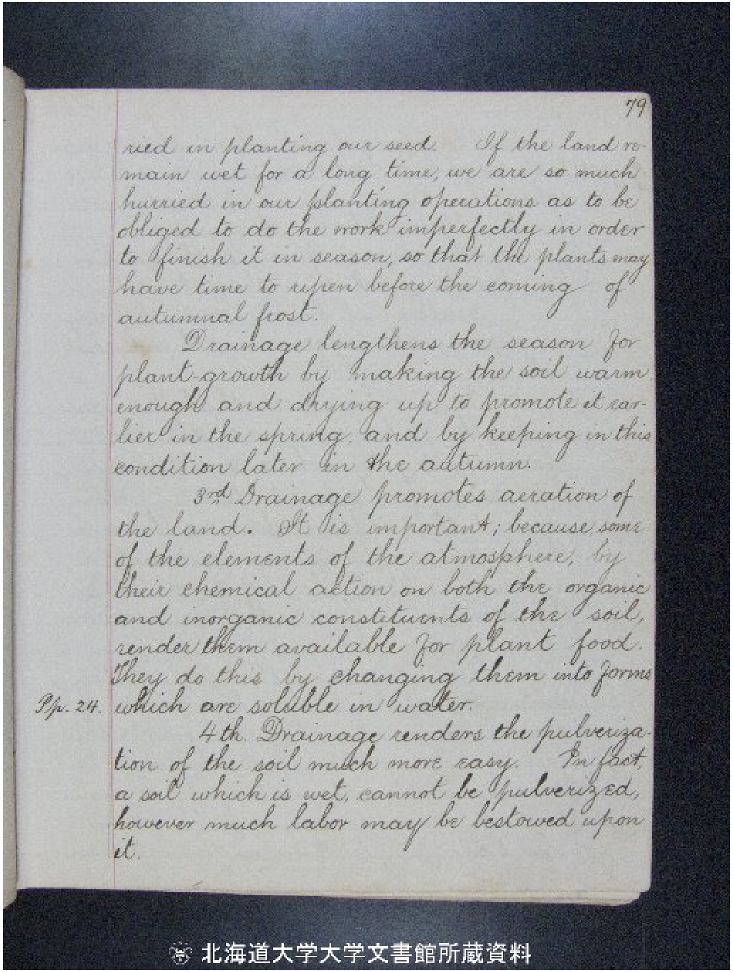
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They do this by changing them into forms
Pp. 24. which are soluble in water.

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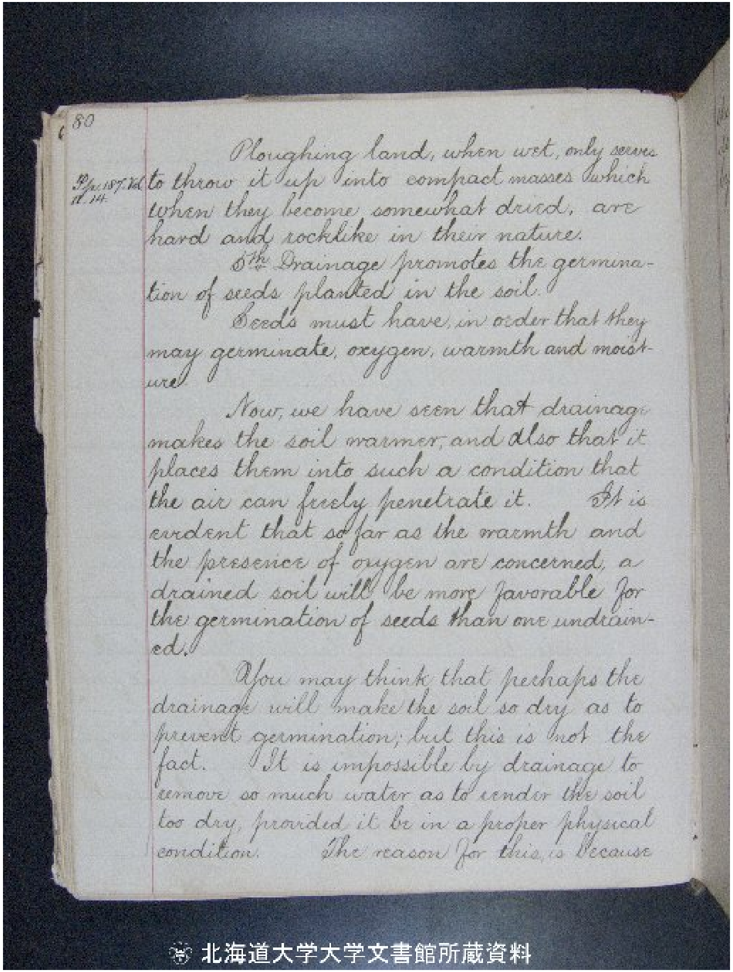


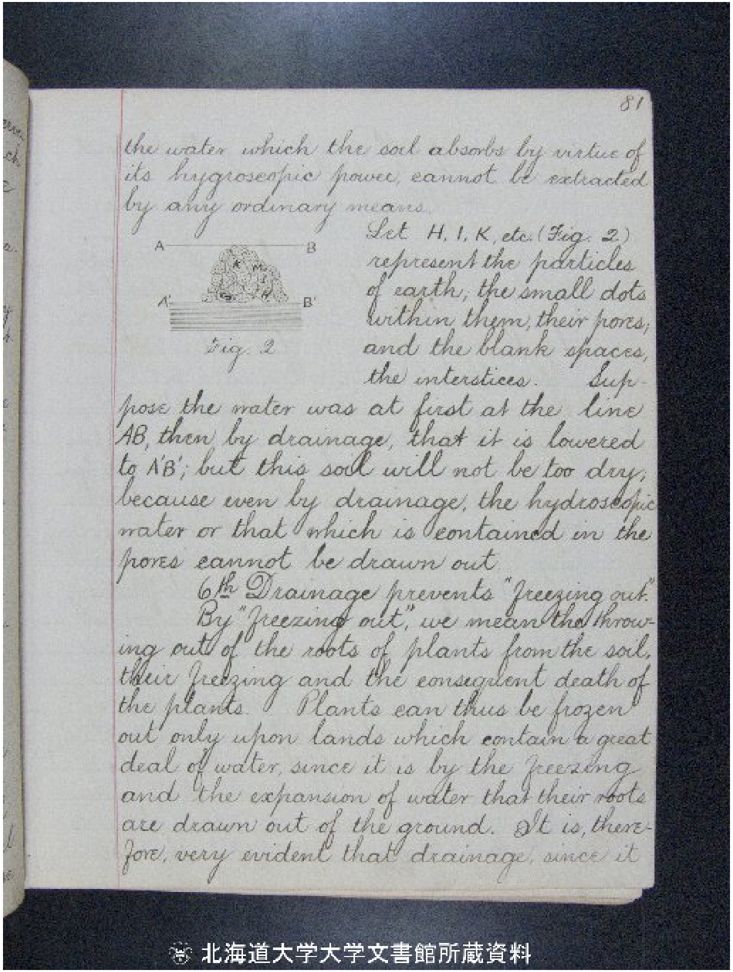
Ploughing land, when wet, only serves to throw it up into compact masses which when they become somewhat dried, are hard and rocklike in their nature.

5th Drainage promotes the germination of seeds planted in the soil.

Seeds must have, in order that they may germinate, oxygen, warmth and moisture.

Now, we have seen that drainage makes the soil warmer, and also that it places them into such a condition that the air can freely penetrate it. It is evident that so far as the warmth and the presence of oxygen are concerned, a drained soil will be more favorable for the germination of seeds than one undrained.

You may think that perhaps the drainage will make the soil so dry as to prevent germination,; but this is not the fact. It is impossible by drainage to remove so much water as to render the soil too dry, provided it be in a proper physical condition. The reason for this is because



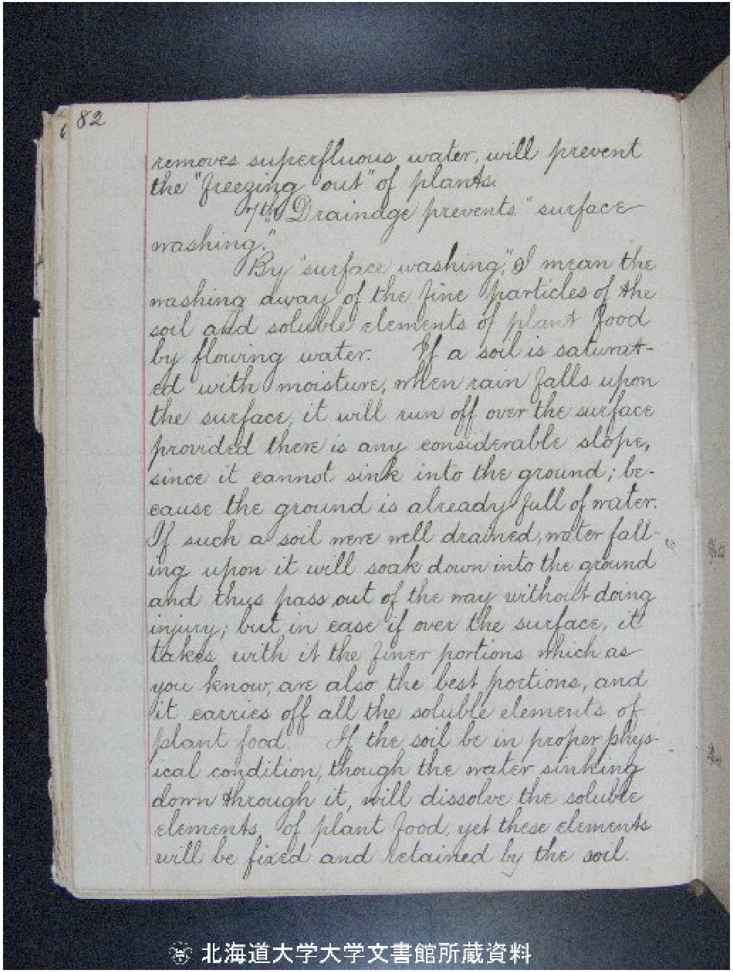
the water which the soil absorbs by virtue of its hygroscopic power, cannot be extracted by any ordinary means.

Fig.2

Let H, I, K, etc. (Fig. 2) represent the particles of earth; the small dots within them, their pores; and the blank spaces, the interstices Suppose the water was at first at the line AB, then by drainage, that it is lowered to A'B'; but this soil will not be too dry; because even by drainage, the hydroscopic water or that which is contained in the pores cannot be drawn out.

6th Drainage prevents "freezing out."

By "freezing out," we mean the throwing out of the roots of plants from the soil, their freezing and the consequent death of the plants. Plants can thus be frozen out only upon lands which contain a great deal of water, since it is by the freezing and expansion of water that their roots are drawn out of the ground. It is, therefore, very evident that drainage, since it



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removes superfluous water, will prevent the "freezing out" of plants.

7th Draindge prevents "surface washing."

By "surface washing," I mean the washing away of the fine particles of the soil and soluble elements of plant food by flowing water. If a soil is saturated with moisture, when rain falls upon the surface, it will run off over the surface provided there is any considerable slope, since it cannot sink into the ground; because the ground is already full of water. If such a soil were well drained, water falling upon it will soak down into the ground and thus pass out of the way without doing injury; but in case if over the surface, it takes with it the finer portions which as you know, are also the best portions, and it carries off all the soluble elements of plant food. If the soil be in proper physical condition, though the water sinking down through it, will dissolve the soluble elements of plant food, yet these elements will be fixed and retained by the soil.

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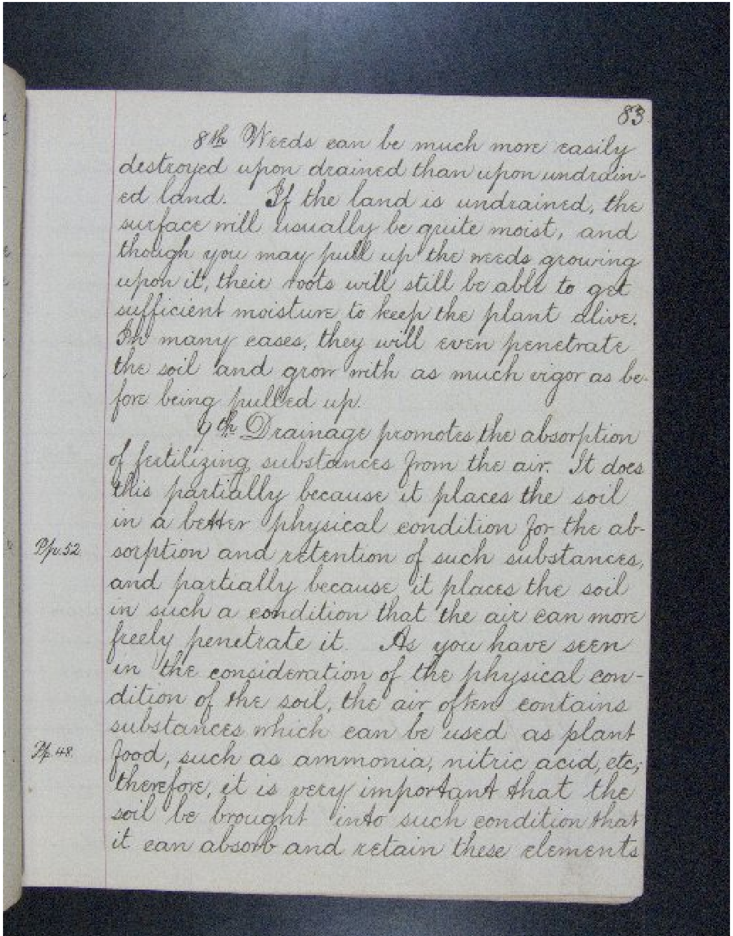

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8th Weeds can be much more easily destroyed upon drained than upon undrained land. If the land is undrained, the surface will usually be quite moist, and though you may pull up the weeds growing upon it, their roots will still be able to get sufficient moisture to keep the plant alive. In many cases, they will even penetrate the soil and grow with as much vigor as before being pulled up.

9th Drainage promotes the absorption of fertilizing substances from the air. It does this partially because it places the soil in a better physical condition for the ab-
D/p.52 sorption and retention of such substances, and partially because it places the soil in such a condition that the air can more freely penetrate it. As you have seen in the consideration of the physical condition of the soil, the air often contains substances which can be used as plant
D/p.48 food, such as ammonia, nitric acid, etc; therefore, it is very important that the soil be brought into such condition that it can absorb and retain these elements

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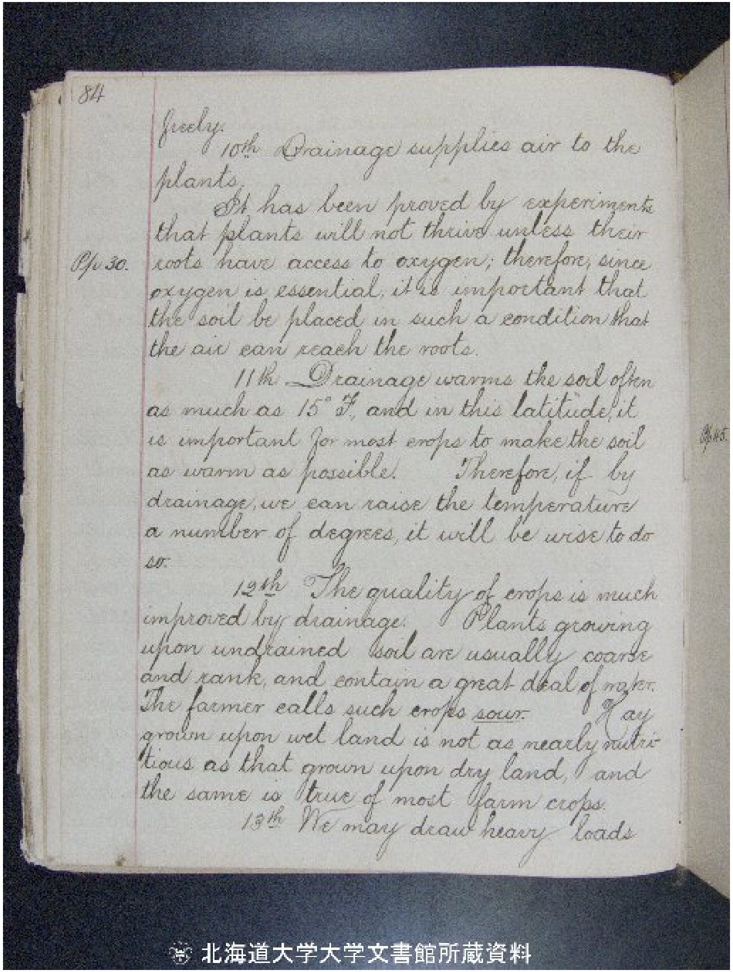
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freely.
10th Drainage supplies air to the plants.
It has been proved by experiments that plants will not thrive unless their roots have access to oxygen; therefore, since oxygen is essential, it is important that the soil be placed in such a condition that the air can reach the roots.
Op. 30.
11th Drainage warms the soil often as much as 15° F. and in this latitude, it is important for most crops to make the soil as warm as possible. Therefore, if by drainage, we can raise the temperature a number of degrees, it will be wise to do so.
Op. 45.
12th The quality of crops is much improved by drainage. Plants growing upon undrained soil are usually coarse and rank, and contain a great deal of water. The farmer calls such crops sour. Hay grown upon wet land is not as nearly nutritious as that grown upon dry land, and the same is true of most farm crops.
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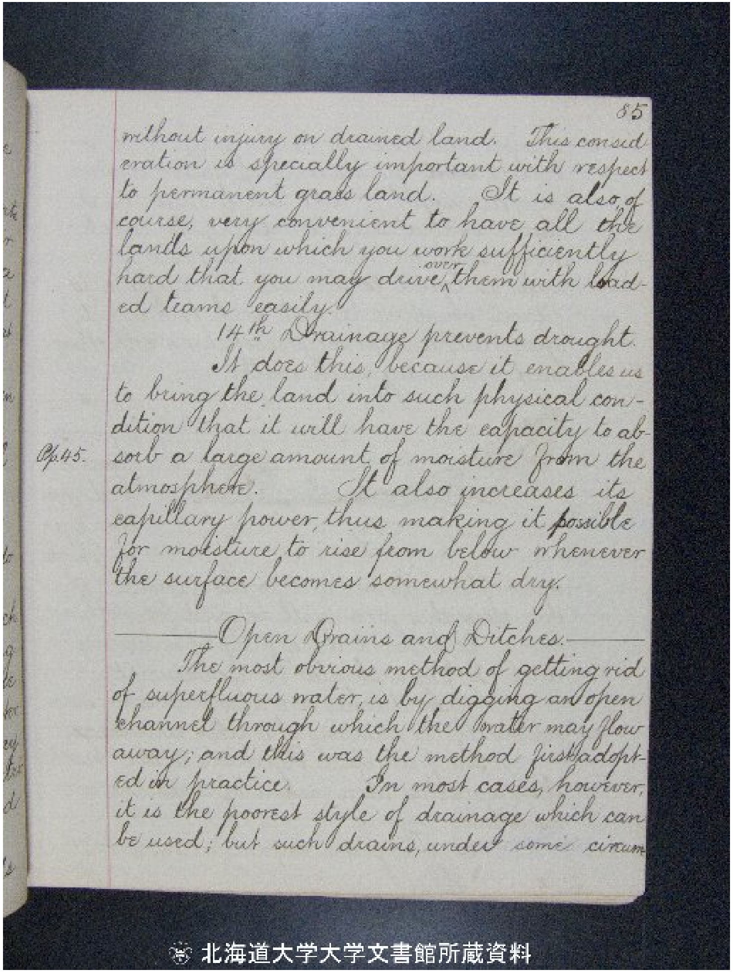
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without injury on drained land. This consideration is specially important with respect to permanent grass land. It is also of course, very convenient to have all the lands upon which you work sufficiently hard that you may drive over them with loaded teams easily.

14th Drainage prevents drought.

It does this, because it enables us to bring the land into such physical condition that it will have the capacity to absorb a large amount of moisture from the atmosphere. It also increases its capillary power, thus making it possible for moisture to rise from below whenever the surface becomes somewhat dry.

Op. 45.

Open Drains and Ditches.

The most obvious method of getting rid of superfluous water, is by digging an open channel through which the water may flow away; and this was the method first adopted in practice. In most cases, however, it is the poorest style of drainage which can be used; but such drains, under some circum

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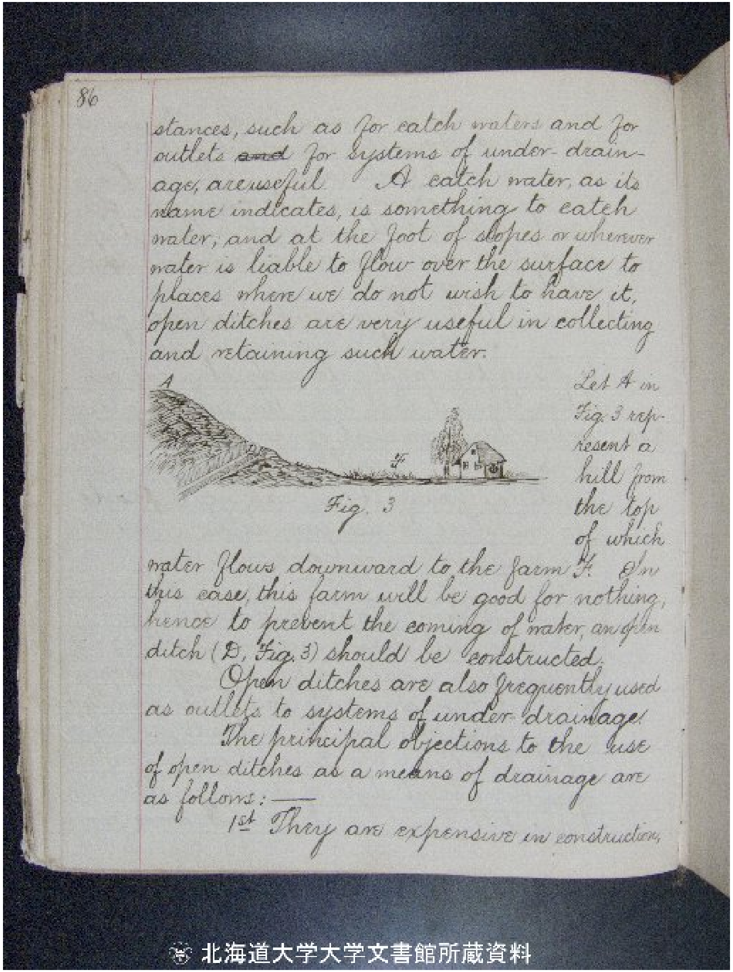
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stances, such as for catch waters and for outlets ~~and~~ for systems of under-drainage, are useful. A catch water, as its name indicates, is something to catch water, and at the foot of slopes or wherever water is liable to flow over the surface to places where we do not wish to have it, open ditches are very useful in collecting and retaining such water.

Fig. 3

Let A in Fig. 3 represent a hill from the top of which water flows downward to the farm F. In this case, this farm will be good for nothing, hence to prebent the coming of water, an open ditch (D, Fig. 3) should be constructed.

Open ditches are also frequently used as outlets to systems of under drainage.

The principal objections to the use of open ditches as a means of drainage are as follows:—

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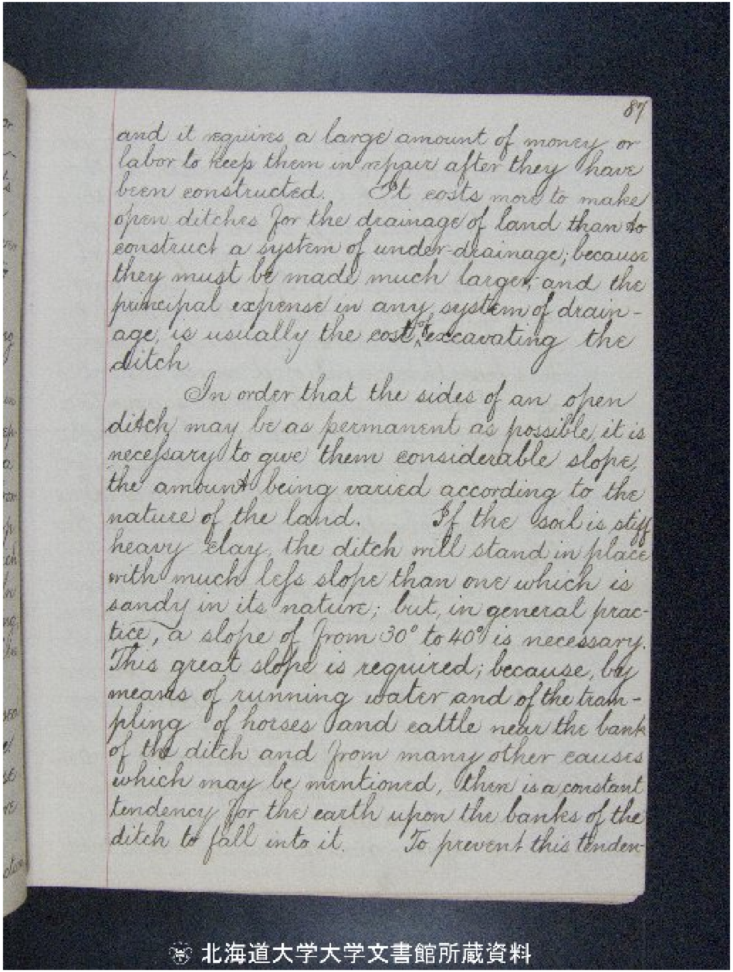

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and it requires a large amount of money or labor to keep them in repair after they have been constructed. It costs more to make open ditches for the drainage of land than to construct a system of under-drainage; because they must be made much larger, and the principal expense in any system of drainage is usually the cost, excavating the ditch

In order that the sides of an open ditch may be as permanent as possible, it is necessary to give them considerable slope, the amount being varied according to the nature of the land. If the soil is stiff heavy clay, the ditch will stand in place with much less slope than one which is sandy in its nature; but, in general practice, a slope of from 30° to 40° is necessary. This great slope is required; because, by means of running water and of the trampling of horses and cattle near the bank of the ditch and from many other causes which may be mentioned, there is a constant tendency for the earth upon the banks of the ditch to fall into it. To prevent this tenden-

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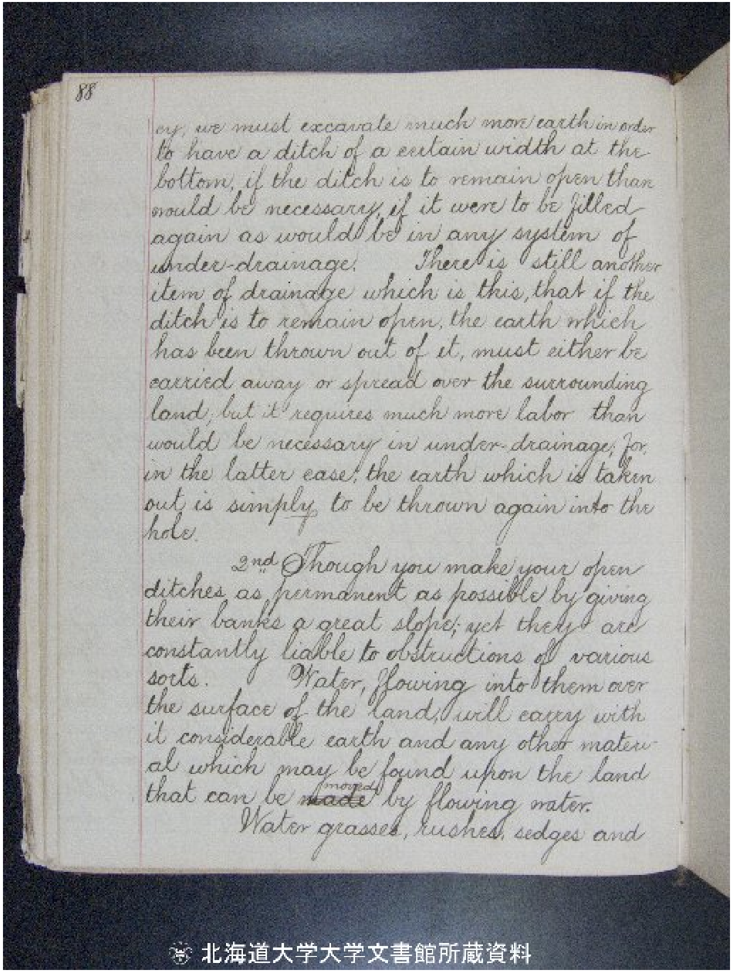
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or, we must excavate much more earth in order to have a ditch of a certain width at the bottom, if the ditch is to remain open than would be necessary, if it were to be filled again as would be in any system of under-drainage. There is still another item of drainage which is this, that if the ditch is to remain open, the earth which has been thrown out of it, must either be carried away or spread over the surrounding land, but it requires much more labor than would be necessary in under-drainage; for in the latter case; the earth which is taken out is simply to be thrown again into the hole.

2nd Though you make your open ditches as permanent as possible by giving their banks a great slope; yet they are constantly liable to obstructions of various sorts. Water, flowing into them over the surface of the land, will carry with it considerable earth and any other material which may be found upon the land that can be ~~made~~ moved by flowing water.

Water grasses, rushes, sedges and

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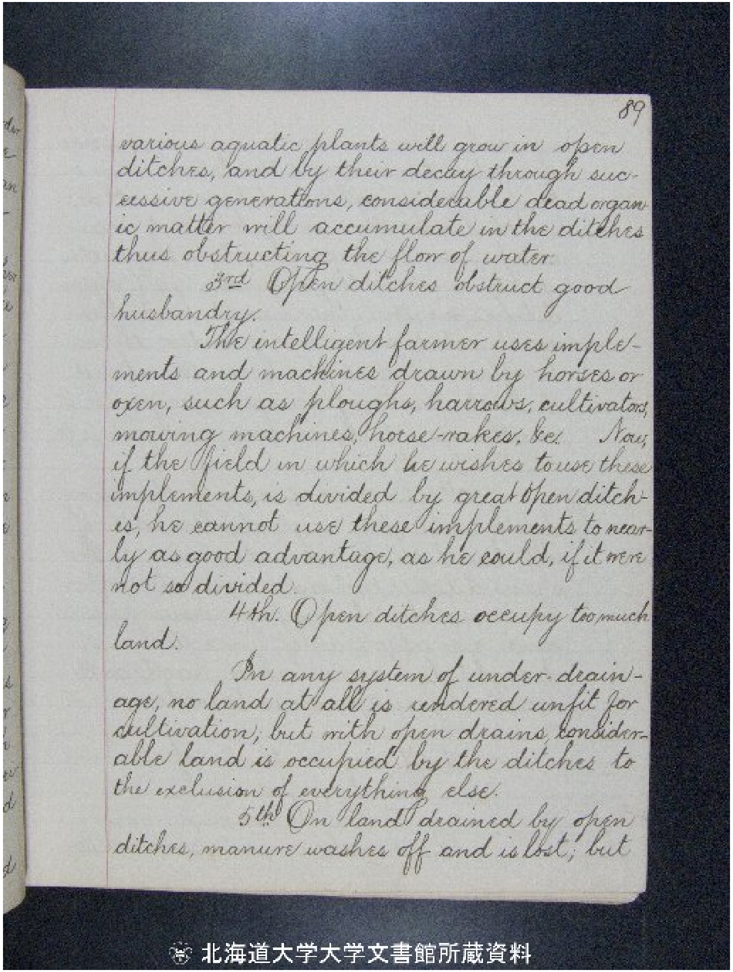

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various aquatic plants will grow in open ditches, and by their decay through successive generations, considerable dead organic matter will accumulate in the ditches thus obstructing the flow of water.

3rd Open ditches obstruct good husbandry.

The intelligent farmer uses implements and machines drawn by horses or oxen, such as ploughs, harrows, cultivators, mowing machines, horse-rakes, &c. Now, if the field in which he wishes to use these implements, is divided by great open ditches, he cannot use these implements to nearly as good advantage, as he could, if it were not so divided.

4th. Open ditches occupy too much land.

In any system of under-drainage, no land at all is rendered unfit for cultivation; but with open drains considerable land is occupied by the ditches to the exclusion of everything else.

5th On land drained by open ditches, manure washes off and is lost; but

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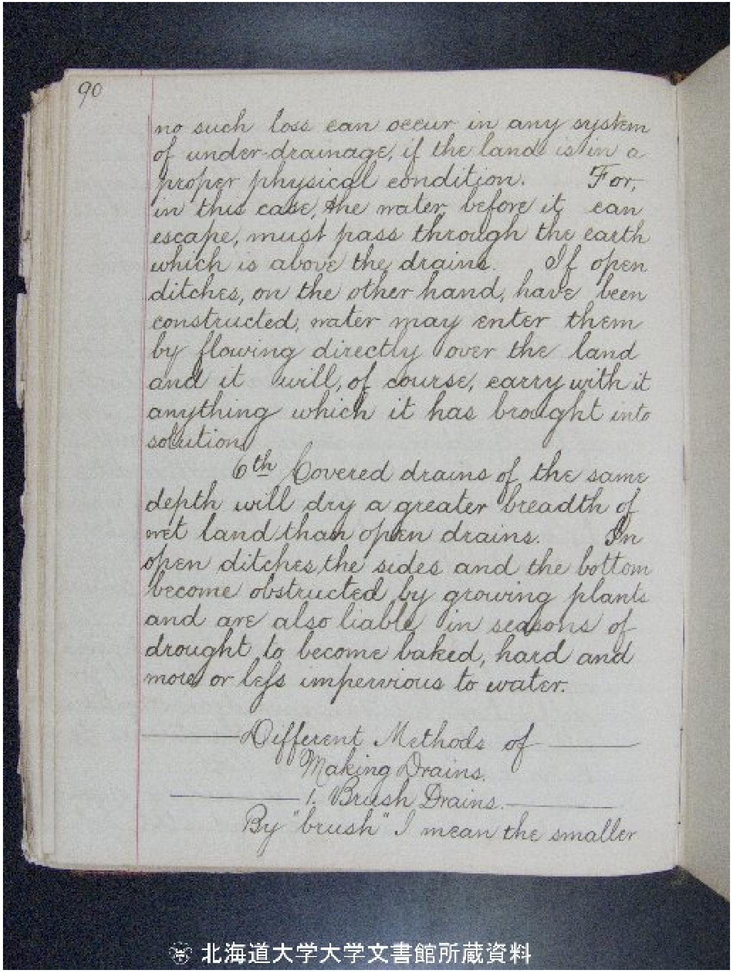

no such loss can occur in any system of under-drainage, if the land is in a proper physical condition. For, in this case, the water before it can escape, must pass through the earth which is above the drains. If open ditches, on the other hand, have been constructed, water may enter them by flowing directly over the land and it will, of course, carry with it anything which it has brought into solution.

6th Covered drains of the same depth will dry a greater breadth of wet land than open drains. In open ditches the sides and the bottom become obstructed by growing plants and are also liable in seasons of drought to become baked, hard and more or less impervious to water.

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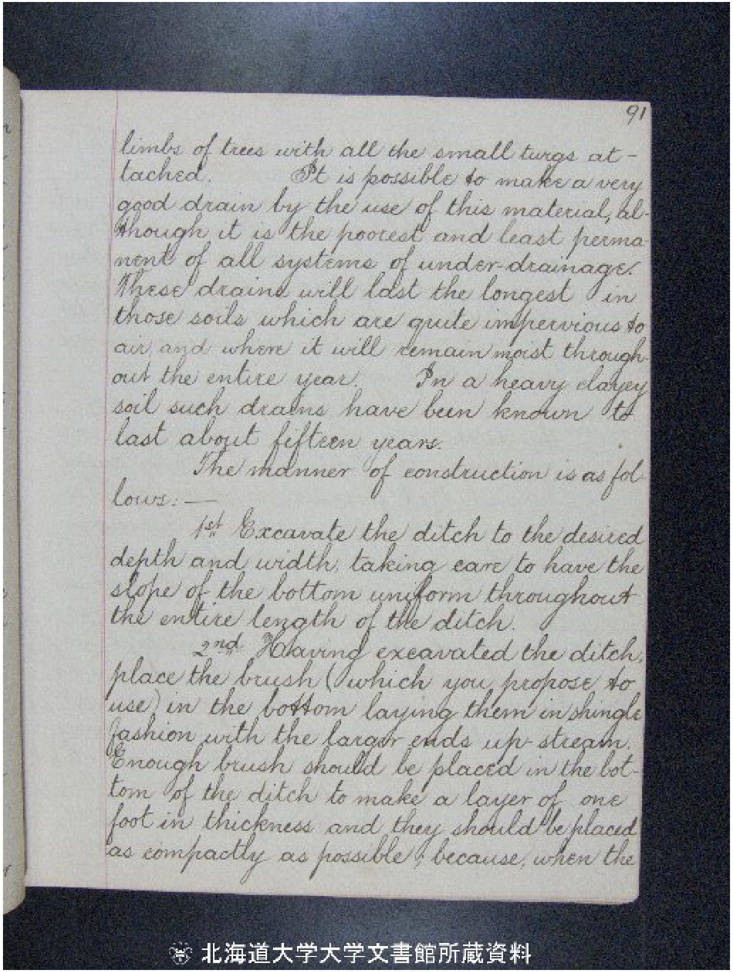

limbs of trees with all the small twigs attached. It is possible to make a very good drain by the use of this material, although it is the poorest and least permanent of all systems of under-drainage. These drains will last the longest in those soils which are quite impervious to air and where it will remain moist throughout the entire year. In a heavy clayey soil such drains have been known to last about fifteen years.

The manner of construction is as follows:—

1st Excavate the ditch to the desired depth and width, taking care to have the slope of the bottom uniform throughout the entire length of the ditch.

2nd Having excavated the ditch, place the brush (which you propose to use) in the bottom laying them in shingle fashion with the larger ends up-stream. Enough brush should be placed in the bottom of the ditch to make a layer of one foot in thickness and they should be placed as compactly as possible, because, when the

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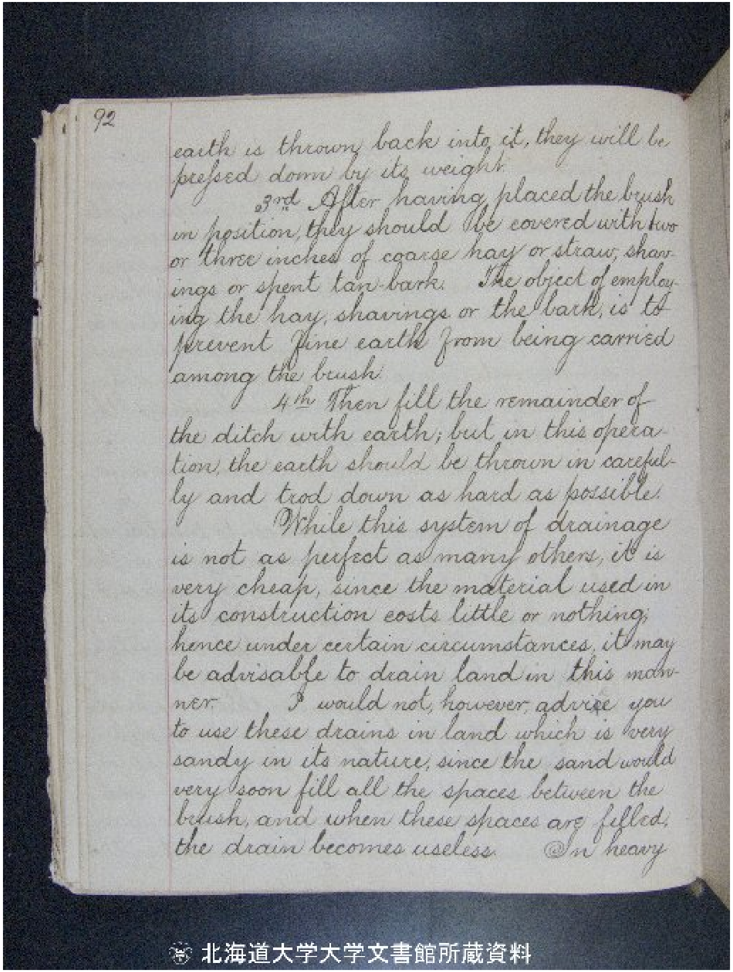

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earth is thrown back into it, they will be pressed down by its weight.

3rd After having placed the bush in position, they should be covered with two or three inches of coarse hay or straw, shavings or spent tan-bark. The object of employing the hay, shavings or the bark, is to prevent fine earth from being carried among the brush.

4th Then fill the remainder of the ditch with earth; but in this operation, the earth should be thrown in carefully and trod down as hard as possible.

While this system of drainage is not as perfect as many others, it is very cheap, since the material used in its construction costs little or nothing; hence under certain circumstances, it may be advisable to drain land in this manner. I would not, however, advice you to use these drains in land which is very sandy in its nature, since the sand would very soon fill all the spaces between the brush, and when these spaces are filled, the drain becomes useless. In heavy

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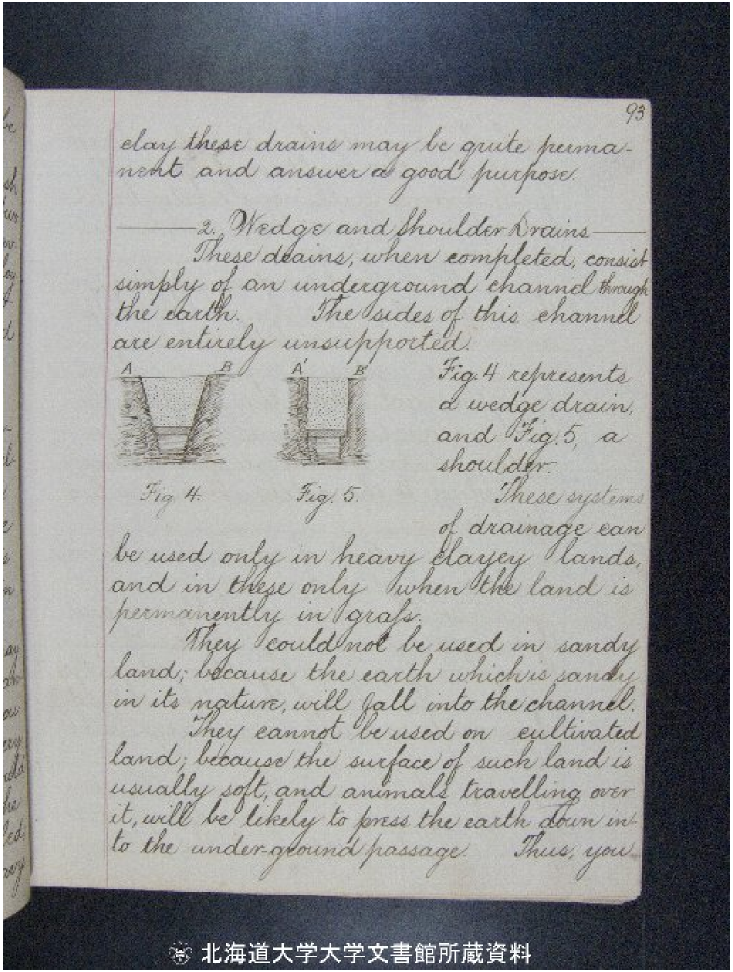
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—2. Wedge and Shoulder Drains—
These drains, when completed, consist simply of an underground channel through the earth. The sides of this channel are entirely unsupported.

Fig. 4. Fig. 5.
Fig. 4 represents a wedge drain, and Fig. 5, a shoulder.
These systems of drainage can be used only in heavy clayey lands, and in these only when the land is permanently in grafs.
They could not be used in sandy land; because the earth which is sandy in its nature, will fall into the channel.
They cannot be used on cultivated land; because the surface of such land is usually soft, and animals travelling over it, will be likely to press the earth down in to the under-ground passage. Thus, you

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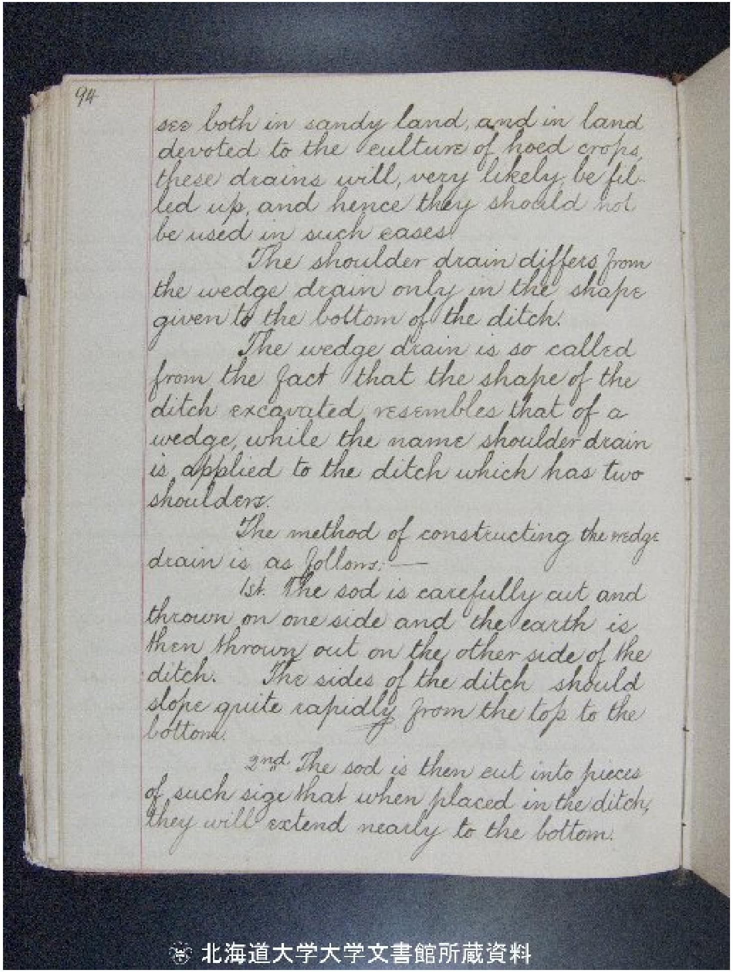

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see both in sandy land, and in land devoted to the culture of hoed crops, these drains will, very likely, be filled up, and hence they should not be used in such cases.

The shoulder drain differs from the wedge drain only in the shape given to the bottom of the ditch.

The wedge drain is so called from the fact that the shape of the ditch excavated, resembles that of a wedge, while the name shoulder drain is applied to the ditch which has two shoulders.

The method of constructing the wedge drain is as follows. —

1st. The sod is carefully cut and thrown on one side and the earth is then thrown out on the other side of the ditch. The sides of the ditch should slope quite rapidly from the top to the bottom.

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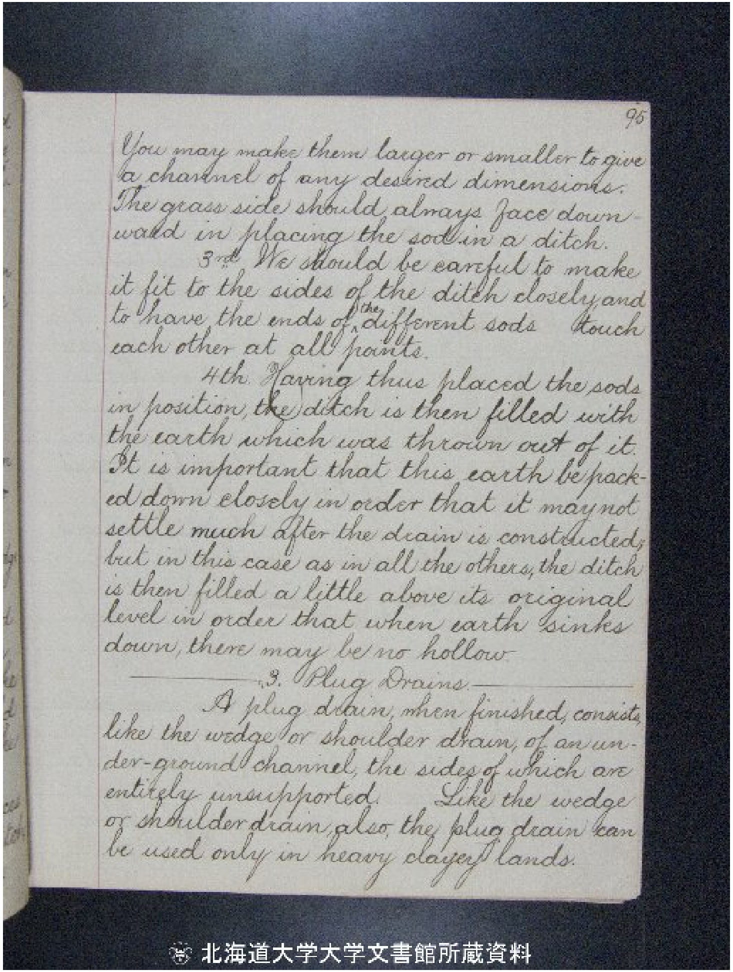

You may make them larger or smaller to give a channel of any desired dimensions. The grass side should always face downward in placing the sod in a ditch.

3rd We should be careful to make it fit to the sides of the ditch closely and to have the ends of the different sods touch each other at all points.

4th. Having thus placed the sods in position, the ditch is then filled with the earth which was thrown out of it. It is important that this earth be packed down closely in order that it may not settle much after the drain is constructed; but in this case as in all the others, the ditch is then filled a little above its original level in order that when earth sinks down, there may be no hollow.

3. Plug Drains

A plug drain, when finished, consists like the wedge or shoulder drain, of an under-ground channel, the sides of which are entirely unsupported. Like the wedge or shoulder drain, also, the plug drain can be used only in heavy clayey lands.

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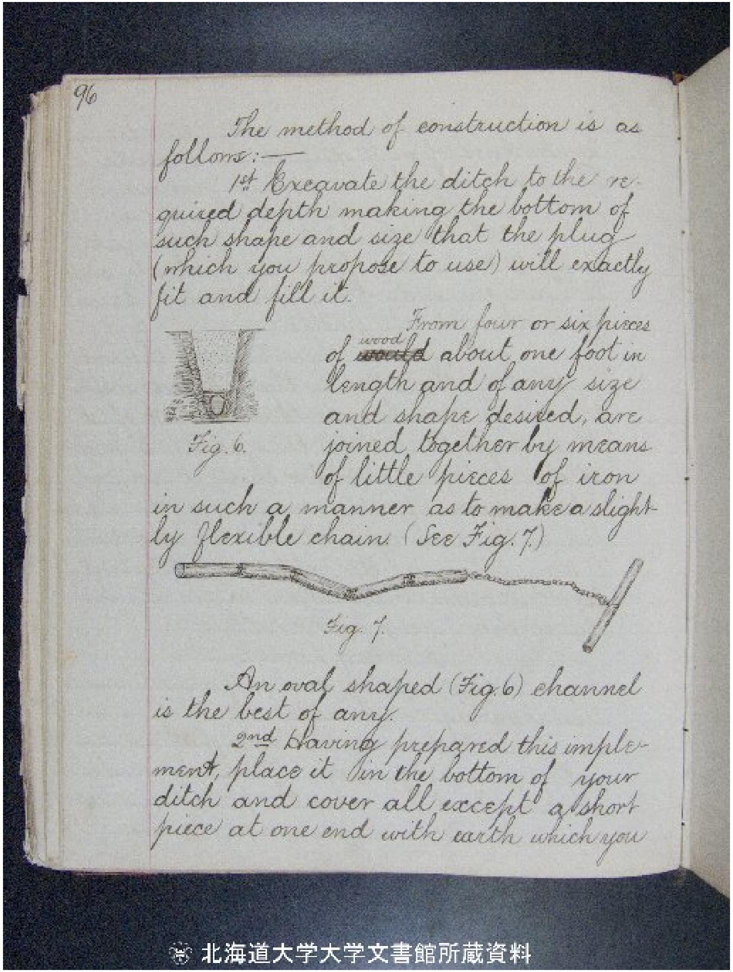
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The method of construction is as follows:—

1st Excavate the ditch to the required depth making the bottom of such shape and size that the plug (which you propose to use) will exactly fit and fill it.

From four or six pieces of ~~wald~~ wood about one foot in length and of any size and shape desired, are joined together by means of little pieces of iron in such a manner as to make a slightly flexible chain. (See Fig. 7)

Fig. 6.

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An oval shaped (Fig. 6) channel is the best of any.

2nd Having prepared this implement, place it in the bottom of your ditch and cover all except a short piece at one end with earth which you

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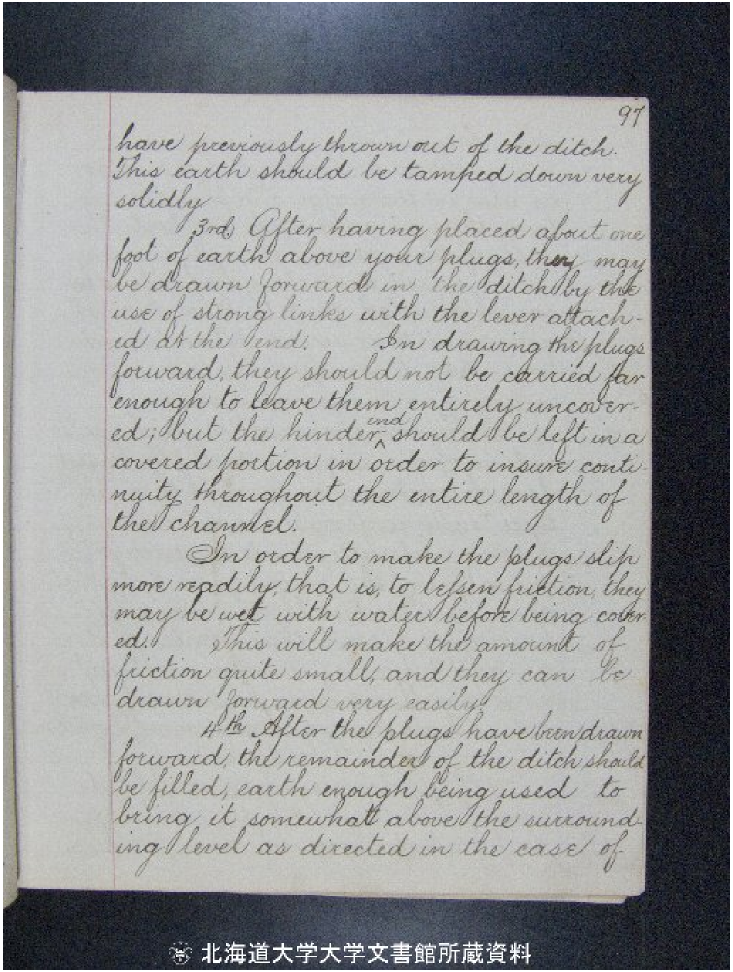
Fig.7

bottom of your ditch and cover all except a short piece at one and with earth which you


97
have previously thrown out of the ditch. This earth should be tamped down very solidly.
3rd After having placed about one foot of earth above your plugs, they may be drawn forward in the ditch by the use of strong links with the lever attached at the end. In drawing the plugs forward, they should not be carried far enough to leave them entirely uncovered; but the hinder end should be left in a covered portion in order to insure continuity throughout the entire length of the channel.
In order to make the plugs slip more readily, that is, to lessen friction, they may be wet with water before being covered. This will make the amount of friction quite small, and they can be drawn forward very easily.
4th After the plugs have been drawn forward, the remainder of the ditch should be filled, earth enough being used to bring it somewhat above the surrounding level as directed in the case of

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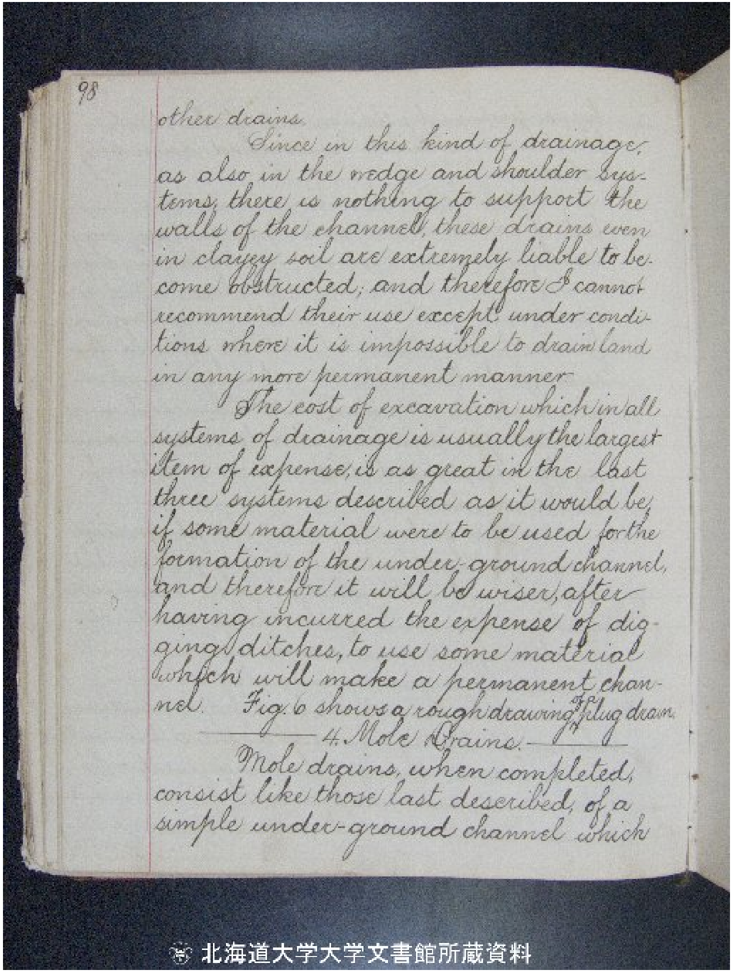

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other drains.

Since in this kind of drainage, as also in the wedge and shoulder systems, there is nothing to support the walls of the channel, these drains even in clayey soil are extremely liable to become obstructed; and therefore I cannot recommend their use except under conditions where it is impossible to drain land in any more permanent manner.

The cost of excavation which in all systems of drainage is usually the largest item of expense, is as great in the last three systems described as it would be, if some material were to be used for the formation of the under-ground channel, and therefore it will be wiser, after having incurred the expense of digging ditches, to use some material which will make a permanent channel. Fig. 6 shows a rough drawing of plug drain.

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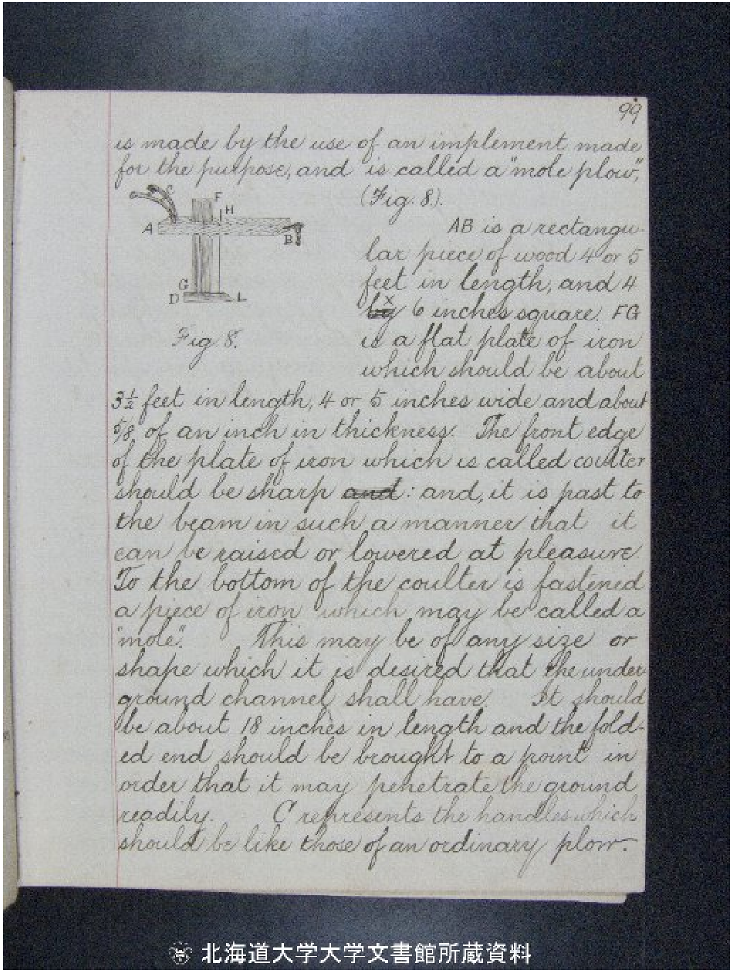
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is made by the use of an implement made for the purpose, and is called a "mole plow," (Fig. 8).

Fig. 8.

AB is a rectangular piece of wood 4 or 5 feet in length, and 4 × 6 inches square. FG is a flat plate of iron which should be about $3\frac{1}{2}$ feet in length, 4 or 5 inches wide and about 5/8 of an inch in thickness. The front edge of the plate of iron which is called coulter should be sharp ~~and~~: and, it is past to the beam in such a manner that it can be raised or lowered at pleasure. To the bottom of the coulter is fastened a piece of iron which may be called a "mole." This may be of any size or shape which it is desired that the under ground channel shall have. It should be about 18 inches in length and the folded end should be brought to a point in order that it may penetrate the ground readily. C represents the handles which should be like those of an ordinary plow.

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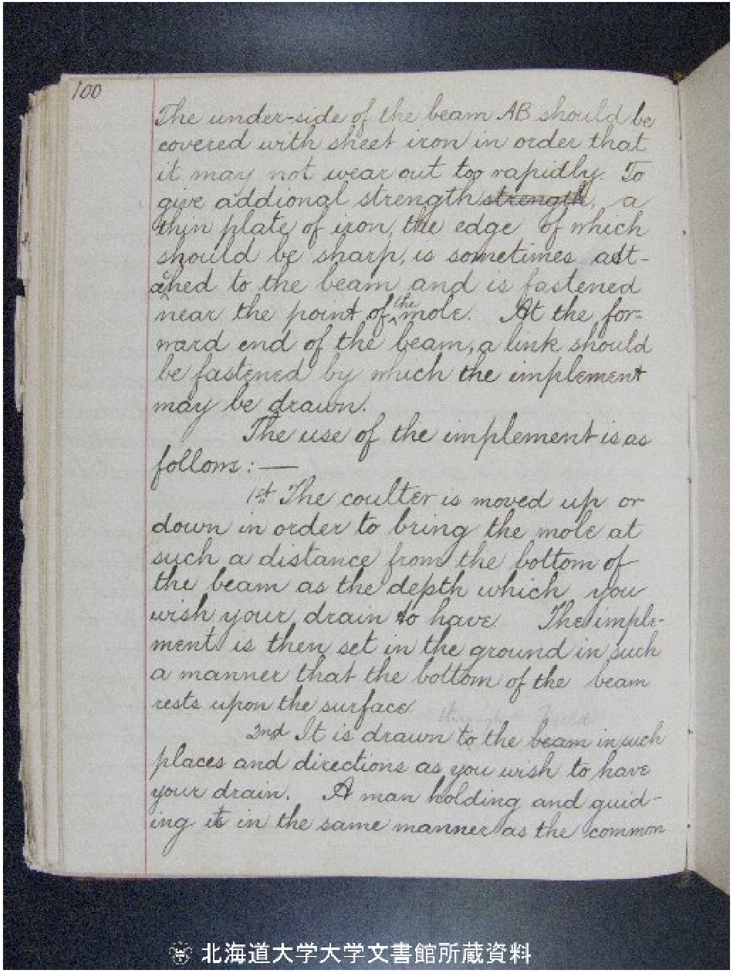

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The under-side of the beam AB should be covered with sheet iron in order that it may not wear out too rapidly. To give addional strength ~~strength~~, a thin plate of iron, the edge of which should be sharp, is sometimes attached to the beam and is fastened near the point of the mole. At the forward end of the beam, a link should be fastened by which the implement may be drawn.

The use of the implement is as follows:—

1st The coulter is moved up or down in order to bring the mole at such a distance from the bottom of the beam as the depth which you wish your drain to have. The implement is then set in the ground in such a manner that the bottom of the beam rests upon the surface.

2nd It is drawn to the beam in such places and directions as you wish to have your drain. A man holding and guiding it in the same manner as the common

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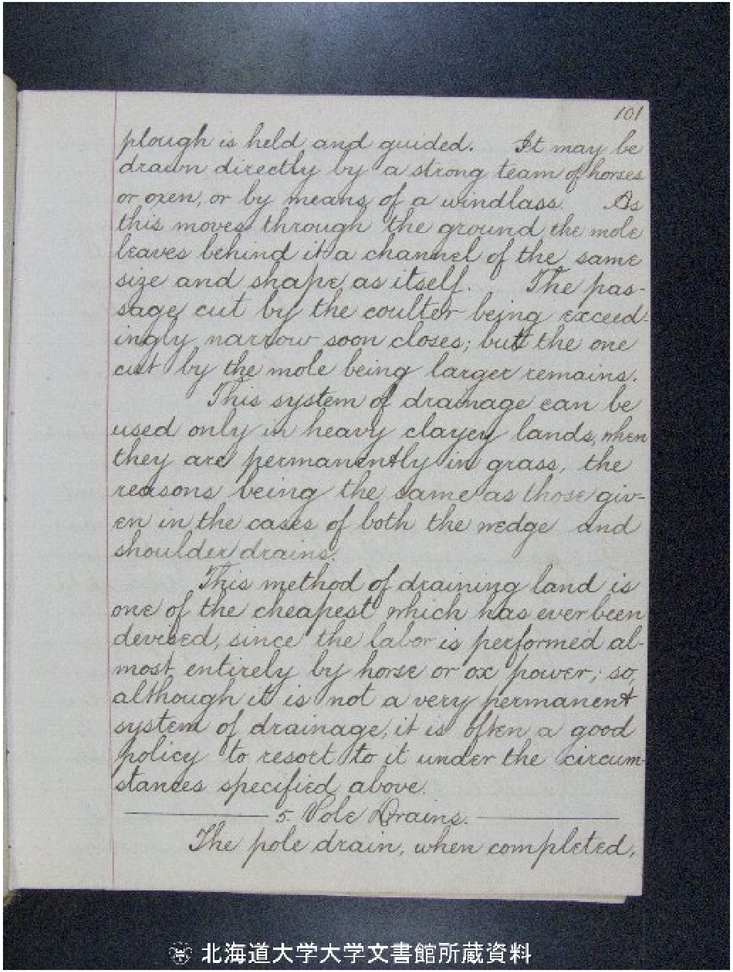

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plough is held and guided. It may be drawn directly by a strong team of horses or oxen, or by means of a windlass. As this moves through the ground the mole leaves behind it a channel of the same size and shape as itself. The passage cut by the coulter being exceedingly narrow soon closes; but the one cut by the mole being larger remains.

This system of drainage can be used only in heavy clayey lands, when they are permanently in grass, the reasons being the same as those given in the cases of both the wedge and shoulder drains.

This method of draining land is one of the cheapest which has ever been devised, since the labor is performed almost entirely by horse or ox power; so, although it is not a very permanent system of drainage, it is often a good policy to resort to it under the circumstances specified above.

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The pole drain, when completed,

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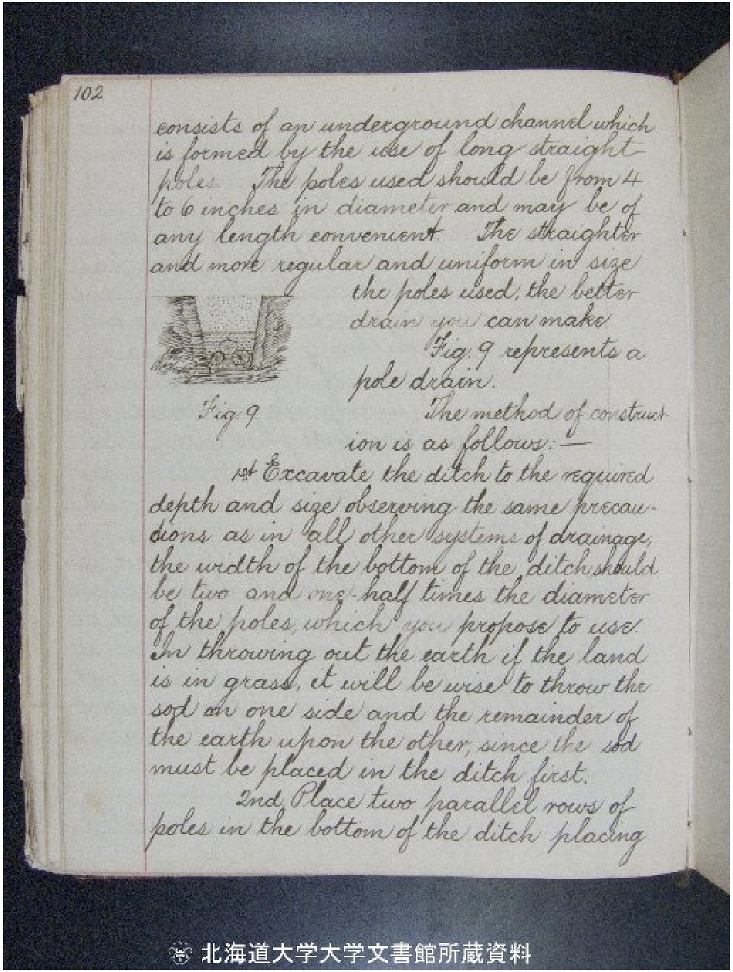

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consists of an underground channel which is formed by the use of long straight poles. The poles used should be from 4 to 6 inches in diameter and may be of any length convenient. The straighter and more regular and uniform in size the poles used, the better drain you can make.

Fig. 9 represents a pole drain.

Fig. 9

The method of construction is as follows:—

1st Excavate the ditch to the required depth and size observing the same precautions as in all other systems of drainage, the width of the bottom of the ditch should be two and one-half times the diameter of the poles, which you propose to use. In throwing out the earth if the land is in grass, it will be wise to throw the sod on one side and the remainder of the earth upon the other, since the sod must be placed in the ditch first.

2nd Place two parallel rows of poles in the bottom of the ditch placing

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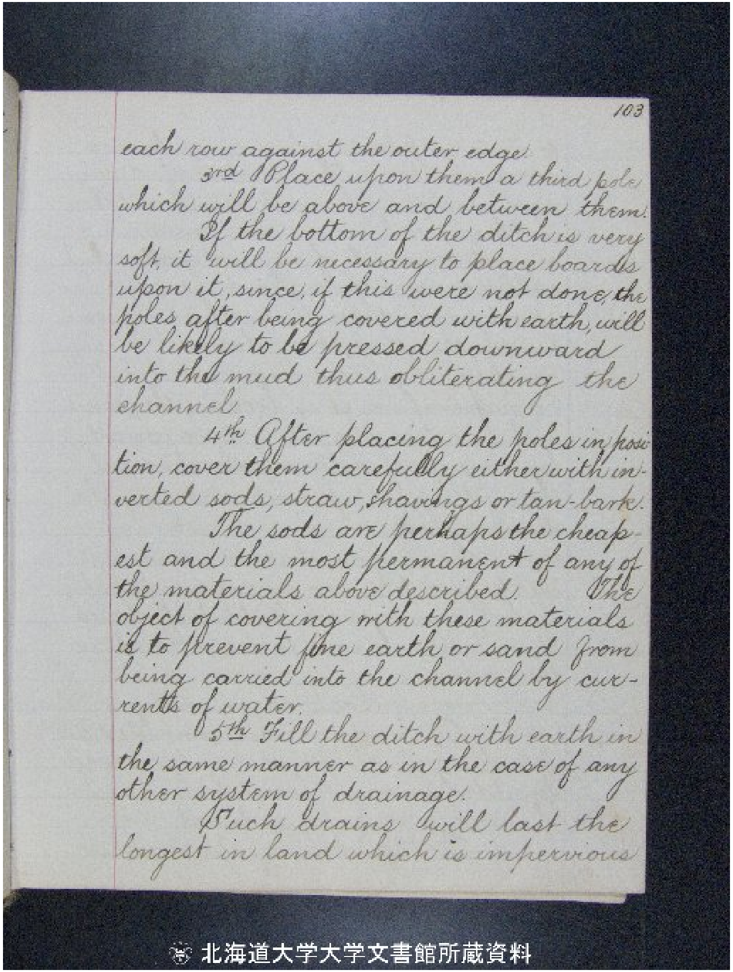

each row against the outer edge.

3rd Place upon them a third pole which will be above and between them.

If the bottom of the ditch is very soft, it will be necessary to place boards upon it, since, if this were not done, the poles after being covered with earth, will be likely to be pressed downward into the mud thus obliterating the channel.

4th After placing the poles in position, cover them carefully either with inverted sods, straw, shavings or tan-bark.

The sods are perhaps the cheapest and the most permanent of any of the materials above described. The object of covering with these materials is to prevent fine earth or sand from being carried into the channel by currents of water.

5th Fill the ditch with earth in the same manner as in the case of any other system of drainage.

Such drains will last the longest in land which is impervious

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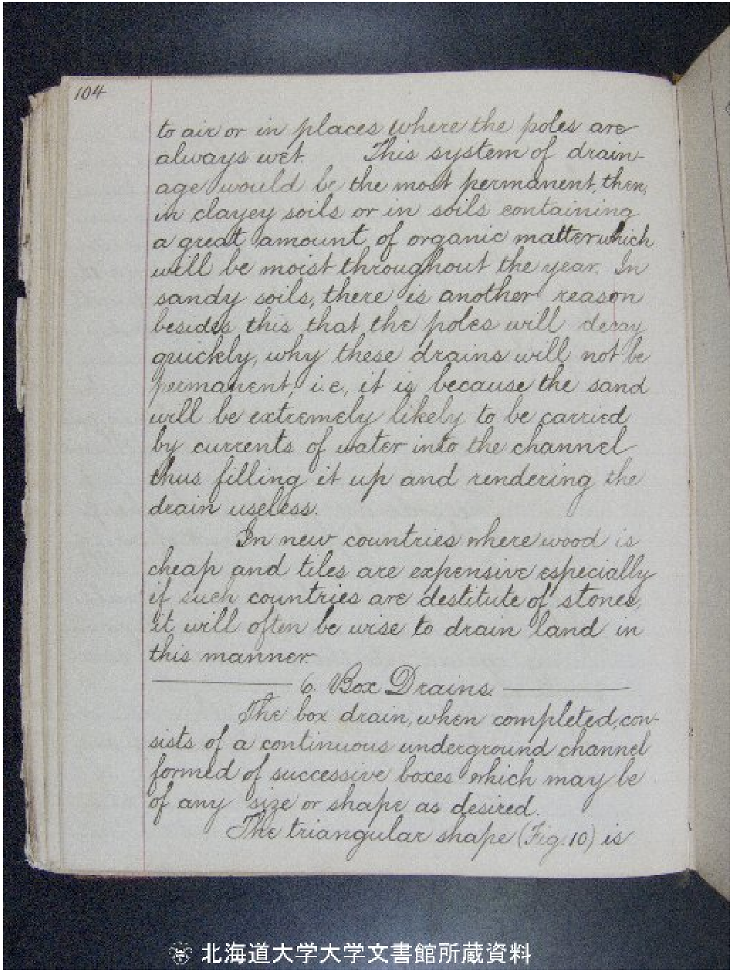

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to air or in places where the poles are always wet. This system of drainage would be the most permanent then, in clayey soils or in soils containing a great amount of organic matter which will be moist throughout the year. In sandy soils, there is another reason besides this that the poles will decay quickly, why these drains will not be permanent, i.e, it is because the sand will be extremely likely to be carried by currents of water into the channel thus filling it up and rendering the drain useless.

In new countries where wood is cheap and tiles are expensive especially if such countries are destitute of stones, it will often be wise to drain land in this manner.

6. Box Drains

The box drain, when completed, consists of a continuous underground channel formed of successive boxes which may be of any size or shape as desired.

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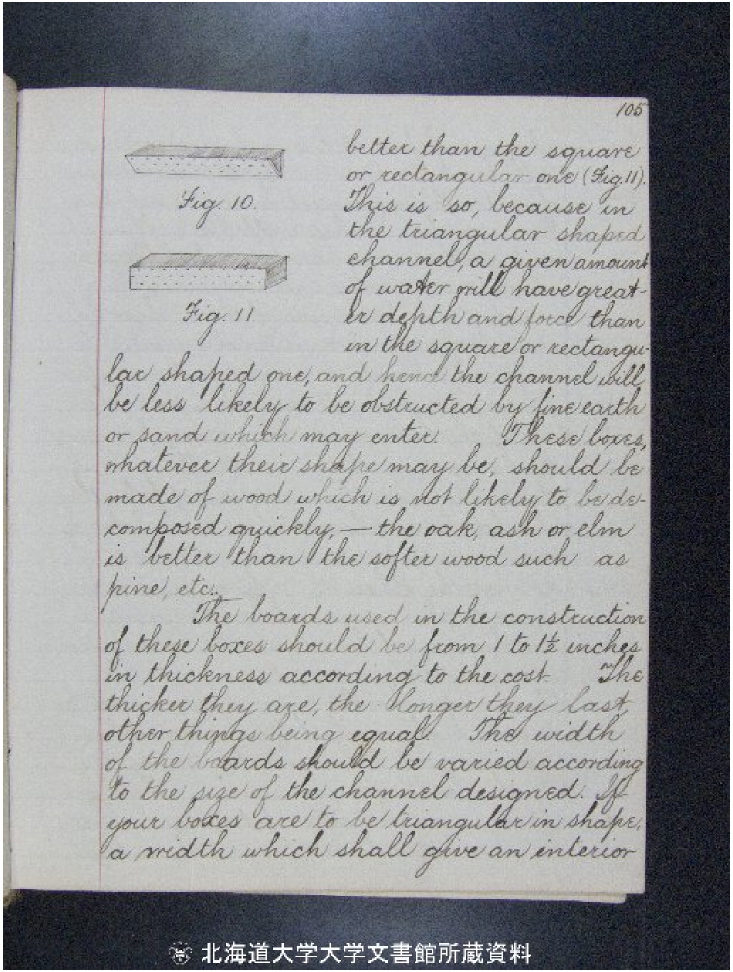
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Fig. 10.

Fig. 11

better than the square or rectangular one (Fig. 11). This is so, because in the triangular shaped channel, a given amount of water will have greater depth and force than in the square or rectangular shaped one, and hence the channel will be less likely to be obstructed by fine earth or sand which may enter. These boxes, whatever their shape may be, should be made of wood which is not likely to be decomposed quickly, — the oak, ash or elm is better than the softer wood such as pine, etc.

The boards used in the construction of these boxes should be from 1 to 1½ inches in thickness according to the cost. The thicker they are, the longer they last other things being equal. The width of the boards should be varied according to the size of the channel designed. If your boxes are to be triangular in shape, a width which shall give an interior

Fig.10

Fig.11

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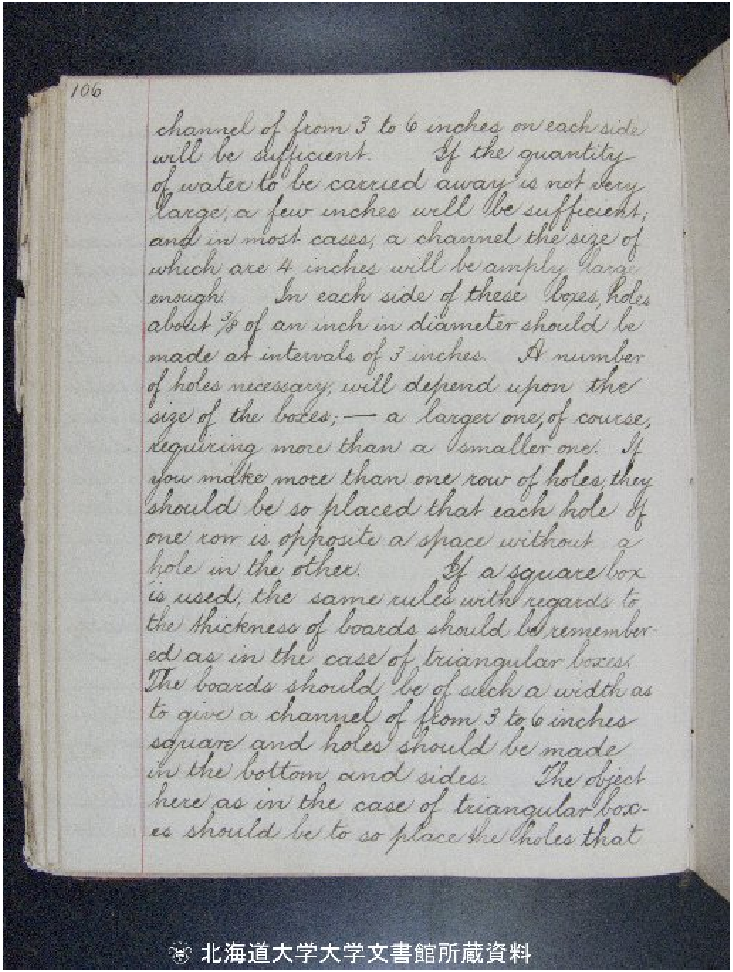

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channel of from 3 to 6 inches on each side will be sufficient. If the quantity of water to be carried away is not very large, a few inches will be sufficient; and in most cases, a channel the size of which are 4 inches will be amply large enough. In each side of these boxes, holes about 3/8 of an inch in diameter should be made at intervals of 3 inches. A number of holes necessary, will depend upon the size of the boxes; — a larger one, of course, requiring more than a smaller one. If you make more than one row of holes they should be so placed that each hole of one row is opposite a space without a hole in the other. If a square box is used, the same rules with regards to the thickness of boards should be remembered as in the case of triangular boxes. The boards should be of such a width as to give a channel of from 3 to 6 inches square and holes should be made in the bottom and sides. The object here as in the case of triangular boxes should be to so place the holes that

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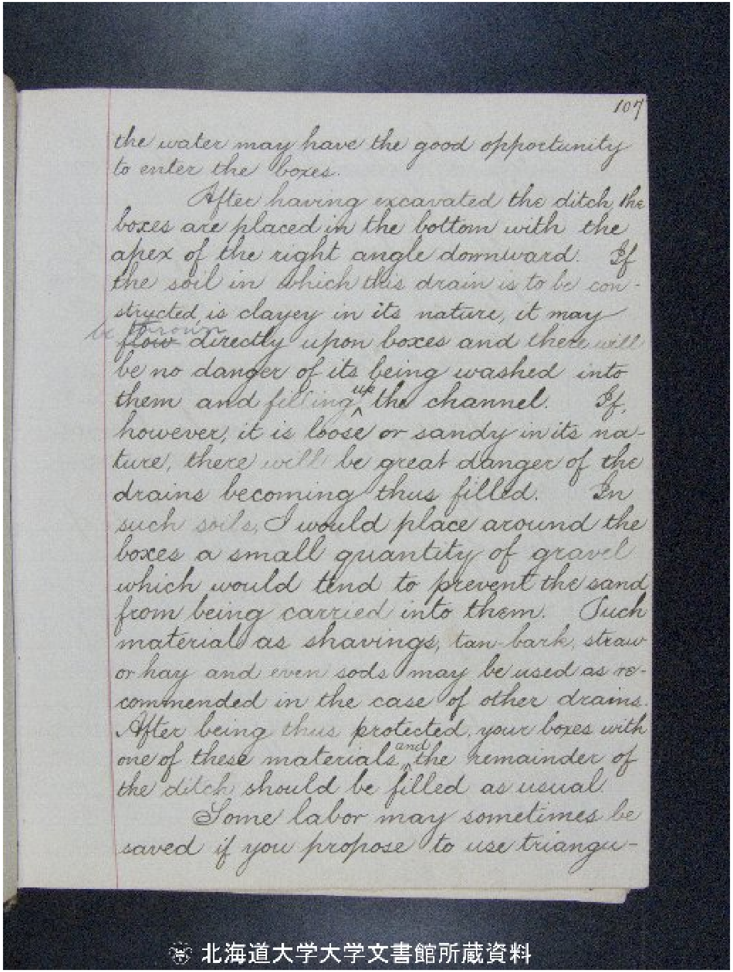

the water may have the good opportunity to enter the boxes.

After having excavated the ditch the boxes are placed in the bottom with the apex of the right angle downward. If the soil in which this drain is to be constructed is clayey in its nature, it may be thrown ~~flow~~ directly upon boxes and there will be no danger of its being washed into them and filling up the channel. If, however, it is loose or sandy in its nature, there will be great danger of the drains becoming thus filled. In such soils, I would place around the boxes a small quantity of gravel which would tend to prevent the sand from being carried into them. Such material as shavings, tan-bark, straw or hay and even sods may be used as recommended in the case of other drains. After being thus protected, your boxes with one of these materials and the remainder of the ditch should be filled as usual.

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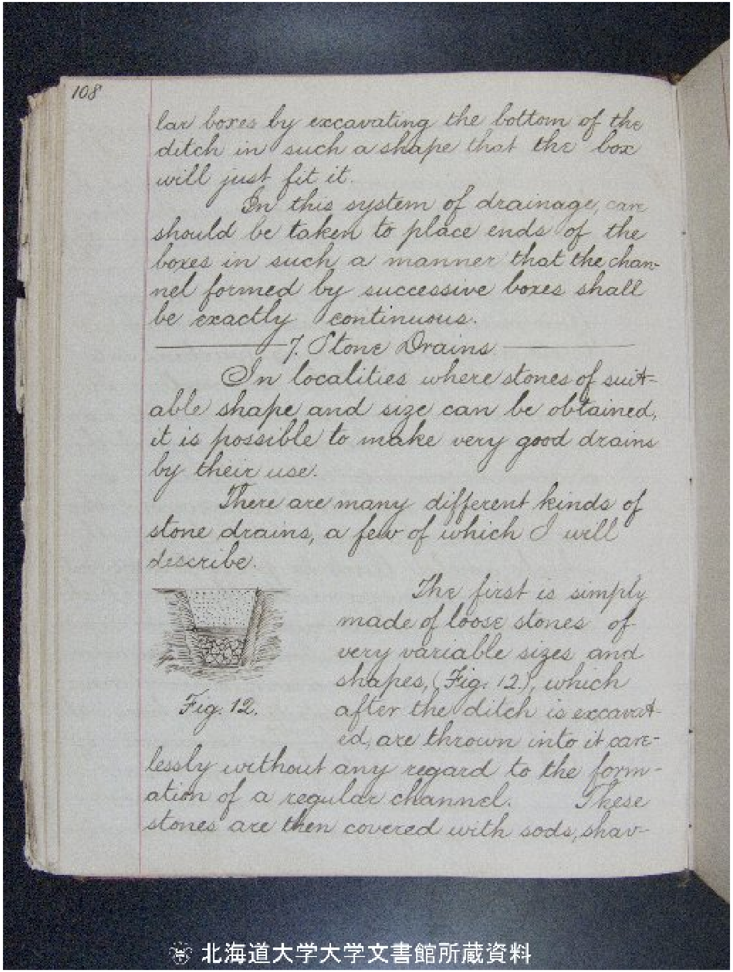
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lar boxes by excavating the bottom of the ditch in such a shape that the box will just fit it.

In this system of drainage, care should be taken to place ends of the boxes in such a manner that the channel formed by successive boxes shall be exactly continuous.

— 7. Stone Drains —

In localities where stones of suitable shape and size can be obtained, it is possible to make very good drains by their use.

There are many different kinds of stone drains, a few of which I will describe.

Fig. 12.

The first is simply made of loose stones of very variable sizes and shapes, (Fig. 12.), which after the ditch is excavated, are thrown into it carelessly without any regard to the formation of a regular channel. These stones are then covered with sods, shav-

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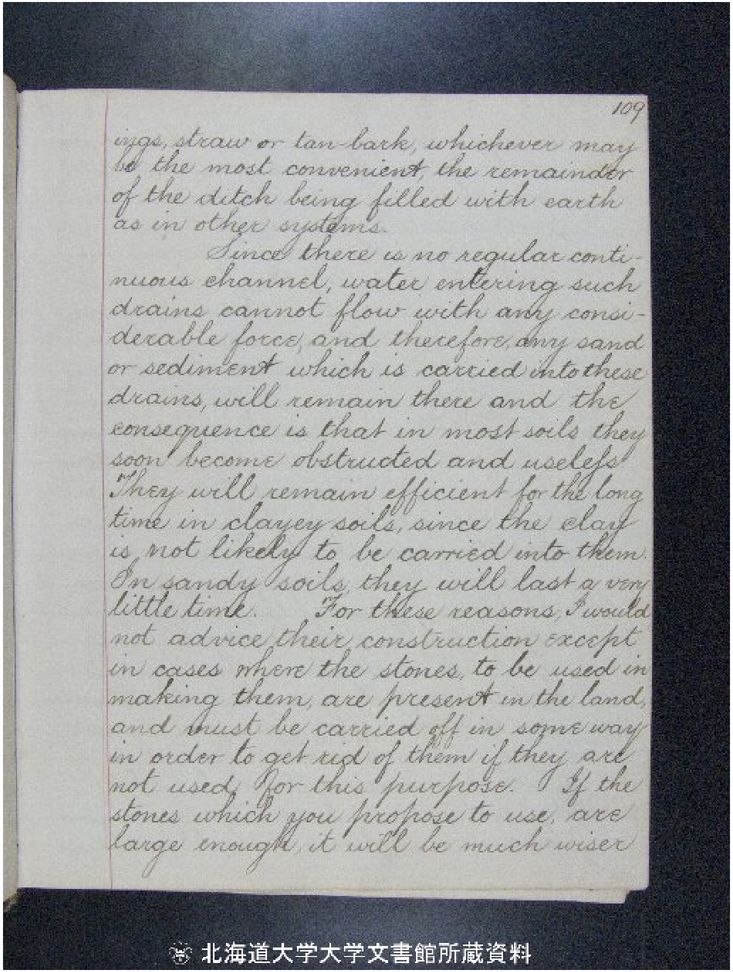

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ings, straw or tan-bark, whichever may be the most convenient, the remainder of the ditch being filled with earth as in other systems.

Since there is no regular continuous channel, water entering such drains cannot flow with any considerable force, and therefore, any sand or sediment which is carried into these drains, will remain there and the consequence is that in most soils they soon become obstructed and useless. They will remain efficient for the long time in clayey soils, since the clay is not likely to be carried into them. In sandy soils, they will last a very little time. For these reasons, I would not advice their construction except in cases where the stones, to be used in making them, are present in the land, and must be carried off in some way in order to get rid of them if they are not used for this purpose. If the stones which you propose to use, are large enough, it will be much wiser

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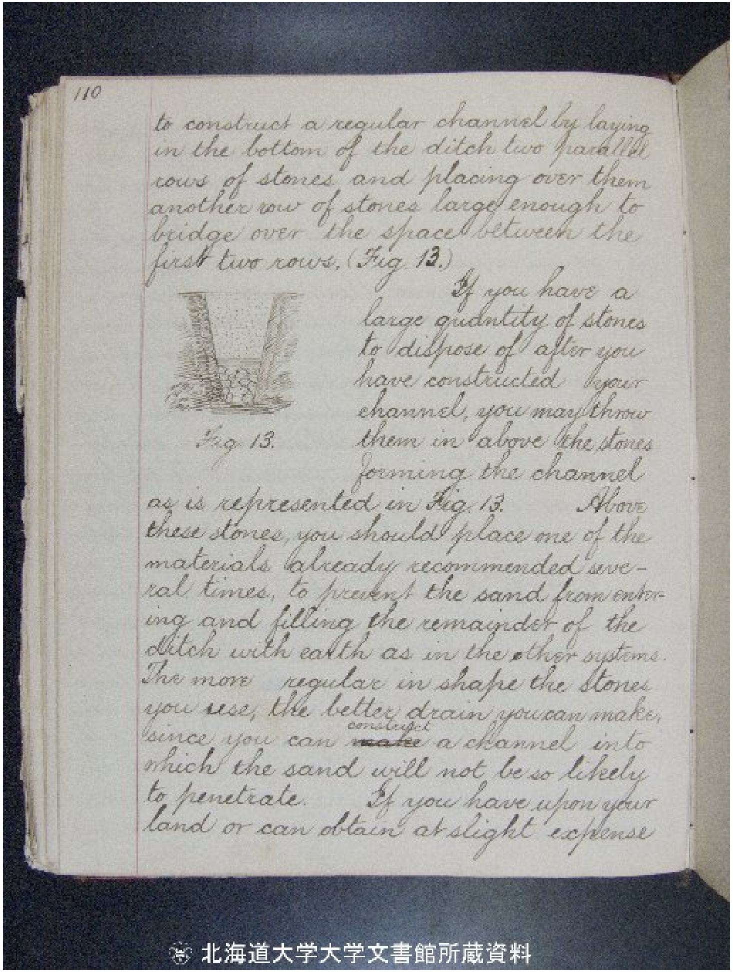
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to construct a regular channel by laying
in the bottom of the ditch two parallel
rows of stones and placing over them
another row of stones large enough to
bridge over the space between the
first two rows, (Fig. 13.)

If you have a
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Fig. 13.

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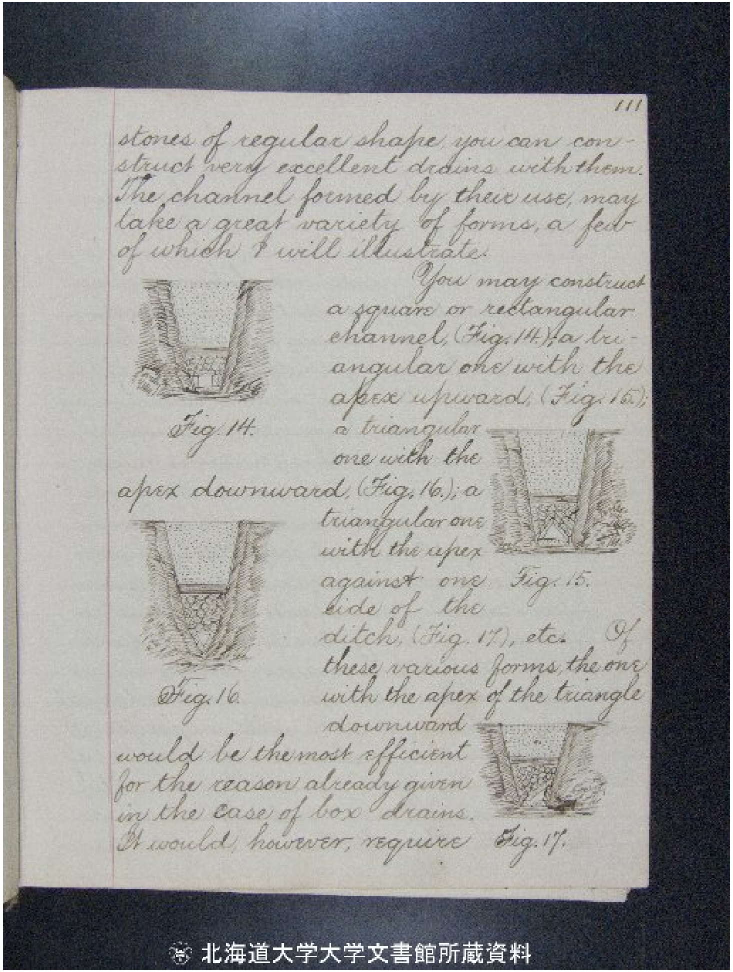
Fig.13

If you have a large quantity of stones to dispose of after you have constructed your channel, you may throw them in above the stones forming the channel as is represented in Fig. 13. Above these stones, you should place one of the materials already recommended several times, to prevent the sand from entering and filling the remainder of the ditch with earth as in the other systems. The move regular in shape the stones you use, the better drain you can make, since you can construct a channel into which the sand will not be so likely to penetrate. If you have upon your land or can obtain at slight expense



stones of regular shape you can construct very excellent drains with them. The channel formed by their use, may take a great variety of forms, a few of which I will illustrate.

You may construct a square or rectangular channel, (Fig. 14.); a triangular one with the apex upward, (Fig. 15.); a triangular one with the apex downward, (Fig. 16.); a triangular one with the apex against one side of the ditch, (Fig. 17.), etc. Of these various forms, the one with the apex of the triangle downward would be the most efficient for the reason already given in the case of box drains. It would, however, require

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

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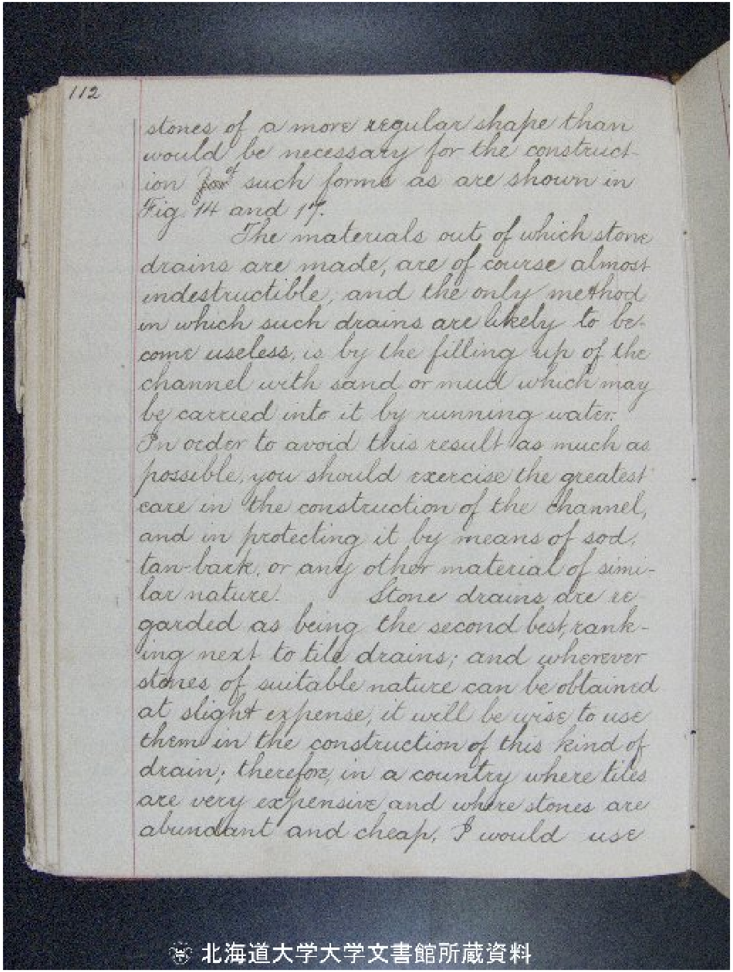
Fig.15

Fig.16

Fig.17

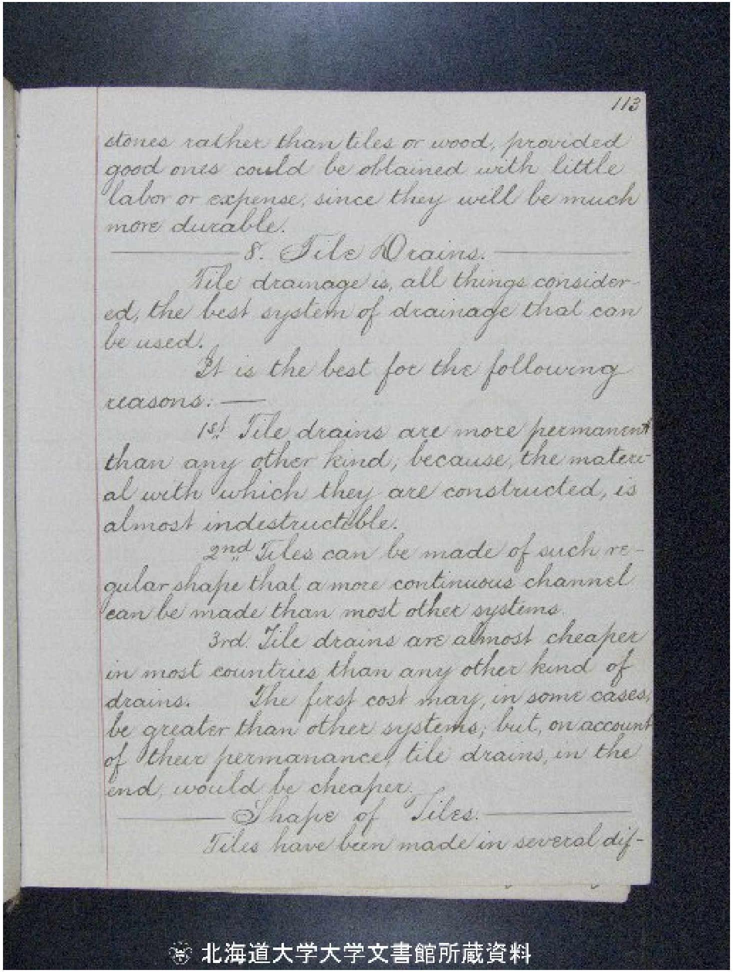


stones of a more regular shape than would be necessary for the construction ~~for~~ of such forms as are shown in Fig. 14 and 17.

The materials out of which stone drains are made, are of course almost indestructible, and the only method in which such drains are likely to become useless, is by the filling up of the channel with sand or mud which may be carried into it by running water. In order to avoid this result as much as possible, you should exercise the greatest care in the construction of the channel, and in protecting it by means of sod, tan-bark, or any other material of similar nature. Stone drains are regarded as being the second best, ranking next to tile drains; and wherever stones of suitable nature can be obtained at slight expense, it will be wise to use them in the construction of this kind of drain; therefore, in a country where tiles are very expensive and where stones are abundant and cheap, I would use

stones of a more regular shape than would be necessary for the construction of such forms as are shown in Fig.14 and 17.

The materials out of which stone drains are made, are of course almost indestructible; and the only method in which such drains are likely to become useless, is by the filling up of the channel with sand or mud which may be carried into it by running water. In order to avoid this result as much as possible, you should exercise the greatest care in the construction of the channel, and in protecting it by means of sod, tan-bark, or any other material of similar nature. Stone drains are regarded as being the second best, ranking next to tile drains; and wherever stones of suitable nature can be obtained at slight expense, it will be wise to use them in the construction of this kind of drain; therefore, in a country where tiles are very expensive and where stones are abundant and cheap, I would use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stones rather than tiles or wood, provided good ones could be obtained with little labor or expense, since they will be much more durable.

— 8. Tile Drains. —

Tile drainage is, all things considered, the best system of drainage that can be used.

It is the best for the following reasons: —

1st Tile drains are more permanent than any other kind, because, the material with which they are constructed, is almost indestructible.

2nd Tiles can be made of such regular shape that a more continuous channel can be made than most other systems.

3rd. Tile drains are almost cheaper in most countries than any other kind of drains. The first cost may, in some cases, be greater than other systems; but, on account of their permanance, tile drains, in the end, would be cheaper.

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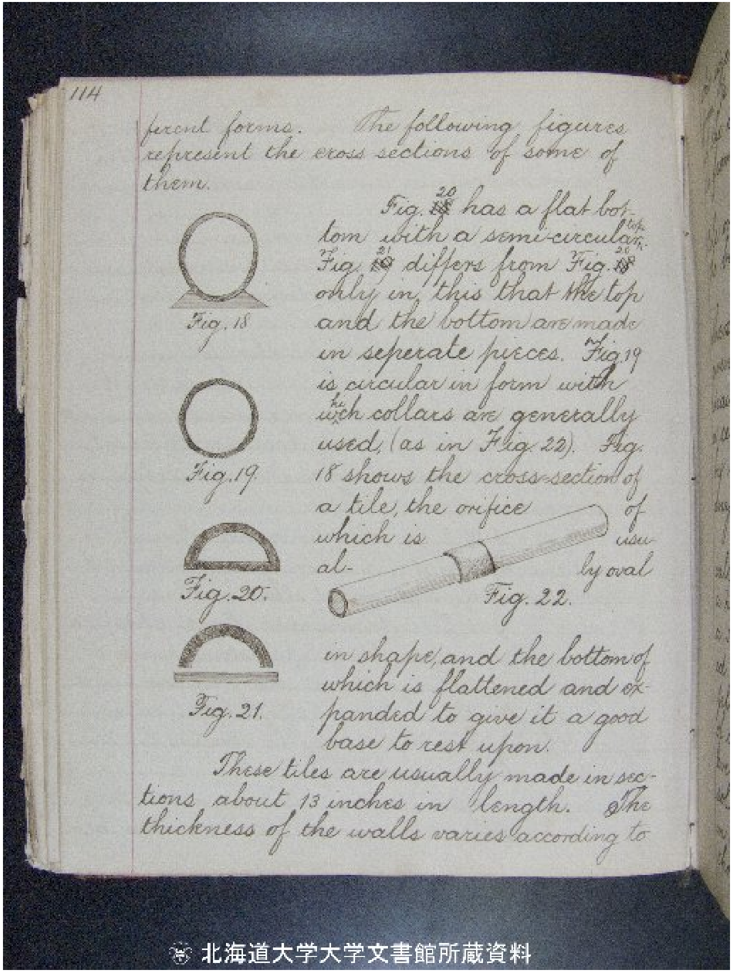

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ferent forms. The following figures represent the cross sections of some of them.

Fig. 20 has a flat bottom with a semi-circular top. Fig. 21 differs from Fig. 20 only in this that the top and the bottom are made in seperate pieces. Fig 19 is circular in form with which collars are generally used, (as in Fig. 22). Fig. 18 shows the cross-section of a tile, the orifice of which is usually oval in shape, and the bottom of which is flattened and expanded to give it a good base to rest upon.

Fig. 18

Fig. 19

Fig. 20.

Fig. 21.

Fig. 22.

These tiles are usually made in sections about 13 inches in length. The thickness of the walls varies according to

forms. The following figures represent the cross sections of some of them.

Fig.18

Fig.19

Fig.20

Fig.21

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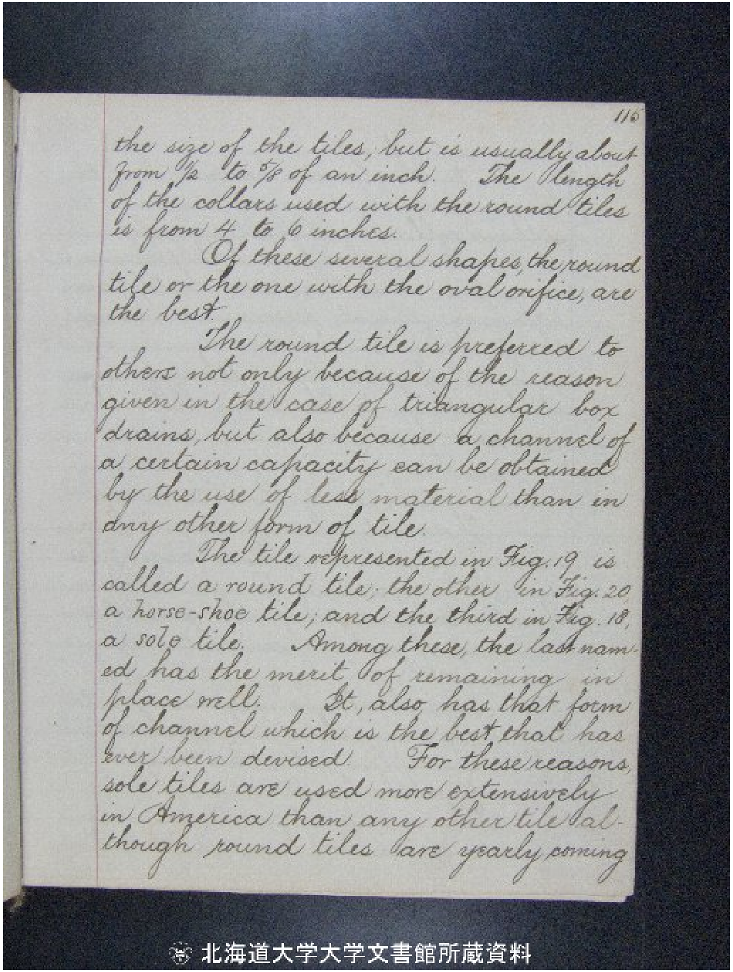

the size of the tiles, but is usually about from 1/2 to 5/8 of an inch. The length of the collars used with the round tiles is from 4 to 6 inches.

Of these several shapes, the round tile or the one with the oval orifice, are the best.

The round tile is preferred to others not only because of the reason given in the case of triangular box drains, but also because a channel of a certain capacity can be obtained by the use of less material than in any other form of tile.

The tile represented in Fig. 19 is called a round tile, the other in Fig. 20 a horse-shoe tile; and the third in Fig. 18, a sole tile. Among these, the last named has the merit of remaining in place well. It, also has that form of channel which is the best that has ever been devised. For these reasons, sole tiles are used more extensively in America than any other tile although round tiles are yearly coming

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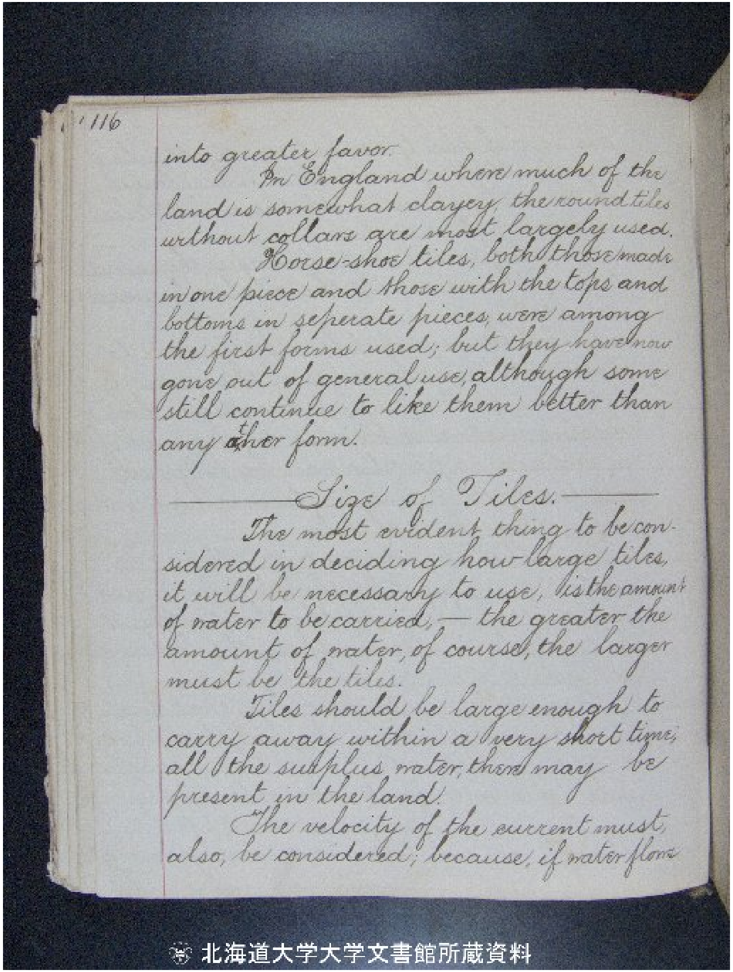

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into greater favor.
In England where much of the land is somewhat clayey, the round tiles without collars are most largely used.
Horse-shoe tiles, both those made in one piece and those with the tops and bottoms in seperate pieces, were among the first forms used; but they have now gone out of general use, although some still continue to like them better than any other form.

—Size of Tiles.—

The most evident thing to be considered in deciding how large tiles, it will be necessary to use, is the amount of mater to be carried,— the greater the amount of mater, of course, the larger must be the tiles.
Tiles should be large enough to carry away within a very short time, all the surplus mater, there may be present in the land.
The velocity of the current must, also, be considered; because, if mater flows

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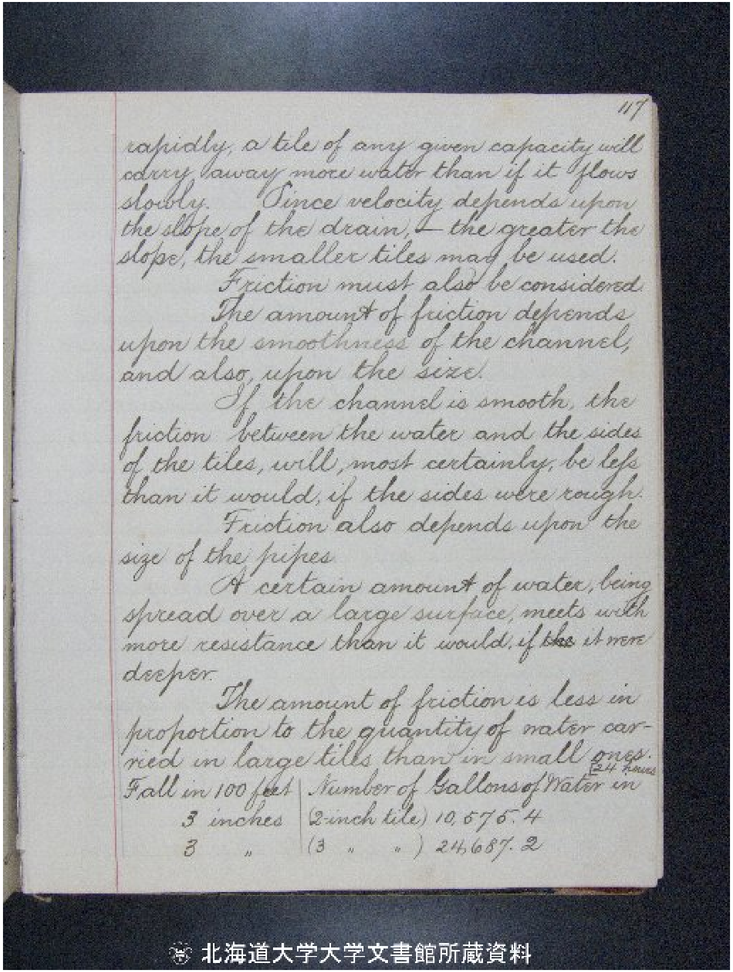
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rapidly, a tile of any given capacity will carry away more water than if it flows slowly. Since velocity depends upon the slope of the drain, — the greater the slope, the smaller tiles may be used.

Friction must also be considered.

The amount of friction depends upon the smoothness of the channel, and also, upon the size.

If the channel is smooth, the friction between the water and the sides of the tiles, will, most certainly, be less than it would, if the sides were rough.

Friction also depends upon the size of the pipes.

A certain amount of water, being spread over a large surface, meets with more resistance than it would, if ~~the~~ it were deeper.

The amount of friction is less in proportion to the quantity of water carried in large tiles than in small ones.

Fall in 100 feet	Number of Gallons of Water in 24 hours
3 inches	(2-inch tile) 10,575.4
3 "	(3 " ") 24,687.2

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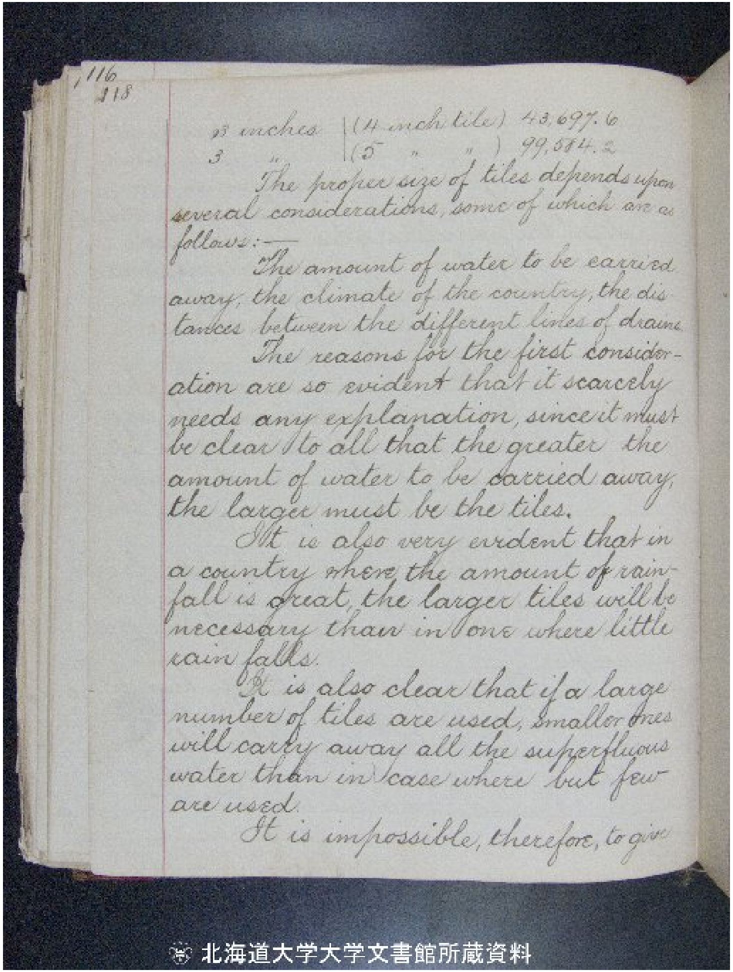
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3 inches	(4 inch tile)	43,697.6
3 "	(5 " ")	99,584.2

The proper size of tiles depends upon several considerations, some of which are as follows:—

The amount of water to be carried away, the climate of the country, the distances between the different lines of drains.

The reasons for the first consideration are so evident that it scarcely needs any explanation, since it must be clear to all that the greater the amount of water to be carried away, the larger must be the tiles.

It is also very evident that in a country where the amount of rainfall is great, the larger tiles will be necessary than in one where little rain falls.

It is also clear that if a large number of tiles are used, smaller ones will carry away all the superfluous water than in case where but few are used.

It is impossible, therefore, to give

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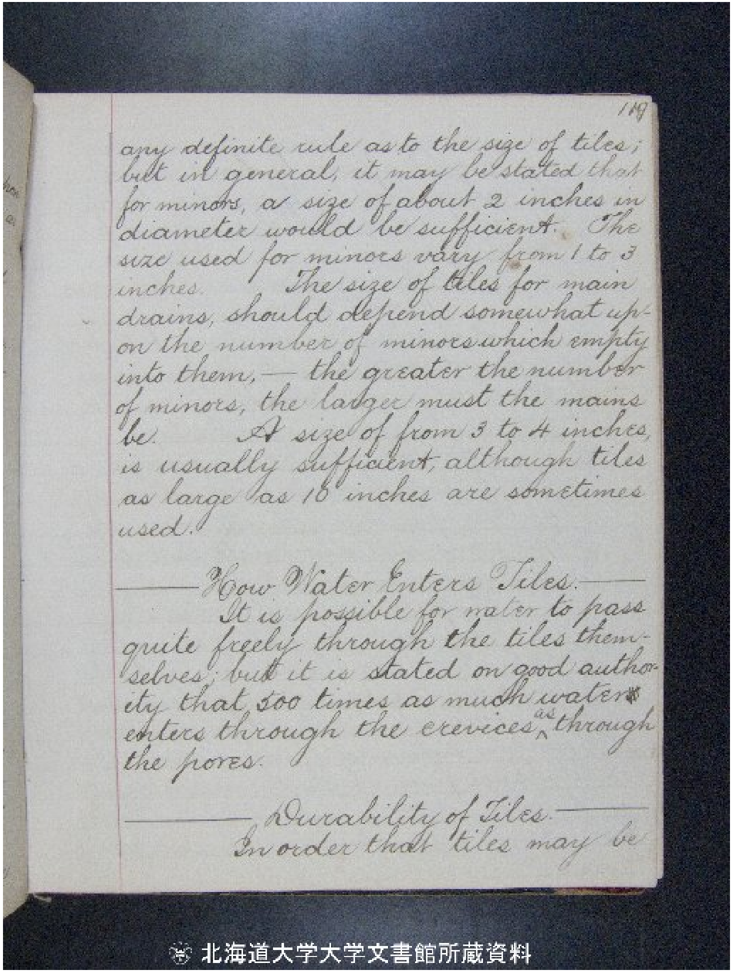
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any definite rule as to the size of tiles; but in general, it may be stated that for minors, a size of about 2 inches in diameter would be sufficient. The size used for minors vary from 1 to 3 inches. The size of tiles for main drains, should depend somewhat upon the number of minors which empty into them, — the greater the number of minors, the larger must the mains be. A size of from 3 to 4 inches, is usually sufficient, although tiles as large as 10 inches are sometimes used.

—How Water Enters Tiles.—

It is possible for water to pass quite freely through the tiles themselves; but it is stated on good authority that 500 times as much water enters through the crevices as through the pores.

—Durability of Tiles.—

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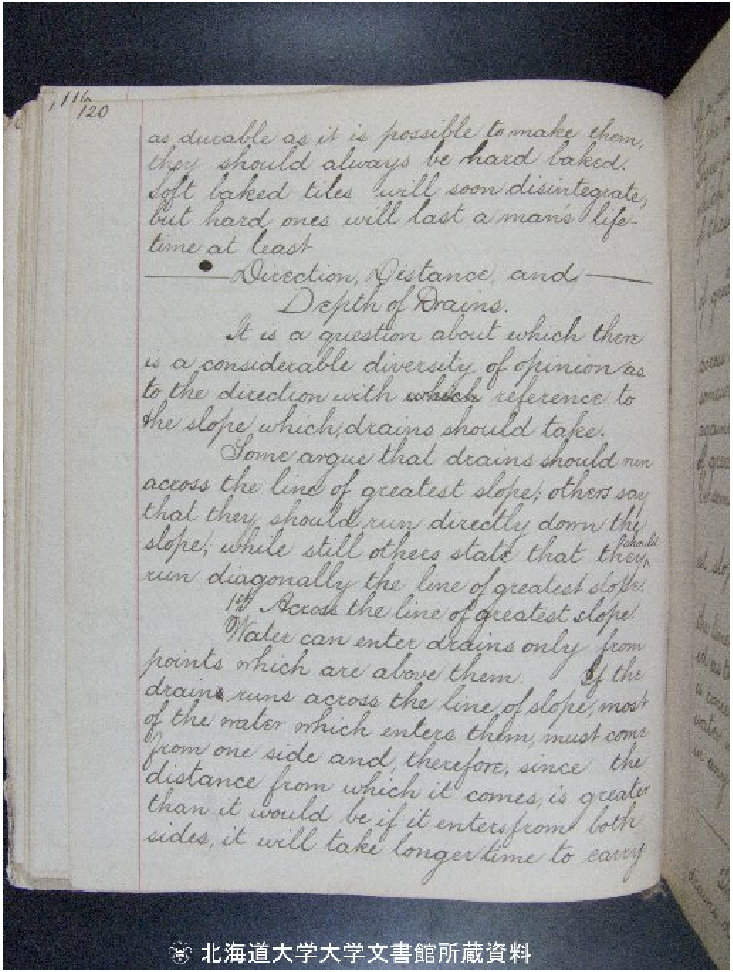

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as durable as it is possible to make them, they should always be hard baked. Soft baked tiles will soon disintegrate, but hard ones will last a man's life-time at least

Direction, Distance and Depth of Drains.

It is a question about which there is a considerable diversity of opinion as to the direction with ~~which~~ reference to the slope which, drains should take.

Some argue that drains should run across the line of greatest slope; others say that they should run directly down the slope; while still others state that they should run diagonally the line of greatest slope.

1st Across the line of greatest slope.

Water can enter drains only from points which are above them. If the drains runs across the line of slope, most of the water which enters them, must come from one side and, therefore, since the distance from which it comes, is greater than it would be if it enters from both sides, it will take longer time to carry

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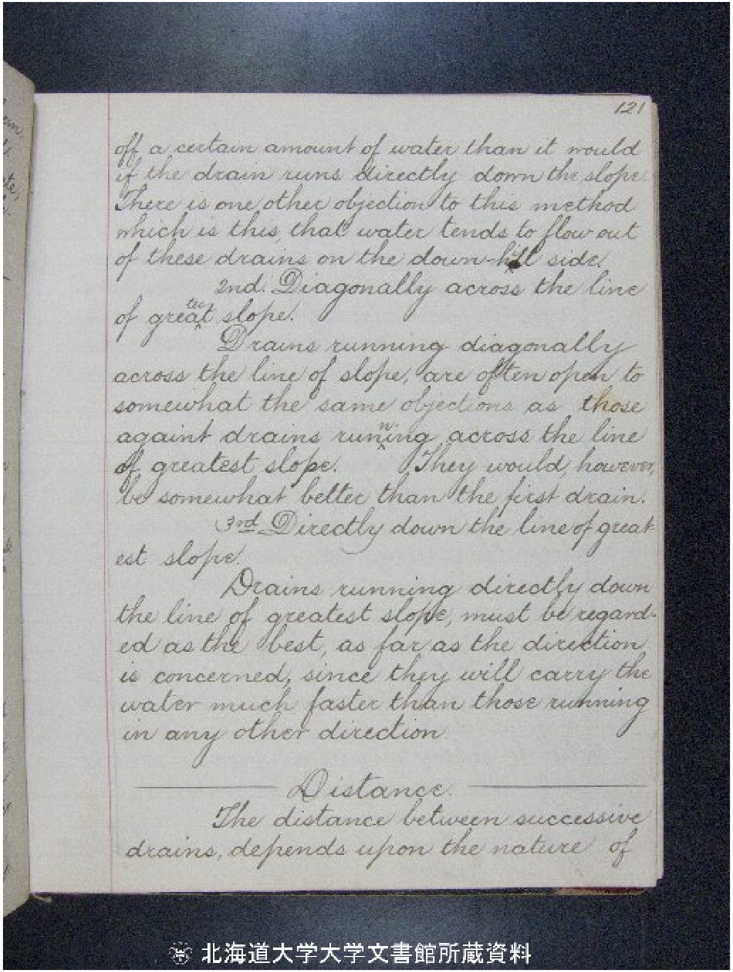


off a certain amount of water than it would if the drain runs directly down the slope. There is one other objection to this method which is this, that water tends to flow out of these drains on the down-hill side.

2nd Diagonally across the line of greatest slope.

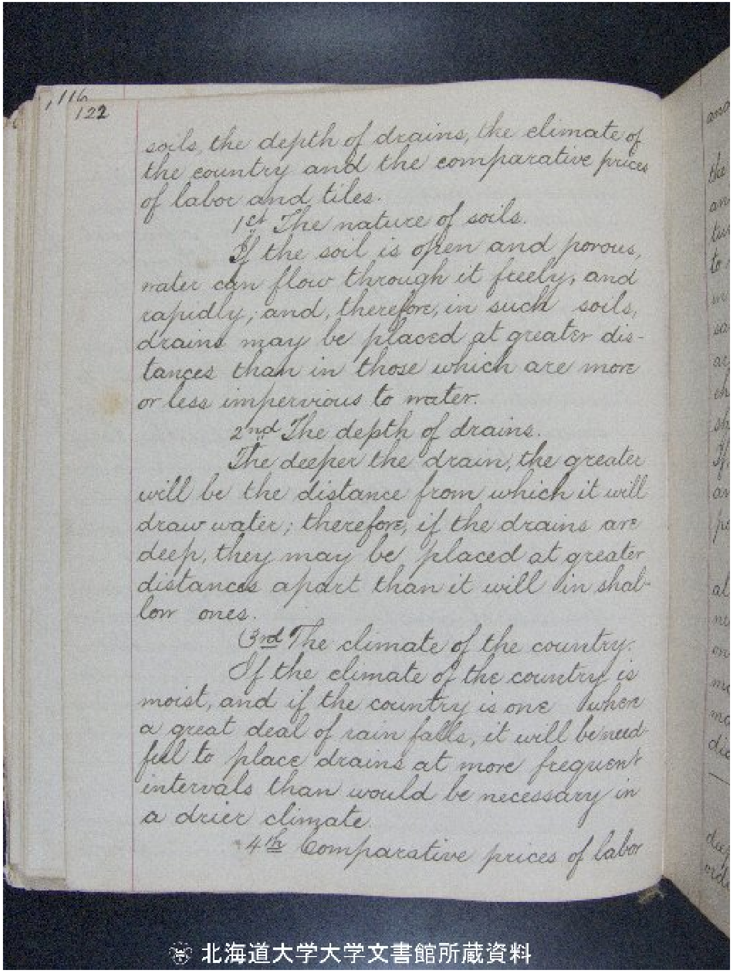
Drains running diagonally across the line of slop, are often open to somewhat the same objections as those againt drains running across the line of greatest slope. They would, however, be somewhat better than the first drain.

3rd Directly down the line of greatest slope.

Drains running directly down the line of greatest slope, must be regarded as the best, as far as the direction is concerned, since they will carry the water much faster than those running in any other direction.

———— Distance ————

The distance between successive drains, depends upon the nature of



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soils, the depth of drains, the climate of the country and the comparative prices of labor and tiles.

1st The nature of soils.

If the soil is open and porous, water can flow through it freely, and rapidly; and, therefore, in such soils, drains may be placed at greater distances than in those which are more or less impervious to water.

2nd The depth of drains.

The deeper the drain, the greater will be the distance from which it will draw water; therefore, if the drains are deep, they may be placed at greater distances apart than it will in shallow ones.

3rd The climate of the country.

If the climate of the country is moist, and if the country is one where a great deal of rain falls, it will be needful to place drains at more frequent intervals than would be necessary in a drier climate.

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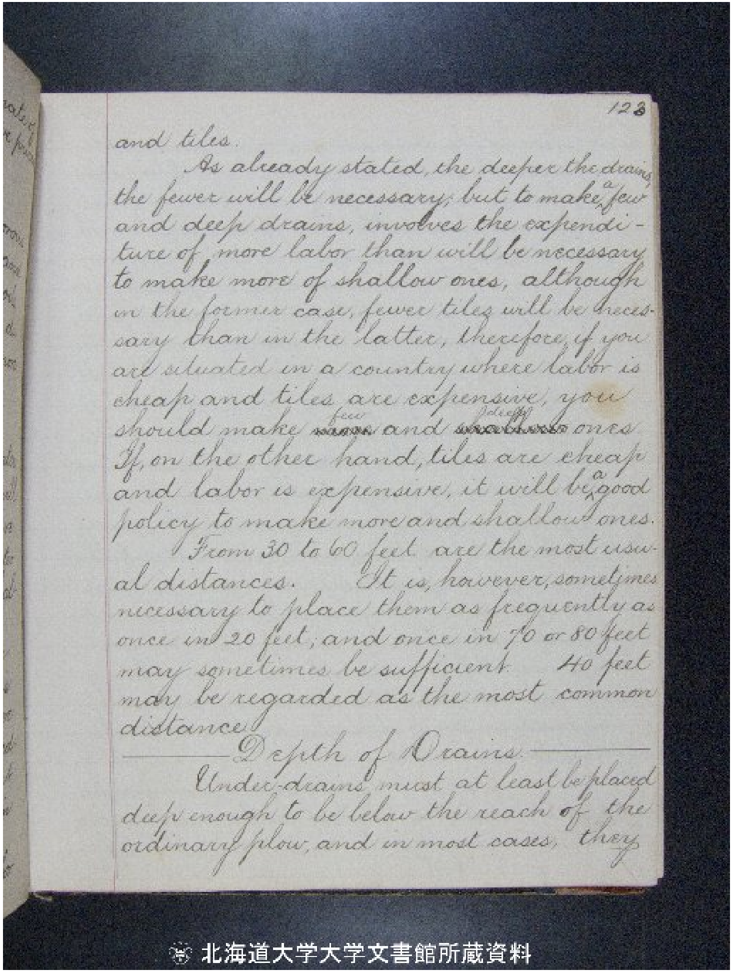
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and tiles.
As already stated, the deeper the drains the fewer will be necessary; but to make a few and deep drains, involves the expenditure of more labor than will be necessary to make more of shallow ones, although in the former case, fewer tiles will be necessary than in the latter, therefore, if you are situated in a country where labor is cheap and tiles are expensive, you should make few and deep ones. If, on the other hand, tiles are cheap and labor is expensive, it will be a good policy to make more and shallow ones.
From 30 to 60 feet are the most usual distances. It is, however, sometimes necessary to place them as frequently as once in 20 feet, and once in 70 or 80 feet may sometimes be sufficient. 40 feet may be regarded as the most common distance.
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Under-drains must at least be placed deep enough to be below the reach of the ordinary plow, and in most cases, they

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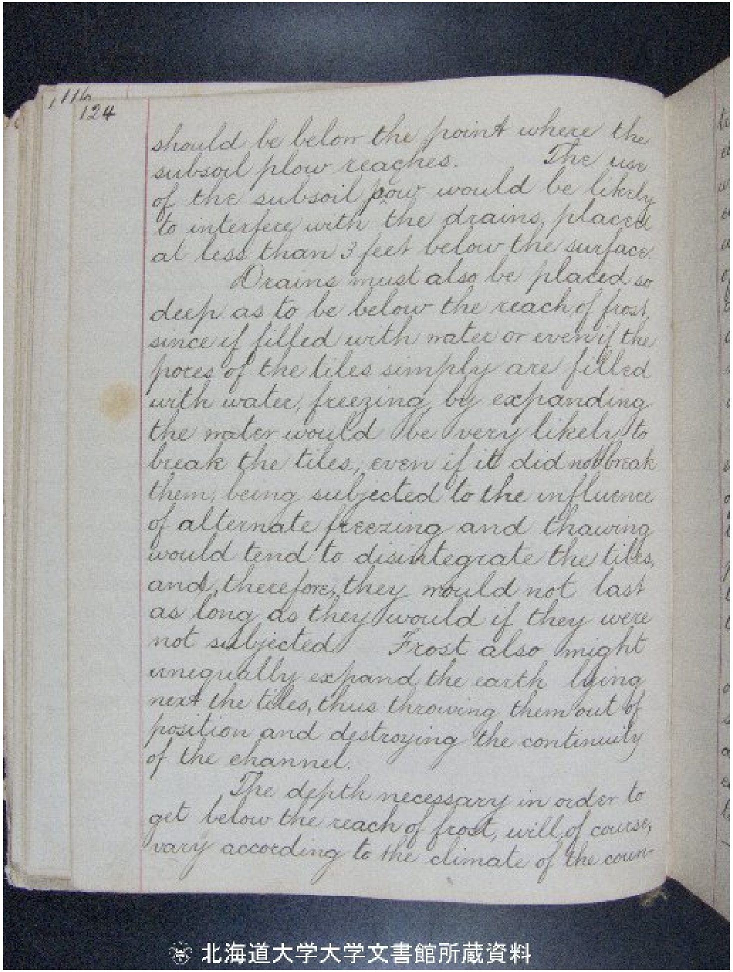
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should be below the point where the subsoil plow reaches. The use of the subsoil plow would be likely to interfere with the drains placed at less than 3 feet below the surface.

Drains must also be placed so deep as to be below the reach of frost, since if filled with water or even if the pores of the tiles simply are filled with water, freezing, by expanding the water would be very likely to break the tiles, even if it did not break them, being subjected to the influence of alternate freezing and thawing would tend to disintegrate the tiles, and, therefore, they would not last as long as they would if they were not subjected. Frost also might unequally expand the earth lying next the tiles, thus throwing them out of position and destroying the continuity of the channel.

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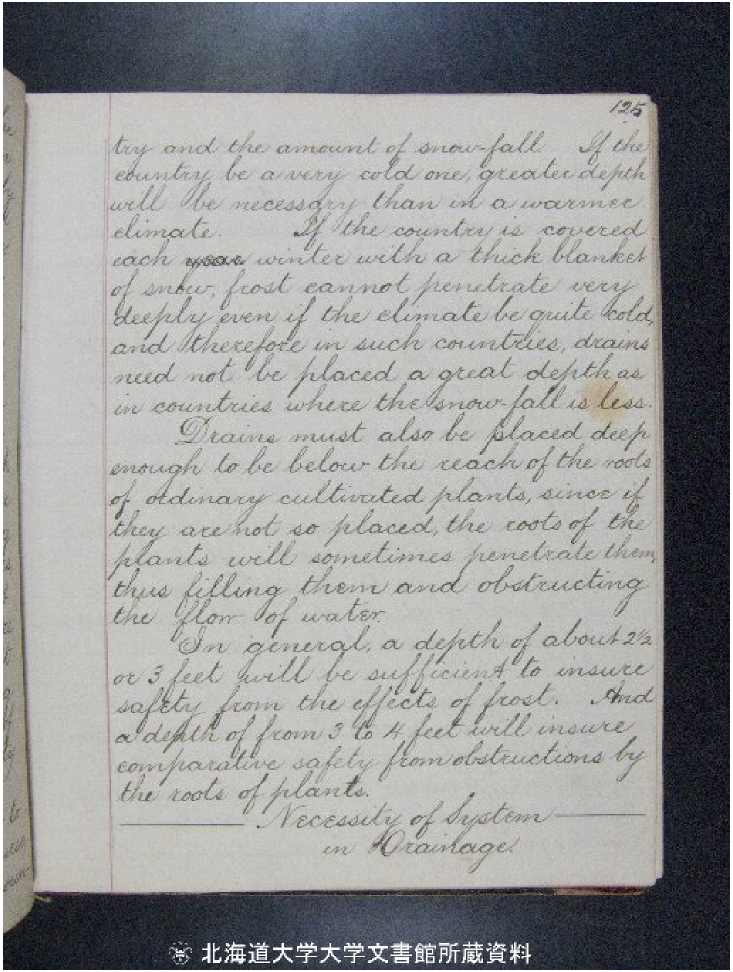

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try and the amount of snow-fall. If the country be a very cold one, greater depth will be necessary than in a warmer climate. If the country is covered each ~~year~~ winter with a thick blanket of snow, frost cannot penetrate very deeply even if the climate be quite cold, and therefore in such countries, drains need not be placed a great depth as in countries where the snow-fall is less.

Drains must also be placed deep enough to be below the reach of the roots of ordinary cultivated plants, since if they are not so placed, the roots of the plants will sometimes penetrate them, thus filling them and obstructing the flow of water.

In general, a depth of about 2½ or 3 feet will be sufficient to insure safety from the effects of frost. And a depth of from 3 to 4 feet will insure comparative safety from obstructions by the roots of plants.

Necessity of System in Drainage.

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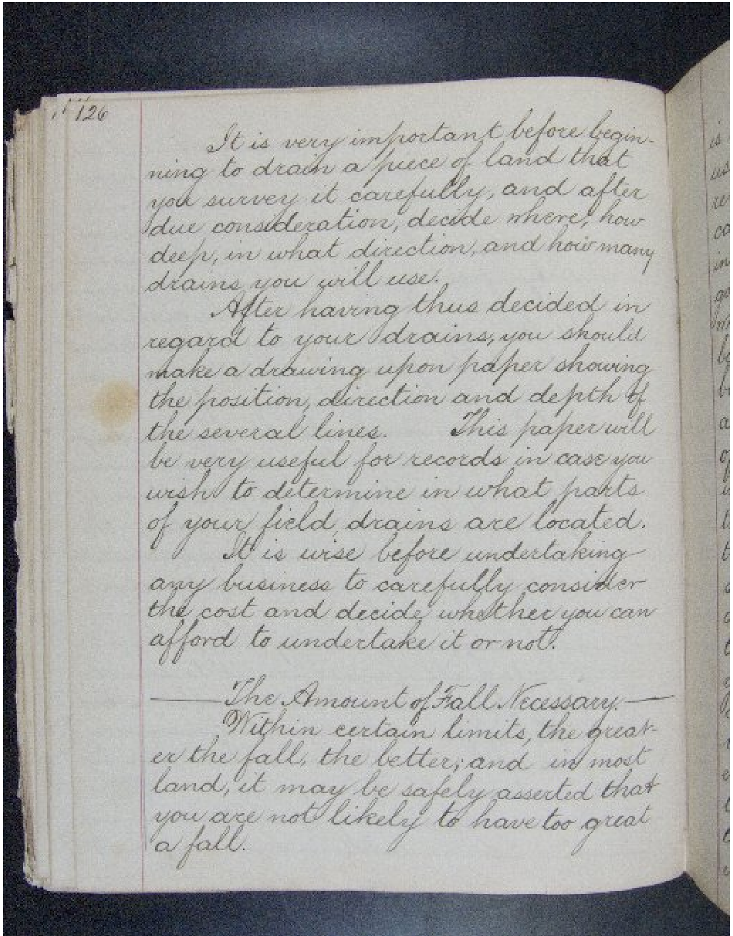
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It is very important before beginning to drain a piece of land that you survey it carefully, and after due consideration, decide where, how deep, in what direction, and how many drains you will use.

After having thus decided in regard to your drains, you should make a drawing upon paper showing the position, direction and depth of the several lines. This paper will be very useful for records in case you wish to determine in what parts of your field, drains are located.

It is wise before undertaking any business to carefully consider the cost and decide whether you can afford to undertake it or not.

The Amount of Fall Necessary

Within certain limits, the greater the fall, the better; and in most land, it may be safely asserted that you are not likely to have too great a fall.

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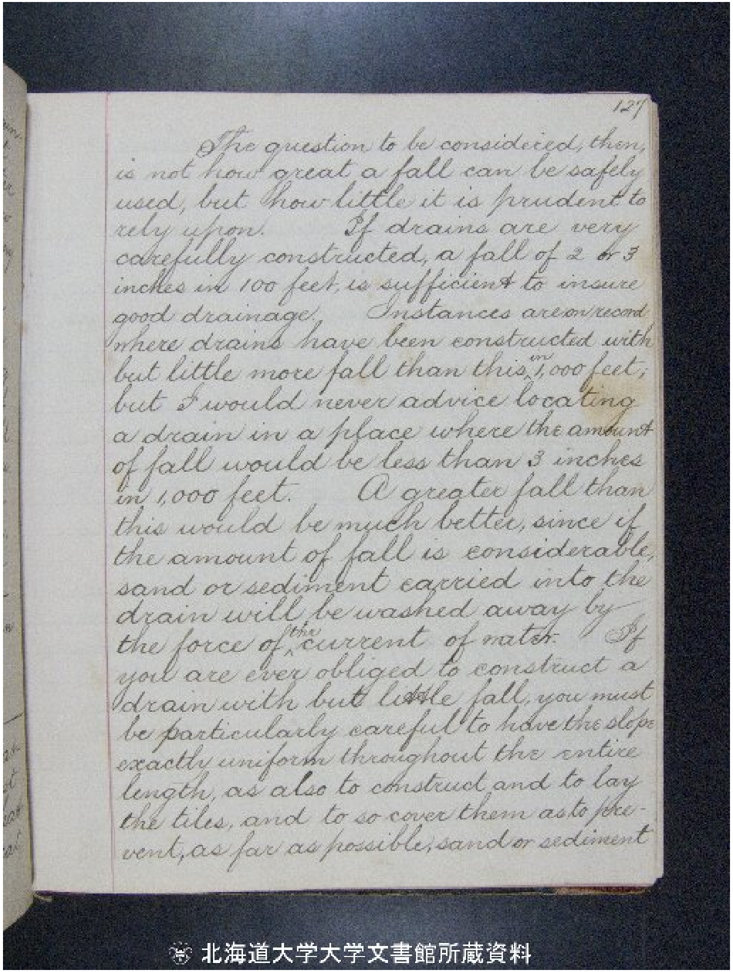
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inches in 100 feet, is sufficient to insure
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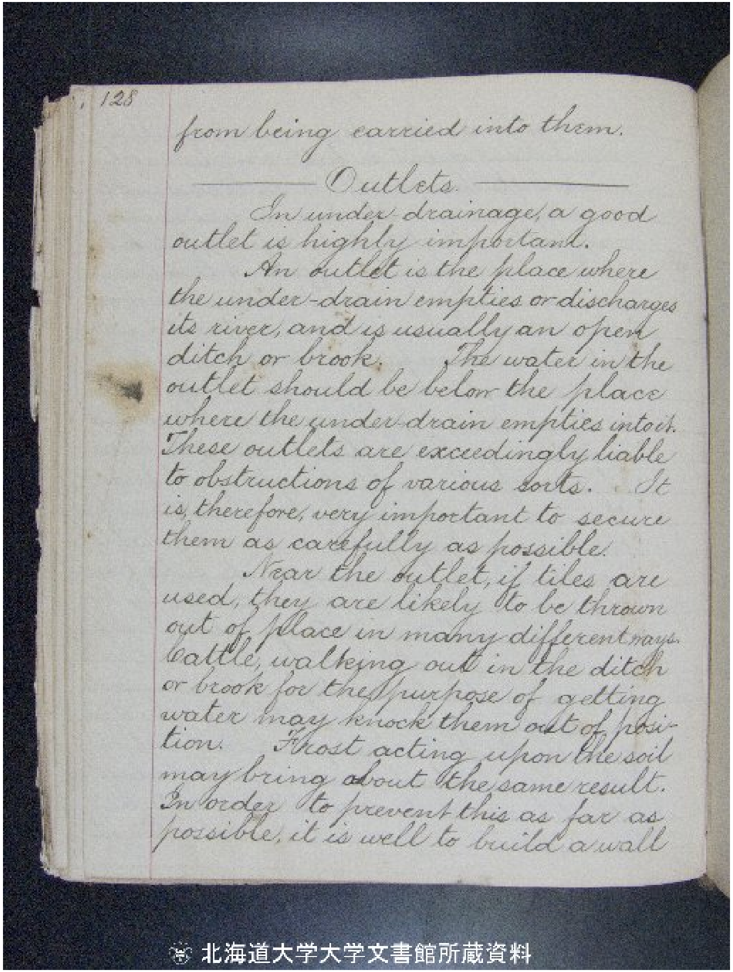

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from being carried into them.

Outlets

In under drainage, a good outlet is highly important.

An outlet is the place where the under-drain empties or discharges its river, and is usually an open ditch or brook. The water in the outlet should be below the place where the under-drain empties into it. These outlets are exceedingly liable to obstructions of various sorts. It is, therefore, very important to secure them as carefully as possible.

Near the outlet, if tiles are used, they are likely to be thrown out of place in many different ways. Cattle, walking out in the ditch or brook for the purpose of getting water may knock them out of position. Frost acting upon the soil may bring about the same result. In order to prevent this as far as possible, it is well to build a wall

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An outlet is the place where the under-drain empties or discharges its river, and is usually an open ditch or brook. The water in the outlet should be below the place where the under-drain empties into it. These outlets are exceedingly liable to obstructions of various sorts. It is, therefore, very important to secure them as carefully as possible.

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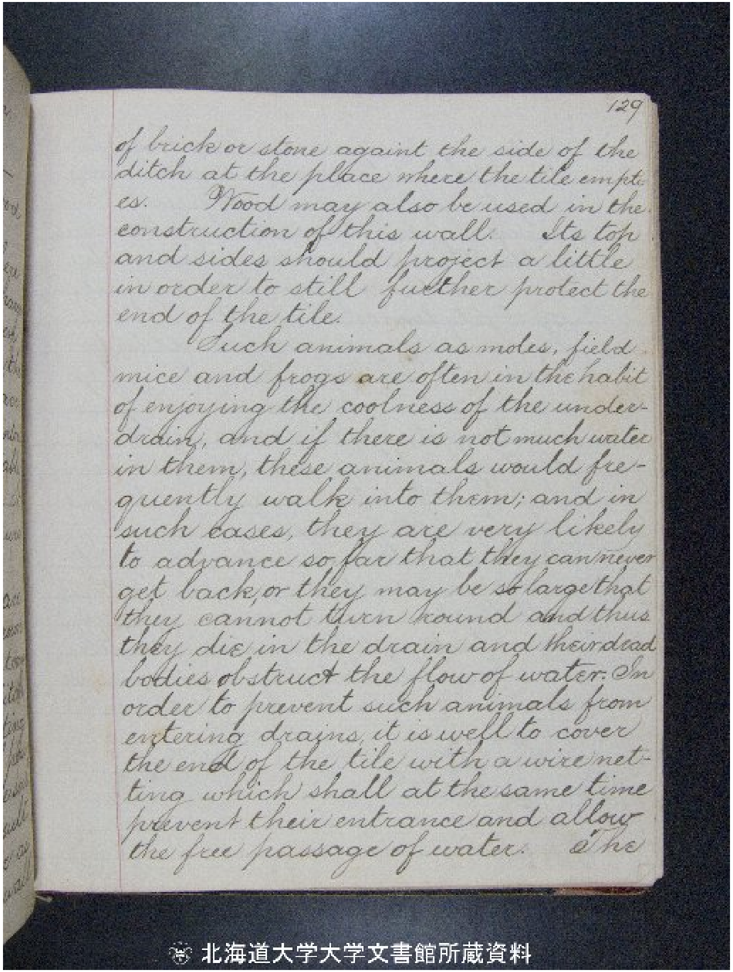
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of brick or stone againt the side of the
ditch at the place where the tile empti-
es. Wood may also be used in the
construction of this wall. Its top
and sides should project a little
in order to still futher protect the
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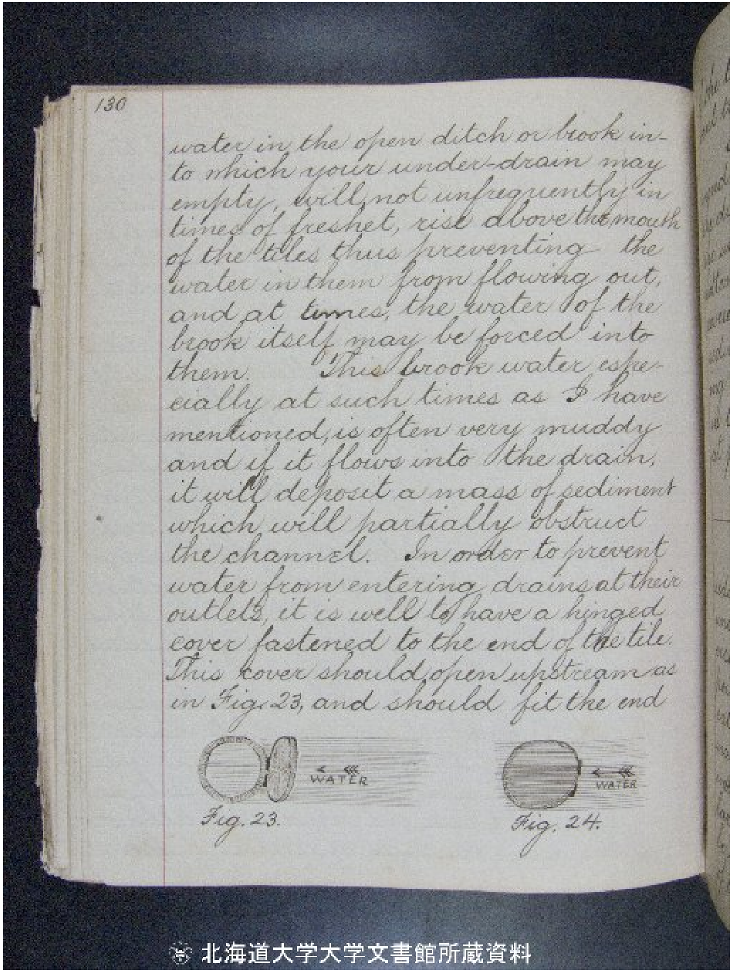
Such animals as moles, field mice and frogs are often in the habit of enjoying the coolness of the under-drain, and if there is not much water in them, these animals would frequently walk into them; and in such cases, they are very likely to advance so far that they can never get back, or they may be so large that they cannot turn round and thus they die in the drain and their dead bodies obstruct the flow of water. In order to prevent such animals from entering drains, it is well to cover the end of the tile with a wire netting which shall at the same time prevent their entrance and allow the free passage of water. The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water in the open ditch or brook into which your under-drain may empty, will not unfrequently in times of freshet, rise above the mouth of the tiles thus preventing the water in them from flowing out, and at times, the water of the brook itself may be forced into them. This brook water especially at such times as I have mentioned, is often very muddy and if it flows into the drain, it will deposit a mass of sediment which will partially obstruct the channel. In order to prevent water from entering drains at their outlets, it is well to have a hinged cover fastened to the end of the tile. This cover should open upstream as in Fig. 23, and should fit the end

Fig. 23.   Fig. 24.

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Fig.23

Fig.24

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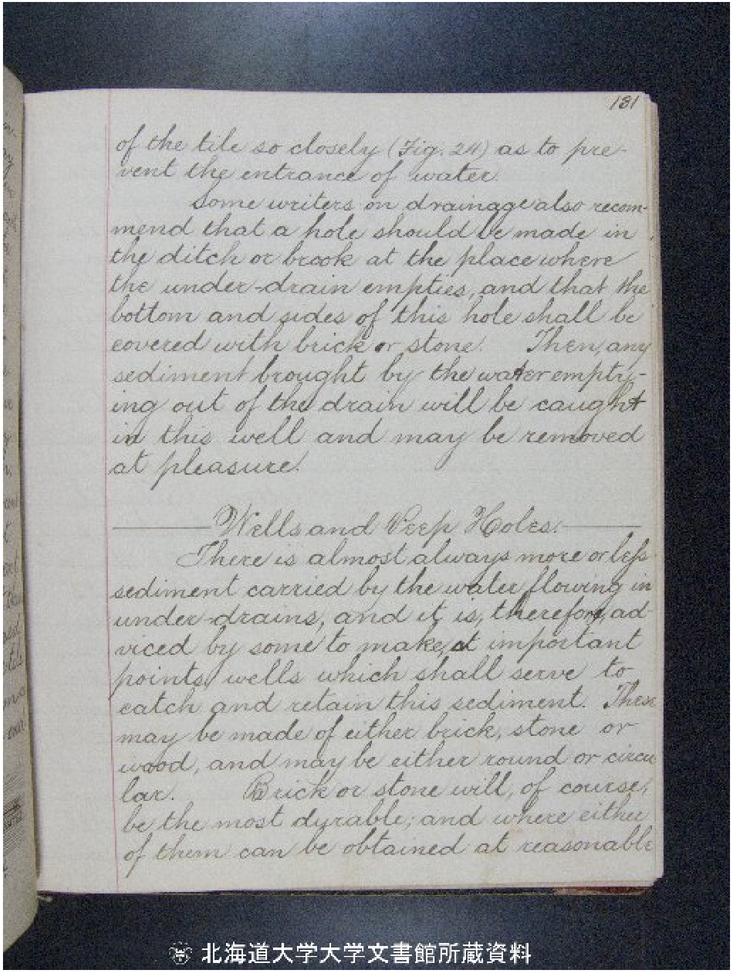

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of the tile so closely (Fig. 24) as to pre-
vent the entrance of water.
Some writers on drainage also recom-
mend that a hole should be made in
the ditch or brook at the place where
the under-drain empties, and that the
bottom and sides of this hole shall be
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Wells and Peep Holes.

There is almost always more or less
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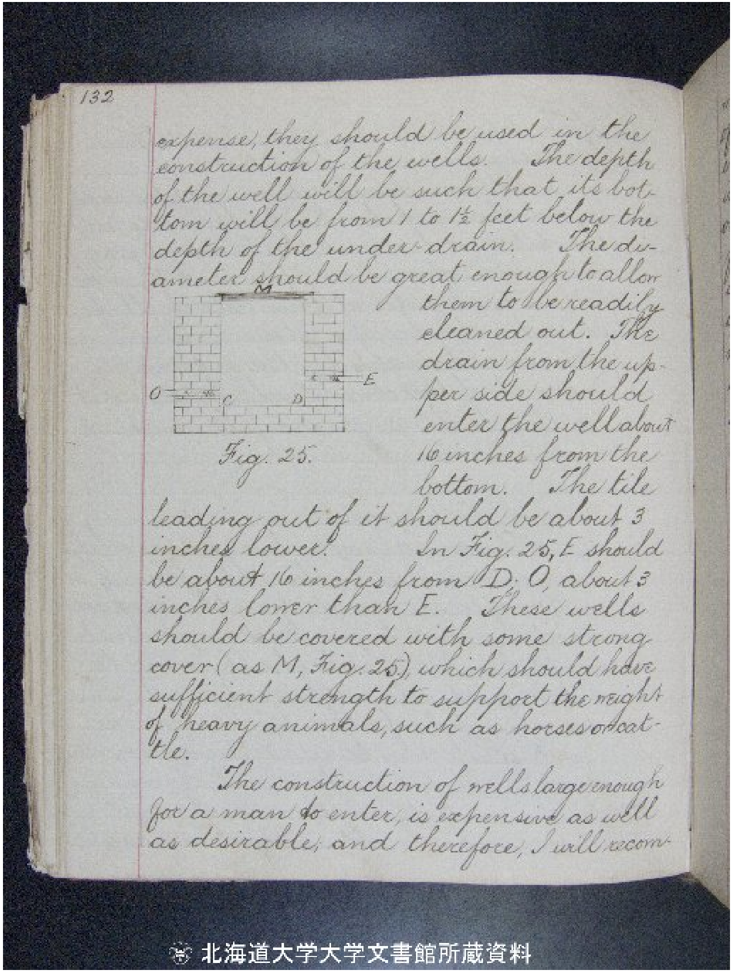

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expense, they should be used in the construction of the wells. The depth of the well will be such that its bottom will be from 1 to 1½ feet below the depth of the under drain. The diameter should be great enough to allow them to be readily cleaned out. The drain from the upper side should enter the well about 16 inches from the bottom. The tile leading out of it should be about 3 inches lower. In Fig. 25, E should be about 16 inches from D. O, about 3 inches lower than E. These wells should be covered with some strong cover (as M, Fig. 25) which should have sufficient strength to support the weight of heavy animals, such as horses or cattle.

The construction of wells large enough for a man to enter, is expensive as well as desirable, and therefore, I will recom-

expense, they should be used in the construction of the wells. The depth of the well will be such that its bottom will be from 1 to 1 feet below the depth of the under-drain. The diameter should be great enough to allow them to be readily cleaned out. The drain from the upper side should enter the well about 16 inches from the bottom. The tile leading out of it should be about 3 inches lower. In Fig. 25, E should be about 16 inches from D. O, about 3 inches lower than E. These wells should be covered with some strong cover (as M, Fig. 25.), which should have sufficient strength to support the weight of heavy animals, such as horses or cattle.

Fig.25

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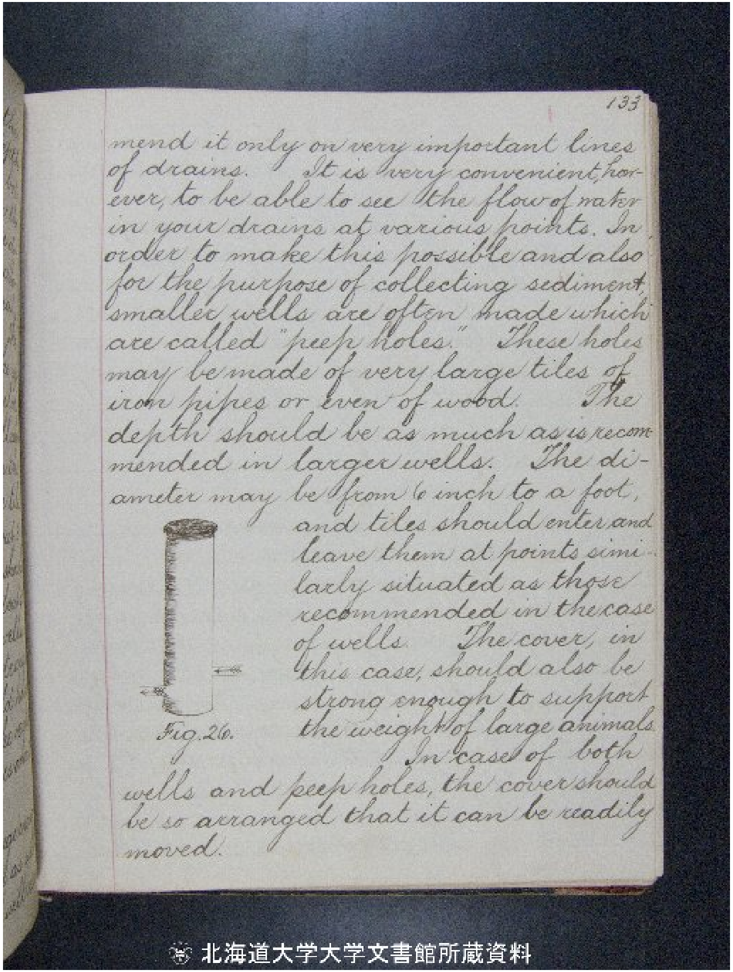
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mend it only on very important lines of drains. It is very convenient, however, to be able to see the flow of water in your drains at various points. In order to make this possible and also for the purpose of collecting sediment, smaller wells are often made which are called "peep holes." These holes may be made of very large tiles of iron pipes or even of wood. The depth should be as much as is recommended in larger wells. The diameter may be from 6 inch to a foot, and tiles should enter and leave them at points similarly situated as those recommended in the case of wells. The cover, in this case, should also be strong enough to support the weight of large animals. In case of both wells and peep holes, the cover should be so arranged that it can be readily moved.

Fig.26.

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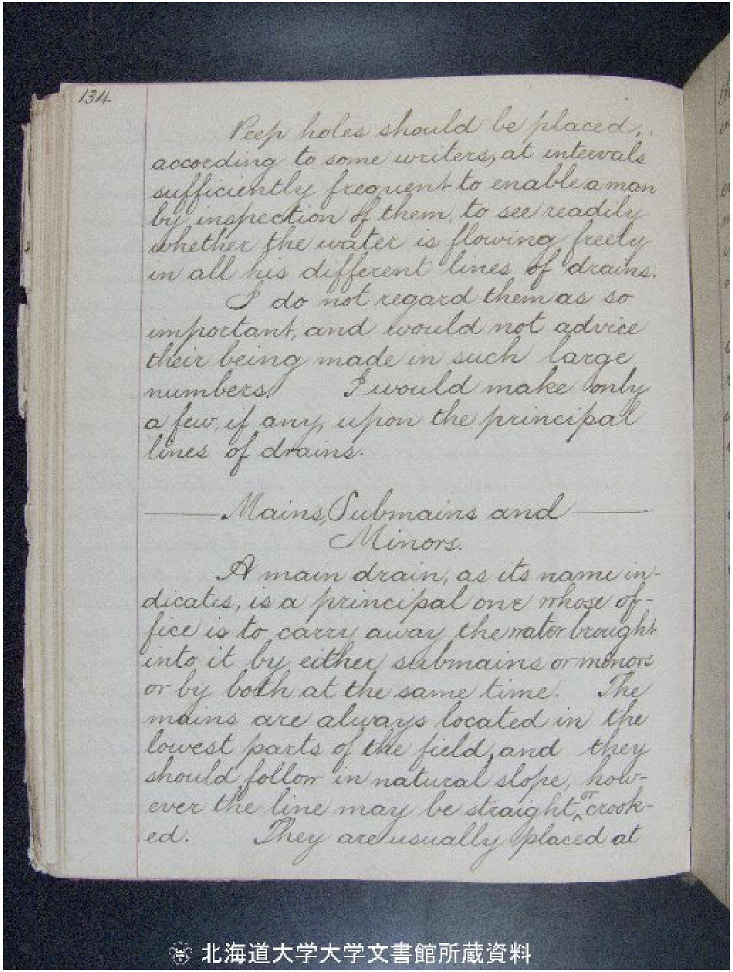
Fig.26

In case of both wells and peep holes, the cover should be so arranged that it can be readily moved.

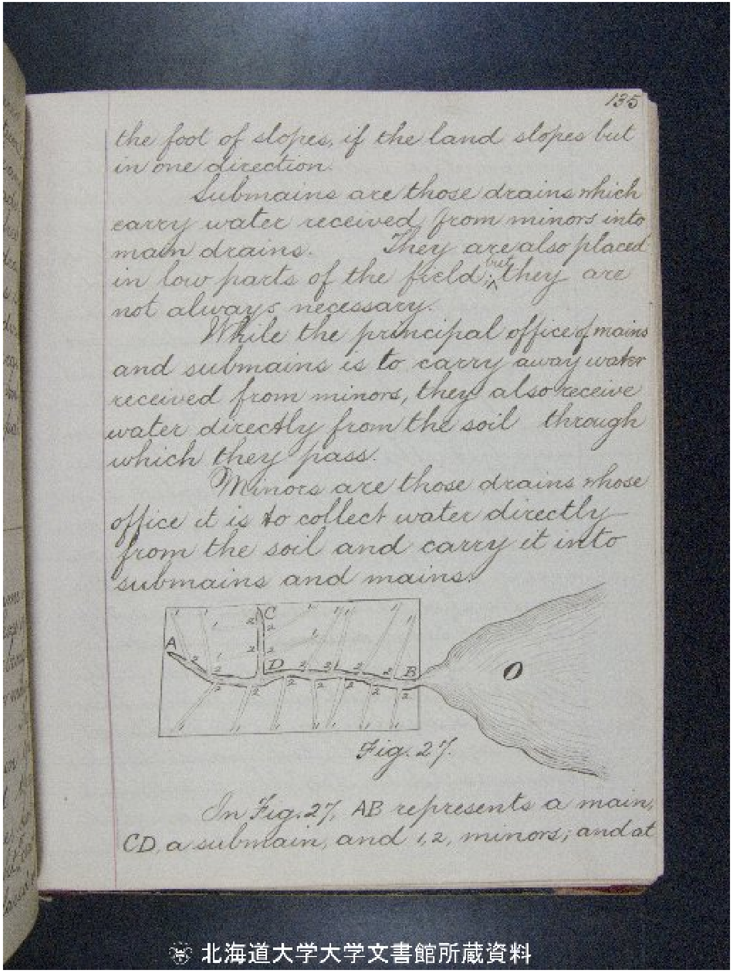


Peep holes should be placed, according to some writers, at intervals sufficiently frequent to enable a man by inspection of them, to see readily whether the water is flowing freely in all his different lines of drains.

I do not regard them as so important, and would not advice their being made in such large numbers. I would make only a few, if any upon the principal lines of drains.

Mains, Submains and Minors.

A main drain, as its name indicates, is a principal one whose office is to carry away the water brought into it by either submains or minors or by both at the same time. The mains are always located in the lowest parts of the field, and they should follow in natural slope, however the line may be straight or crooked. They are usually placed at



the foot of slopes, if the land slopes but in one direction.

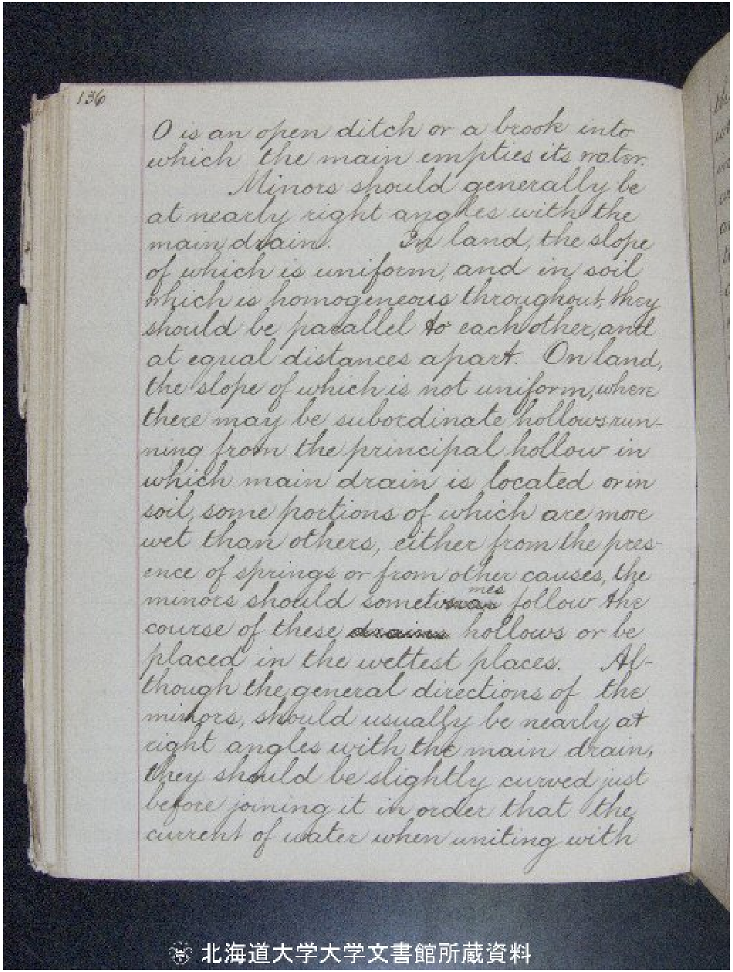
Submains are those drains which carry water received from minors into main drains. They are also placed in low parts of the field; but they are not always necessary.

While the principal office of mains and submains is to carry away water received from minors, they also receive water directly from the soil through which they pass.

Minors are those drains whose office it is to collect water directly from the soil and carry it into submains and mains.

Fig.27

In Fig. 27, AB represents a main, CD, a submain, and 1, 2, minors; and at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O is an open ditch or a brook into which the main empties its water. Minors should generally be at nearly right angles with the main drain. In land, the slope of which is uniform, and in soil which is homogeneous throughout, they should be parallel to each other, and at equal distances apart. On land, the slope of which is not uniform, where there may be subordinate hollows running from the principal hollow in which main drain is located or in soil, some portions of which are more wet than others, either from the presence of springs or from other causes, the minors should sometimes follow the course of these ~~drains~~ hollows or be placed in the wettest places. Although the general directions of the minors, should usually be nearly at right angles with the main drain, they should be slightly curved just before joining it in order that the current of water when uniting with

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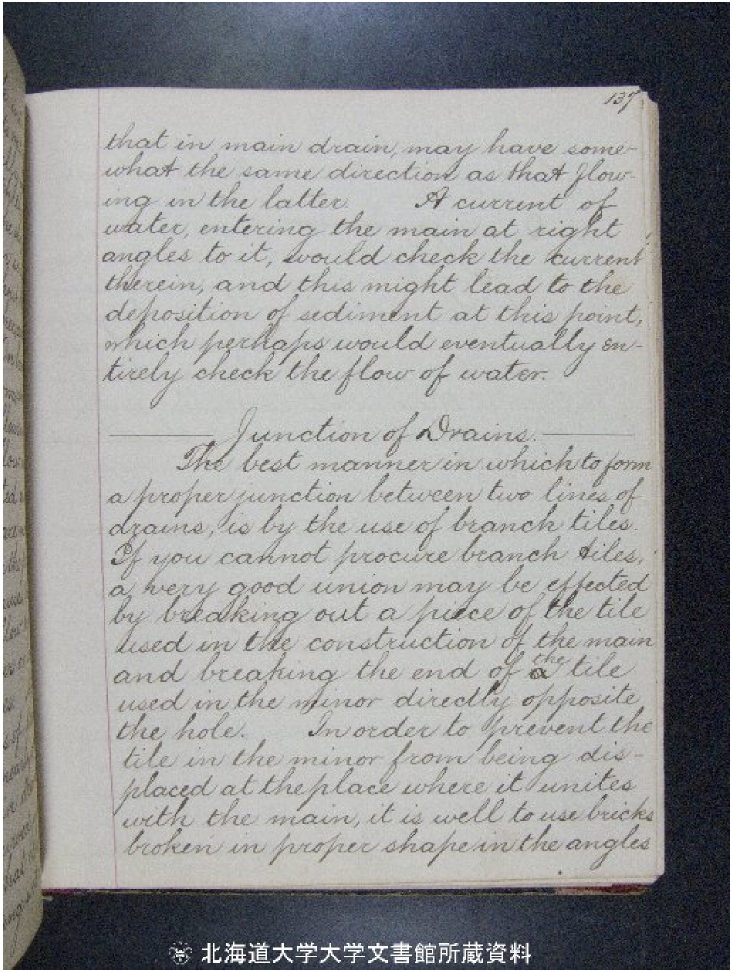

that in main drain, may have somewhat the same direction as that flowing in the latter. A current of water, entering the main at right angles to it, would check the current therein, and this might lead to the deposition of sediment at this point, which perhaps would eventually entirely check the flow of water.

Junction of Drains.

The best manner in which to form a proper junction between two lines of drains, is by the use of branch tiles. If you cannot procure branch tiles, a very good union may be effected by breaking out a piece of the tile used in the construction of the main and breaking the end of the tile used in the minor directly opposite the hole. In order to prevent the tile in the minor from being displaced at the place where it unites with the main, it is well to use bricks broken in proper shape in the angles

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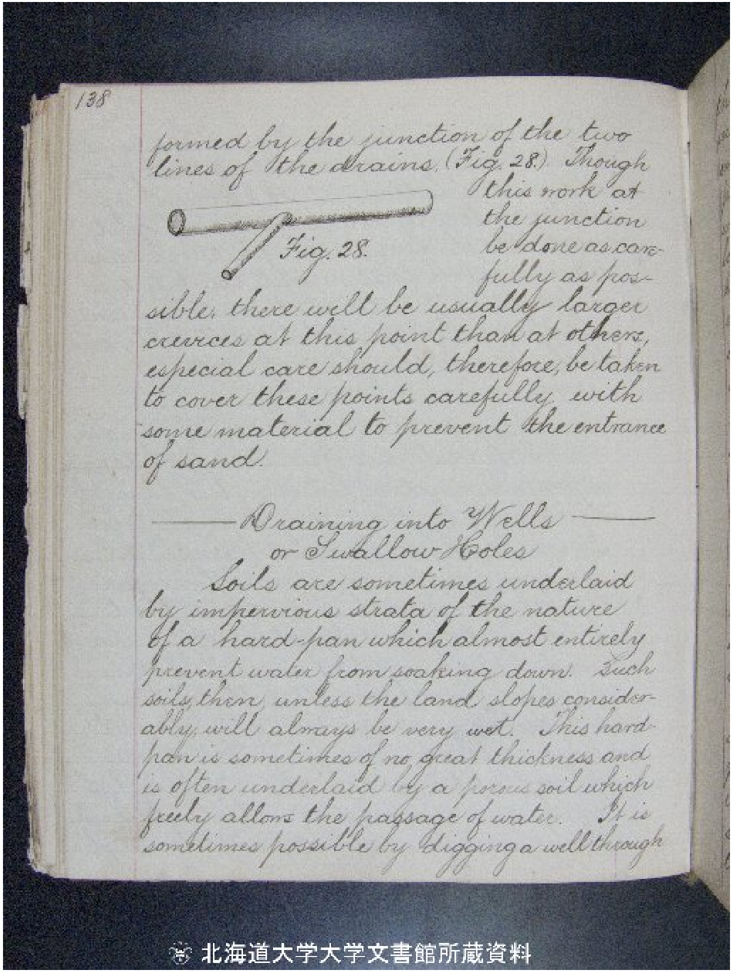
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formed by the junction of the two lines of the drains (Fig. 28). Though this work at the junction be done as carefully as possible, there well be usually larger crevices at this point than at others, especial care should, therefore, be taken to cover these points carefully with some material to prevent the entrance of sand.

Fig. 28.

—— Draining into Wells ——
or Swallow Holes

Soils are sometimes underlaid by impervious strata of the nature of a hard-pan which almost entirely prevent water from soaking down. Such soils then, unless the land slopes considerably, will always be very wet. This hard-pan is sometimes of no great thickness and is often underlaid by a porous soil which freely allows the passage of water. It is sometimes possible by digging a well through

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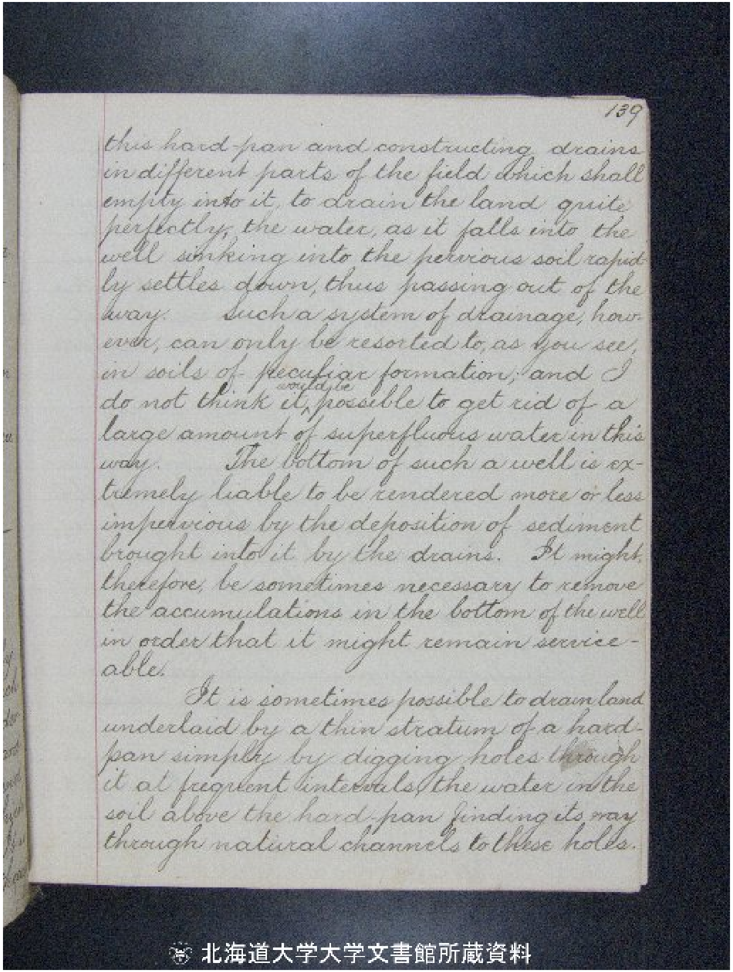
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this hard-pan and constructing drains in different parts of the field which shall empty into it, to drain the land quite perfectly, the water, as it falls into the well sinking into the pervious soil rapidly settles down, thus passing out of the way. Such a system of drainage, however, can only be resorted to, as you see, in soils of peculiar formation, and I do not think it would be possible to get rid of a large amount of superfluous water in this way. The bottom of such a well is extremely liable to be rendered more or less impervious by the deposition of sediment brought into it by the drains. It might, therefore, be sometimes necessary to remove the accumulations in the bottom of the well in order that it might remain serviceable.

It is sometimes possible to drain land underlaid by a thin stratum of a hard-pan simply by digging holes through it at frequent intervals, the water in the soil above the hard-pan finding its may through natural channels to these holes.

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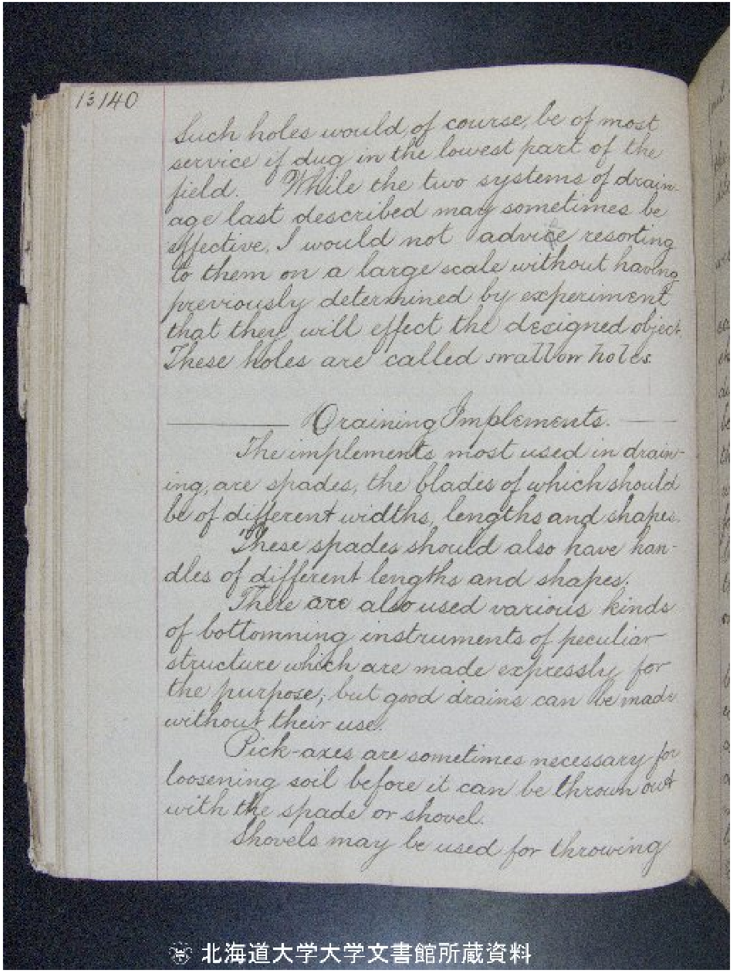
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Such holes would, of course, be of most service if dug in the lowest part of the field. While the two systems of drainage last described may sometimes be effective, I would not advise resorting to them on a large scale without having previously determined by experiment that they will effect the designed object. These holes are called swallow holes.

Draining Implements.

The implements most used in draining, are spades, the blades of which should be of different widths, lengths and shapes.

These spades should also have handles of different lengths and shapes.

There are also used various kinds of bottomning instruments of peculiar structure which are made expressly for the purpose; but good drains can be made without their use.

Pick-axes are sometimes necessary for loosening soil before it can be thrown out with the spade or shovel.

Shovels may be used for throwing

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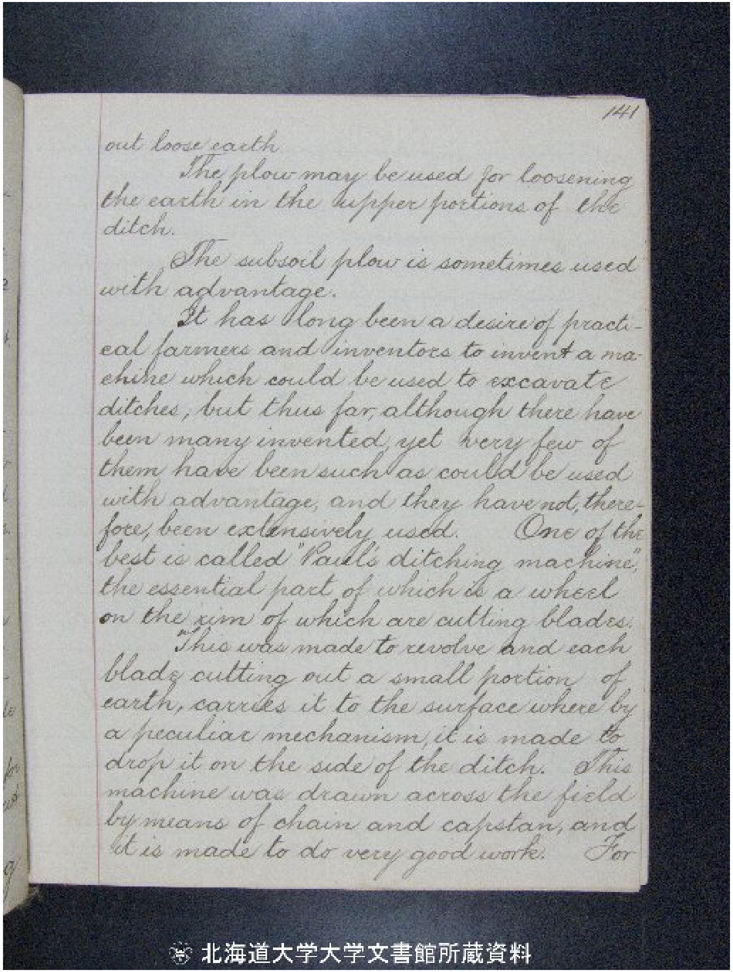

out loose earth
The plow may be used for loosening the earth in the upper portions of the ditch.
The subsoil plow is sometimes used with advantage.
It has long been a desire of practical farmers and inventors to invent a machine which could be used to excavate ditches, but thus far, although there have been many invented, yet very few of them have been such as could be used with advantage, and they have not, therefore, been extensively used. One of the best is called "Paul's ditching machine", the essential part of which is a wheel on the rim of which are cutting blades.
This was made to revolve and each blade cutting out a small portion of earth, carries it to the surface where by a peculiar mechanism, it is made to drop it on the side of the ditch. This machine was drawn across the field by means of chain and capstan, and it is made to do very good work. For

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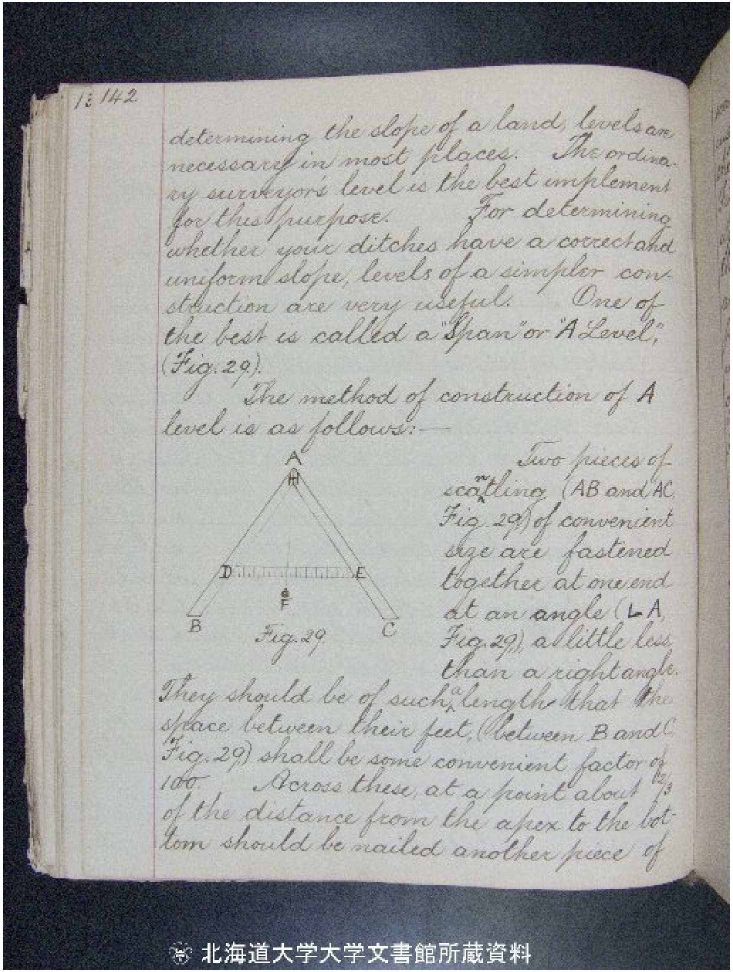

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determining the slope of a land, levels are necessary in most places. The ordinary surveyor's level is the best implement for this purpose. For determining whether your ditches have a correct and uniform slope, levels of a simpler construction are very useful. One of the best is called a "Span" or "A Level," (Fig. 29).

The method of construction of A level is as follows:—

Fig. 29

Two pieces of scantling (AB and AC, Fig. 29) of convenient size are fastened together at one end at an angle (∠A, Fig. 29), a little less than a right angle. They should be of such a length that the space between their feet, (between B and C, Fig. 29) shall be some convenient factor of 100. Across these, at a point about ⅔ of the distance from the apex to the bottom should be nailed another piece of

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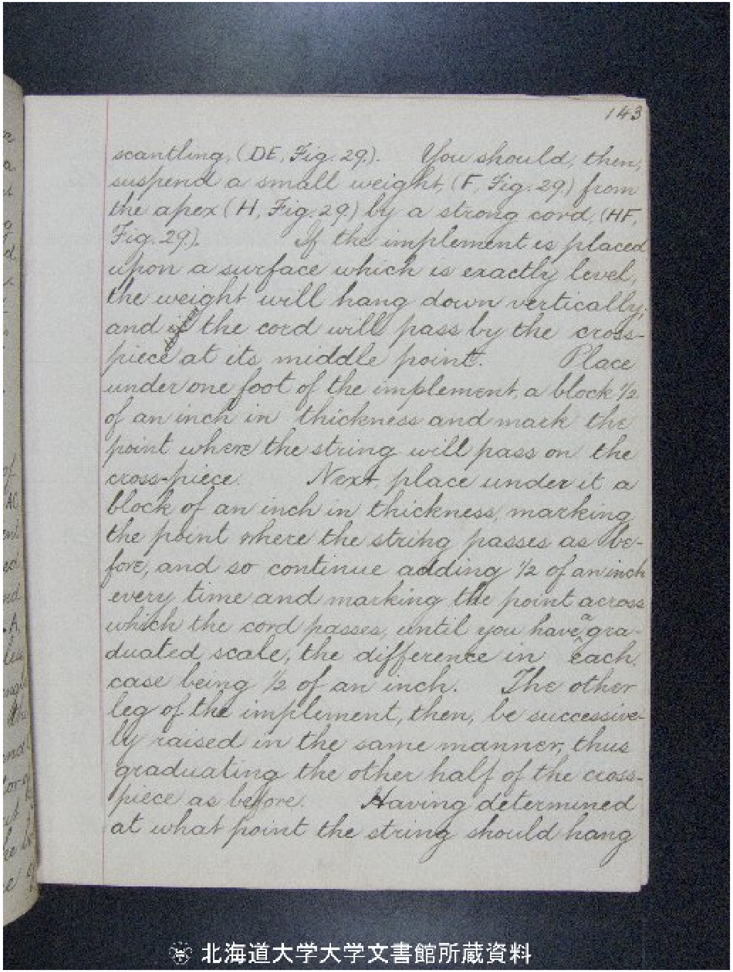
Fig.29

The method of construction of A level is as follows: ——

Two pieces of scantling (AB and AC, Fig. 29.) of convenient size are fastened together at one end at an angle (LA, Fig. 29.), a little less than a right angle. They should be of such a length that the space between their feet, (between B and C, Fig. 29.) shall be some convenient factor of 100. Across these, at a point about 2/3 of the distance from the apex to the bottom should be nailed another piece of



scantling, (DE, Fig. 29). You should, then, suspend a small weight (F, Fig. 29) from the apex (H, Fig. 29) by a strong cord, (HF, Fig. 29). If the implement is placed upon a surface which is exactly level, the weight will hang down vertically and if the cord will pass by the cross-piece at its middle point. Place under one foot of the implement, a block ½ of an inch in thickness and mark the point where the string will pass on the cross-piece. Next, place under it a block of an inch in thickness, marking the point where the string passes as before, and so continue adding ½ of an inch every time and marking the point across which the cord passes, until you have a graduated scale, the difference in each case being ½ of an inch. The other leg of the implement, then, be successively raised in the same manner, thus graduating the other half of the cross-piece as before. Having determined at what point the string should hang

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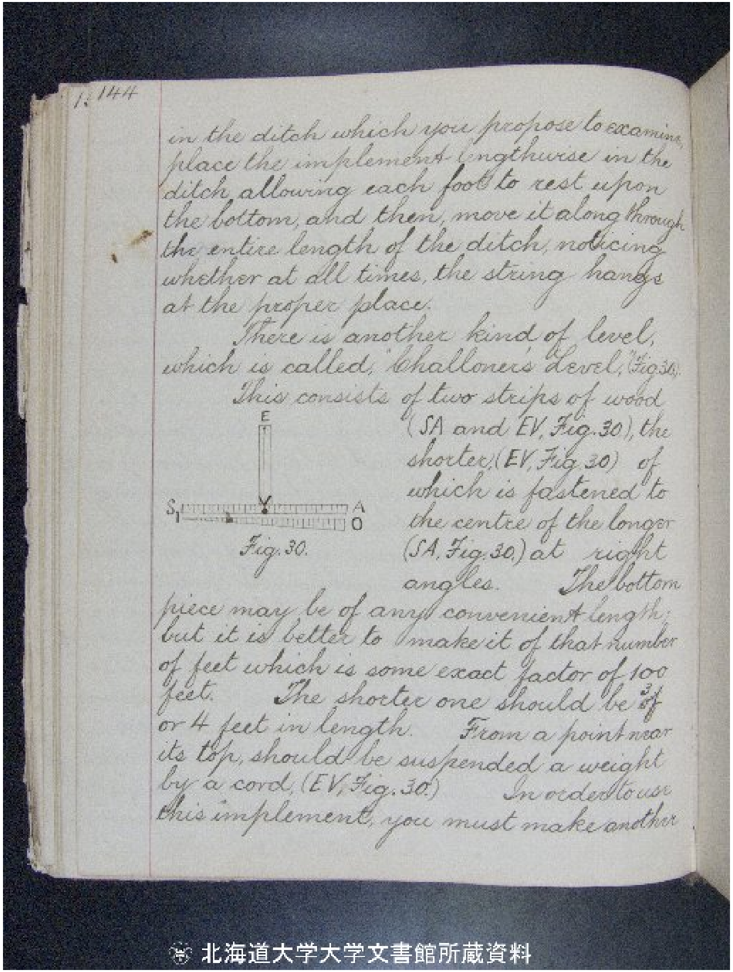
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in the ditch which you propose to examine, place the implement lengthwise in the ditch, allowing each foot to rest upon the bottom, and then, move it along through the entire length of the ditch, noticing whether at all times, the string hangs at the proper place.

There is another kind of level, which is called, "Challoner's devel, (Fig.30).

This consists of two strips of wood (SA and EV, Fig. 30), the shorter, (EV, Fig. 30) of which is fastened to the centre of the longer (SA, Fig. 30) at right angles. The bottom piece may be of any convenient length; but it is better to make it of that number of feet which is some exact factor of 100 feet. The shorter one should be 3 of or 4 feet in length. From a point near its top, should be suspended a weight by a cord, (EV, Fig. 30.) In order to use this implement, you must make another

E

V

S

A

O

Fig. 30.

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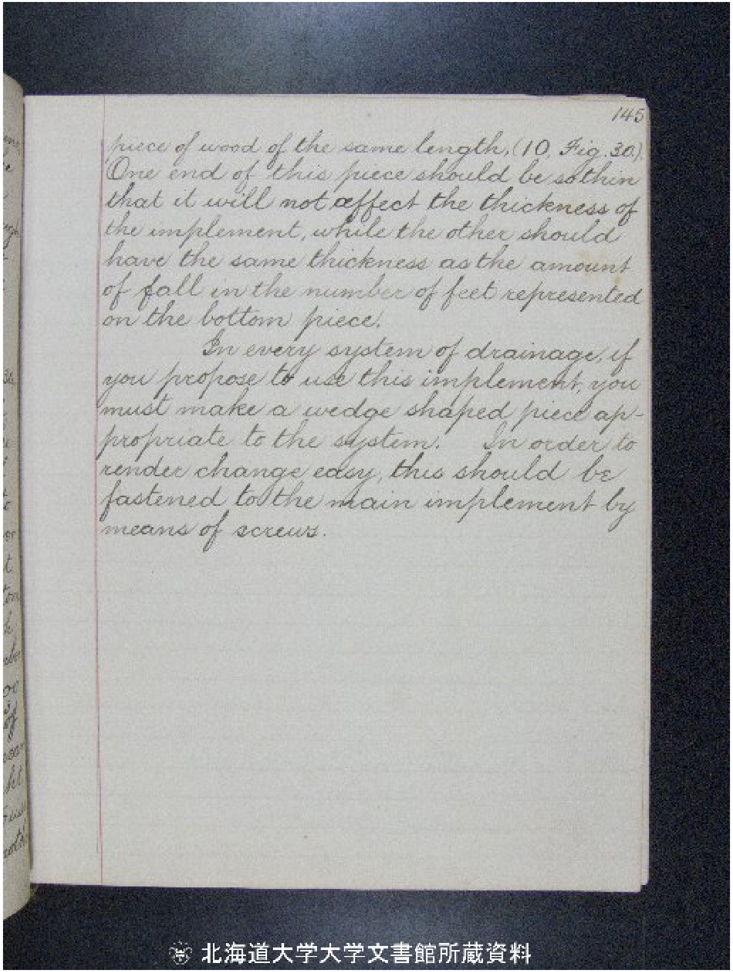
There is another kind of level, which is called, "Challoner's devel," (Fig. 30.).

Fig.30

This consists of two strips of wood (SA and EV, Fig. 30), the shorter, (EV. Fig.30.) of which is fastened to the centre of the longer (SA, Fig. 30) at right angles. The bottom piece may be of any convenient length. but it is better to make it of that number of feet which is some exact factor of 100 feet. The shorter one should by 3 or 4 feet in length. From a point near its top, should be suspended a weight by a cord, (EV, Fig. 30.). In order to use this implement, you must make another



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piece of wood of the same length, (10 Fig. 30). One end of this piece should be so thin that it will not affect the thickness of the implement, while the other should have the same thickness as the amount of fall in the number of feet represented on the bottom piece.

In every system of drainage, if you propose to use this implement, you must make a wedge shaped piece appropriate to the system. In order to render change easy, this should be fastened to the main implement by means of screws.

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