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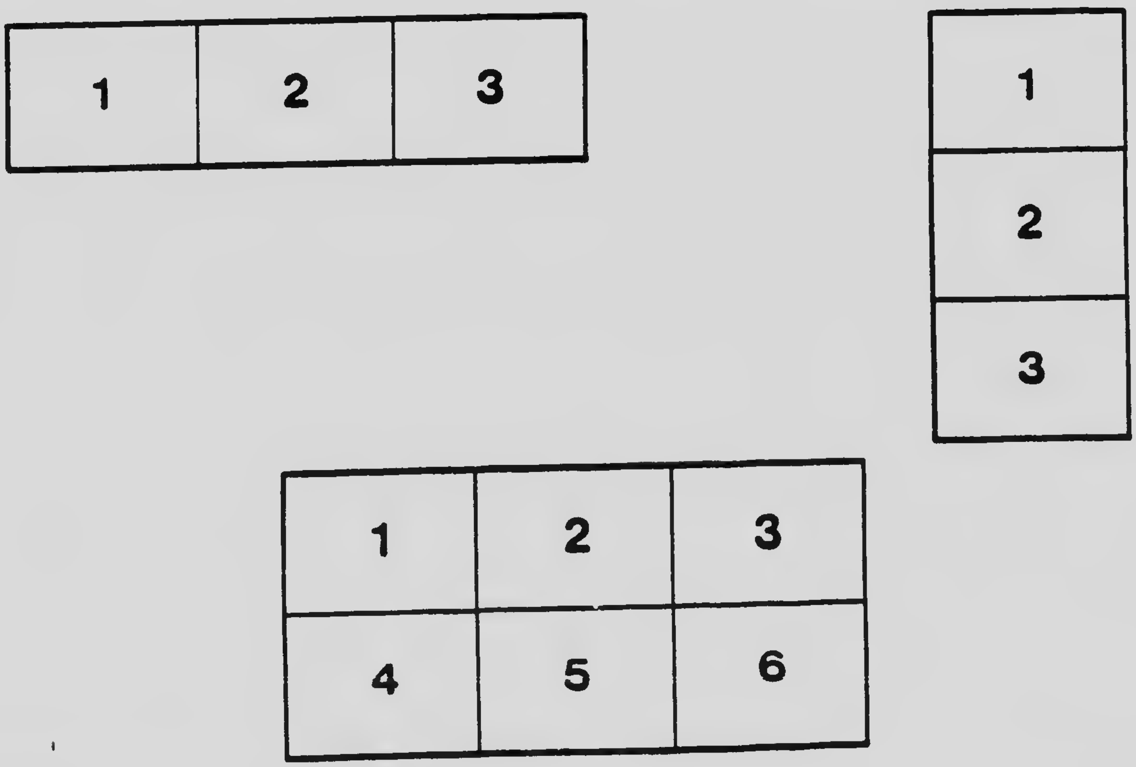
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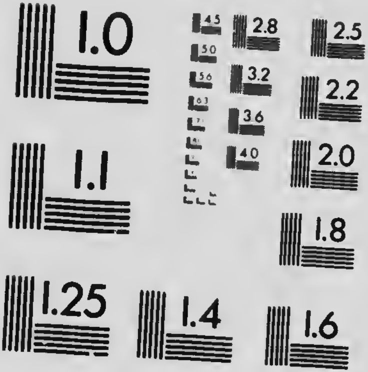

BULLETIN 4 MAY, 1911

Manitoba Agricultural College

Winnipeg - - Canada

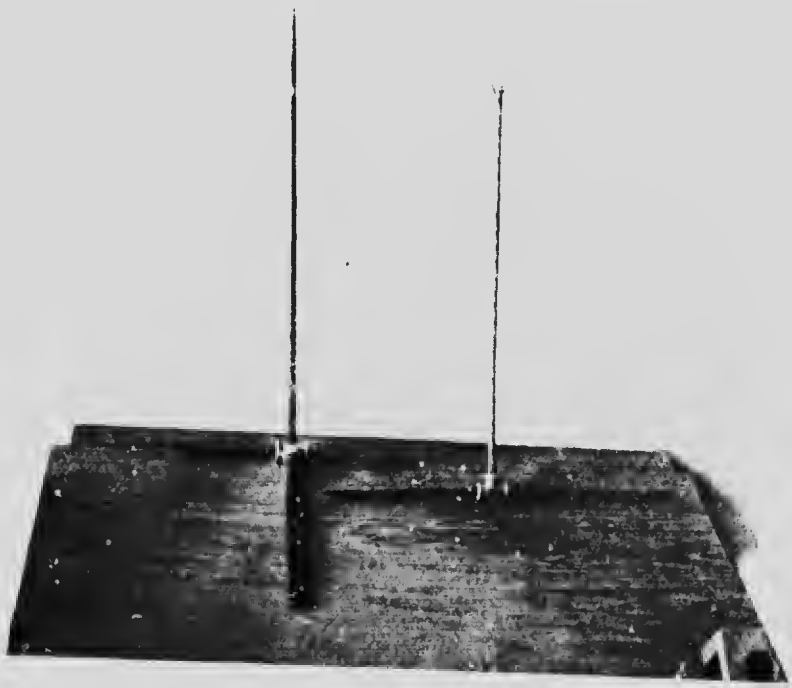

Figure 1

The Protection of Farm Buildings from Lightning

L. J. SMITH

Professor of Mechanics and Engineering

Published by authority of the Honourable R. P. Roblin, Minister of Agriculture.
Printed by Jas. Hooper, King's Printer for the Province of Manitoba.

LETTER OF TRANSMITTAL

MANITOBA AGRICULTURAL COLLEGE,
Winnipeg, Canada.
May, 1911.

To the
HON. R. P. ROBLIN,
Minister of Agriculture and Immigration,
Winnipeg, Man.

Sir.—I beg to present herewith bulletin No. 4 of Manitoba Agricultural College, "Protection of Farm Buildings from Lightning," by Prof. L. J. Smith. It is hoped that this publication will be of great interest and value to the farmers of Manitoba.

Yours very truly,

W. J. BLACK,
Principal.

THE PROTECTION OF FARM BUILDINGS FROM LIGHTNING

INTRODUCTION.

The subject of protecting buildings from lightning is one of growing interest to the farmers of Manitoba. Severe electric storms have done considerable damage to property and have been attended by some loss of life. Naturally, therefore, the farmer has begun to look for some means of preventing these losses.

Two questions are most commonly asked concerning this subject: first, is there any adequate system for protecting buildings from lightning, and second, if buildings can be protected from lightning, what is the most economic and substantial method of protection? This bulletin will discuss these questions as briefly and clearly as possible, explaining methods of protection and materials used, to the end that the farmer can put up his own lightning rods if he cares to do so.

PROTECTION FROM LIGHTNING.

It is an accepted fact that buildings can be adequately protected from lightning. The leading electrical and scientific authorities of the day are a unit in this matter. Electric railroads and telephone companies protect their equipment from lightning. Large factories and power plants protect their chimneys from danger from electrical discharges by use of points and grounds. It has been conclusively proven that buildings properly rodded and grounded with metallic conductors are protected from destruction from electric storms. Sometimes a discharge of lightning is so strong as to almost defy the laws of electricity, and some damage is done to parts of a protected building; but this damage is slight, as the metallic conductor handles enough of the discharge to afford protection from fire in these extreme and unusual cases.

EXPLANATION OF DISCHARGES OF LIGHTNING.

It is not the object of this bulletin to go into a detailed technical discussion of the phenomena of lightning, except whatever may be necessary for the understanding of the practical phases of protection from lightning. Generally speaking, there are two kinds of electricity, known for the want of better names as positive and negative electricity. One kind is not produced without also producing the other. These opposite kinds of electricity have a strong attraction for each other.

and when they meet, equal amounts of each are neutralized. If charges of these two kinds of electricity are some distance apart with a non-conducting medium, such as air, between them, the attraction between the two charges will exist, but the charges cannot meet and be neutralized unless some path of sufficient conductivity be offered.

If a metallic connection, such as iron or copper wire, be made between the two charges, the electricity would meet quietly and would be neutralized. Now if a metallic connection were made between these two opposite charges, except for an air gap for a small distance, the charges of electricity would break down the resistance of the air and jump the gap, making an electric spark if the voltage or electrical pressure of the charges were sufficiently high. To apply this explanation to a stroke of lightning, there is a negative charge of electricity in the earth and a positive charge in the cloud above the earth. These charges have an attraction for each other, the amount depending upon the voltage or electric pressure of the charges. The fact that air is a non-conductor of electricity prevents the charges from meeting under normal conditions, but at the time of a thunder storm, when the voltage of the charges becomes tremendously high or when the cloud comes sufficiently close to the earth, this electrical pressure is strong enough to overcome the resistance of the air and there is a stroke of lightning. This discharge naturally follows the path of least resistance, and if a tree or windmill or building or even a fence offers less resistance than the same distance of air, as they generally do, the lightning passes through the object on its way to the earth, and in this sense objects may be said to have an attraction for lightning. If these materials are good conductors of electricity, or in other words if they offer little resistance to the passage of the electricity, no damage is done, but if the resistance is high, as in the case of wooden structures, the discharge damages the material through which it passes, causing fire if the resistance is sufficiently high.

Water is a fairly good conductor of electricity. Often a wet building is struck by a comparatively weak stroke of lightning and no great amount of damage is done, but if the charge is large, fire is almost sure to result.

In some cases lightning overcomes the resistance of over a mile of air to reach the ground, and the charge of electricity necessary to do this is tremendous. The problem of protecting a building from damage by lightning is one of providing a good conductor of sufficient size to offer an ample path for the lightning should it pass down the building on its way to the earth. It seems impossible to calculate the size of a conductor necessary for the protection of buildings. This information is gotten from actual practice and experience along these lines.

DISCUSSION OF MATERIALS USED

THE CABLE OR CONDUCTOR.

Two materials are commonly used as conductors for carrying the lightning to the ground—iron or steel cable and woven or twisted copper cable. There was a time when copper was the only material used, but investigation and experience have proved that well galvanized iron or steel cable will answer the purpose just as well in every respect as copper. In fact, some of the highest authorities have advocated iron in preference to copper. In discussing this matter, A. J. Henry, Professor of Meteorology of the Weather Bureau, Washington, D.C., says: "While iron is not so good a conductor as copper, it is less likely to cause dangerous side flashes, and it also dissipates the energy of the lightning flash more effectively than does the copper." Sir Oliver Lodge, F.R.S., in reporting for the Lightning Research Committee of Great Britain, 1905, writes in regard to conductors as follows: "A lightning conductor of perfect conductivity, if struck, would deal with the energy in far too rapid and sudden a manner, and the result would be equivalent to an explosion. A conductor of moderate resistance, such as iron, would get rid of it in a slower and therefore much safer and quieter manner, though with too thin a wire there is a risk of fire." In the report of this committee, it says: "Iron is in many situations a very useful material for lightning rods. This metal, however, unfortunately oxidizes rapidly in towns and smokey districts, and the use of copper as a material is still recommended for main conductors in inaccessible positions." It is to be noted in the above that the committee does not discourage the use of well galvanized iron even in cities. Quoting Mr. Henry again: "Iron oxidizes rapidly when exposed to air; it is necessary, therefore, that it be galvanized."

The writer recommends 5-16 inch galvanized steel or iron strand for the conductor, or galvanized guy wire, as it is often called. The iron is preferable to the steel on account of its somewhat greater durability, though the steel cable is used by the telephone companies because of its greater strength, they figuring that the durability of steel is sufficiently great, twenty-five to thirty years being considered the minimum life of their cable located in cities. From this we may figure a much longer life for iron cable stretched loosely on buildings in the country, and not exposed to strain or danger of scraping off the galvanized surface. This durability can be increased indefinitely by a good coat of a common paint, which does not effect the efficiency of the conductor. In selecting cable, see that the galvanizing is free from cracks. The galvanizing can be easily tested by bending the cable sharply. If the galvanizing does not crack, it is good. This cable is made up of seven strands of solid galvanized wire about .11 of an inch thick. Be careful not to use the iron elevator cable which is composed of strands of ungalvanized wire, which are in turn made up of a number of still smaller iron wires. This cable is intended for inside work and will not weather. The 5-16 inch cable recommended costs from 1½ to 2 cents per running foot and weighs in the neighborhood of one-fifth of a pound per foot. It can be gotten from almost all the wholesale hardwares or builders' supply houses in Winnipeg and the price given should include the profits of the local hardware.

Some authorities advise a slightly smaller cable, but the above size given does not cost but a trifle more than the ¼-inch strand cable, and therefore one might better get the additional protection, if any is to be had, for the same expense. In this connection, the Weather Bureau at Washington, D.C., recommended No. 3 or No. 4 double galvanized telegraph wire, which sizes are about a quarter of an inch in diameter, No. 3 being a little larger than No. 4. This is also recommended by the writer if the wire is available. The German authorities recommend iron cable 8mm. in diameter, which is about five-sixteenths of an inch in our system of measurements, and copper cable one-half the cross sectional area of the iron cable.

In Hungary, as in other parts of Europe, the common barbed wire is used, and is said to afford satisfactory protection from lightning. The wire is strung and stapled over the chimney and outlines of the buildings, forming a cage-like covering which has proved to be an ample protection if properly grounded. While this system has not been used in this country, the recommendations coming from where it has been used leave no reason for doubt as to its value.

It is readily seen from the above discussion that even the most conservative cannot doubt but that the iron conductor is as good as, if not better than, copper for protection purposes except for durability. Even if any special value were attached to the fact that copper has six or seven times the conductivity of iron, it would be a small argument in favor of copper, since the length of the cable running over the barn is comparatively short. The resistance offered by copper to a discharge of lightning over such short lengths is almost nothing, and six or seven times that amount is too small to be worthy of consideration.

It might be inferred from the discussion as to the relative merits of copper and iron cable that copper is not effective as a protection from lightning. To clear up this point, it should be said that copper conductors have been used for years and have effectively protected buildings. The chief objection against copper is its high cost.

Method of Fastening Cable.

Cable should be fastened directly to the building by means of $1\frac{3}{4}$-inch galvanized fence wire staples, put in every two or three feet apart. It was once thought that the cable should be insulated from the building, but this has been found to be unnecessary. If the staples split the wood, it is well to have holes bored for them with a brace and gimlet bit.

Points.

Copper or iron points may be used. They should be strongly fastened vertically to the peak of the roof, not more than twenty feet apart. Points should be placed on cupolas and chimneys. It was once thought that points should extend quite high above the buildings, but this is no longer considered necessary. It is sufficient if the tips of the points are from twenty to thirty-six inches above the parts of the building upon which they are located; twenty inches above the chimney, and thirty-six inches above the peak when the point is on the ridge of the roof. The ends of the points should be sharp. This allows the negative electricity to pass off the point and become neutralized, preventing the building from a stroke of lightning if the electric charge gives sufficient time to become dissipated, and at least tending to lessen the strength of the stroke by making it cover a longer period of time. Figure 1 shows two points which can be readily and inexpensively made on almost any farm equipped with repair tools. Both points are fastened to the horizontal cable that runs along the peak of the roof by means of $\frac{3}{8}$-inch galvanized iron tees such as are used in ordinary pipe work, but the method of holding the points in a vertical position is different in each case. The point to the left is made of $\frac{3}{8}$-inch round iron; the upper end is drawn out at the forge and filed to a sharp point; the lower end has a few threads cut on it. The tee is drilled and tapped at the proper angle to tightly fit the threads on the lower end of the point, and the horizontal cable is passed through the tee, the point being screwed down tightly against the cable. The following method is used to hold the point in a vertical position: A piece of $\frac{1}{2}$-inch round iron, about ten inches long, is flattened out as shown in the figure and drilled and counter-sunk for three No. 10 screws. The upper end, which is left round, is threaded with a $\frac{3}{8}$-inch pipe die, so that it can be screwed into the galvanized tee. This piece of iron is fastened to the slope of the roof, as shown in Figure 6, and can be readily bent to hold the rod upright.

The point on the right (Fig. 1) is very simple in construction. It is a short piece of the five-sixteenth inch galvanized cable with four of the strands of the upper end spread and the other three twisted loosely, all the ends being sharply pointed with a file. The lower end is set in a $\frac{3}{8}$-inch galvanized tee in contact with the cable that passes through the tee, and is held in place by a $\frac{3}{8}$-inch set-screw (Fig. 2). The tee is drilled and tapped for two $\frac{3}{8}$-inch set-screws, one to hold the point and one to prevent the tee from working horizontally along the cable. Figure 2 illustrates the method of supporting the point. A short piece of 2×4 is sawed at one end to fit the ridge boards, and

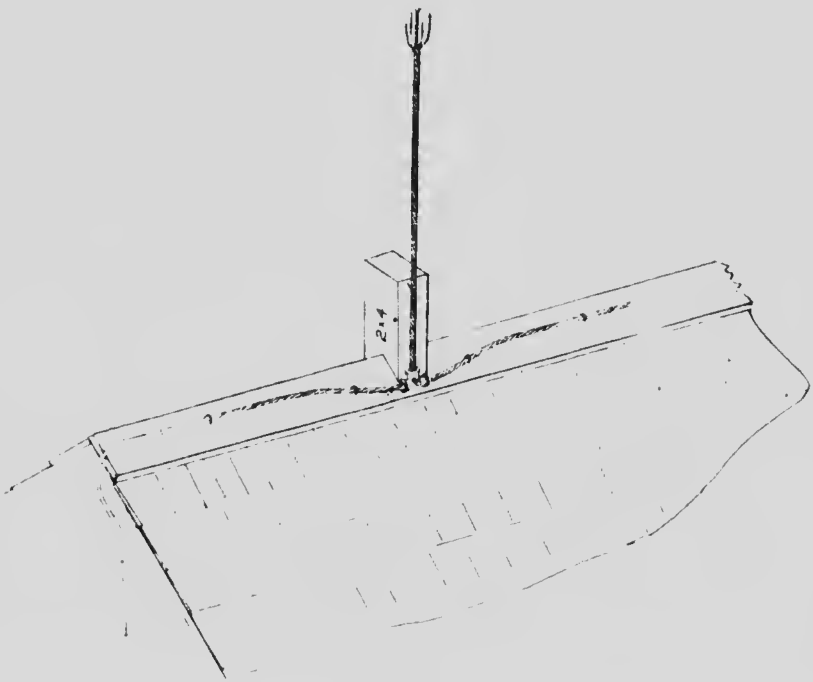

Figure 2

is toe-nailed securely to the peak of the roof, preferably plumbing the 2×4 to get it vertical. The point is run up along the edge of the 2×4, and is held securely in place by a staple. The illustration shows only one set screw in the tee. This point is very easy to put up. All that is necessary is the $\frac{3}{8}$-inch set-screws, three-quarters or one inch long, and the galvanized tees, which can be drilled and tapped for the set-screws in town if the tools are not available on the farm. A $\frac{3}{8}$-inch plug tap is the proper one for use, not a bolt tap, and the size drill is a full nine-thirty-seconds of an inch in diameter. The parts of the point not galvanized should be given two coats of aluminum paint.

Points for Chimneys.

It will be remembered that a column of hot air rising from the chimney offers an easier path for lightning than the surrounding medium. Then, too, the chimney is generally the highest part of the building. Because of these facts, the chimney is struck more often than any other part of the house. Figure 3 shows the method of pro-

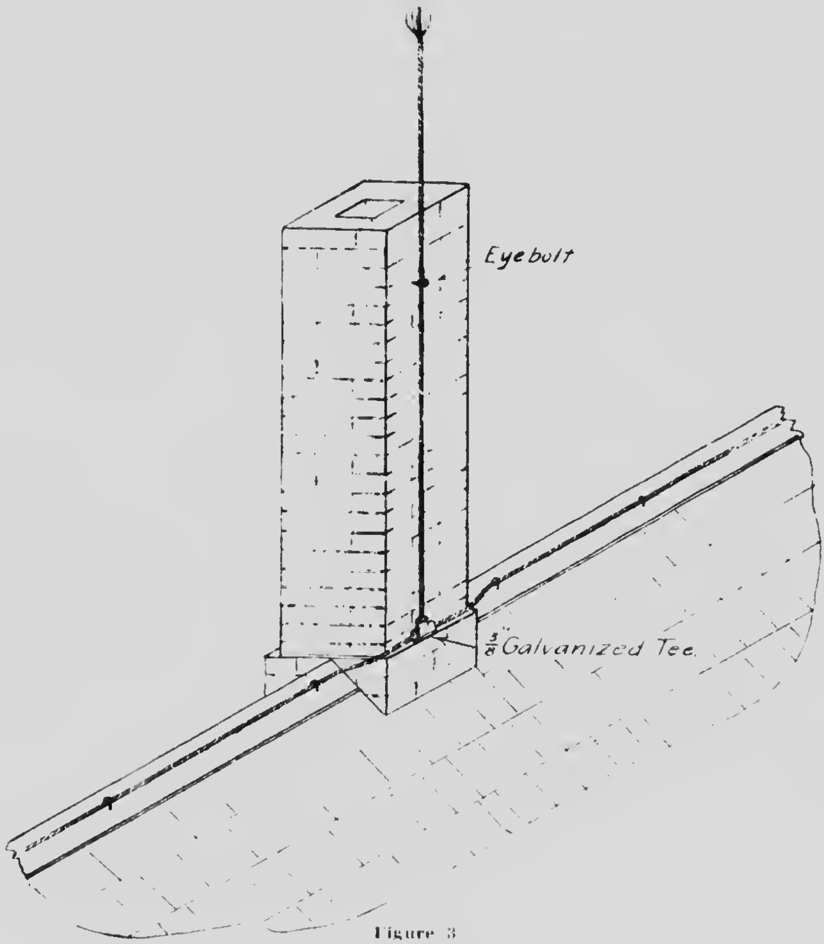

Figure 3

tecting the chimney, the point used being very similar to the one last explained. A ⅜-inch eye-bolt, made by cutting off the head from a common bolt and turning an eye on the end, is put through the chimney and fastened on the inside by a nut and washer. This supports the upper part of the point.

Grounds.

One of the most essential parts of a lightning-rod system is the selecting of a good connection between the conductor and permanently moist earth. The term used is "grounding" the conductor. The ideal condition is reached when the "ground" extends far enough below the surface of the earth to reach a permanent water-level, but this condition is not often attained except in low places or where a stratum of clay or hard pan keeps the water near the surface. A metallic connection put down seven or eight feet below the surface of the earth would reach permanently damp soil. If a building were properly rodded, with the exception of the grounds, the lightning would pass down the conductor to the point nearest the surface of the earth and then jump the gap to damp earth, making a heavy spark at that point which might set fire to the barn. Then, too, there would be danger of the lightning not entirely following the conductor and thus damaging the building.

Every building should have at least two grounds. A good rule is to allow one ground for every two points used. If a third or centre ground is necessary, it should be fastened to the horizontal cable at the peak of the roof by means of a galvanized tee and set-screws, as shown in Figure 6.

The iron conductor can be run off the side of the building directly into the ground to damp earth. Here is where the durability of copper wire makes it of value. The iron cable will be eaten away in time, even with the galvanizing, the length of time depending on the character of the soil, and if put in the ground, should be watched to see when it is about to give out. If iron grounds are used, a good plan would be to put in three pieces of the same cable in the ground under the same conditions and at the end of five years take one out, and the other two at still later periods, to learn the condition of the other grounds. Copper cable will remain in the ground indefinitely, and is recommended for "grounds." If the copper cable cannot be readily bought, the ordinary wire can be purchased and twisted into a cable. Seven strands of No. 14 or No. 16 wire would be sufficient. The conductor can be brought down to the earth's surface and then be either twisted around the iron cable and held securely in place by winding with fine wire, or the two cables can be slipped past each other in a piece of pipe having set screws as shown in Figure 6. After these set-screws are screwed down tightly, the joint may be made more perfect by filling the pipe with melted lead or babbitt metal. In case the cables are twisted together and wound, it would be well to have the joint protected by putting it into a piece of ½-inch pipe about two feet long and letting the pipe rest loosely on the ground. The joint could be examined at any time by sliding up the pipe.

Several methods can be used for putting down the "grounds." Sometimes an old auger is welded to a square rod and used to bore the hole. Often a piece of $^3/_4$-inch or 1-inch gas-pipe is hammered flat at one end like a chisel and is driven into the ground and pulled out again. Sometimes the earth is such that a post hole has to be dug, and then filled in again after putting down the cable.

Splicing the Cable.

If for any reason the cable has to be spliced, it can be quickly done, as shown in Figure 6, by means of a piece of $^3/_8$-inch galvanized pipe, about one foot long, drilled and tapped for four set-screws, one set being drilled "on the quarter" with the other set. The ends are inserted in the pipe until they meet at the middle, and are fastened by the set-screws; or, better still, the ends can be twisted together and fastened in a similar manner in a $^3/_4$-inch pipe.

Paint, etc.

All parts of the system not galvanized should be covered with two coats of aluminum paint. When painting or re-painting the building it is a good idea to paint the conductor also.

It is well to plug the galvanized tees with some waterproof material, preferably of a metallic nature. Lead or babbitt will do very well, but it is hard to get the melted liquid up on the roof. Putty is not bad, if well put in. There is a putty-like preparation on the market for stopping leaks in eaves that does very well. A metallic preparation used in the foundry called "Smooth On" makes a joint nearly as hard as cast iron. It is mixed with water to a plastic condition and applied, making a fine joint.

GENERAL DESCRIPTION OF RODDING A BUILDING

Let us now consider Figure 4 as an example of a barn, and discuss the general methods of putting up rods and cost of material, etc. The barn represented is 40×75 feet. The first thing to consider is the number of points. At a glance at the illustration, it is evident that a point should be put on each of the cupolas and one on each end of the barn; but that leaves a pretty long gap between cupolas. Putting a point there makes five in all, and if the end points are five or six feet from the ends of the roof, no points on the building could be over eighteen feet apart, which would be inside of the twenty-foot limit. Having decided on the number and location of points, the next thing to consider is the grounds. Allowing one ground to two points, two

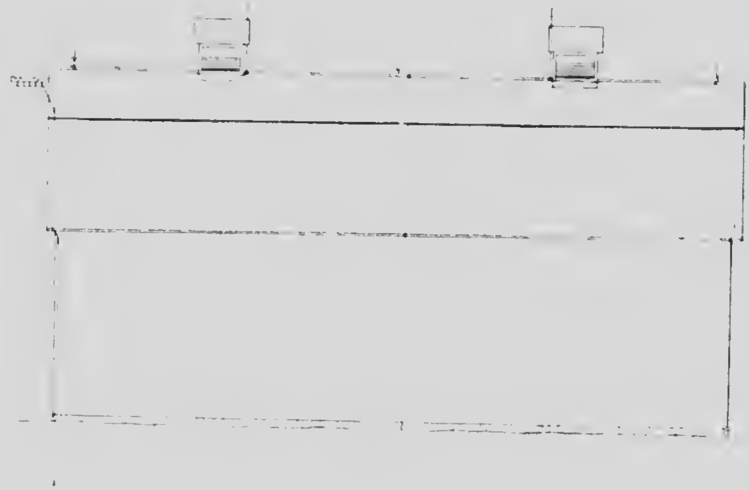

Figure 4

grounds are nearly sufficient, though the barn would be better protected with the three, which number we will decide on using. The next consideration is the location of grounds. Grounds should not be near doors or manure piles or small yards or paddocks, if any are adjacent to the barn for exercising stock.

Other conditions being satisfactory, grounds are best located at the corners where the eave pipes run the water to the earth, as the soil is sure to be wet at that point. Sometimes the conductors are carried

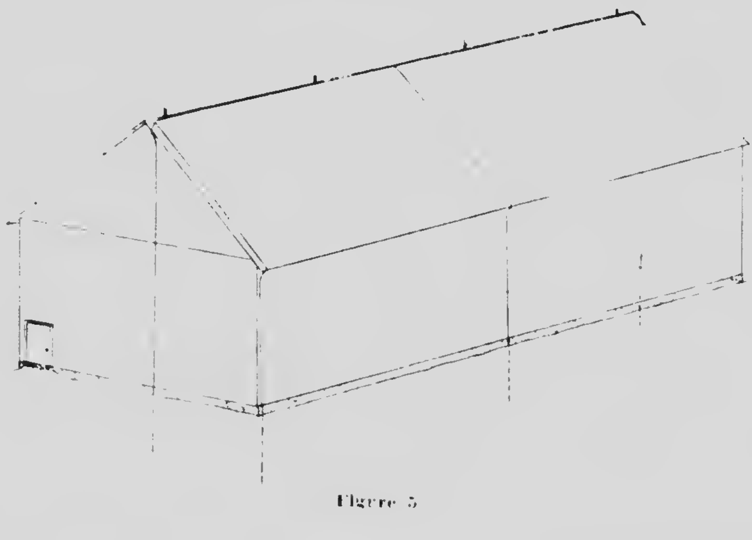

Figure 5

over the end of the roof and grounded at the centre of each end of the barn, as illustrated in Figure 5. This saves a little in the length of the cable, but is generally a little harder to staple. Another advantage of grounding at the corners is that there the rain gets the best chance to moisten the earth around the grounds.

The next thing is to figure the materials necessary. The length of cable is computed as follows:—

Rise to eaves	21	feet
Eaves to ridge	28	"
Length of barn	75	"
Ridge of eaves	28	"
Eaves to ground	21	"
Ground to ridge (centre ground cable)	19	"
Cable for points	24	"
Cable around cupolas	10	"
Total	256	feet

Staples every two feet call for 120 staples ($1\frac{3}{4}$ inches), or about two pounds. There will be one galvanized tee for each point and one for the centre ground—six in all—and two set screws for each tee. Allowing ten feet for each copper cable, the three grounds will use thirty feet of cable, or 210 feet of No. 11 wire, using seven strands to make up the cable. This wire weighs a little over .01 pounds per foot, making two and a quarter pounds of copper needed.

Having gotten together the material, the first thing is to run the cable from one corner ground up to the peak, along the ridge, and down the other corner, as shown in Figure 4, stapling it to the building as you go, and not forgetting to slide on the proper number of tees for points and grounds, and putting them at their proper places as the stapling is being done. Then put on the centre ground cable. The conductor being on the building, the points are next in order. If there is a 4×4 post at the end of the roof to support the bracing for the end of the hay track, the end point can be stapled up along side of it. A $\frac{3}{8}$-inch hole should be bored in the edge of the roof of the cupola and the point passed down through it and fastened into the tee. In passing the cable around the cupola, keep it at the same level as when on the roof. Figure 4 shows a connection with ordinary fence wire from a hay track bolt to the cable where it runs down the first slope of the gambrel roof. This grounds the track, so that if any electricity should come through the roof it would run along the track to the cable and on down to the ground. The eave trough should be in connection with the cable where it passes down over the roof to the side of the building.

The following is a detailed statement of the average cost of rodding the barn:—

256 ft. of five-sixteenth inch cable, at \$.01½.......	\$3.84
2 lbs. of 1¾-gal. staples, at \$.06.................	.12
6 ⅜-gal. tees, at \$.07...........................	.42
12 ⅜ set-screws, ¾ inches long, at \$.02............	.24
2¼ lbs. copper wire, No. 14, at \$.45..............	1.02
½ pt. can aluminum paint........................	.40
Labor: 2 men, 1 day.............................	

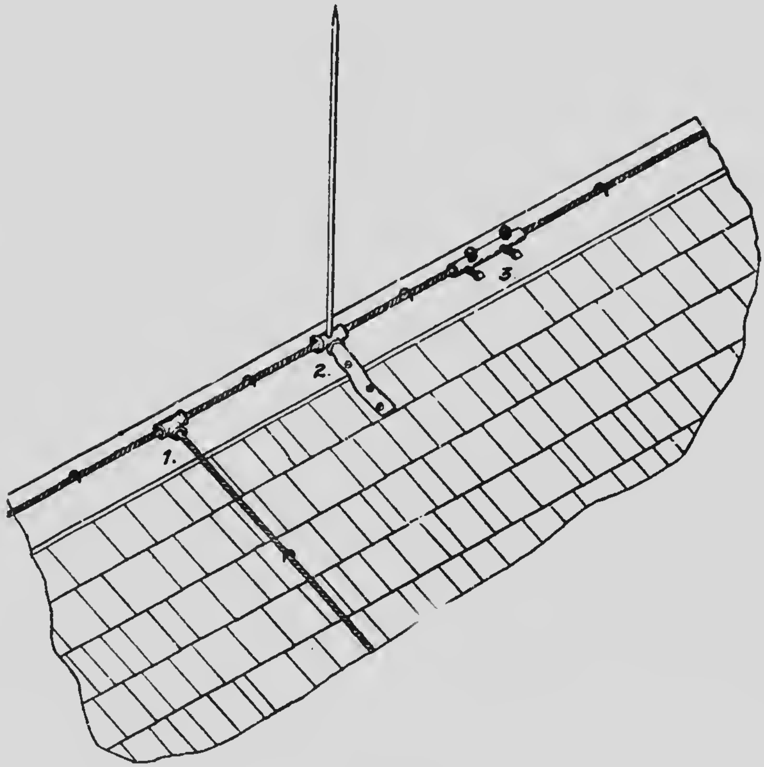

Figure 6

Metallic Roofs.

Buildings having metallic roofs need no points. All that is necessary is to ground the four corners with common heavy fence wire.

Grounding of Fences.

Wire fences should be grounded every sixth post to protect live stock in the fields from lightning where it strikes and runs along the fence wires. The method is simple and inexpensive. All that is needed is to force a ¼-inch round pointed rod down along the post to make a hole, and then put down a piece of heavy galvanized wire, going down about thirty inches. The wire should be long enough to reach the top of the post, and should be fastened to the horizontal fence wires with staples.

In conclusion, a word should be said about watching the lightning conductor system. Like everything else, it is apt to get out of repair and, like everything else, the sooner repaired the better. Do not allow the points to become bent, and see that the grounds and all connections are in good condition.

LIST OF BULLETINS

Prepared by Manitoba Agricultural College, Winnipeg, Canada.

No.	Date	Title	Author
1	May, 1910	Classification of Horses	W. H. Peters
2	June, 1910	Twelve Noxious Weeds....	S. A. Bedford C. H. Lee
3	May, 1911	Care of Milk and Cream..	J. W. Mitchell
4	May, 1911	The Protection of Farm Buildings from Lightning	L. J. Smith

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