

556e

+

1894

Thesis:-

An investigation into the condition of the
atmosphere of cowhouses and stables
in Edinburgh, Leith and the county of
Midlothian

John Macmillan

M.B., B.Sc.

ed.

The research which forms the subject of this Thesis was proposed to me by Dr. Hunter Stewart^{Ed} of the Public Health Laboratory and the investigations connected with it have been carried out in the ^{at} [Public Health] Laboratory under his superintendence.

The method of investigation and the apparatus used are those of Pettenkofer. Though somewhat cumbersome [and entailing considerable labour in its transport from place to place] yet as its results are more accurate than those of any other apparatus for the same purpose I deliberately chose it.

The portable apparatus consisted of a wooden box containing apparatus to be described and a thermometer.

Fig. I represents the box. It is $1\frac{3}{4}$ foot long, $1\frac{1}{2}$ foot broad and $1\frac{1}{6}$ foot deep, made of pine wood and having lock and key. The front

portion opens as seen in Fig II. The box contains twelve compartments. The uppermost holds a 100cc. pipette. Below are five small compartments holding four 150cc bottles and a funnel. Four large compartments contain four bottles holding, respectively, 4075, 4000, 4000, 4100 cc. At the left hand side is a compartment containing the bellows used for pumping the air to be examined into the bottles. On the right-hand side is a Baryta-water bottle of the usual form. Each compartment is carefully padded. So well has this been done that during the whole time the investigation has been carried on no breakage occurred. The

Thermometer

with stand is seen in Fig III. The two thermometers are fixed on an oak stand - the common form of a wet and dry bulb thermometer. The vessel for water is movable so that when the instrument is in use it is not beneath the wet bulb and consequently no evaporation from it affects that bulb. As the threads passing from the wet bulb to the water vessel may not conduct water sufficient to thoroughly moisten the linen covering the bulb the precaution was taken of dropping distilled water from a pipette on the wet bulb when the instrument was being used. One or more of

the 150cc bottles always contained distilled water. The covering slides over the stand as seen in the figure and is secured to the base by a padlock and hasp. In Fig. III the covering is on: it is seen off in Fig. IV. To give the whole instrument greater stability the base is weighted with lead. Attached to the top of the covering is a handle for carrying it.

The instrument was made by Fraser of Edinburgh and was rated at Kew. A Kew certificate was received with the instrument - one certificate for each thermometer.

[For the design of the stand I am indebted to Dr. Hunter Stewart and to Dr. Young of the Public Health Laboratory.]

Method of Work

Box and thermometer were carried to the place to be examined the day before the examination. The thermometer was left in the building whose air was to be examined so that next morning it quickly showed the temperature. On arrival the thermometer is taken from the case and placed where the sample of air is to be taken. This is usually at the centre of the building. When the air of the building has been pumped into one of the 4000cc bottles

baryta water added and the bottle shaken for some time the thermometer reading is taken. In five or ten minutes the thermometer is read off again. When two consecutive readings agree the temperature so shown is recorded as the temperature of that place. After the inside temperature had been recorded the outside temperature was taken. My visits were so timed that I had just sufficient time to take samples of air and inside temperatures before the men and women came to work in the mornings. I thus got the air and the temperature of a place which had been shut up for seven or eight hours. The samples of the air were taken and the temperatures observed at a level of between eighteen inches and two feet from the floor. The thermometer was placed at the same level outside.

The winter has been a very mild one. Often a mild, balmy West wind was blowing at 3 A.M. This had a great effect on the ventilation. Many ventilators were left open which in cold weather would have been shut and openings [which] admitted air were also left open which, in colder weather would have been stopped with straw. Had the winter been a severe one a much greater amount of Carbonic

The difference is $12^{\circ}.1$

The meaning of these results I shall enter more fully into under the subject of Warming

Humidity

An occupied room under ordinary circumstances contains more water vapour than the outside air.

This moisture is increased if the inmates of the room undergo exertion or if gas is burnt. The amount of water vapour given off from the body is fairly constant when the work done by man or animal is constant. Now in all cow-houses and stables the animals do no work requiring muscular exertion. The consequence of this is that though the Humidity in a given building is high it is not so high as one might expect from the number of animals kept there.

My results as regards Humidity are expressed in the following terms

- I. Absolute Humidity, that is, the amount of moisture in the air in terms of its pressure expressed in millimeters of mercury
 - (a) of the room or building
 - (b) of the outside air

7
II Excess over the outside air or excess of Absolute Humidity that is, the difference between (a) and (b).

III Relative Humidity that is the relation expressed as a percentage between the amount of moisture actually in the air and the amount that would be in the air if it were saturated with moisture.

IV Defect of Saturation: the amount of moisture which the air can still take up or the evaporating power of the air more plainly the drying power of the air expressed in millimeters of mercury

The highest absolute humidity noted is

16.35 mm. of mercury on 13th Jan'y 1894 at 3.15 a.m. in No. 45
Other three records are

14.70 mm. on 13th January 1894 at 3.45 a.m. in No 46

13.97 mm. on 11th November 1893 at 3 p.m. in No 21

13.97 mm. on 17th October 1893 at 5.6 p.m. in No. 2

The lowest recorded absolute humidity is

4.77 mm. of mercury on 23rd January 1894 at 4.15 a.m. in No. 50

Next 4.98 mm. " " " 13th February 1894 at 5.15 a.m. in No 62

The Relative Humidity ranges from 100% to 59%.

The Relative Humidity is

100% on May 22nd 1894 at 3.10 a.m. in No. 99

59% on 30th October 1893 at 4 p.m. in No 13

It must be noted that the drying power of air varies with its temperature thus the relative humidity gives a knowledge of the drying power of the air only when the temperature is stated.

Different authors give a different amount of moisture consistent with a healthy atmosphere.

Galton gives 75% as the high limit

De Chaumont gives 73% with a temperature of 63°F

The average defect of saturation in the 108 observed cases is 1.99mm. and the average temperature is 55.5°F This is a low drying power for the temperature but not so low as the state of the houses would lead one to expect.

Cubic Space and Floor Space

The appendix to "Rules and Regulations for Cattlehouses &c in Scotland, 1866" says "For every animal kept in a cattle shed, cowhouse or byre there shall be at least 800 cubic feet of space." When I found that this was so I thought I should be saved the labour of measuring the different cowhouses and

stables the air of which I had examined. Accordingly I applied to Authority A. In the district under authority A the cowhouses had been measured by the burgh surveyor and an inspector. The length breadth and height of each cowhouse along with the number of animals in it were duly recorded. Since that time, however, changes had taken place. New places had been built, some had been given up and most important the number of animals in a particular house had often changed. Thus one place set down as holding two animals with a consequent cubic space for each I found to contain six animals. This gave each animal a different number of cubic feet. What was a legal number of cubic feet for two animals could not possibly be sufficient for six. In short though I did not doubt the good faith and accuracy of the report yet so many changes had taken place since it was made that I felt compelled to measure not a few of the places I had examined.

Next as to the district under authority B. I saw the official whose duty it was to measure and to record the measurements of the various licensed cowhouses. He talked vaguely of having measured them in 1878 but had no written record whatever, did not know what the cubic content

of any one has, said that I might safely assume⁽¹⁾
 the space for each animal to be 800 cubic feet.
 I next applied to Authority C. This authority keeps a
 large beautifully bound book in which are recorded
 the names and addresses of all who have cowhouses under
 his jurisdiction. On the page opposite that on which
 the names are remarks are made as to the condition
 of the various places. But a record of measurement
 of length, breadth, height there is absolutely none.
 This authority confessed frankly that it believed few
 if any of its own places came up to the required
 standard nor did it think those of authority B
 did so. Next I enquired at another set of author-
 ities of B. These also knew nothing. I next applied
 to a solicitor who knew some of the authorities of
 B. He enquired at these. They did not know, they
 could find no record, they might some time in
 some way get the required measurements, in
 the mean time they were so extremely busy that
 they could give no help. In short I measured
 all the cowhouses of Authority B and of author-
 ity C. In one of the cowhouses of B, built three
 years ago up to the standard of 800 cubic feet for
 each animal I found the cubic space to be
 695 cubic feet for each. The owner who was present

(1) Some days afterwards when he knew that my friend had applied for official returns, I met him. He looked
 daggers at me. I had dared to doubt his august municipal word.

expressed astonishment at the result since only three years ago the official whose duty it is to give permission for the erection of any houses in B had passed the plans which showed 800 cubic feet for each animal. Each animal had 695 cubic feet. The following are the measurements of cubic space of the cowhouses examined by me licensed by authority B. ^{be kept like at 500 ft} and ^{the other three accounts might} 713, 419, 457, 453, 462, 774, 771, 623, 695, 444, 853.

I wish to mention that the number of animals varies. In all cases I have given the number of cubic feet per animal present. In many cases there are stalls for a greater number of animals than the number recorded. Thus the cubic space given is not the minimum.

Under authority C the cowhouses are generally good. [See under "General Observations"]. All the keepers of cowhouses with whom I have spoken agree in saying that 800 cubic feet is far too much. With such a space they cannot keep the cows warm in winter. Where there is an open space above the rafters to lessen the real cubic space of the house and so keep it warmer they cover the rafters with straw. In the Appendix to the Regulations already quoted article 12 says "In every case where a loft exists above the Byre there shall

be a clear space left above the heads of the cows, separated from the loft by a wooden or other partition, and communicating with ventilators either in the roof or outer wall. Straw shall not be placed on rafters or stages over the cows, and cobwebs must be carefully brushed away from the ceiling or inner surface of the roof as the case may be."

This loft is usually carefully stopped with straw. In the cowhouses examined the cubic space varies from 304 cubic feet to 942 cubic feet per animal.

Five cowhouses have less than half the legal space, viz 304, 378, 346, 324, 387.

Those above 800 cubic feet are 813, 853, 942, 825, 946, 815.

Cubic space is so closely connected with ventilation that it will be again referred to under that head. In stables much more room has been

given: the least stable gives 717 cubic feet to each horse and the greatest gives 1991: the mean cubic space is 1298 cubic feet. I have given the total floor space for each animal. Several times a passage not more than three feet wide separates the animals from the outer wall. The legal requirements are: "Every stall containing one animal shall have a width of not less than four feet, and a length of not less than eight feet; and every stall in which two animals are kept shall have a width of not less than seven feet, and a

length of not less than eight feet." This gives the animals little more than standing room.

Ventilation.

A question that meets us at the outset is how many cubic feet of air per hour should each animal receive? I quote from Parkes' *Practical Hygiene*, p. 187 "The amount (of air) for animals is an important question which has been little studied. Märcker gives the following from experiments:—

For large cattle (viz., oxen, &c) 30 to 40 cubic metres per hour for every 1000 lb weight, or 1 to 1½ cubic foot for every pound weight.

For small cattle (viz., sheep, &c) 40 to 50 cubic metres per hour for every 1000 lb weight, or 1½ to 1¾ cubic foot for every pound weight; the higher quantity being given on account of the more rapid tissue change in the smaller animals. These quantities seem absurdly small, and the chief reason for so limiting them seems to have been the fear of lowering the temperature too far. This is an erroneous view: animals properly fed will thrive better in a well-ventilated place at a low temperature than in a warmer place ill-ventilated. There seems no reason why the same rule should not apply to animals as to man, in which case something like 20 to 25 cubic feet per hour per lb.

of body-weight ought to be supplied. A horse or a cow ought, therefore, to have from 10,000 to 20,000 cubic feet per hour, - in short, it ought to be practically in the open air."

Should an animal receive less pure air in proportion to its size than a human being receives? Assuredly not. Should the house in which it is kept have as wholesome an atmosphere as a dwelling house? More so. For, the animal from the time it is put into the cowhouse till it come out is tied up constantly, never gets out to breathe the fresh air, is continually breathing an atmosphere contaminated beyond any admissible limit of contamination. Need it be said that it becomes unhealthy, sickly, feverish? Can such an animal yield wholesome milk? Even an animal with incipient tuberculosis in the place in which it is kept are found all the elements for the development of tuberculosis. When working in such places I could tell by the headache ensuing that the amount of carbonic acid would be large. In any place with more than 30 volumes of carbonic acid in 10,000 volumes of air the headache was certain and acute. How can animals breathe such an atmosphere for a year? They do not breathe it for a year. In No 17 on 4th November 1893 the carbonic acid was 46.2 volumes per 10,000: I found twelve animals. On re-visiting

the place on 9th January 1894 I found six animals.
 When I visited it on 20th June 1894 it was empty.
 The cowhouse is new and has been built with all modern improvements as to cubic space, lighting, ventilation. But at my examination I found the ventilators almost all shut and the atmosphere stifling. The animals hung their heads and had a drowsy, sickly, enfeebled look. Before making any observation I had always to get permission from the Keeper of the cowhouse. My visit was known and, in many cases, prepared for. Thus the records do not show the ventilation in its worst light. Visiting the place for something left I found the atmosphere far worse than on my first visit. No animal could have lived long in such an atmosphere. Yet there was sufficient means for ventilation if it had been used. The cubic space is given by the authorities as 800 ft. It is not enough to build places with a sufficient cubic space and sufficient means for ventilation, there must be some one who will make frequent visits of surprise to see that these appliances are properly used. Till this is done the law will remain a dead letter and the ventilation even worse than before. For, these places are supposed to be properly built and properly ventilated and no one looks after them. The result is an at-

mosphere containing 46.2 volumes of carbonic acid in
 10,000 volumes of air - quite enough to poison the
 strongest animals in a brief space of time. If
 such is the state of the ventilation in cowhouses
 built with all modern improvements how
 does it fare with those not built with any im-
 provements at all? Far better. Such places
 are Nos 7 and 8. These are built of wood. There are
 no ventilators visible and open if indeed they
 exist, yet the ventilation is fairly good. The
 wooden boards have shrunk so that between ev-
 ery two boards there are small spaces left which
 act as ventilators. When a strong West wind is
 blowing the draught through the chinks is suff-
 cient to blow out a candle held close to them.
 And though in winter all places which act as ven-
 tilators which can be stopped with straw are so
 stopped yet the gaping boards act as fairly eff-
 cient ventilators. The owner complains of the
 coldness of the place in winter and thinks the
 cubic space too much. Among several other
 places of similar construction are Nos 18 and 19.
 These well illustrate the kind of erections which
 have been utilised as a cowhouse. A disused
 shed, any ramshackle (I use the word advisedly)
 shed is patched up and used as a byre. Before
 any regulations existed as to the kind of building

to be used as a cowhouse such shanties were so used and were continued provided each animal had sufficient space. This was easily managed. The place was licensed, say, for two animals and afterwards six were kept in it.

Carbonic Acid in volumes per 10,000.

The lowest recorded amount of CO_2 is 11.8 vols per 10,000. This occurred in one of the modern shanties just described. Outside temperature was 49°F , inside 54°F . The date, February 2nd 1894 at 4.30 a.m. 49°F . is a high outside temperature for the 2nd of February at 4.30 a.m. In frosty weather every available opening would have been stopped with straw and ventilation would have been accomplished by the gaping boards.

The highest recorded amount of CO_2 in a cowhouse is 46.2 vols per 10,000. It has already been noticed.

The average amount of carbonic acid in cowhouses is 22.8 volumes per 10,000 volumes of air.

The places examined may be divided into groups according to the observed amounts of carbonic acid.

Those having 15 volumes or less, those having between 15 and 20 volumes, between 20 and 25 volumes, between 25 and 30 volumes, between 30 and 35 volumes, between 35 and 40 volumes, above 40 volumes. Twenty cowhouses and stables have 15 volume, and under, the mean amount is taken and recorded. And so for the others.

Mean of 20 cases - the amount of carbonic acid being less than 15 in 10,000

CO_2	Temperature	Relative Humidity	Defect of Sat.	Temperature of outside air
13.6	51°.4 F.	80.2%	1.97 mm. merc.	43°.5 F.

Mean of 29 cases - the carbonic acid being less than 15 + 20 ^{between} in 10,000

CO_2	Temperature	Rel. Humidity	Defect of Sat.	Temperature of outside air
17.5	53°.9	78%	2.01	44°.0

Mean of 24 cases - the carbonic acid between 20 and 25 in 10,000

CO_2	Temperature	Rel. Humidity	Defect of Sat.	Temperature of outside air
22.5	56°.8	83.9%	1.90	42°.7

Mean of 18 cases - the carbonic acid between 25 + 30 in 10,000

CO_2	Temperature	Rel. Humidity	Defect of Sat.	Temperature of outside air
25.3	54°	77.1%	2.00	40°.1

Mean of 11 cases - the carbonic acid between 30 + 35 per 10,000

CO_2	Temperature	Rel. Humidity	Defect of Sat.	Temperature of outside air
32.1	58°	80%	2.06	43°

Mean of 3 cases - the carbonic acid between 35 and 40 in 10,000

CO_2	Temperature	Rel. Humidity	Defect of Sat.	Temperature of outside air
35.6	60°.9	69.3%	1.94	44°.4

Mean of 3 cases - the carbonic acid over 40 in 10,000

CO_2	Temperature	Rel. Humidity	Defect of Sat.	Temp outside air
42.9	57°.6	71.3	1.55	39°.2

From this table we note that, in the whole, the amount of carbonic acid and the inside temperature increase side by side. Since no artificial warmth is supplied the atmosphere is warmed by exposed air and consequently the warmer it is the more poisonous it is. A strong plea for the supply of artificial warmth.

It is not alone the construction of wooden cowhouses that gives them a comparatively low amount of carbonic acid there is another reason for it. The owners or occupants of recent buildings, confident in the efficiency of their 800 cubic feet of space and their means of ventilation took no pains to prepare for a visit while those whose cowhouses were of the inferior kind already mentioned took pains to have their places as well ventilated as possible when they were being examined. Thus the amount of carbonic acid shown by these latter may be looked on as the lowest possible. If, instead of getting permission to examine, as a favour from each occupier I had obtained official permission all would have been on the alert and the results would not have been so trustworthy as they are. I will give a short description of two places examined to shew what has been done in making cowhouses nearly if not altogether what they should be. Nos 99 and 100 [see Plan I] finished a

few months ago^o are under one roof. The cowhouse can hold 81 cows, 40 in one part, 41 in the other. Length $7\frac{1}{4}$ feet, breadth $26\frac{1}{3}$ feet, height of one part to eaves $11\frac{1}{4}$ feet, height of other part to eaves $10\frac{2}{3}$ feet, height above eaves to ridge-plate 18 feet. Cubic feet per animal in one part $97\frac{1}{4}$ cubic feet, in other part 958 cubic feet. Floor space 47 and 48 square feet respectively. On the plan are shown a.a., - roof lights; b, b., - roof ventilators. In this building there is sufficient air, light, means of cleaning. The house is kept clean. The food is prepared in a covered building "Feeding Shed" in the plan. A large shed for straw enters from the cowhouse. This is open to objection unless the door is open only when the animals are being fed. There is a well-made manure pit. The place is in the country more than 300 feet above sea-level, high, dry, airy, well drained naturally. An excellent place. All it requires to make it complete is an apparatus for artificial warming. As there is a constant supply of hot (boiling) water in the feeding shed hot water pipes could be laid round the inside of the building at a moderate cost.

No 92 is an admirable place. The cowhouse is flanked on each side by empty rooms as large as itself. These rooms communicate with the cowhouse. The carbonic acid is small in

amount, the place has every facility for being kept clean and is so kept. Situated on a rising ground it is well drained, dry and wholesome. It is not surrounded by other buildings. It is admirably managed and if it were supplied with hot-water pipes or any heating apparatus it would be practically faultless.

I need scarcely observe that cubic space does not give pure air. It is the removal of the air sufficiently often which keeps an atmosphere wholesome. In Plan II is seen a sketch of a cowhouse which is, I think, an improvement on those existing. Observe first that there is a passage 5 feet wide between the head of the stalls and the outside wall. This is a decided advantage, where two animals are tied up with their heads touching the wall as is almost always the case the expired air is breathed over again when a passage exists at the head as is shown in the plan the expired air is carried to some distance from the animal's head, and, rising in the five-foot passage is carried off.

Next notice a passage in the middle of the building for the same purpose. No passage exists, for this purpose, in Plan I and the animals

standing head to head are too near. The plan shows a five-foot passage at each wall. Moreover along by the side of each wall and along the middle passage I have placed hot-water pipes (indicated by the blue line). This I consider indispensable. No ^{unit} possible proper ventilation is possible without these. Contraband must have their cows harmed, they have no apparatus for supplying artificial heat and therefore their only plan of obtaining heat is by shutting the ventilators and stopping up all other means of letting in air. The consequence is an atmosphere absolutely poisonous, weakly, sickly animals and milk of a kind to be expected from such animals.

The cost of such improvements is not great. The five foot passages mean, each, five feet more wall - no serious expense, the hot-water pipes mean the outlay of several pounds sterling. But what is that where the health of the community is concerned? What the decrease of infant mortality would be if good sound wholesome milk were given from every I am unable to say. It would certainly shew a marked decline and that great scourge Phthisis which forms nearly one-seventh ~~seventh~~ of the yearly mortality of Europe would be lessened to a most gratifying extent.

The stables I examined were all well constructed, about half of them well-ventilated. Some of them had the door removed permanently and ventilation going on constantly through the doorway and by means of other ventilators. The results in some cases would have been much better if the ventilators in existence had been used. The highest amount of carbonic acid observed in the stables was 41 volumes in 10,000 and the lowest 11.8 in 10,000. This is the amount observed in the middle of the stable, at the end of it the amount was 14.8 in 10,000.

The average amount observed was 21.2 vols. in 10,000. The average cubic space of each stable is 1298 we have therefore to conclude that the means of ventilation in the stables examined is inferior to that of the cowhouses examined. In many cases the means of ventilation in stables is practically nil. The stable which gave 41 vols in 10,000 was examined at 5.15 a.m. on the 3rd March, 1894. Outside temperature $37^{\circ} 2$, inside temperature 55° . The hygiene of this and other stables in the same place is under the control of an officer who does not look on modern methods, ^{in Public Health} with favour.

Intimately connected with Ventilation is
Warming

I have already spoken of this subject but will do so here in more detail. Every cowkeeper is anxious to have the temperature in his cowhouse as high as possible, often I was asked "Were my temperatures all right last night?" A few who could read the thermometers were anxious to do so that they might know how they stood. The idea that an atmosphere charged with carbonic acid gas and a corresponding amount of excreted organic matter is deleterious had never entered their minds, I did not find one who had even heard of carbonic acid. A gentleman educated at Bonn always spoke of it as Carbolic Acid. Experience has shown cowkeepers that with a warmer atmosphere the cows yield more milk, therefore they use every means to keep the animals warm. As no artificial heat is ever used the only way that this can be done is by closing the ventilators and stopping every hole possible with straw. Artificial heat would help much to purify the atmosphere and it ought to be adopted for the following reasons

First: It is cheap. Nearly every cowhouse has a boiler on the outside the fire of which is kept burning all night that there may be hot water for the animals' food in the morning. The judicious outlay of a few pounds sterling would

lay a row of 4-inch iron pipes round the inside of each house. The outside air could be made to flow over these pipes before entering the cowhouse and thus a supply of pure warm air would be obtained.

Second: It is efficient. The fresh air entering ^{warm} would leave no excuse for stopping all ventilators, hence the house would be filled by the pure, warm, inflowing air.

In Photograph No 7 is seen a large steam boiler. The three cowhouses there might be kept perfectly ventilated if hot-water pipes were laid in each house and the ventilators kept open.

Photographs

Several of the cowhouses I examined have been photographed. These photographs will aid the verbal description. The Photographs are numbered on the back.

No 1 shows a view from the public road of two cowhouses. The one in front with three ventilators contains six animals, the upper story - in such a small place there should be no upper story - is a pigeon house. The cubic space for each animal is 378 cubic feet, official measurement. Carbonic acid 18.2: 10,000. The one to the left with the ventilator open contains 1 horse, 9 cows; carbonic acid

18.2. Both places gave some result. The amount given by a surprise visit not known. This is a fair example of a cowhouse made of any material that came to hand. It will be observed that the half of the green has been used in the construction of the cowhouse.

No 2 is the yard of No 1. The yard is very small, no flushing apparatus visible. The grass shed has in it several goats and many hens. Cows' grass is covered with hens which are sitting on it [The net shown: photo - shed shown]. Place wonderfully clean.

No 3 shows a cowhouse on the second storey. It is constructed with all modern improvements and gave 46.2 vols of carbonic acid in 10,000 - the highest recorded. It contained at first 12 cows now contains none. It has already been referred to.

No 4. Good. Observe the cottage-roof giving a covered space in front of the cowhouse. Water is abundant and used. The yard is clean, drainage is excellent. The place has a sweet wholesome smell. The owner puts on a clean white dress when he goes to milk. Altogether we have here as good a cowhouse as we may expect to have in a town.

No 5 is the same building shewing the asphalt-pavement. It is clean as are the animals in =

side the building. It is built with modern improvements and these are not merely so in name.

No 6. There are three cowhouses containing, respectively 32, 31, 47 cows. Cubic space 776, 813, 659. Carbonic Acid 13, 14.3, 17 volume, 10,000. In the house containing the 47 cows many of the animals have one stall each - the only place I have observed this arrangement. Moreover in live houses there is a five-foot space between the head of the stall and the outer wall.

No 7 is taken from the yard of No 6. In front is a steam boiler. To the left is a large airy shed. The cowhouses are entered from this shed and their doors may be left open in cold weather and good ventilation obtained without draughts.

No 8. The foreman and three of the dairymaids of No 6. They live in cottages near, are well fed, strong, healthy, happy and clean. Milking was not going on at the time the photo was taken. When I examined the place the weather was comparatively warm and I asked the owner if he would kindly shut up the houses for one night that I might compare the state of the houses with and without ventilation. He promised to do so. I found, however, that the ventilators of one of the three places - that on the right in Photo No 6 -

had been left open. The other ventilators were nearly all shut.

With the ventilators open the results are given in Nos 101, 102, 103:

With the ventilators shut (two shut) the results are given in Nos 104, 105, 106.

It is to be noted that, with the ventilators open No 2 has 14.3 volumes of carbonic acid per 10,000, with ventilators shut 27.6 volumes.

In conclusion I am most anxious to state some

General Considerations

concerning the subject of this research.

The subject of my investigation has, primarily, the state of the atmosphere of cowhouses and stables and that investigation has brought out at least one point of vital importance and has confirmed to some extent what has known of other points. And first as to the point of vital importance.

Infection.

It is allowed by all that milk may be the means of carrying infection - the germs of disease. The question is, how? Usually by children who deliver the milk from house to house. These children come from homes - often crowded - bring the germs of infectious disease

with them and that infection is conveyed by means of milk they carry. Precautions are taken to prevent infection being so carried and these precautions are good. But there is another and not less certain means by which infection is conveyed by milk and nothing so far as I know has been done to prevent it; viz. by the women who come to milk the cows at various hours in the morning and during the day. At hours from 3 a.m. till 5.30 a.m. women come from their homes to do this work. It is obvious that only those impelled by necessity get up so early to perform work far from agreeable. One has simply to see these women who come at 3 a.m. to understand that they are poor, poorly clad, their faces and hands un-rashed and their clothing dirty. In such a state they begin milking at once. Not any overgarment put on. Any germs of disease about their persons cannot fail to get into the milk and so be carried through the town. Now, as they live in the most crowded localities - the localities where disease is most prevalent - any infectious disease existing in these localities is carried with almost certainty by these women to the milk. Yet the authorities take no precautions to prevent this certain means of propagating infectious disease. Let any one not convinced of the truth

of what is here said go at 3 a.m. or from 3 a.m. till 5.30
 a.m. to a cowhouse containing from 40-60 cows, observe
 the women who come to milk the cows and he will
 see that they answer the description just given.
 Let the women who come at this early hour be fed,
 be made to wash themselves & be provided with a clean
 milking dress which shall completely envelop
 them. Let their houses be inspected daily by the
 medical officer of health and let the very first threat-
 ening of infectious disease be notified and pre-
 cautions taken to prevent its spread. Till this
 is done all other means at present in use to
 prevent infection being conveyed by milk are futile.
 Again, it is scarcely necessary to repeat that tuberculo-
 sis may be conveyed to children and weak persons
 by milk containing tubercle bacilli. Professor
 Macfadyen has demonstrated that in cases of tu-
 berculosis, bacilli may be found lying free in what
 are otherwise apparently healthy ducts. Woodhead
 and Macfadyen examined the milk of 600 cows
 and found tubercle bacilli in the milk of 20. The
 inspector of a slaughter house in one of the districts
 in which my investigations were carried on told
 me that of the cows sent from the cowhouses to be
 slaughtered two carcasses out of a hundred are
 condemned as being tubercular. When a carcass is
 condemned tuberculosis has affected practically

all the carcass but there are, nevertheless many carcasses which are tuberculous and which, after being "stripped" are allowed to be sold as food, and the milk of these tubercular animals contain tubercle bacilli. It is highly probable that it did. The question may be properly asked what connection has the atmosphere of cowhouses with the tubercle bacillus and its spread? The animals which experience has shown to be the best milkers are highly bred animals. Such animals are known to be more or less tubercular. Such animals are placed in a badly-ventilated unwholesome cowhouse and are there fed in such a manner as to excite the greatest milk secretion. Moreover, they get no exercise whatever. Seldom even in summer are they put out to the open fields. Experience has shown that they yield most milk when kept indoors. In short, they are placed in a situation highly favourable for the development of tubercle. Can such a state of things be remedied? Not readily. For, the health officers must be convinced that these things are so and they must convince the Local Authorities who must enact stringent regulations for prevention. And the public must be convinced of their danger before they will move in the matter. In short, all concerned must be so educated that they can

realise the danger they are in. When it is considered that one-seventh of the total deaths in Europe is due to Phthisis, surely a sufficient clinician, is thereby given to use every means to lessen the virulence of this scourge of mankind. In as far as propagation by milk is concerned the various forms of disease are preventible.

Let them be prevented.

Can anything be done in addition to looking after the milk supply? Much can be done.

The hovels in which a few cows are kept should be abolished, all cowhouses should be removed from the heart of towns and placed on the outskirts or, better still, several miles into the country where they are no longer surrounded by densely populated areas, where dry, well drained soil can be obtained for a site.

Have the general public to see the places from which their milk comes, the persons who milk the cows, the condition of the cows and the places they are kept in. They would not seldom absolutely refuse to use the milk coming from such places. One such place shall be described. The owner chews tobacco, spits tobacco juice among the cows' food and then carries it in to them. Inside the cowhouse is filthy. On such rafters as are not ^{covered} occupied with

straw hens are roosting. It is exceedingly difficult to move anywhere to read the thermometer, pump air into a bottle or shake it without being soiled by the droppings of the hens above. The floor is covered in most places with these droppings. The pans containing milk cannot possibly escape. The animals - the cows themselves, are filthy as is the dress of the women who milk them. Sometimes their arms are caked with dirt. Outside the yard, badly paved with coarse blocks, is always wet. Two ducks struggle for a livelihood in the wettest corner! The road leading to this place is in wet weather almost impassable on account of mud and water. From its low situation all liquids gravitate to it. Tall buildings keep the sun from it. All such places should be abolished, new cowhouses made in the country and the cows transferred to them.

Could educated public opinion - and there is such a thing - be brought to bear on such a state of things I am confident it would soon cease to exist.

For encouragement in the prosecution of this laborious

(1) In this place the owner of which has most courteous I was allowed to put my box on a bench in the shed reserved for the milk pans. Pushing it towards the head of the bench a black object against which I pushed it emitted a feeble "cock!"

I enquired what it was. "Oh! that's the codd cock. He gaed STACHERIN about a mi' milk till he gaed aff's legs and then he put him there."

research. I have to thank the Head of the Public Health Laboratory

Sir Douglas MacLagan.

I do not forget, too, the kindness of Dr. Allan Gray of Leith who got me permission from a few owners of courthouses to begin my examination. There is their kin, introduced me to others. I was thus enabled to visit the number of places recorded.

John Macmillan

Site. Photos in the slip made for them: also sketches of Cox and plans.

Examination of Cowhouses Nos 1-11

Number of Cowhouse	Number of Animals	Cubic Feet per Animal	Floor Space in square feet per Animal	CO ₂ in volumes per 10,000	Humidity				Temperatures				Dew Points		Hour and Date
					Absolute Humidity in mm. of Mercury	Relative Humidity	Excess over outside air in mm. of Mercury	Defect of Saturation in mm. of Mercury	Inside Dry Bull.	Inside Wet Bull.	Outside Dry Bull.	Outside Wet Bull.	Inside	Outside	
1	6	772	58	19.7	13.62	75%	5.33	2.83	66.4	61.4	54.8	51°	57°3	47°3	5.30 p.m. 17.X.93
2	14	553	46	35.3	13.97	75%	5.68	2.69	66.8	64	54.8	51°	57°3	47°3	6 p.m. 17.X.93
3	6 cows 1 horse	825	75	22.6	11.31	75%	3.02	2.31	61°	58.2	54.8	51°	55°7	47°4	5 p.m. 17.X.93
4	6 cows 1 horse	776	55	30.7	12.95	75%	4.66	2.70	65°	62°	54.8	51°	59°4	47°3	4.30 p.m. 17.X.93
5	8 cows 2 horses	422	38	25.4	13.71	86%	4.24	1.94	65°	64°	55°	53°	63°	51°	6.30 p.m. 19.X.93
6	17	553	46	24.3	13.02	86%	4.15	1.55	64.2	61°	55°	53°	62°	51°	7.30 p.m. 19.X.93
7	8	543	54	18.9	10.88	78%	2.75	3.63	62.8	59°	53.2	50°	54°7	46°8	5.45 p.m. 23.X.93
8	9	544	54	17.4	13.2	78%	5.07	1.87	63.8	61.8	53.2	50°	60°	46°8	7.15 p.m. 23.X.93
9	10	492	63	18.6	11.02	85%	4.07	0.88	57°	56°	47°	45°	55°	42°7	3.40 p.m. 26.X.93
10	10	492	63	14.2	10.26	85%	3.31	1.73	57.4	55.2	47°	45°	53°2	42°7	4.5 p.m. 26.X.93
11	10	304	35	15.1	9.75	85%	2.80	0.85	54°	52.8	47°	45°	51°6	42°7	4.30 p.m. 26.X.93

Examination of Cowhouses No 12-22

Number of Cowhouse	Number of Animals	Cubic Feet per Animal	Floor Space in square feet per Animal	CO ₂ in volumes per 10,000	Humidity				Temperatures				Dew Points		Hour and Date
					Absolute in mm of Mercury Humidity	Relative Humidity	Excess over Outside Air in mm of Mercury	Defect of Saturation in mm of Mercury	Inside		Outside		Inside	Outside	
									Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb			
12	2 cows 1 horse	468	48	24	8.5	85%	1.55	2.1	54°	51.2	47°	45°	48°	42.7	5.30 p.m. 26.X.93
13	6	941	99	25.7	10.26	59%	4.2	3.64	57°	55°	48.4	44°	53°	39°	4 p.m. 30.X.93
14	12	539	49	32.4	11.31	77%	7.15	1.80	60°	57.8	41°	36°	58.6	29.7	2.30 p.m. 31.X.93
15	12	514	49	22.4	11.16	77%	5.47	2.46	61°	58°	41°	36°	55.4	29.7	3 p.m. 31.X.93
16	11	800	63	15.1	8.40	64%	4.24	1.86	54.2	49°	40.8	35.4	47.8	29.6	3 p.m. 4.X.93
17	12	800	60	46.2	10.73	64%	6.73	1.41	57.8	56°	40.8	35.4	54.4	29.6	3.45 p.m. 4.XI.93
18	9 cows 1 horse	667	55	18.2	6.95	64%	2.49	1.86	49.4	46°	42°	38.2	42.7	32.7	2.15 p.m. 7.XI.93
19	6	378	47	18.2	4.67	64%	2.47	2.35	50.2	46°	42°	38.2	41.5	32.7	2.45 p.m. 7.XI.93
20	12	800	44	24	13.37	90.9%	5.88	1.89	64.2	62.2	47.2	46°	60.7	44.6	3 p.m. 11.XI.93
21	12	800	44	23.8	13.97	90.9%	6.48	1.68	65°	63.2	47.2	46°	61.7	44.6	4 p.m. 11.XI.93
22	15	462	57	19.5	9.67	83%	3.66	2.01	56.5	54°	43.5	41.4	51.5	38.9	2.45 p.m. 14.XI.93

Examination of Cowhouses Nos 23-33

Number of Cowhouse	Number of Animals	Cubic Feet per Animal	Floor Space in square feet per Animal	CO ₂ in volumes per 10,000	Humidity				Temperatures				Dew Points		Hour and Date
					Absolute Humidity in mm. of Mercury	Relative Humidity	Excess over Outside Air in mm. of Mercury	Defect of Saturation in mm. of Mercury	Inside Dry Bulb	Inside Wet Bulb	Outside Dry Bulb	Outside Wet Bulb	Inside	Outside	
23	10	538	50	32.2	9.99	83%	3.36	1.47	56.2	54.2	43.5	41.4	52.3	38.9	3 p.m. 14.XI.93
24	18 cows 1 horse	409	51	31.3	12.38	86.9%	5.98	1.56	62.2	60.2	47.2	44°	58.3	40.4	7.30 p.m. 16.XI.93
25	21	497	47	22.5	6.76	78.9%	1.28	1.88	48.2	45.2	37.5	33°	41.9	31.5	2 p.m. 18.XI.93
26	18	346	43	20.9	5.77	78.9%	1.28	1.88	45.2	41.8	37.5	33	37.8	31.5	2.30 p.m. 18.XI.93
27	16 cows 1 horse	630	52	22.4	9.79	78%	4.92	1.23	55°	53.4	39.8	37°	51.8	33.4	2.30 p.m. 21.XI.93
28	6	648	72	15.5	8.57	78%	3.7	0.91	46°	44.5	39.8	37°	42.8	33.4	3.30 p.m. 21.XI.93
29	20	478	42	35.2	9.92	65%	6.05	1.91	57°	54.5	38.4	34°	52.2	28°	2 p.m. 23.X.93
30	12	387	39	13	9.23	86%	1.05	2.15	56°	53°	51°	49°	50.2	46.9	3.30 p.m. 25.XI.93
31	9	324	39	21.8	11.16	86%	2.98	2.46	61°	58°	51°	49°	55.4	46.9	4.30 p.m. 25.XI.93
32 ₌₁	6	772	58	19.4	10.46	77%	3.88	2.00	58.6	56°	48°	45.2	53.6	41.3	3.45 a.m. 4.XII.93
33 ₌₂	14	553	46	16.4	10.32	77%	3.74	2.38	59°	56°	48°	45.2	53.3	41.3	4.35 a.m. 4.XII.93

Examination of Cowhouses Nos 34-44

Number of Cowhouse	Number of Animals	Cubic Feet per Animal	Floor Space in square feet per Animal	CO ₂ in volumes per 10,000	Humidity				Temperatures				New Points		Hour and Date
					Absolute Humidity in mm. of Mercury	Relative Humidity	Excess over outside air in mm. of Mercury	Defect of Saturation in mm. of Mercury	Inside Dry Bulb	Inside Wet Bulb	Outside Dry Bulb	Outside Wet Bulb	Inside	Outside	
34-3	6 cows 1 horse	776	75	18	8.02	83%	2.9	1.9	51.2	48.8	39.5	37.2	46.3	34.8	4.30 a.m. 9.XII.93
35-4	6 cows 1 horse	825	55	14.7	7.39	83%	2.27	0.96	47.5	44	39.5	37.2	44.3	34.8	3.45 a.m. 9.XII.93
36-6	17	553	46	17.2	5.53	59.8%	1.31	1.52	42.8	40	35.2	33.2	36.7	30	4 a.m. 14.XII.93
37-7	7	543	54	14	10.12	85%	1.01	2.10	58	55.2	54.2	51	52.7	47.9	4.10 a.m. 16.XII.93
38-8	8	544	54	15.5	10.12	85%	1.01	2.10	58	55	54.2	51	52.7	47.9	4.50 a.m. 16.XII.93
39-14	13	539	49	41.5	12.22	68%	7.93	0.98	60.2	59	40	37.2	57.9	33.6	2.45 a.m. 19.XII.93
40-15	13	514	49	36.5	11.46	68%	7.17	1.24	59	57.5	40	37.2	56.2	33.6	3.45 a.m. 19.XII.93
41-18	9 cows 1 horse	667	55	17	7.70	78%	2.4	1.77	51	48.2	42	39.2	45.3	35.7	4.30 a.m. 22.XII.93
42-19	6	378	47	14	7.70	78%	2.4	1.77	51	47	42	39.2	45.3	35.7	5.30 a.m. 22.XII.93
43-17	6	800	63	26.6	6.86	83%	2.37	0.74	45	43.8	36	34.2	42.4	31.5	5 a.m. 9.I.94
44-16	11 cows 2 goats	800	60	24.3	7.00	83%	2.51	1.81	49	46	36	34.2	42.7	31.5	4.30 a.m. 9.I.94

Examination of Cowhouses Nos 45-55

Number of Cowhouse	Number of Animals	Cubic Feet per Animal	Floor Space in square feet per Animal	CO ₂ in volumes per 10,000	Humidity				Temperatures				Dew Points		Hour and Date
					Absolute Humidity in mm. of Mercury	Relative Humidity in mm. of Mercury	Excess over outside air in mm. of Mercury	Defect of Saturation in mm. of Mercury	Inside Dry Bulb	Inside Wet Bulb	Outside Dry Bulb	Outside Wet Bulb	Inside	Outside	
45 ₌₂₀	12	800	44	32.6	16.35	83%	9.25	1.15	68.2	66.8	49°	46.2	66.3	43.2	3.15 a.m. 13.I.94
46 ₌₂₁	12	800	44	30.7	14.70	83%	7.60	0.95	65°	64°	49°	46.2	63.18	43.2	3.45 a.m. 13.I.94
47 ₌₂₂	10	462	57	16.5	7.75	76%	1.94	1.79	52.4	49°	45°	41.8	45.6	38	4.30 a.m. 20.I.94
48 ₌₂₃	15	538	50	24.8	11.09	76%	5.28	1.61	59°	57°	45°	41.8	55.2	38°	5 a.m. 20.I.94
49	11	629	62	20	6.90	61%	4.18	1.34	47.2	45°	31°	28°	42.5	19.9	4.30 a.m. 23.I.94
50	10	942	74	16.5	4.77	61%	2.05	1.08	38.2	36°	31°	28°	33°	19.9	4.50 a.m. 23.I.94
51 ₌₂₄	18	409	51	30	8.46	84%	3.90	1.40	52°	50°	36°	34.5	47.9	32.2	3.40 a.m. 26.I.94
52 _{=25,26}	39	497	47	26	8.18	84%	3.62	1.29	51°	49°	36°	34.5	46.9	32.2	4.15 a.m. 26.I.94
53 ₌₂₉	19	478	42	21	9.47	84%	4.20	0.72	53°	52°	40°	38°	51°	35.4	3.30 a.m. 30.I.94
54 ₌₂₇	16 cows 1 horse }	630	52	26	8.63	84%	4.67	1.82	53.5	51°	40°	38°	48.5	35.4	3.50 a.m. 30.I.94
55 ₌₃₁	9	324	39	11.8	8.52	75%	1.85	2.08	54°	51°	49°	45.5	48°	41.7	4.30 a.m. 2.II.94

Examination of Cowhouse 56 and Stables 57-66

Number of Cowhouse or Stable	Number of Animals	Cubic Feet per Animal	Floor Space in square feet per Animal	CO ₂ in volumes per 10,000	Humidity				Temperature				Dew Points		Hour and Date
					Absolute Humidity in mm. of Mercury	Relative Humidity	Excess over outside air in mm. of Mercury	Defect of Saturation in mm. of Mercury	Inside Dry Bulb	Inside Wet Bulb	Outside Dry Bulb	Outside Wet Bulb	Inside	Outside	
56-30	12	387	39	14.3	8.18	75%	1.51	2.01	53°	50°	49°	45.5°	47.7°	45.7°	5 a.m. 2.II.94
57	29 horses	1991	93	18.2	7.19	78%	1.26	1.62	49°	46.4°	45°	42°	43.6°	38.5°	4 a.m. 9.II.94
58	30	1892	88	15.4	6.81	78%	0.88	1.65	48°	45.2°	45°	42°	42°	38.5°	4.30 a.m. 9.II.94
59	33	1803	84	14.3	6.76	78%	0.83	1.48	47.2°	45°	45°	42°	42°	38.5°	5 a.m. 9.II.94
60 = 57 at middle	29	1991	93	11.8	5.16	83%	1.66	1.74	40.4°	38°	34°	31°	34.9°	25.7°	4.15 a.m. 13.II.94
61 = 57 inner end	29	1991	93	14.8	6.06	83%	2.56	0.30	42.5°	41°	34°	31°	39.16°	25.7°	4.35 a.m. 13.II.94
62 = 58 inner end	30	1892	88	14.2	4.98	70%	1.48	1.33	42.5°	41°	34°	31°	39.16°	25.7°	5.15 a.m. 13.II.94
63 = 58 middle	30	1892	88	13	6.06	70%	2.56	0.84	40.2°	38°	34°	31°	39.16°	25.7°	5.30 a.m. 13.II.94
64	48	1278	83	15.7	6.72	91%	4.62	1.37	57°	55.2°	41°	40°	43.8°	38.7°	4.15 a.m. 16.II.94
65 end	31	824	86	25	10.39	91%	4.62	1.37	57°	55.2°	41°	40°	53.5°	38.7°	4.30 a.m. 16.II.94
66 = 65 at middle	31	824	86	21.9	9.11	91%	3.93	1.56	54.2°	52°	41°	40°	49.8°	38.7°	5.30 a.m. 16.II.94

Examination of Stables Nos 67-77

Number of Stable	Number of Animals	Cubic Feet per Animal	Floor Space in square feet per Animal	CO ₂ in volumes per 10,000	Humidity				Temperatures				Dew Points		Hour and Date
					Absolute Humidity in mm. of Mercury	Relative Humidity	Excess over outside air in mm. of Mercury	Deficit of Saturation in mm. of Mercury	Inside Dry Bulb.	Inside Wet Bulb.	Outside Dry Bulb.	Outside Wet Bulb.	Inside	Outside	
67	22	1755	104	25.9	9.23	81.7%	4	1.86	55.3	53.2	40.5	38.2	50°	35°	4 a.m. 21. II. 94
68	20	1931	114	23.4	9.67	81.7%	4.44	1.28	55°	53.2	40.5	38.2	51.4	35°	4.20 a.m. 21. II. 94
69	18	1116	84	17.8	8.35	84%	2.66	1.91	53.2	50.4	42°	40°	47.6	37.5	4.15 a.m. 23. II. 94
70	18	1405	91	20	8.93	84%	3.24	2.45	56°	52.5	42°	40°	49.2	37.5	5 a.m. 23. II. 94
71	15	1816	129	20.7	9.35	76%	3.97	2.03	56°	53.2	43°	39.8	50.5	35.9	4.15 a.m. 27. II. 94
72	15	1718	128	20.3	7.75	76%	2.37	2.51	53.2	49.4	43°	39.8	45.6	35.9	4.35 a.m. 27. II. 94
73	16	717	69	14.5	8.35	83%	2.66	2.37	55°	51.2	42°	40°	47.5	37.5	4.50 a.m. 6. III. 94
74	14	717	69	14	7.75	83%	2.06	2.51	53°	49.2	42°	40°	45.4	37.5	5.30 a.m. 6. III. 94
75	16	717	69	29.5	10.32	70%	5.90	2.38	59°	56°	40°	38°	53°	33°	5 a.m. 9. III. 94
76	14	717	69	32.2	9.99	70%	5.51	2.31	58°	55°	40°	38°	52°	33°	5.40 a.m. 9. III. 94
77	16	717	69	41	8.75	82%	4.12	2.27	55°	52.5	37°	35°	48.7	32.3	15 5.45 a.m. 13. III. 94

Examination of Stables Nos 78-80, Cowhouses Nos 81-88.

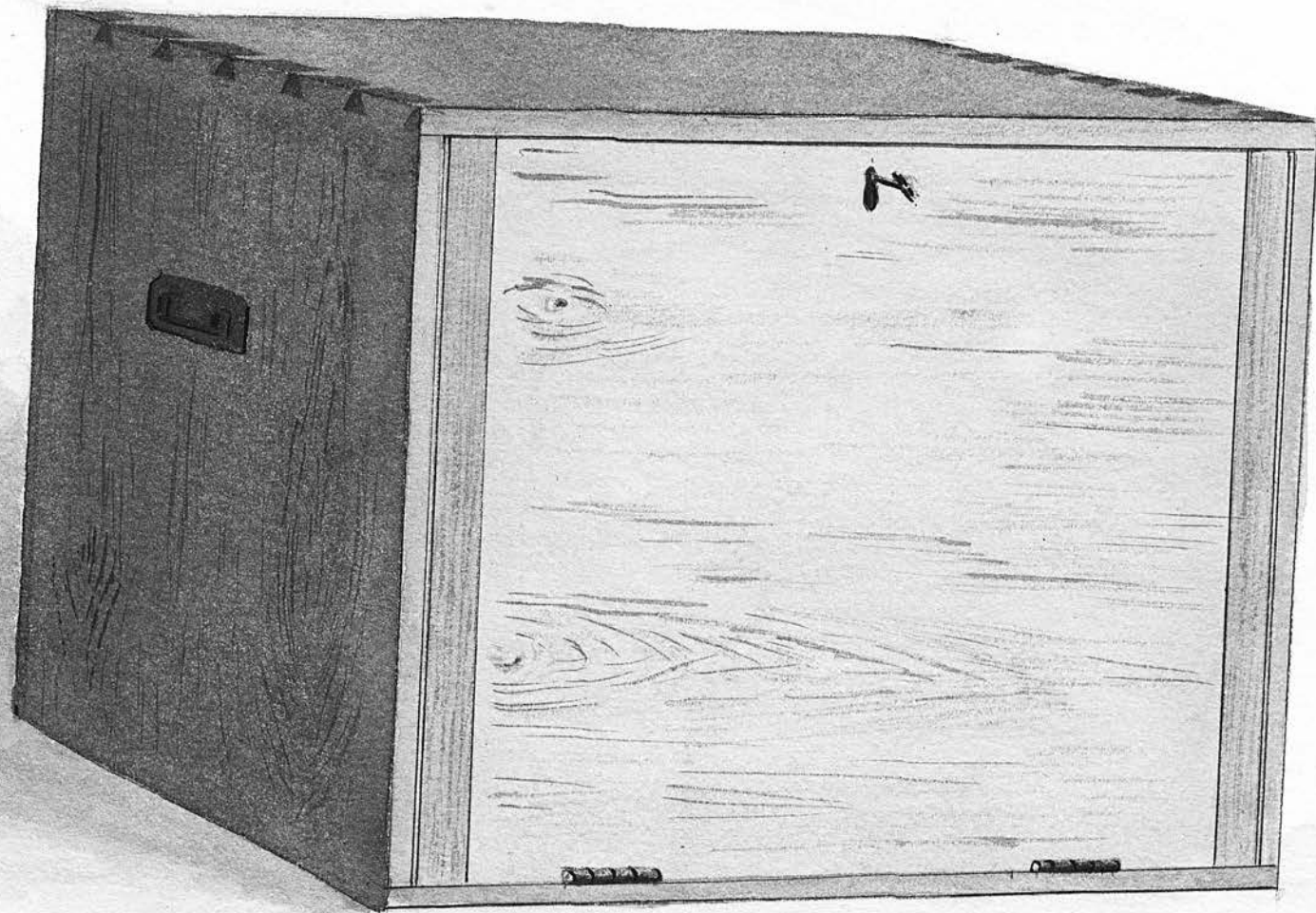
Number of Cowhouse	Number of Animals	Cubic Feet per-Animal	Floor Space in square feet per-Animal	CO ₂ in volumes per 10,000	Humidity				Temperature				Dew Points		Hour and Date
					Absolute Humidity in mm of Mercury	Relative Humidity in mm of Mercury	Excess over outside air in mm of Mercury	Defect of Saturation in mm of Mercury	Inside Dry Bulb	Inside Wet Bulb	Outside Dry Bulb	Outside Wet Bulb	Inside	Outside	
78	15	717	69	34.7	8.69	82%	4.06	3.25	53.5	51	37	35	48.5	32.3	5.45 a.m. 13.III.94
79	6	914	89	17.5	8.81	88%	1.16	2.14	55	52	48	47	49	45	5.20 a.m. 19.III.94
80	6	914	89	14.3	8.99	88%	1.34	2.03	55.2	53	48	47	50.9	45	5.50 a.m. 19.III.94
81	24	713	60	26	11.42	76%	5.72	1.69	60	56.5	45	41.5	53.4	37.4	3.25 a.m. 24.IV.94
82	13	419	36	33.4	9.35	76%	3.65	3.35	59	54.5	45	41.5	50.5	37.4	3.45 a.m. 24.IV.94
83	10	457	45	21.2	12.90	76%	7.20	1.52	63	61	45	41.5	59.3	37.4	4.10 a.m. 24.IV.94
84	30	453	49	25.5	10.32	84%	5.05	2.38	59	56	40	38	53.3	35.4	2.40 a.m. 27.IV.94
85	32	462	48	29	10.39	84%	5.12	2.72	60	56.5	40	38	53.4	35.4	3.10 a.m. 27.IV.94
86	22	774	50	26.5	9.35	73%	4.08	2.95	58.2	54.2	45	40.5	50.6	35.3	4.45 a.m. 1.V.94
87	20	771	48	27.3	8.87	65%	4.78	2.15	55	52	40	36	49	30.7	5 a.m. 4.V.94
88	10	623	38	31.3	10.39	65%	6.30	2.31	59	56	40	36	53.3	30.7	5.15 a.m. 4.V.94

Examination of Cowhouses Nos 89-99

Number of Cowhouse	Number of Animals	Cubic Feet per Animal	Floor Space in square feet per Animal	CO ₂ in volumes per 10,000	Humidity				Temperatures				Dew Points		Hour and Date
					Absolute Humidity in mm. of Mercury	Relative Humidity	Excess over outside air in mm. of Mercury	Defect of Saturation in mm. of Mercury	Inside		Outside		Inside	Outside	
									Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb			
89	22	695	44	28	10.80	78.8%	4.35	2.82	61°	57.5	47°	44	54.4	40.6	4.30 a.m. 8.V.94
90	13	444	57	13.6	7.60	78.8%	1.15	3.07	54.2	49.5	47°	44	44.9	40.6	4.45 a.m. 8.V.94
91	20 cows 1 goat	853	69	22	7.60	78.8%	2.90	1.81	55.5	53°	47°	44	50.6	40.6	5.15 a.m. 8.V.94
92	21	656	56	12.7	7.60	88%	0.88	2.67	53°	49°	45°	43°	45°	40.6	3 a.m. 11.V.94
93	30	780	64	32.5	13.80	88%	7.08	1.85	65°	63°	45°	43°	61.3	40.6	3.40 a.m. 11.V.94
94	47	624	50	28.5	11.16	98.4%	3.33	2.46	61°	58°	46.2	46°	55.4	45.7	3.15 a.m. 15.V.94
95	45	514	42	26.4	9.60	98.4%	1.77	1.17	57°	54°	46.2	46°	51.2	45.7	3.30 a.m. 15.V.94
96	57	612	51	22.7	8.93	90%	2.26	2.90	57°	53°	44.2	43°	49.3	41.6	3.30 a.m. 18.V.94
97	26	815	75	19.6	9.92	90%	3.25	2.30	58°	55°	44.2	43°	52.3	41.6	3.50 a.m. 18.V.94
98	21	583	43	25.1	10.39	90%	3.72	2.72	60°	56.5	44.2	43°	53.4	41.6	4.10 a.m. 18.V.94
99	36	974	47	24.6	8.57	100%	2.39	2.81	56°	52°	29°	29°	48.2	29°	2.55 a.m. 22.V.94

Examination of Cowhouses Nos 100-107. Stable 108

Number of Cowhouse	Number of Animals	Cubic Feet per Animal	Floor Space in square feet per Animal	CO ₂ in volumes per 10,000	Humidity				Temperatures				Dew Points		Hour and Date
					Absolute Humidity in mm of Mercury	Relative Humidity	Excess over outside air in mm of Mercury	Defect of Saturation in mm of Mercury	Inside Dry Bulb	Inside Wet Bulb	Outside Dry Bulb	Outside Wet Bulb	Inside	Outside	
100	36			21.2	8.57	100%	2.39	2.81	56°	52°	29°	29°	48° 2	29°	3.10 a.m. 22.V.94
101	32	776	54	13	8.57	74%	3.12	3.26	57°	52° 5	44°	40° 5	48° 3	36° 3	3.15 a.m. 25.V.94
102	31	813	54	14.3	9.29	74%	3.84	3.01	58°	54°	44°	40° 5	50° 4	36° 3	3.35 a.m. 25.V.94
103	47	659	52	17	8.69	74%	3.24	4.01	59°	54°	44°	40° 5	49° 5	36° 3	3.55 a.m. 25.V.94
104 ₌₁₀₁	32	776	54	16	9.73	87%	3.12	2.49	58°	54°	43° 5	42°	51° 6	40° 2	3.25 a.m. 29.V.94
105 ₌₁₀₂	31	813	54	27.6	12.95	87%	6.64	2.70	64°	62°	43° 5	42°	59° 5	40° 2	3.40 a.m. 29.V.94
106 ₌₁₀₃	47	659	52	21.2	11.09	87%	4.78	2.62	61° 2	58°	43° 5	42°	55° 5	40° 2	4. a.m. 29.V.94
107	36	644	58	20	10.60	84.8%	4.15	3.02	61°	57° 2	45°	43°	53° 9	40° 6	4.15 a.m. 31.V.94
108	16 ^{horses}	1113	77	13	8.52	84.8%	2.07	2.08	54°	51°	45°	43°	48°	40° 6	4.35 a.m. 31.V.94



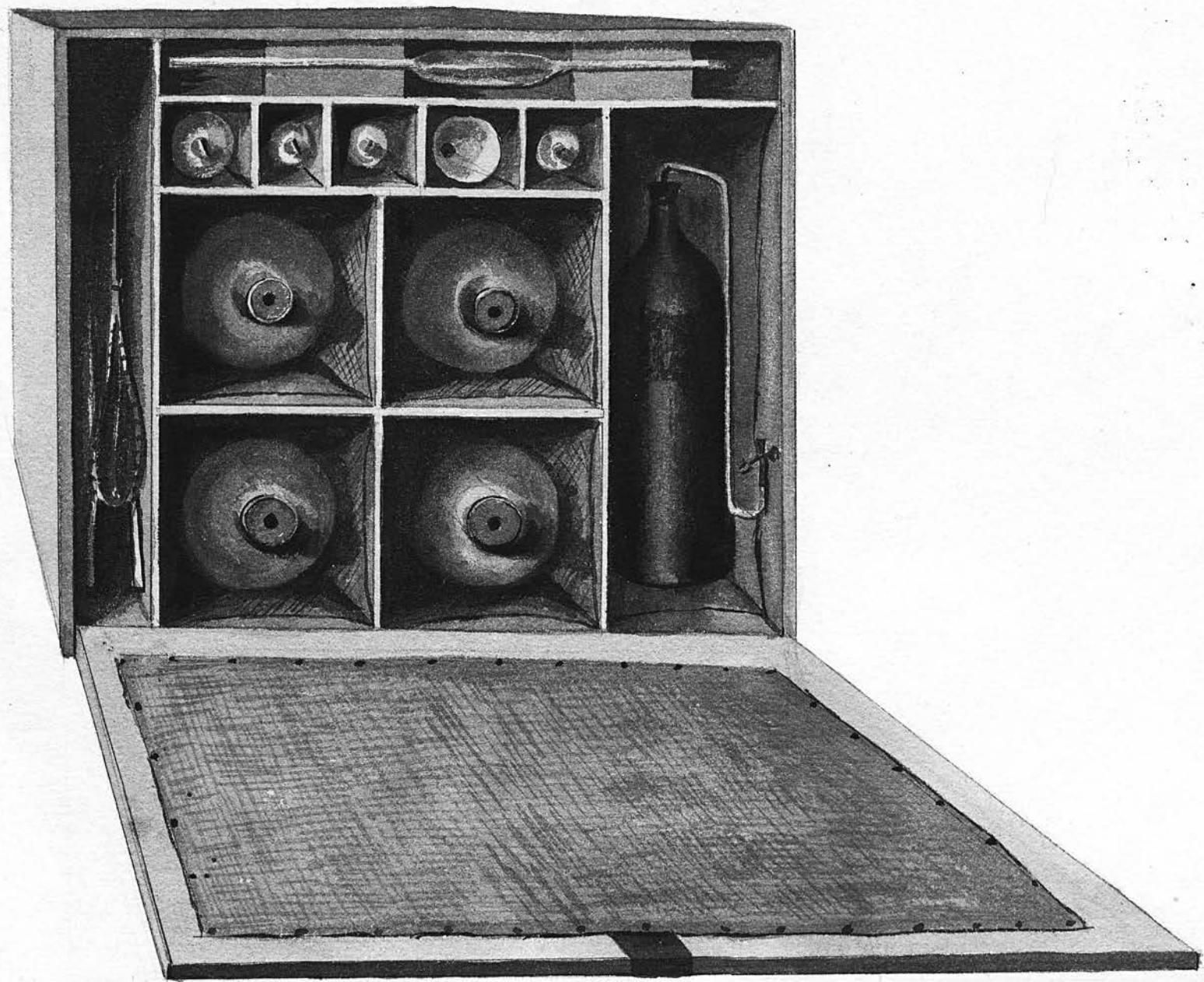


Fig. III

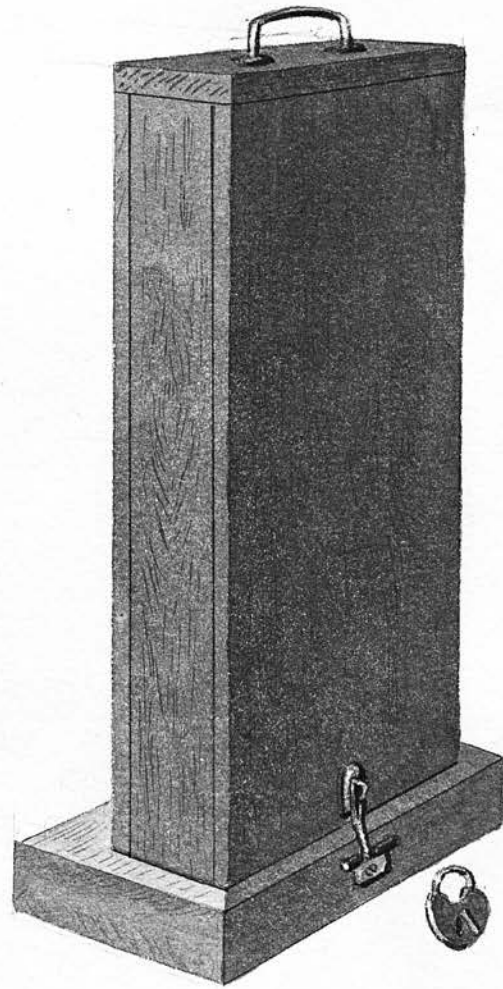
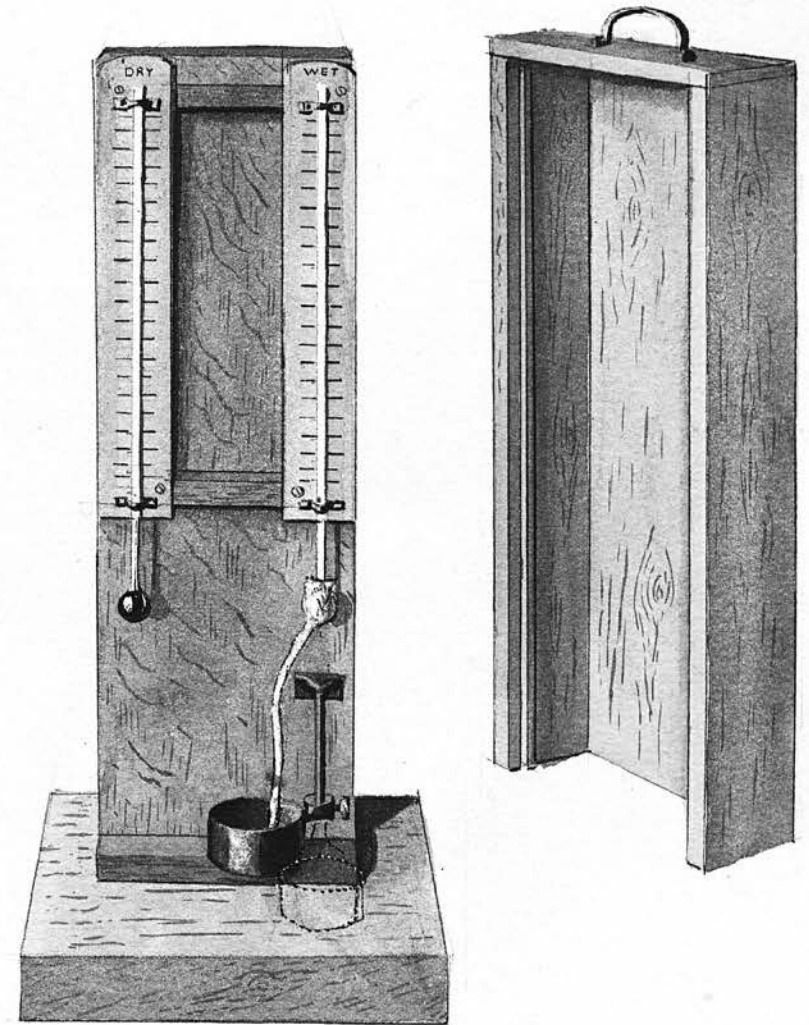
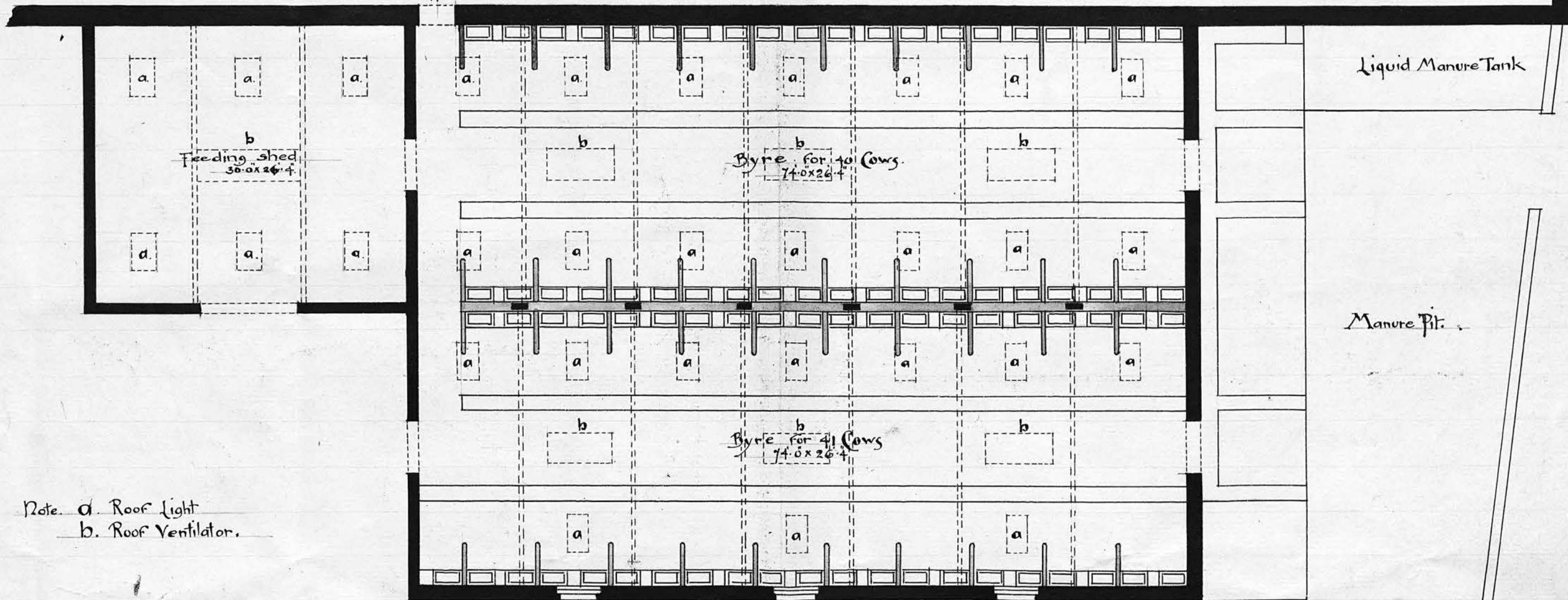


Fig. IV

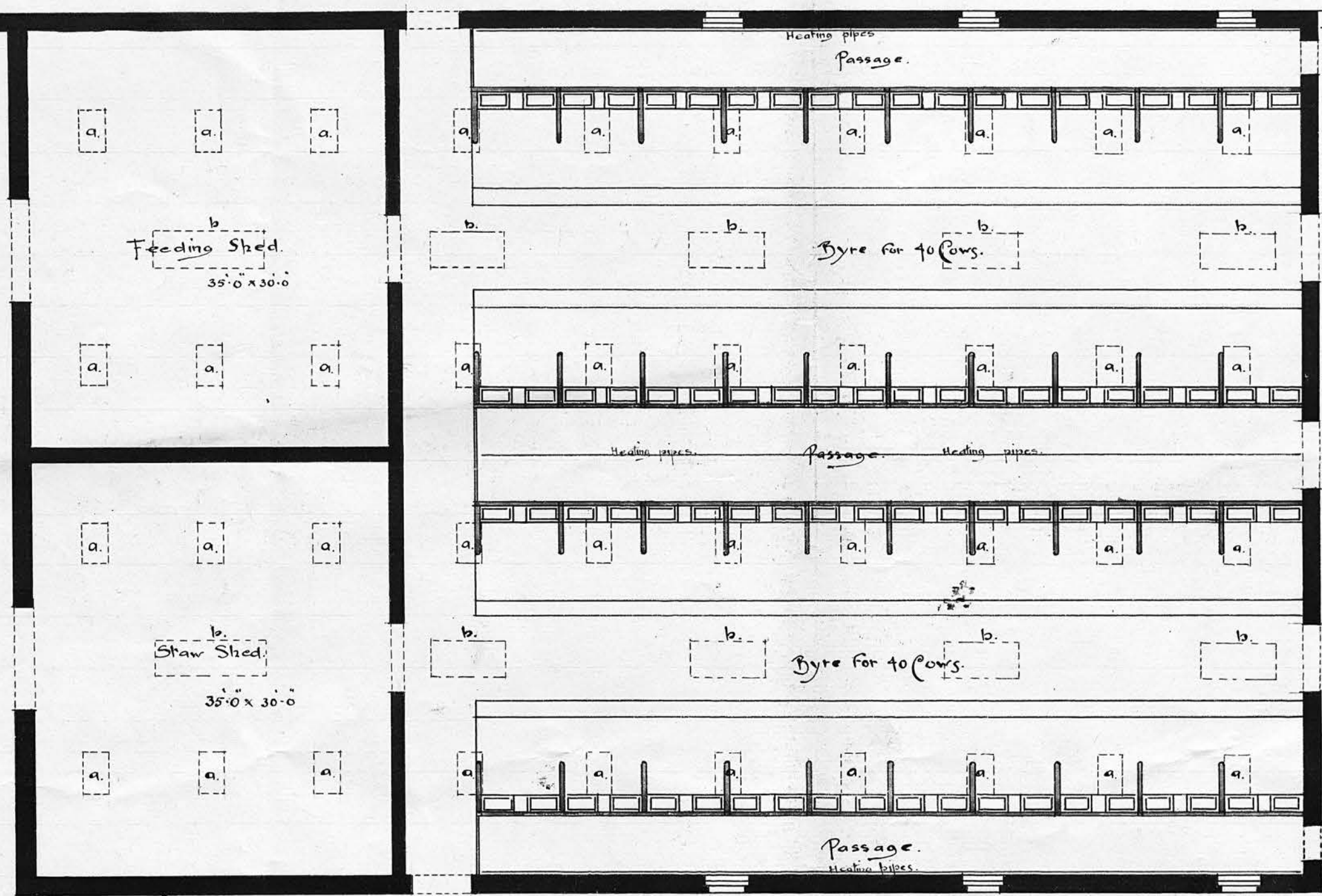


Door to Strawshed.



Note. a. Roof Light
b. Roof Ventilator.





Manure Pit

Note. a. Roof light.
b. Roof Ventilator.









