DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

DIVISION OF ANIMAL HUSBANDRY

# VENTILATION OF FARM BUILDINGS

BY

J. H. GRISDALE, B. Agr.,
*Director, Dominion Experimental Farms*

AND

E. S. ARCHIBALD, B.A., B.S.A.,
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BULLETIN No. 78

Published by authority of Hon. MARTIN BURRELL, Minister of Agriculture, Ottawa, Ont.
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63070—1

The Honourable
The Minister of Agriculture,
Ottawa.

SIR,—I have the honour to transmit herewith, for your approval, Bulletin No. 78 of the Regular Series, on the Ventilation of Farm Buildings, prepared conjointly by the Dominion Animal Husbandman, Mr. E. S. Archibald, and myself.

The ever-increasing interest being taken by live stock men in the matter of the ventilation of farm buildings is the justification for the preparation of this bulletin. Canadian farmers seem to be awakening to the absolute necessity of an abundant and uniform supply of fresh air in all buildings used for shelter for live stock of any description, as horses, cattle, sheep, swine and poultry. The demand for information as to how best to ventilate the various classes of farm buildings has grown very rapidly in the last year or so, hence it has been thought advisable to collect the various articles written by Mr. Archibald and myself on this subject and published in other bulletins or in our annual reports, and make of them a single publication, dealing fairly exhaustively with the matter.

Much experimental work has been carried on here in farm building ventilation during the past ten years or more and the recommendations as set forth are made only after most thorough investigation and repeated trial under every likely condition or handicap.

While it is not desired to condemn any possibly satisfactory system of ventilation, it must be stated that the only system that has invariably proven satisfactory wherever properly installed and operated is that known as the Rutherford System. This system was, so far as I know, first installed, described and advocated by Dr. J. G. Rutherford, late Veterinary Director General and Live Stock Commissioner for Canada.

It is now in operation in our barns and stables of all kinds from Charlottetown, P.E.I., to Agassiz, B.C., and has proven uniformly satisfactory and effective.

I believe, therefore, that the accompanying bulletin will serve a useful purpose in helping our farmers improve hygienic conditions in their barns and stables and so do much to advance our Canadian live stock interests.

I have the honour to be, sir,

Your obedient servant,

J. H. GRISDALE,
*Director, Dominion Experimental Farms.*

OTTAWA, May 11, 1914.



63070—1½

# PART I.

# VENTILATING THE COW BARN.

## THE ESSENTIALS OF A GOOD SYSTEM.

The absolute need for pure air in our stables of all kinds is to-day conceded by practically every stockman. Yet only once in many visits does one find things right. The causes of imperfect success where efforts have been made are various. One of the most common is failure to give proper attention to the system installed. Another often met with is imperfect installation, while ignorance of what good ventilation really is accounts for the most failures of all.

To spend good money and careful thought installing a ventilating system, only to neglect keeping it in operation, is criminal. No effective system ever devised for use in stables is automatic in adjustment to varying atmospheric conditions. Changes in temperature or variation in wind velocity will always necessitate some change in the arrangement of the controls or checks.

Neglect to open or increase the capacity once it has been cut off in some measure in a cold time is the most common cause leading to the condemnation of what might otherwise have been a good system. Another quite frequent cause leading to the condemnation of a system is the too small capacity of the installation. The average carpenter is apt to gauge the requirements of the stable in the way of air by the coldest weather requirements. For this reason installations are very apt to be too limited in capacity for average weather conditions, and much too limited for warm weather.

Then again, an installation may be condemned unfairly because the owner of a stable expects it to do more than any system of ventilation could ever do. A common standard by which the effectiveness of a system is judged is its ability to keep the walls and ceiling free from moisture. This is frequently a most unfair test. Precipitation of moisture on walls or ceiling is due to the warm vapour or water-charged exhalations of the animals, rising and lying for too great a length of time in contact with the cold wall or ceiling as the case may be. If the construction of wall or ceiling be faulty, as for instance, where only double boards with paper between constitute the same, then no system of ventilation could keep them dry without lowering the inside temperature to practically the same as the outside. Walls possible of being kept fairly dry must have more or less insulation, that is, a dead-air space or a concrete core or shavings, or something to prevent too rapid conduction of heat. Then with a fairly rapid circulation of air the walls and ceiling may be kept dry. A ceiling protected by straw or hay overhead is the most satisfactory.

Walls with a dead-air space may usually be kept dry fairly easily. Stone walls or solid cement walls must be wood-lined to insure their being fairly dry. No system of ventilation would otherwise ever keep them dry in very cold weather.

## CUBIC FEET OF AIR PER COW.

The number of cattle in a given cubic space is quite an important factor making for the effectiveness of any system. Too many cattle makes it difficult to ventilate in such a way as to avoid draughts, too few makes it impossible to keep the temperature up to the comfortable point and at the same time provide for sufficient air circulation. Low temperature does not always mean pure air, and here is a point where a great many stablemen make a mistake. The air in a stable where the thermometer shows several degrees of frost may quite easily be most vile. From all this it seems important, in the first place, to so arrange matters that there shall be about the right number of animals in the given stable, allowing, say, from 600 to 800 cubic feet of air space for each cow two years old and over.

## DIMENSION OF VENTILATORS.

This condition existing, there should then be provided about 15 square inches or more of controlled outlet area, and about 8 square inches or more of controlled inlet area for each animal in the stable. For instance, a stable 36 feet x 30 feet x 10 feet, which might be expected to accommodate eighteen or twenty head, should have an outlet about 18 inches square or 20 inches in diameter, if round, and the inlets should be at least 6 inches by 12 inches, and two in number.

By controlled inlets and outlets is meant that it should be possible to cut off the whole or any part of the inlet and outlet by means of some kind of damper or key.

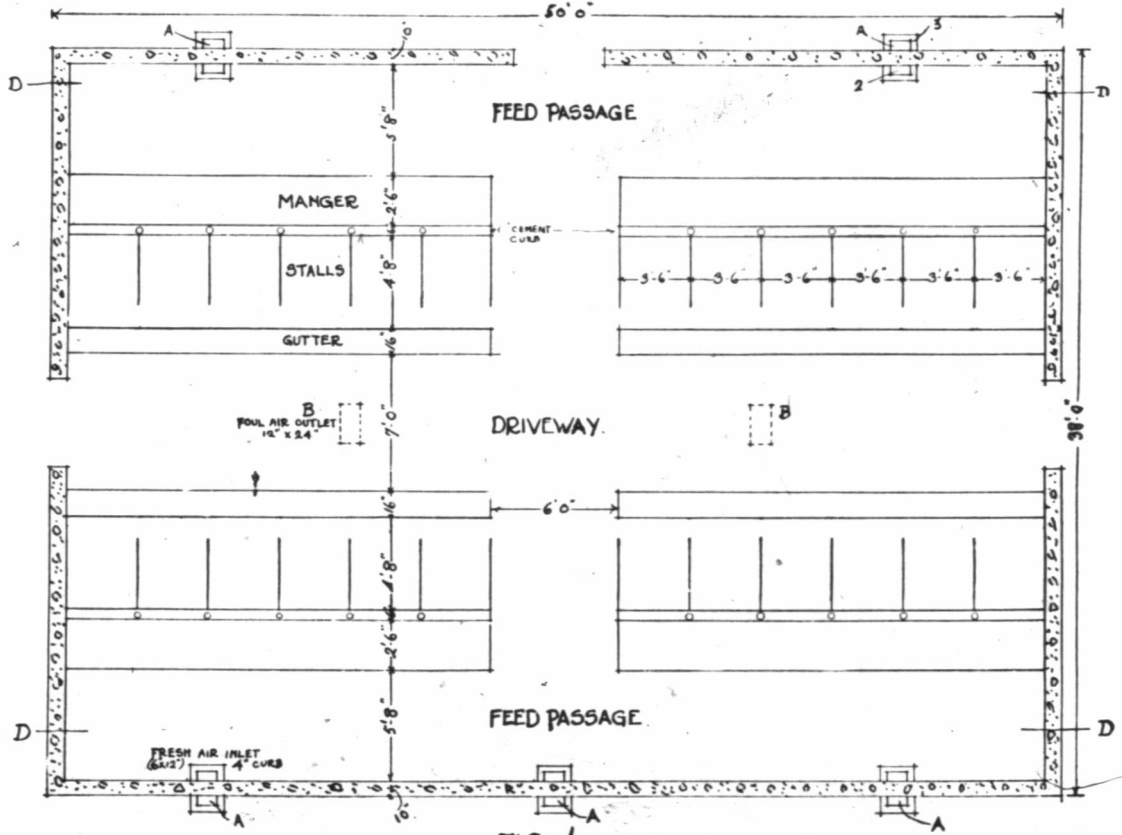
The controls are necessary for the reason that cold air being much heavier than warm air compels a very much more rapid circulation or inflow and outflow of air in extremely cold weather than in warm. This must be controlled or temperatures will fall too low in cold weather and rise too high in warm weather.

The dimensions of shafts or outlets and inlets given above allow for friction of air currents in the shaft, for while 8 to 10 square inches per head in outlet area might be sufficient in very large stables, the same relative area in a small stable would certainly be found faulty. Outlet shafts must be neither too small nor too large. Where materially exceeding the area per head given above, they are likely to work unsatisfactorily and to be constantly dripping in warm weather and freezing in cold, due to the air currents being too sluggish. Where less in area by any considerable amount they are sure to be wet and dripping practically all the time, and to carry impure air off too slowly.

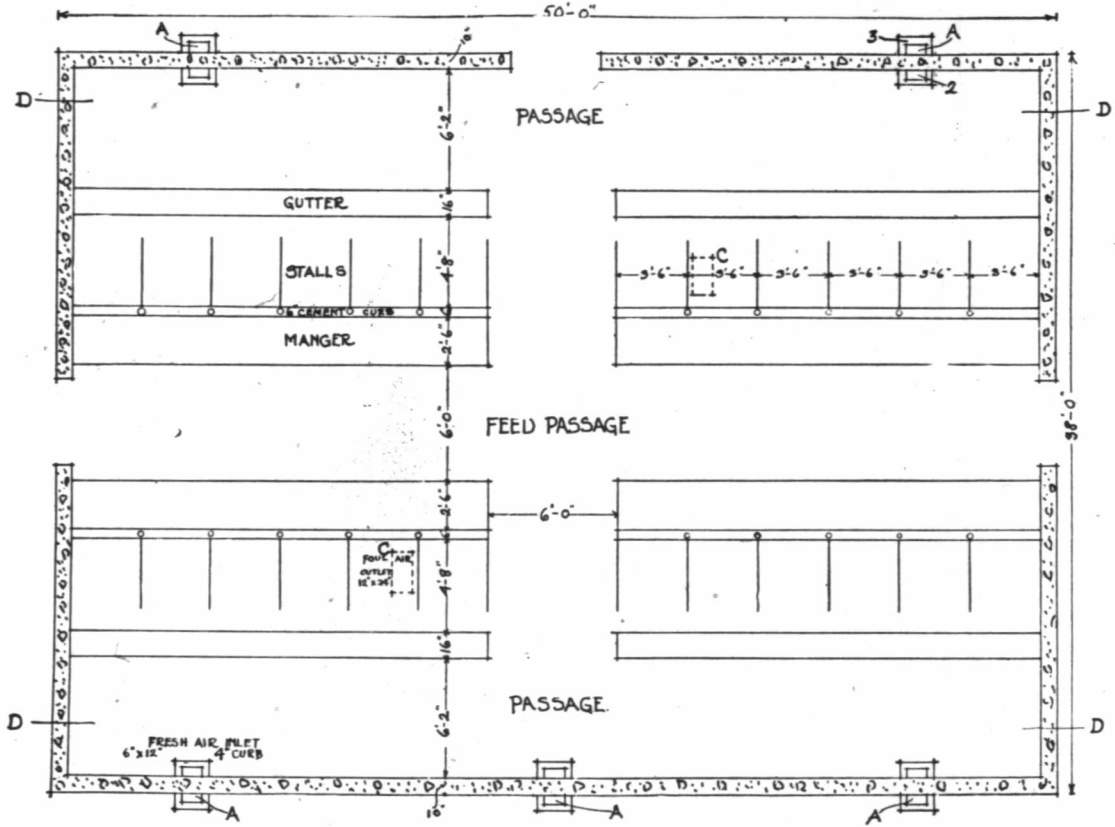
Many systems of ventilation have been devised and advocated. The perfect system has not yet been thought out. It is, besides, practically certain that a system capable of operating satisfactorily under any set of conditions that might be imposed never will be constructed. During the last ten years the writers have tested out some thirty or forty different schemes, systems or devices for ventilating farm buildings, such as cow barns, horse barns and piggeries, and have during that time, learned two things very thoroughly. These two items of information well learned are:—

(1) Good ventilation is a necessary and very profitable feature of any stable.

(2) No known system of ventilation is absolutely automatic or faultless.


50'0"
A
D
FEED PASSAGE
MANGER
CEMENT CURB
STALLS
3'6"
GUTTER
B
FOUL AIR OUTLET
12" x 24"
DRIVEWAY
38'0"
6'0"
FEED PASSAGE
FRESH AIR INLET
4" CURB

-FIG. 1-


50'-0"
A
D
PASSAGE
GUTTER
STALLS
CEMENT CURB
MANGER
C
3'-6"
FEED PASSAGE
6'-0"
38'-0"
FOUL AIR OUTLET 12"x20"
PASSAGE
FRESH AIR INLET 6"x12"
4" CURB
10"

-FIG. 2.-

RUTHERFORD SYSTEM OF VENTILATION.

It has also been possible to come to some conclusion as to the relative merits and adaptability of the various systems tried out. Many systems have shown more or less effectiveness, but of the thirty and odd systems experimented with, we may say that the system commonly known as the Rutherford System of Ventilation has proven much superior to any other tried.

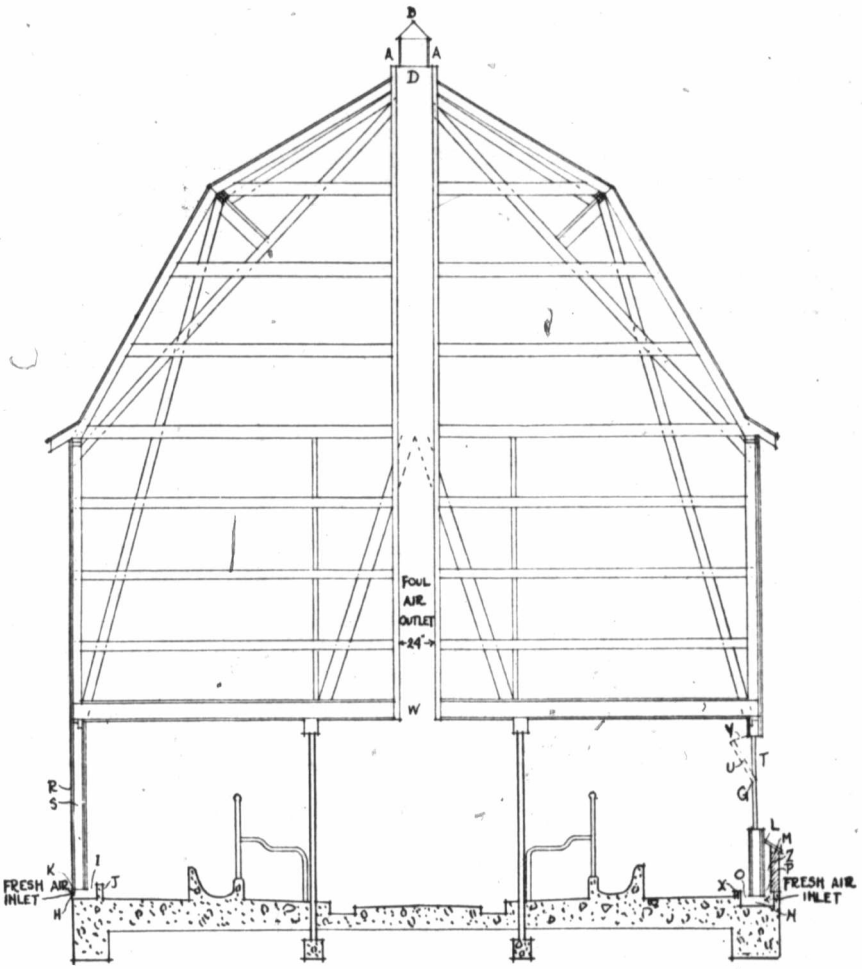



FIG 3.

SUPERIORITY OF RUTHERFORD SYSTEM.

The superiority of this system is due to various features, the chief being:—

(1) Ease in installation, in buildings old and new.
(2) Adaptability to all classes of stables.
(3) Suitability to variety of weather and climate.
(4) Facility of operating and control.
(5) Effectiveness in control of temperature in all parts of stable.

INSTALLATION OF RUTHERFORD SYSTEM.

As just stated, it is susceptible of easy introduction into old stables and may be readily and conveniently installed in new buildings. A study of diagrams given will show probably the best relative positions for inlets and outlets. There is, however, but slight objection to any number of other possible or necessary different arrangements.

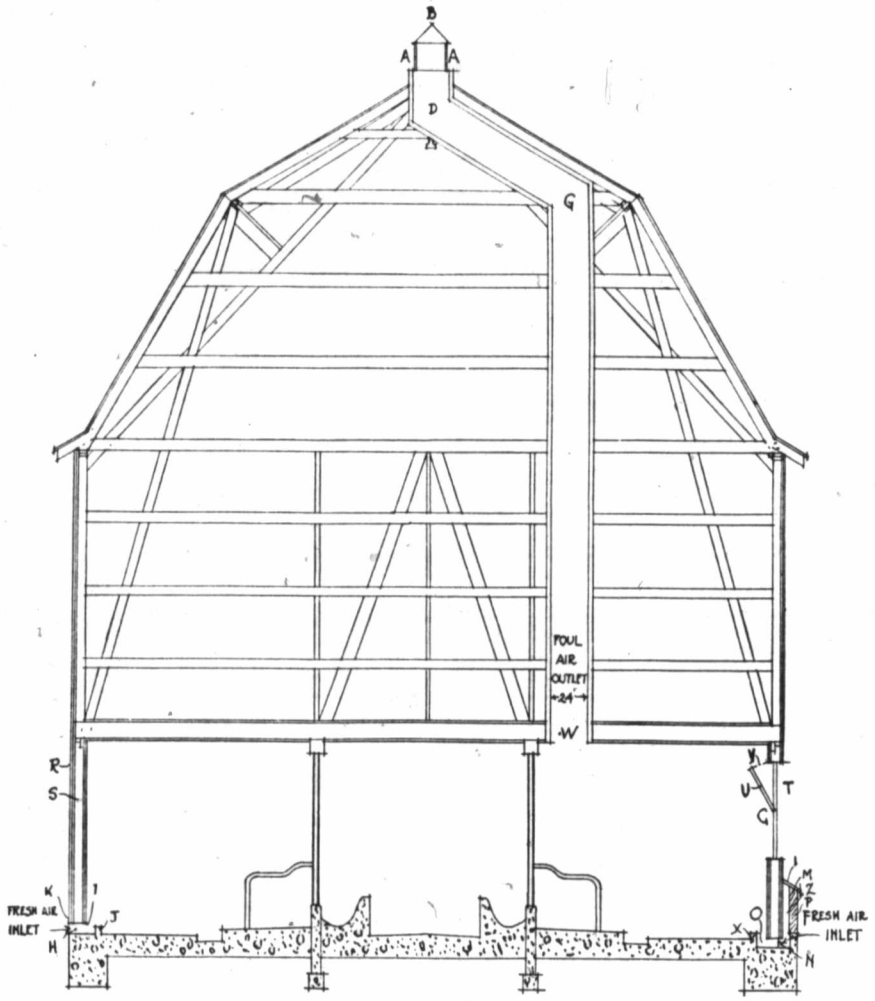



FIG. 4.

Fig. 1, showing floor plan of a stable for, say, twenty-four cattle, also illustrates probably the best relative positions of fresh air intakes A A A A A and foul air outlets B B (beginnings of shaft in ceiling, see W D, Fig. 3). This arrangement suits where nothing in use in the loft or superstructure interferes in any way.

If a hay carrier is to be used in the superstructure, then it might be necessary to change positions of B B to C C, Fig. 2, where shafts would need to be constructed as shown in Fig. 4 by lines W G D. The fact of the outlet shaft changing directions at G and D will not interfere materially with its efficiency. These outlet shafts, provided they are staunchly built as described further on, may take almost any desired course so long as it is always more or less upwards.

The area indicated, 1 foot x 2 feet each, or 4 square feet for the two outlet shafts, is somewhat greater than is really necessary, but it is much better to have shafts slightly larger than any smaller than the minimum of 15 square inches per cow mentioned above.

The intakes A A A A A might, if necessary, be changed to pass under or through walls at D D D D with slightly increased dimensions in each case, say 7 inches by 12 inches, to make up for one opening less. This new arrangement would be advisable in case outlet openings had to be placed at C C.

In the intakes, see Fig. 2, fresh air enters at 1, passes under wall and enters stable at 2, with an upward tendency. The wall, 3, should be about 6 inches thick, and on this wall should be built the little guard shown at M in Fig. 3. The inner wall corresponding to 3 need not be over 4 inches thick.

Fig. 3, showing a stable in cross-section, will indicate the best method of building walls and ceiling, and also illustrate two different methods of introducing the fresh air in the Rutherford System. There is very little to choose between these two methods; that on the left is somewhat more cheaply installed and can be introduced at any time, while the method on the right is probably somewhat more effective, slightly more expensive, and must be installed when the building is being erected. The following explanatory paragraphs will help to a full understanding of the features illustrated:—

### FOUL AIR OUTLET.

The outlet shaft for foul air, W D, should be in duplicate, and should be about 1 foot by 2 feet inside measurement. The best construction is boards running vertically, two ply, with inch air space and two papers between. The opening at the top should be roofed (see Fig. 3). The roof should be supported on four posts, A A, leaving a clear space about 15 or 16 inches between top of shaft and bottom of roof B. The amount of air to escape by these shafts in any given time may be controlled by means of a key as at E. The key may be regulated by cords F F. The key should never be entirely closed. Where the shafts are large enough there is no objection to their being used as chutes for feed or litter, but care should be taken to so hang the door as to insure its remaining tightly closed when not held open to allow of shaft being used as a chute.

### FRESH AIR INTAKE.

The fresh air inlets require careful consideration. The method on the left is very simple of installation. The passage through from H to I should be about 12 inches by 6 inches, the greater dimension being horizontal. K is a protection or roof, H the intake, I the outlet into the stable through which the air passes with an upward tendency. J is a guard or band so placed as to direct air currents upwards. To do this it will need to extend about 4 inches above top of opening through wall. It will, of course, be nailed to the projecting 6-inch sides of this fresh air shaft inside the building, just as K will be nailed to the same sides outside the building. These passages might be controlled by means of small keys or hinged covers, but it is not usually necessary or advisable to so control the intake shafts.

The method on the right hand side (Fig. 3) admits air by the passage N, 12 inches by 6 inches below the level of the floor. Air enters this passage L under shelter of the snow and rain guard M and flows into the stable at O, with an upward tendency. The cement or wooden guard X is to prevent dirt or dust being knocked

or swept in. The top or opening should be protected by a grating of some description. It is possible, but seldom necessary or advisable, to provide these inlets with keys or controls. If it is found necessary to use some system of control, then the control P had better be outside the building but inside the guard cabin M where it can be regulated by a cord passing out at Z.

The careful installation of this system of ventilation, with either method of fresh air intake, will ensure an abundance of good fresh air at all times, provided it is allowed to operate. If, however, it is left to the mercies of the average hired man, it, like any other system, will be found useless.

To get best results in ventilating any stable and to ensure a comfortable, dry building possible of being kept well ventilated, clean and hygienic, attention to the following small details in construction will be found very helpful:—

1. Use simple fixings. 2. Ceil under joists. 3. Put in all the windows the superstructure will permit. 4. Let windows be high (see cut). 5. Hinge windows in bottom at C. 6. Use chains at V to allow them to open inwards at top. 7. Provide double windows for winter. 8. Walls should be built to include air space. Starting from the outside inward, the following construction for stable walls, see Fig. 4, will be found satisfactory: Battens, R, inch dressed lumber, two tar papers, studding 2 by 6 and air space S, two tar papers, V-joint.

## CONSTRUCTION OF THE VENTILATING FLUES.

A good ventilating flue should have all the characteristics of a good chimney. It should be constructed with air-tight walls, so that no air can enter except from the stable. It should rise above the highest portions of the roof, so as to get the full force of the wind.

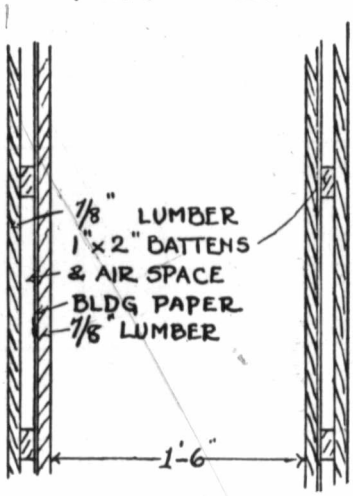
Stronger currents through the ventilators will be secured by making one or more larger ones than where many small ones are provided, and it is usually best to have as few as possible, and not leave the impure air in distant parts of the stable.

A good form of ventilating flue is made of half-inch matched stuff with building paper or deadening felt between to make it air-tight, for every hole and crack lessens the ventilative power.

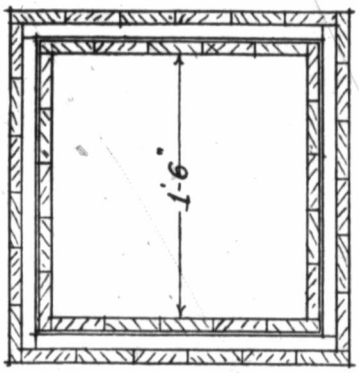
A dead air space in wall of flue prevents cold from penetrating thus precluding the possibility of condensation in flue.

# -PLATE I.-

SECTION.




PLAN.




## FOUL AIR OUTLET.
## 1½ IN SCALE.

PLATE I.—Sections of foul air shaft, showing dead air space for insulation, building paper and two ply lumber.

# -PLATE II.-

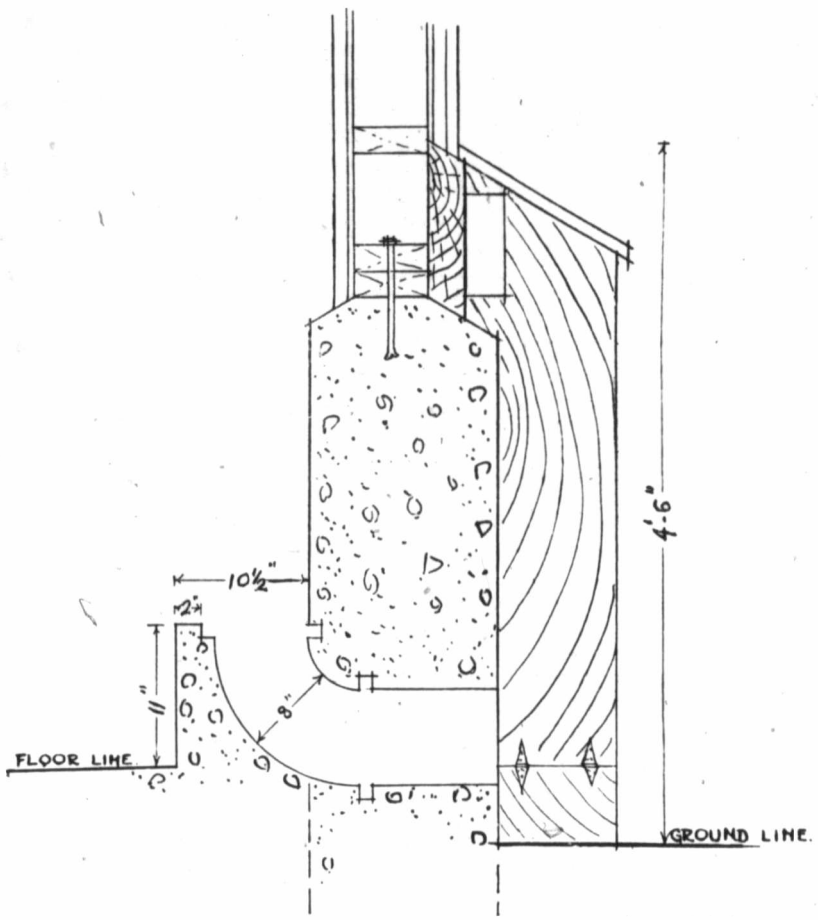


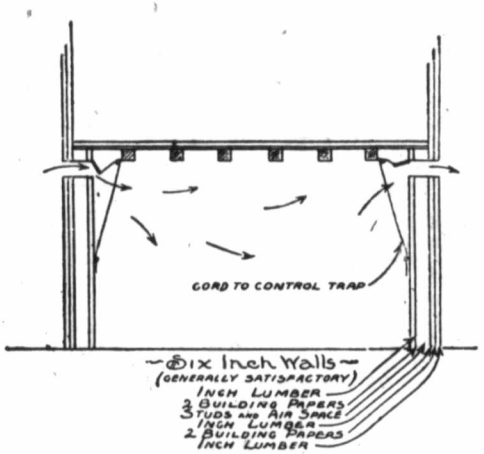

PLATE II.—Showing a good fresh air inlet made from sewer tile elbows.

NOTE.—1. Wood box protector on outside with opening at top of side ; 2, Height of intake in barn ; 3. Good wall construction.

## RESULTS OF EXPERIMENTS WITH DIFFERENT SYSTEMS OF COW BARN VENTILATION.

### SYSTEM OF VENTILATION "A"—PIERCED WALLS.

This system of ventilation is simple and cheap of installation. All that is required is the piercing of square or round holes on all sides exposed to air. These holes or openings in our standard stable (30 by 36) should be 4 inches in diameter at 3-foot intervals, or 6 inches in diameter at 6-foot intervals in at least three sides of the building. They had better be provided with some sort of door or key to control either incoming or outgoing currents of air. The fresh air will, if permitted, enter from the side against which the wind strikes. Hence the openings serving as inlets one day or at one moment may be outlets the next moment or any other day, depending of course upon the direction of the wind. When calm prevails, internal influences will exert the controlling forces as to which openings shall act as inlets and which others as outlets.




**Plan A—Pierced Walls.**

The controlling and limiting of the rate of inflow of air is essential. The outflow will usually require that the controls or keys be fully open. The temptation to partially plug the holes with wisps of hay or straw must be guarded against.

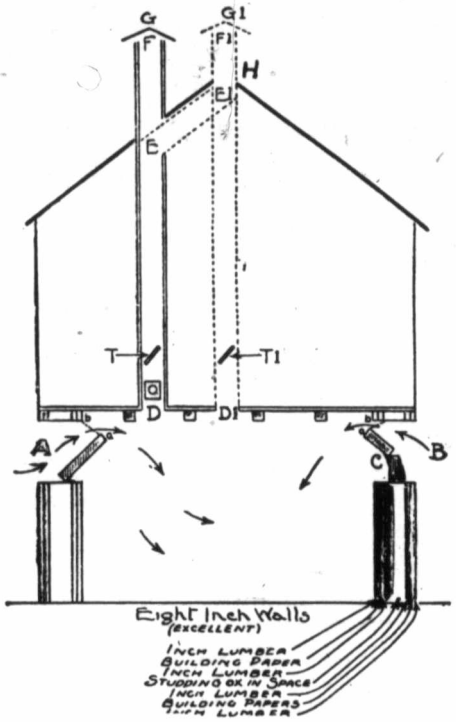
### SYSTEM OF VENTILATION "B"—VENTILATION BY CONVECTION.

In the system described below the proper distribution of pure air throughout the stable depends for the most part upon convection or circulation of air in the lower half of the stable due to the heat from the animals causing displacement of the lower air which when warmed will ascend and be replaced by cool fresh air entering by "A" or "B" or by both or numerous similar openings.

The impure air leaves the stable by outlet D.

C C are windows hinged at the bottom and held in position by small chains from a to b. The windows may be of any desired width or height. If very high it is advisable to have the lower half stationary and the upper hinged thereto as in B.

The outlet D E F for such a stable as mentioned, if single, should be about 2 feet square. If it is preferred to have two outlets, as is probably somewhat better, then each outlet pipe should be 1½ feet square. This outlet pipe D E F may be in the centre or to one side. So far as satisfactory working is concerned we may say that we have had almost equally good results when the pipe took the courses D E F, D $E^1$ $E^1$ $F^1$ or $D^1$ $E^1$ $F^1$ provided always that the outlet F or $F^1$ was 2 or 3 feet higher than H, the apex of the roof. To prevent in some measure inflow of snow or rain, a cap G should be constructed over the outlet pipe. If conveniently situated, D might serve as an opening through which to drop bedding or feed.




**Plan B—Ventilation by Convection.**

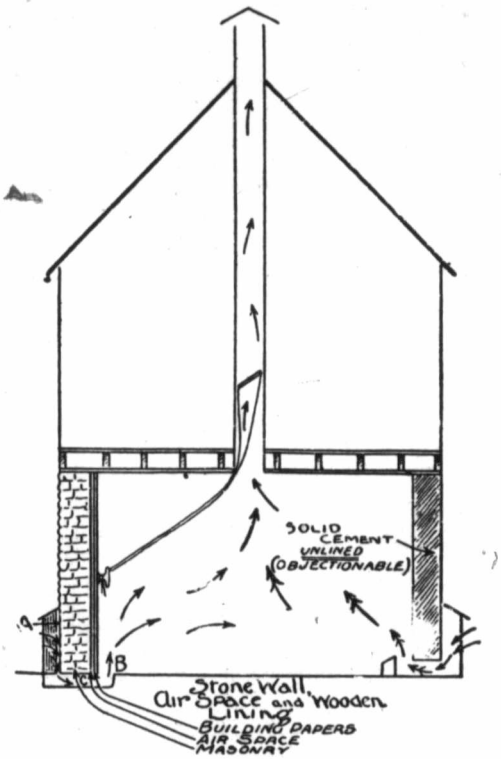
The amount of air to escape through the outlet is controlled by the trap T which may be regulated by cords descending into the stable.

### SYSTEM OF VENTILATION "C"—THE RUTHERFORD SYSTEM.

This system is no doubt pretty well known to most readers, but a few descriptive paragraphs will probably not be out of place. It is the system most commonly used here for the reason that it has proven to be most simple of manipulation and affords the least opportunity of being badly worked or blocked by cattlemen unwisely anxious as to the comfort of their charge.

This system requires that the air enter at or near the floor level. The best plan of bringing it in is probably as shown on the left hand side in the diagram where the single-headed arrows indicate the entrance of the air and its passage through A C B under the wall. When the air current enters the stable it has an upward direction, which it retains in some degree, but once free from the confining passage it spreads and takes usually the course indicated by the single-headed arrow.

If for any reason it is not considered advisable to pass under the wall, then an opening through the wall at the level of the floor will serve the purpose. In such case it will, however, be found necessary to so surround the opening into the stable as to




**Plan C—Rutherford System.**

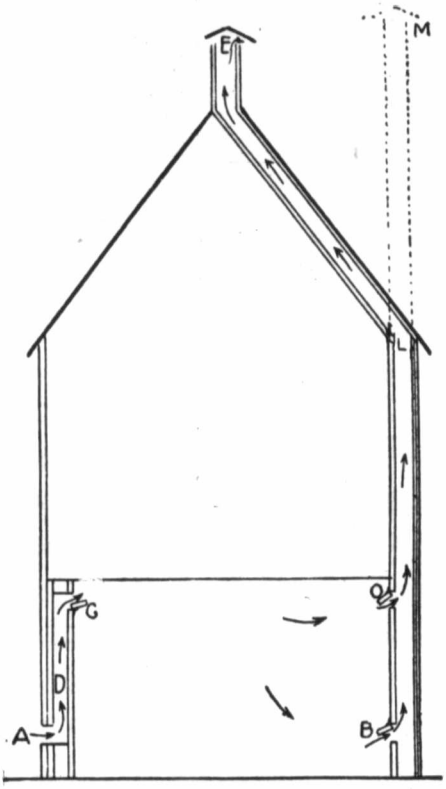
give the entering air current an upward tendency. The air current would then follow the directions indicated by the double-headed arrows. As to outlet, the same plan serves as was described in writing of Ventilation Plan "B."

### SYSTEM OF VENTILATION "D"—THE KING SYSTEM.

Like the system just discussed, the King system is probably known to many readers. It has many admirers, and many have succeeded with it. It is most remarkable in this that the foul air is drawn from the floor and the fresh air enters at the ceiling. In the previously discussed systems, as will be remembered, the foul air in every case was drawn from the ceiling, while the fresh air came in at different points from the floor to the ceiling according to the system being considered.

The advocates of the King system claim that since carbonic acid gas is the chief impurity in stables, and since this gas is heavier than pure air, it is likely to be found in largest quantities near the floor, and therefore outlets for impure air should begin near the floor level.

In the cross-section diagram the inlet is shown by arrows running from A to C. The outlet begins at B and the foul air goes up the tube and out at E. Both inlets and outlets occur on each side, and should be at intervals of about 10 feet, say three of each on each side. Where this number occur, then each inlet and each outlet should have a cross sectional area of at least 60 square inches, say 4 inches by 15 inches. Where it is intended to install this system it should be provided for when building the walls. Spaces between the studs will serve for both inlets and outlets.




**Plan D—King System.**

The outlet B L E might be modified to take the course B L M, in which case it would probably be necessary to extend M above the level of the apex of the roof. At O openings should be made into the outlets so that the warm air at the ceiling may be allowed to escape when the average stable temperature rises too high.

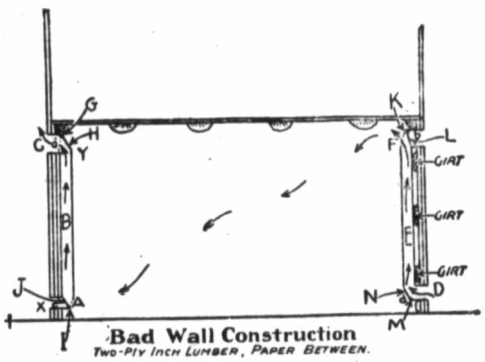
The chief objection to this system is the large number of long pipes or boxes necessary to admit pure air, and discharge foul air as the case may be.

This objection is particularly in evidence when it becomes necessary to install the system in an old building. A modification of the system and one that is easy of introduction in an old or new wooden building is given below.

SYSTEM OF VENTILATION " E."

This system, a modification of the King permitting of cheap and easy installation in either new or old frame or log buildings, is one which the writers devised and put into operation some years ago at the Experimental Farm and elsewhere. It has worked very satisfactorily wherever installed. That it is cheap as well as effective, is proven by the fact that in a stable for twenty-two cattle it cost $12 for labour and material. The pipes in this system are entirely inside the stable. For twenty cattle in the standard stable these should be six in number ,each about 12 inches by 6 inches or 12 inches by 7 inches in cross-section, three on each side (east and west sides if possible).

Each ventilation pipe must have two openings to the outside air, one, an inch or so below the ceiling level as *a* and *b*, and the other 6 inches to 8 inches above the floor level as *c* and *d*. These openings should be of the same dimensions as the pipes. The air enters the building by passing into the right hand pipe at D up past E and into the stable at F at the ceiling. It circulates through the building, enters the outlet at A, passes up through B and out at C. If the wind were blowing from the left, however, it would enter at X up through B and out into the stable at Y, finding its way out by entering the right hand tube at *d* passing up through E and out at *b*.




**Plan E - Modified King System**

H J L N represent barriers or trap doors hinged at G I K and M respectively. As set in diagram air enters by D E F and discharges by A B C. If set as per dotted lines then entry would be by X B *y* and discharge by *d* E *b*.

When properly attended to this is an exceedingly satisfactory system, but when neglected does not always work well. If desired, trap doors H J L U may be arranged so as to permit of air entering directly, that is by flowing through X A and D *d* and leaving stable at ceiling that is *b* and Y C, which would be a modified Rutherford system. This latter modification works well in warm weather.

MUSLIN CURTAIN VENTILATION.

In addition to the above an experiment in muslin curtain ventilation has been conducted here recently and a report thereon will probably be of interest.

The stable in which the experiment was carried on is a well built, well lighted and well ventilated (otherwise than by muslin curtain system) building about 100 by 25 feet with a 10-foot ceiling. It is divided into six box stalls and was, during the time the experiment was under way, occupied by thirty-seven head of cattle (steers 1 and 2 years old). During the experiment with muslin curtain ventilation the inlets and outlets of the other system of ventilation were kept closed. The building where the experiment was carried on is known as the steer stable.

On each side of the building are ten windows each 2½ feet by 4 feet.

These windows are 6 feet from the floor and extend to about 18 inches from the ceiling. They are hinged at the bottom and are, by means of chains, held at an angle of about 60 degrees with the floor when open. It is evident, therefore, that the air that managed to get through the "muslin" met no further opposition in getting into the stable. The only effect of the windows standing at 60° angle was to start any air currents upward rather than downward and so caused a more perfect intermixture of the incoming air with that already in the stable.

The curtains covered the whole window area, being held in place on the frames outside by means of laths nailed over the margin of the cotton. The cotton used was of two grades: Grade 1, the cheapest grade of grey cotton costing 6 or 7 cents per yard; grade 2, cheesecloth. On the east side were five cotton and four cheesecloth curtains. On the west side were four cotton and 5 cheesecloth curtains.

The experiment lasted forty days and was most interesting. For instance, during a few warm days when the thermometer showed about 40° Fahr. outside and there was no breeze blowing, the inside steer stable thermometer showed 82° in spite of the fact that every curtained window (eighteen windows 4 feet by 2½ feet) was open. As soon as the doors were opened, however, the temperature began to fall, and in a short time the thermometer showed only a few degrees more heat than the outside.

The following record of inside, that is steer barn, temperature, and outside temperatures as well as record of temperatures in the main barn or cow stables (where another system of ventilation was in operation) and a few notes on the wind will be self-explanatory and instructive.

REPORT ON MUSLIN VENTILATION EXPERIMENT.

| — | December 23. | | | | December 24. | | | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | 12 a.m. | 2 p.m. | 5 p.m. | 10 p.m. | 5 a.m. | 9 a.m. | 12 a.m. | |
| | * | | | | | | | |
| Open air | 26 | 27 | 30 | 28 | 26 | 24 | 24 | *Windows open both sides of steer stable. |
| Cow stable | 50 | 52 | 53 | 52 | 50 | 50 | 50 | |
| Steer stable | 52 | 53 | 57 | 62 | 46 | 44 | 42 | |
| Wind | V. light. | V. L. | V. L. | Calm. | Breeze. | Light. | Light. | |

| — | December 24. | | | December 25. | | | Remarks. |
|---|---|---|---|---|---|---|---|
| | 3 p.m. | 5 p.m. | 11 p.m. | 5 a.m. | 9 a.m. | 12 a.m. | |
| Open air | 27 | 25 | 20 | 14 | 14 | 16 | |
| Cow stable | 51 | 52 | 50 | 48 | 48 | 48 | |
| Steer stable | 51 | 52 | 50 | 50 | 55 | 52 | |
| Wind | V. light | Light. | Calm. | Calm. | V. L. | V. L. | |

| — | December 25. | | | December 26. | | | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3 p.m. | 5 p.m. | 11 p.m. | 5 a.m. | 9 a.m. | 12 a.m. | 3 p.m. | 5 p.m. | 11 p.m. | |
| | * | | | + | | | | ‡ | § | |
| Open air | 18 | 21 | 15 | 18 | 8 | 13 | 15 | 8 | 2 | *Windows open both sides of steer stable. |
| Cow stable | 48 | 48 | 47 | 47 | 47 | 46 | 50 | 50 | 47 | †Closed 1 side of steer stable. |
| Steer stable | 50 | 52 | 56 | 35 | 42 | 46 | 52 | 58 | 62 | ‡Opened up window again. |
| Wind | V. L. | V. L. | Calm. | Breeze. | Light. | Calm. | Calm. | Calm. | Calm. | §Steer stable full of fog and dripping wet. |

| | December 27. | | | | | | December 28. | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5 a.m. | 9 a.m. | 12 a.m. | 3 p.m. | 5 p.m. | 12 p.m. | 5 a.m. | 9 a.m. | 12 a.m. | |
| | * | | | | | | | | † | |
| Open air.... | 14 | 20 | 20 | 28 | 22 | 33 | 32 | 36 | 34 | *Window open as at commencement. |
| Cow stable.. | 47 | 49 | 50 | 52 | 52 | 49 | 53 | 50 | 51 | †Windows open both sides of steer stable. |
| Steer stable. | 50 | 48 | 58 | 59 | 46 | 58 | 44 | 56 | 58 | |
| Wind ..... | V. L. | V. L. | Calm. | V. L. | Light. | Light. | Breeze. | V. L. | V. L. | |

| Summary. | Max. | Min. |
|---|---|---|
| Open air ..... | 36 | 2 |
| Cow stable ..... | 53 | 46 |
| Steer stable ..... | 62 | 36 |

The maximum and minimum columns of the above table are eloquent of the one great weakness of this system of ventilation. While the temperature where one system of ventilation was in operation varied only 8 degrees in spite of a variation of 34 degrees outside, the temperatures of the stable where the muslin curtain ventilation was in operation varied 26 degrees, although every effort was made to maintain a uniform temperature by opening and closing curtained windows as necessary.

It might be objected that not temperature but pure air is the consideration. This is true, of course, but in a stable so well built as the one where the experiment was conducted, to maintain a temperature of from 45 to 50 degrees will permit of excellent ventilation. When this temperature maintains inside, a person breathes quite comfortably and has none of the sensations due to impure air and so regrettably well known to most of us who are accustomed to visit stables in this country.

### ADVANTAGES OF.

In favour of this system it may be said:—

1. That with the exercise of much care it is possible to ventilate by means of muslin over window or other opening, and that of the two cheese cloth is to be preferred to grey cotton since a smaller area will do the work and do it better.

2. That it is cheaply installed and much better than no ventilation.

### OBJECTIONS TO.

The objections appear to be:—

1. Very great watchfulness necessary to insure a fair measure of success.

2. Danger of too great a fall or rise of temperature in the night due to rise or fall of wind.

3. Darkening of stable due to presence of muslin on windows, which renders stable gloomy and damp.

4. The fouling of the muslin on account of changing directions of air currents which wet the curtain permitting foul air to escape and so the curtains soon get muddy in appearance and unsanitary in condition.

# PART II.

# VENTILATING THE HORSE BARN

In 1906 on the Central Experimental Farm was built a horse barn capable of accommodating twenty-three horses. A floor plan and cross-section plan are submitted herewith. A few words of explanation follow:—

The plan of the ground floor explains itself for the most part. The doorway at the end marked "doorway or stall" is not used as an entry or exit for horses. It is of such a size and so constructed that it may, if occasion arises, be used as a stall.

Referring to the cross-section diagram, it is intended to show the (1) wall construction, (2) floor construction and inclines, (3) feed chutes, (4) mangers, (5) King system of ventilation, (6) Rutherford system of ventilation, (7) stall divisions.

### CONSTRUCTION OF WALLS.

The walls starting at the outside are built: vertical inch dressed lumber, battens over joints, two building papers, rough lumber, horizontal; 6-inch studs and air space; rough lumber, horizontal; building paper; V-joint inside finish. The ceiling or upper floor is constructed similarly, joists supported by two beams resting on stall posts.

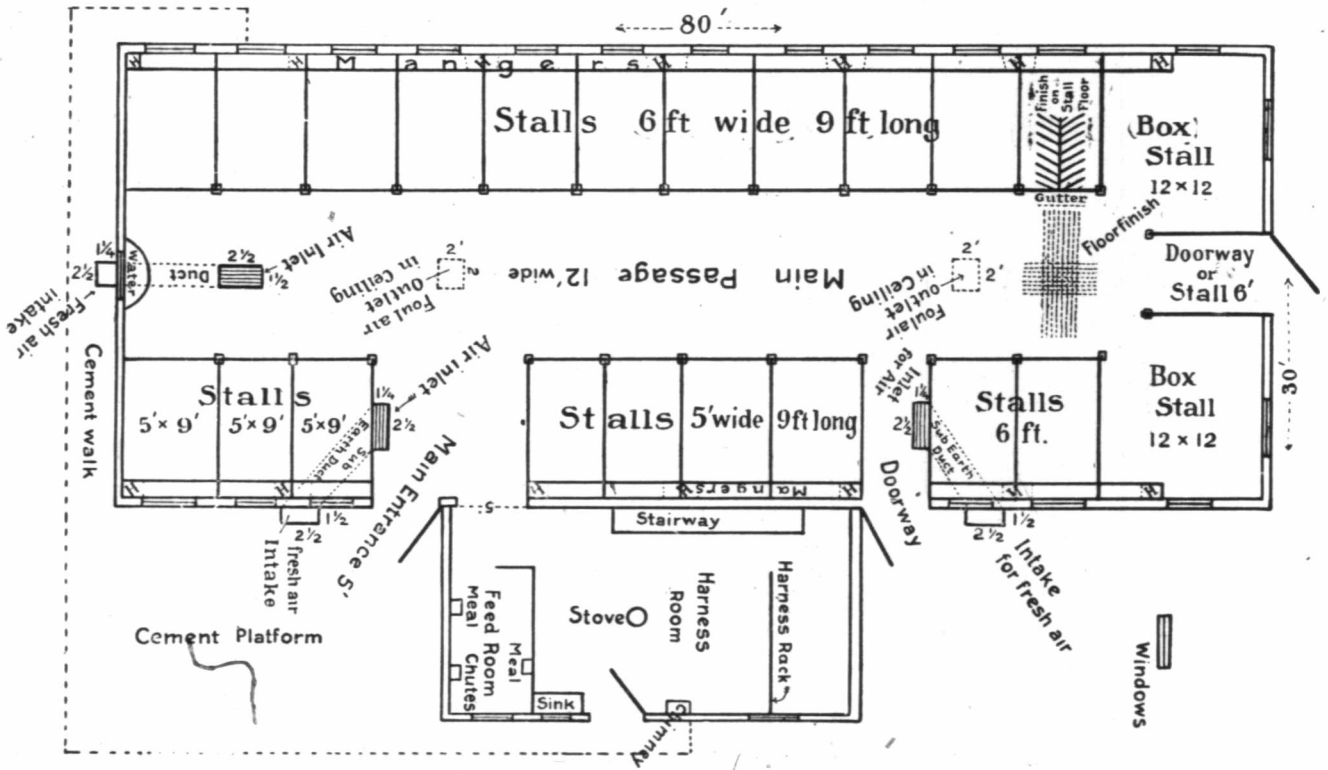
### CONSTRUCTION OF FLOORS.

As indicated the foundation was built of concrete. The floor, a regular cement one with the necessary pitches or inclines, etc., was built of rather unusual strength on account of its being for horses. A good depth of stone was laid on the ground, a layer of about 5 inches of rough concrete (1 cement, 3 sand, 8 gravel) followed and finished off with a second layer, one part cement, two and a half parts coarse sand, and a half part crushed granite. The surface of the passages is cut by inch-deep grooves into 6-inch squares. The main passage, 12 feet wide, is about 3 inches higher in the centre, descending with a convex slope to immediately behind the horses. The stand for the horses is about 4 inches higher than the gutter or lowest point of the 12-foot passage.

The stands are 9 feet long, first 3 feet level, and a fall of 1 inch in 6 feet at rear. Stalls vary in width from 5 feet to 6 feet 1 inch, the centre of the stall floor being one-half inch lower than the outer edges. The horses stand on cement.

Feed chutes, as shown in diagram, begin at the plate and end in the manger. Doors to admit hay into chutes occur at top, about half-way down and near the floor of loft. The chute is slightly bell-shaped so that hay once started drops to manger. This plan of feeding long hay has been found very satisfactory.

The mangers extend clear across the stall, the hay chute falling into one end. The grain or meal is fed in the manger, no special box therefor. Horses are watered by man in charge. Tank at end of 12-foot passage to which they may be led if so desired.


80'
Mangers
Stalls 6 ft wide 9 ft long
Finish on Stall Floor
Gutter
Box Stall 12×12
Floorfinish
Doorway or Stall 6'
30'
Box Stall 12 × 12
Main Passage 12' wide
Air Inlet
Duct
Water
Fresh air Intake
Cement walk
Foul air Outlet in ceiling
Foul air outlet in ceiling
Stalls 5'× 9' 5'×9' 5'×9'
Sub Earth Duct
Air Inlet
Main Entrance
Stalls 5'wide 9ft long
Mangers
Stairway
Doorway
Stalls 6 ft.
Inlet for Air
Sub Earth Duct
Intake for fresh air
Intake fresh air
Cement Platform
Feed Room
Meal Chutes
Meal
Sink
Stove
Harness Room
Harness Rack
Chimney
Windows

(Photo by F. T. Shutt).

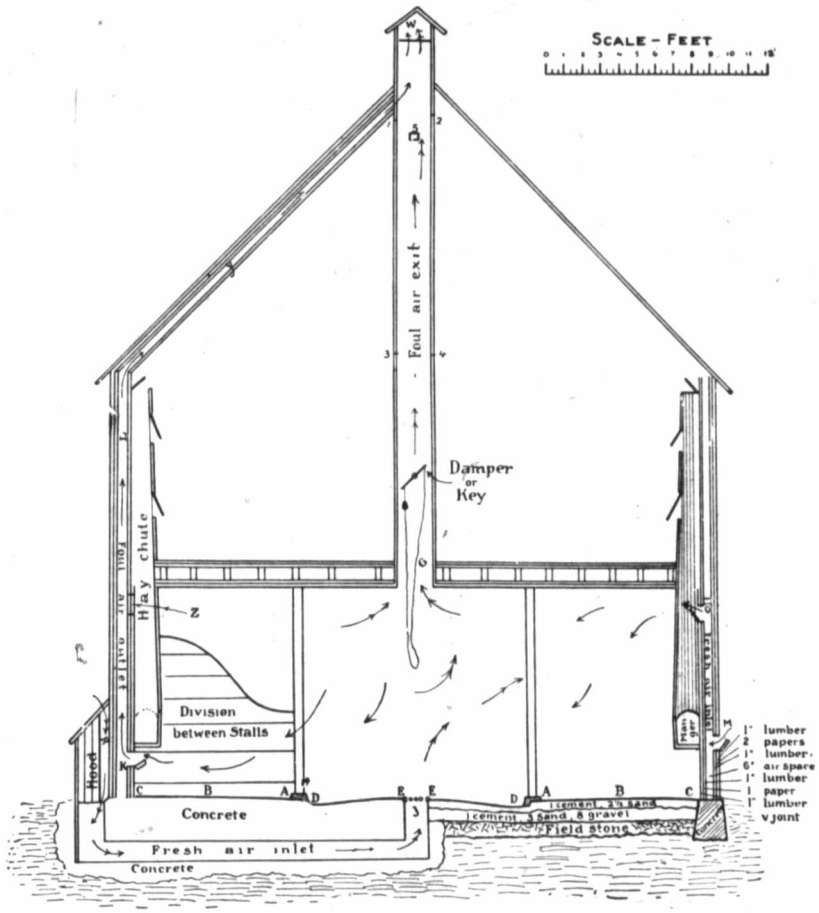
Horse Stable Central Experimental Farm. Note.—Rutherford System of Ventilation.

SYSTEM OF VENTILATION.

This stable is equipped with two distinct systems of ventilation, either one of which may be operated quite independently of the other. They are what are known as (1) the King system of ventilation, (2) the Rutherford system of ventilation. In the King system the fresh air is allowed to enter at the ceiling, and foul air leaves at or near the floor. In the Rutherford system, the air enters at or near the floor level and leaves at the ceiling.

THE KING SYSTEM.

In the diagram the course of the air currents when the King system is in operation is shown by the single-headed arrows. That is, the air enters the intake passage




Cross-section of Horse-barn.

at M on the right, ascends by "fresh-air inlet" to O, where it enters the stable. The air then circulates, is befouled or mixed with the carbon dioxide gas, becomes heavier, falls to the floor, and is then driven out through the openings under the mangers, as at K, passes up through "foul-air outlet" L Y W. If desired, and as recommended,

controlled openings may be left in the outlet passage or tubes near the ceiling, as at z, to be used in case of the stable becoming too warm. This system has been found satisfactory in many stables.

THE RUTHERFORD SYSTEM.

The air currents in the case of the Rutherford system of ventilation follow the course indicated by the double headed arrows. The air enters by passages passing underneath the walls. The external openings are protected by a species of hood (see "hood" in diagram). These passages might open into the stable immediately the wall was passed if the internal arrangement permitted, but may be conducted by underground or surface tubes or passages to whatever point or points may be considered most suitable. In this case air enters at R behind the "hood," passes along underground passages and is discharged into stable at J. It circulates and escapes from the stable by "foul-air exit" G W. This outlet should have a cross-section area of 12 square inches for each horse. The inlet capacity may be satisfactory if somewhat less. The outlet pipe is provided with a damper or key which permits of the air current being controlled. It is also well to provide the "hoods" with keys or dampers to control the incoming air.

The construction of the foul-air outlets and fresh-air intakes should be with as great care in regard to tightness and insulation as described under Part I on "Ventilating the Cow Barn."

These two systems have now been in operation for nearly eight years. Results have been decidedly in favour of the Rutherford system in freeing this stable of moisture and foul air, and in consequence this system only is now used and recommended for climatic conditions resembling those of Ottawa, Ont.

# PART III.

# VENTILATING THE PIGGERY.

In wintering sows in single board cabins, the question of ventilation is a matter of great simplicity. When it becomes, however, a question of wintering pigs in warmer pens, as must be done in the case of young fall pigs if any profits are to be hoped for, the problem of securing an ample supply of fresh air, without lowering the temperature unduly, is exceedingly hard to solve. To gain some information on this subject, two single-pen piggeries were constructed in the autumn of 1898, special provision being made to try various systems of ventilation in each of them.

The buildings were constructed of wood with cement floors. They were in each case 16½ feet long, 15 feet wide and 8-foot ceiling, with double half-pitch roof and loft overhead.

### CONSTRUCTION OF WALLS.

The walls were made of 4-inch studding, two papers outside and one paper inside, single board and batten outside and V-jointed inside. The joists were ceiled. There were four windows in each pen; they were hinged at the bottom and chained to hang about 2 feet open at the top so desired. Double windows were used in winter.

### CONSTRUCTION OF CEILING.

The ceiling of pen 1 had a slightly inverted hopper shape with an outlet pipe from the centre or highest part of the ceiling. The ceiling of pen 2 was slightly higher at the back than at the front; besides this peculiarity, the ceiling or boarding under the joists stopped completely about 4 feet from the rear wall, leaving the joists exposed. Above the joists, rising from a point where the ceiling stopped, and reaching to the plate (about 2 feet above the joists) three or four short beams carry stout slats 2 inches thick nailed in place about 2 inches apart and running horizontally at right angles to the joists. These slats were covered with about 2 feet deep of loose oat straw.

The following report of experiment with illustrations was prepared by Mr. D. D. Gray, farm foreman on the Central Experimental Farm, who conducted the detail work of same under the outline and supervision of the Dominion Agriculturist, Mr. J. H. Grisdale, and is taken from the 1910 report of that officer.

During the continuance of the experiments, two bunches of feeding pigs were housed in these pens. They were usually equal in number and about equal in weight, so that the quantity of air required and the impurities to be carried off were about equal at all times in two pens.

EXPERIMENT No. 1, KING VS. MODIFIED RUTHERFORD SYSTEM.

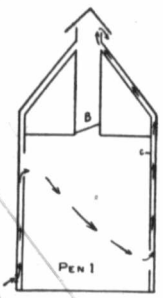
Since it would be exceedingly difficult to convey a clear idea of the direction of air currents and relative locations of inlets and outlets by the use of words alone, cross sections or diagrams are used.

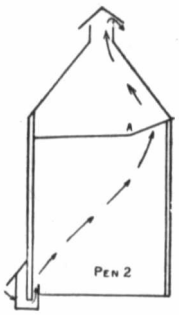
In pen 1, the King system of ventilation is in operation, the shaft B being closed. At the point C is an opening into the outlet flue, but it was kept closed during this experiment.

In pen 2, the escaping air works its way slowly up through the straw resting on the slats as previously described at A, and thence out through the open cupola on the roof.

VENTILATION TABLE 1.

| Period 1. From Feb. 16, 1910 to Feb. 22, 1910, inclusive. | Outside. | | Pen 1. | | | Pen 2. | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature. | | Temperature. | | | Temperature. | | |
| | Av. Max. | Av. Min. | Av. 7.30 a.m. | Av. Max. | Av. Min. | Av. 7·30 a.m. | Av. Max. | Av. Min. |
| | ° | ° | ° | ° | ° | ° | ° | ° |
| Degrees Fahr. | 23·2 | 12·5 | 32·0 | 42·2 | 25·7 | 31·8 | 42·4 | 26·1 |
| Variation from outside. | ..... | ..... | ..... | 19·0 | 13·2 | ..... | 19·2 | 13·6 |
| No. of pigs in pen. | ..... | ..... | | 10 | | | 10 | |
| Remarks | ..... | ..... | Ceiling and walls damp. | | | Ceiling and walls quite dry. | | |



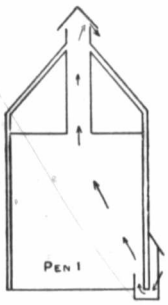



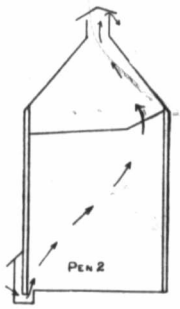
EXPERIMENT NO. 2, RUTHERFORD VS. MODIFIED RUTHERFORD SYSTEMS.

In this experiment the King system was closed up and the Rutherford put into operation in pen 1. The effect was noticeable in the much drier atmosphere, walls and ceiling. In pen 2 the same system as in experiment 1 was continued.

VENTILATION TABLE 2.

| Period 2. From Feb. 23, 1910, to March 8, 1910, inclusive. | Outside. | | Pen 1. | | | Pen 2. | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature. | | Temperature. | | | Temperature. | | |
| | Av. Max. | Av. Min. | Av. 7.30 a.m. | Av. Max. | Av. Min. | Av. 7.30 a.m. | Av. Max. | Av. Mn. |
| | ° | ° | ° | | ° | ° | ° | ° |
| Degrees Fahr. | 23·6 | 10·1 | 30·5 | 42·2 | 26·4 | 29·5 | 40·6 | 26·0 |
| Variation from outside. | ..... | ..... | ..... | 18·6 | 16·3 | ..... | 17·0 | 15·9 |
| No. of pigs in pen. | ..... | ..... | | 10 | | | 10 | |
| Remarks | ..... | ..... | Ceiling and walls dry. Pigs quite comfortable. | | | Ceiling and walls dry. Pigs comfortable. | | |



EXPERIMENT NO. 3, COMBINATION OF KING AND RUTHERFORD SYSTEMS.

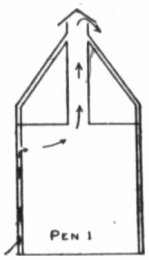
In this experiment trial was made of overhead currents entirely.

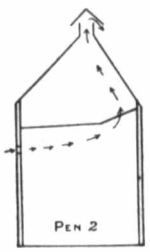
In pen 1.—The King inlet was combined with the Rutherford outlet.

In pen 2.—An opening through the wall near the ceiling let in a direct and unobstructed current of air. The outlet was kept as in experiments 1 and 2. The results were fairly satisfactory, the pen being kept somewhat colder than was liked.

VENTILATION TABLE 3.

| Period 3. From Mar. 9, 1910, to Mar. 15, 1910, inclusive. | Outside. | | Pen 1. | | | Pen 2. | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature. | | Temperature. | | | Temperature. | | |
| | Av. Max. | Av. Min. | Av. 7.30 a.m. | Av. Max. | Av. Min. | Av. 7.30 a.m. | Av. Max. | Av. Min. |
| | ° | ° | ° | ° | ° | ° | ° | ° |
| Degrees Fahr. | 30·2 | 15·5 | 32·2 | 43·8 | 29·7 | 29·8 | 41·2 | 28·2 |
| Variation from outside. | | | | 13.6 | 14·2 | | 11·0 | 12·7 |
| No. pigs in pen | | | | 10 | | | 10 | |
| Remarks | | | Walls and ceiling dry | | | Walls and ceiling dry. | | |



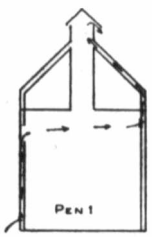
EXPERIMENT NO. 4, KING VS. COMBINATION OF RUTHERFORD AND PIERCED WALL SYSTEMS.

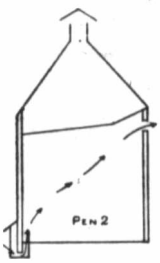
In this experiment the King system of ventilation was put into operation in pen 1, the upper outlet being opened instead of the lower.

In pen 2, the foul air was allowed a free outlet through direct opening in the wall. This was fairly satisfactory.

VENTILATION TABLE 4

| Period 4. From Mar. 16, 1910, to Mar. 29, 1910, inclusive. | Outside. | | Pen 1. | | | Pen 2. | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature. | | Temperature. | | | Temperature. | | |
| | Av. Max. | Av. Min. | Av. 7.30 a.m. | Av. Max. | Av. Min. | Av. 7.30 a.m. | Av. Max. | Av. Min. |
| | ° | ° | ° | ° | ° | ° | ° | ° |
| Degrees Fahr. | 32·1 | 20·4 | 36·6 | 47.8 | 31·0 | 33·0 | 43·7 | 32·5 |
| Variation from outside | ..... | ..... | ..... | 15·7 | 11·3 | ..... | 11·6 | 12·1 |
| No. pigs in pen | ..... | ..... | | 7 | | | 7 | |
| Remarks | ..... | ..... | Walls and ceiling fairly dry. | | | Walls and ceiling fairly dry | | |




CONCLUSIONS.

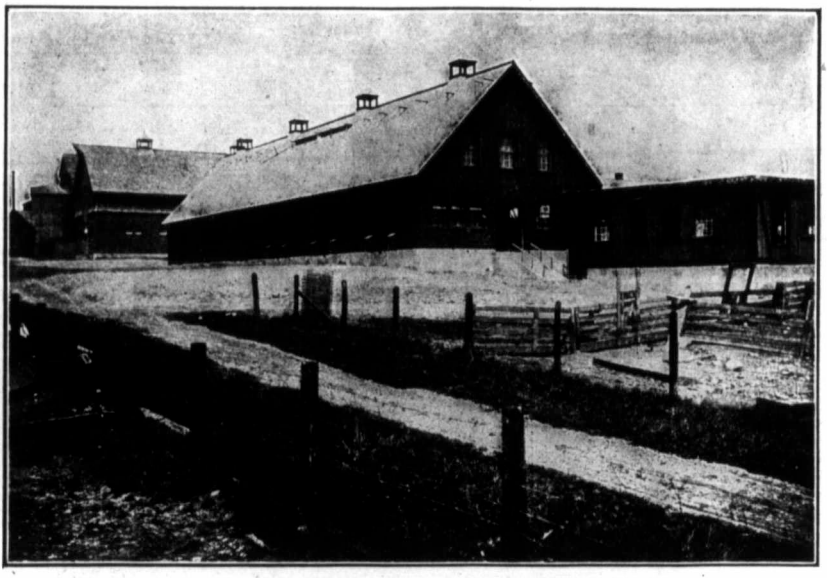
Not quite enough work has as yet been done to permit of absolute conclusions being drawn. In addition to the above experiments, however, various lots of young feeding pigs, sows with pigs and weaning pigs were kept in these pens during the winter, 1909-10. The two systems show in operation in experiment 2, as described above, were continuously retained in action. The results were uniformly satisfactory and would seem to point to either one or other of these two systems as being suitable for piggery ventilation in this latitude.

## A MODERN PIGGERY.

During the year 1910, a large modern piggery was erected at the Central Experimental Farm. As a result of the foregoing experiment, the Rutherford system, as illustrated in pen 1, experiment No. 2, was adopted.

### CONSTRUCTION OF VENTILATORS.

The fresh-air intake opens into the pens on either side of the central passage. Each intake is 9 inches by 18 inches and, being divided by the pen partition, gives



(Photo by F. T. Shutt)

View of main piggery, Central Experimental Farm, Ottawa.

NOTE.—(1) Light supplied to each pen; (2) Fresh air intakes, one for each pair of pens; (3) Caps on roof for foul air outlets.

each pen a 9-inch by 9-inch intake. These intakes in pens were raised to a height of 3 feet in the farrowing pens, to cut off all possible draughts from litters, but left at a height of 1 foot in the feeding pens.

The foul-air outlets, 16 inches square, start at the ceiling of piggery and extend straight to the ventilator cap on roof, as seen in Plate VI.

This system is giving excellent satisfaction.