R E M I N I S C E N C E S

of

EARLY ELECTRICAL DEVELOPMENT

an address by

HON. P. N. NUNN.

At the First Joint Meeting

of

THE UTAH SOCIETY OF ENGINEERS,
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Frank W. Otterstrom
Official Reporter

HON. F. H. NUNN.

Mr. Chairman and Gentlemen:

I want to say at the start that I recognize and appreciate the distinction which has been conferred on me, by this invitation, to address such an assembly of engineers, in the main. Of course, we recognize that the engineers are the "cream" of creation, but we dont often see quite such thick cream.

I feel as if Mr. Ashworth has been talking about me. It seems to me that he has told you a good deal, and I wish it were half true; but I ask you to remember that he was occupying a rather difficult position and that you will excuse him for some of the statements that he made. I wish to correct an impression which he may have given to some of those who are not otherwise informed as to the facts. It is true that in at least four States the name "Nunn" has been pretty well known and known in connection with matters which have met with general approval; but I want to say that most of the complimentary things and the particular esteem which attaches to the name do not belong to this Mr. Nunn. They are due to my brother, the late L. L. Nunn. Peace to his ashes! I was a side light. I was the younger brother, and I never had his nerve.

I am afraid that the reason why many a man with vision does not follow that vision and accomplish greater things is because of his love of the flesh-pots, as the expression goes, his love of ease and comfort and security.

I will tell you frankly that had the decisions all rested with me I should never have had the courage, the hardihood, the gambler's instinct and the nerve to have undertaken many things which my brother did. As I say, it is only fair for me to state, to those who do not know the facts, that I am not the one who has made the name well-known, even in Utah. I have been the engineer; he was the courage.

When I was given a copy of the program, I was a little surprised to find that the subject was to be "Early Electrical Development". I think Mr. Ashworth is a coming man. When he first spoke to me about this talk, it was to be of a few minutes duration-- a maximum of twenty minutes. Later he volunteered that more time might be given, and still later he put the minimum at an hour! (Laughter) The subject agreed upon was "Reminiscences". It is a relatively informal matter to reminisce, particularly with a few old friends who recall matters to your mind; but "Early Electrical Development" is a much more ambitious subject. I cant treat that. I dont know it. The subject is too big. The history of early electrical developments runs from the east of Europe to the Pacific Coast; and it involves the work of many men, others just as great and perhaps much greater than we have been. I can only speak, at this time at least, of personal experience and observation. If one should attempt to do justice to the larger subjects he would want years and volumes; not just an hour; and, certainly, I can say more than I know in an hour, or rather I could say all I know in less than an hour. The subject will have to stand as "Reminiscences".

Mr. Ashworth opened the conversation with this remark: "The younger generation does not appreciate what the older generation was 'up against'". Well, just what do we mean by this generation and the older generation? Since the younger generation, the present generation, is presumed to be told some of the things that the older generation was up against, I take it that I will be that older generation, and as such I feel rather flattered. But, seriously, what is the difference? What has happened between the time of the older generation and the present generation? What were the conditions forty years ago?

Forty years is not so long, for an old man, you know. It is just thirty years this spring since I first visited Salt Lake City, and Salt Lake City then was not what it is today. The site of this building was a wood-pile, if I remember correctly. Perhaps you remember the Telluride Block. I think it is right out on this street, isn't it? That looks like a pretty insignificant little place now. It was one of the important buildings in Salt Lake thirty-five years ago when it was built. I think I am correct in saying that the first time I visited Salt Lake, there was just one block of pavement in the city; and in the Spring the rest of the streets were somewhere between 21-1/2 and 27 inches deep in mud. The "Busy Corner" had the distinction of having planks laid at the crossings, and some of the planks were not very well laid; so the mud was over them. I remember seeing a couple of very dainty ladies trying to cross. The plank tipped up, and they went in the mud. They were in a good way.

Professionally, what is the change in the situation in those years? The General Electric had not been born. The constituent companies, of which the General Electric was later formed, were "pretty small potatoes". The Thompson-Houston Electric, one of the larger companies of those days, perhaps the largest, was a couple of rooms of workshop, operated by a couple of college professors in Lynn. The Weston Electric Company, not the present Weston but a predecessor of the same name, had a force of about fifteen men, among which, in overalls and gum-boots was Maxim, the great Maxim of gun fame of to-day. He was a great big, square-shouldered fellow, working side by side with Kelly, the man whose name later appears with Stanley and Chesney in the S. K. C. Company of Pittsburg, later also taken over by the General Electric. Steinmetz had just landed in this country and had gotten a job as a draftsman at $75.00 a month, over in Jersey. Mr. Mitchell, the "big chief" to a pretty large sprinkling of you, here, had just taken a job, and it was a job as a green salesman, to go out in the wild and woolly Northwest and inveigle the rurals into buying arc machines and arc lamps. In those days, an arc machine which would operate three arc lamps in a series was a dandy. Most of them would operate only two. Will Stanley, the man who later headed the S. K. C. Company, the inventor and patentee of the transformer, was not worth a ten dollar bill. He had been tending a buffing machine in Bridgeport, Connecticut. He had conceived certain notions. He had been reading. He was always a reader, and had just then succeeded in raising enough money to run a three-mile line of small wire between his aunt's home in the suburbs of Great Barrington, Massachusetts, and the Post Office. He had actually transmitted enough "juice" to run an incandescent lamp. Those were the first transformers. He and an associate immediately took patents and, later, sought patents in foreign countries; but, just one jump ahead of them were two men, and they got patents in foreign lands under the name of Gaylord. The Gaylord patents were in litigation in foreign countries for many years, because these patents abroad had been gotten before the American patents were granted. The issuance of the foreign patents to Gaylord was a large factor in the contest over the American transformer patents; and the court records for fifteen years were full of that expression "the Gaylord patents." It was one of the familiar expressions in the technical press, the very early "Electrical World" and such publications, which told of the fight that was being carried on. Of course, Stanley had money behind him. I dont remember who. I think, George Westinghouse. At all events, after the American patents were sustained, George Westinghouse purchased the rights under them, and Will Stanley became his chief engineer. Then Nikola Tesla— Few of you know his name to-day, because he has not been much before the public. He was a great technical man, the forerunner of Steinmetz. It is probable that he was a greater mathematician than Steinmetz; but he could think only in mathematics, where Steinmetz could visualize what he had calculated. Tesla is remembered to-day, principally, because of the Tesla motor. Few of you, perhaps, attach that name to the every-day polyphase motor which you handle, buy and sell, and operate without a thought; but, fundamentally, all induction type alternating motors are Tesla motors, made under the original Tesla patents.

I am not sure whether Tesla is still alive. I think he is. He was a few years ago— a rather familiar figure around one of the big New York hotels. He followed Stanley as the chief engineer of the Westinghouse Company.

What was the Westinghouse Company forty years ago? Two big rooms in the works of the Westinghouse Machine Company, down on Garrison Alley, in Pittsburg. They could not make their own castings. They had to send out patterns and have those made by foundries. Rather "small potatoes" in comparison to these days, were they not?

There was one university, or college, in the United States which had a course in Electrical Engineering. It had just been established— Ohio State. I am not sure that

I am correct, but I think I am. I know of only that one. The other colleges of this country taught a little electricity in advanced physics. It was "heat, light and electricity"-- the three subjects in advanced physics.

The Westinghouse Company, in '88, I believe, acquired the services of a bunch of Ohio State boys who had just completed their electrical engineering course-- Lamme, the man who died recently; C. F. Scott, professor of electrical engineering at Yale, now; Mershon, the international transmission expert; and Shallenberger, the inventor of the first integrating meter, the Shallenberger meter which, in its day, was the only meter recognized in the United States.

These were the conditions forty years ago. There were a few men, such as I have spoken of, who undoubtedly understood the principles of electricity very well, but the language that they talked was a foreign language to the ordinary, intelligent man interested in the subject, just as the "lingo" talked by your grammer school kids to-day, who make radio outfits, is like dead Greek to father and mother. I dont suppose that there were, between the Mississippi river and the Pacific Coast, twenty men who knew what E. C. Cosine Ø stood for. It was part of that secret language which pertained to a few fellows "back East". The sign of frequency did not appear in the press for years after that; and if an engineer had put it in his specifications the lawyers would have marked it out, thinking he had made a mistake, or that his pencil had slipped. We never heard of frequency. We did not hear of cycles per second. The talk was alternations per minute. I wonder how many of you have ever seen a plant operated at 16,000 alternations per minute? Yet that was standard in the 90's. How many cycles per second is that-- you rapid calculators?

Mr. Ashworth: About 133.

Mr. Nunn: And a third. (Laughter) Why 16,000 alternations per minute? No reason, only it just happened to come that way. It is a different language from that which we speak today. It had not occurred at that time; people were not thinking in those terms; they did not know. It was the darkness instead of the light. In comparing this day with that, I might say, as I said a minute ago, that the average grammar school kid today is absorbing through his "hide" more true scientific point-of-view and knowledge than his grandfather ever possessed; and he absorbs it. How, I do not know. How he gets it I do not know. But, look at your news-stands almost anywhere. You can find there from five to fifteen more or less scientific magazines. Some of them are very poor, but so far as they are magazines they are scientific. Every reputable magazine has a scientific department. Twenty years ago there was just one scientific periodical in this country-- the Scientific American. Today there are scores, and even your daily press has a scientific department. Some daily papers have no more than a part given in the Sunday edition; others have it every day; but when a great thinker developes a theory or reads a paper, upon a new theory, like one that was read about two or three weeks ago, in France, we read in our morning paper, the very next morning, the high points of his discovery or his contention, and within a week the man on the street has an opinion, a personal opinion, as to its accuracy or inaccuracy.

The difference between forty years ago and now is the difference between the dawn, before the sunrise, and the mid-day light. You are living in the high noon of light, whereas we, your predecessors, of the last generation, were feeling our way in the semi-light in which we could see just far enough ahead to take another step, and that is all.

Thirty-seven years ago there convened at Niagara Falls an international commission, composed presumably of the ablest scientists in the world, to discuss a great problem. Millions of dollars had been subscribed to an undertaking at Niagara Falls-- the development of power from the water. I suppose that most of you have seen around in the country districts of Utah, somewhere, the remnants of a little old water power. I remember there used to be one at Provo. There was one at Ogden. There was one between here and Ogden. It was a small affair, just a little water power, the only kind of water power that we had in this country. There were only two points in the United States where water power was recognized to any larger degree than that. That was at Lowell, Massachusetts, and Holyoke; Lowell, the great center of looms; and Holyoke the paper-producing center. The idea of developing water power had just taken hold; and here was a great enterprise. Mr. Chauncey Depew was in it clear up to his neck. I have forgotten how much he put into that project. The Commission was sitting at Niagara Falls for the purpose of deciding how to transmit the power developed from the water-wheels of Niagara Falls to Buffalo, a distance of between twenty-five and thirty miles; and the alternative proposals were: wire rope drive, compressed air, liquid air, circulating oil and electricity (Laughter). That was in 1890; and electricity was very much in doubt. Somebody calculated the amount of copper which it would take to convey 20,000 horse power that distance. Of course our D. C. was limited, as it practically is today, to five hundred or six hundred volts. To-morrow, when you think of it, stop and calculate that yourselves, even in this day when we are producing one hundred times as much copper as we were then. It is an appalling figure; so appalling that electricity was not considered a promising means of transmission. Why? Because alternating current had not arrived. They did not know anything about it. They did ultimately decide to use alternating current. They probably would not have done so if Stanley had been born a few years later, because alternating current is absolutely dependant upon the transformer. There is no other purpose in the use of alternating current in the transmission of power.

It was about that time that the concern which had employed my brother, as its counsel, struck it rich in a little mine above timberline in the San Juan country of Colorado. It was away above timberline, hence above the line of fuel. To transport coal to that point would have cost $40.00 a ton, perhaps $50.00. A mill was necessary, and power was necessary to drive the mill. My brother wrote to me and asked how we could utilize a mountain stream, three miles away, to furnish power for that mill. That was the beginning of the first hydro-electric power transmission in the United States if not in the world. There may be some question about the world.

Doctor Mengarini built his famous transmission from the mountains east of Rome into Rome, about that time. He has published a large memorial volume, full of very beautifully engraved plates, illustrating the first plant that was installed there. In that memorial volume he speaks of it as the first in the world. The first time that I saw him was in his office in Rome; and my friend Matsoleni, reading over the first few lines of this memorial volume, stated that Doctor Mengarini claimed that plant was the first in the world. I happened to have with me a copy of a paper which I read before the International Electrical Congress in Saint Louis, presenting the facts regarding the pioneer work of the Telluride Power Company. The Doctor glanced at it. He read English very well. He took this large volume and inscribed something on the front page, which my friend Matsoleni interpreted to me as equivalent to the expression: "I take off my hat to you;" and then gave me the volume. I had to pack it all over Europe and then bring it home (Laughter). I still have it, and I am looking for a museum, somewhere, to which to contribute it. I dont know which was thought first. He started his work before we started ours, but he was not such a fast worker. We actually got into operation some six months before he did. So there may be a question about the first in the world.

Our plant sounds pretty insignificant nowadays. Your local company, here, is operating single units which produce more power than a string of ours, a mile long, would have produced; and they think nothing of it. But there is a difference in location, too. Our machines were big enough to pack where we had to take them.

I have the honor of belonging to all three of the older national societies, and it is a recognized point in the ethics of the technical societies that papers and public speakers should avoid using the big "I". I have always tried to follow that rule; but I dont know that I can do so to-night, since this is to be a talk on reminiscenses. So if I seem to use the first person pronoun too frequently, please pardon me. I must speak of that early plant in Telluride, for a little while.

This is intended to represent the switchboard. It was beautifully made, of oak, 2 x 4's and 1 x 3's, the oak being paraffined. We had a very oppressive sense of the awfulness of high voltage. These are the uprights. They are connected by the cross strips. Upon this board there had been erected a couple of instruments. I will show you, in a moment, what those instruments looked like, more intimately.

In the center of the board is a circuit breaker. That is what its function was, though you would not recognize it as such. There were no circuit breakers. There was not much need for them. Still, in our case there had to be one. This is the product of the Westinghouse Electric Company. It was the Westinghouse Electric Company in that day.

This is the circuit breaker. It is automatic only in the sense that when a man wanted to operate it he might faint and pull the plug out. (Laughter) Otherwise it was manually operated. The plug was an affair about that long, with a paraffined wooden handle and a protecting disc of hard rubber on it, so the hand would not slip on to the bare copper at the end. There was a sort of receptacle that pinched down on it, so as to make good contact and keep it from falling out. When the circuit was to be broken, with the power on, the operator took hold of it and pulled Fig. 1

it out. Perfectly simple. (Laughter). But it was usual that the circuit had to be broken when a motor had just dropped out of step; and anticipating what I will try to explain later, you will understand what a synchronous motor out of step will mean in the lag of the current tenacity of the arc.

The flexible conductor was made six feet long, to give plenty of room. As the size of the units became somewhat larger the cord proved too short; so it had to be extended to eight feet. You can imagine, I fancy, how you would feel, in pulling out a plug like that, running back eight feet, and find the arc still holding. (Laughter). That was unusual. The technique of the situation was to wiggle the plug and get it out. (Laughter). If that did not work, a cap or a hat was used to fan it out. (Laughter). I dont remember that it ever occurred that the operator failed to get it broken, in some way; but I do remember a careless operator pulling the plug, letting it swing by his leg. He got off pretty well, but it cost him a new pair of trousers. (Laughter).

A single pole switch was used here to close the circuit; the circuit breaker to open it.

These are lightning arresters. This affair which looks like the manual of a pipe-organ was the reostat. It was full of fence-wire, curled up. (Laughter).

You are accustomed to good looking instruments which measure accurately and which are portable. If they get out of order you send them back to the factory. Probably most of your portable instruments are still made either by the General Electric (which was not in existence then) or by the Weston Company. The Weston Company has always made the portable and laboratory instruments.

This is one of the first instruments. It is a little bit enlarged, but not very much. It is a good looking black walnut box, with some window glass in front of it. Inside is something constructed like an assayer's balance. On one end of the balance is a bundle of loose iron wires. On the other end is the counter-weight; and the telltale swings back and forth on a scale down here. For alternating current that is the rudimentary instrument. Theoretically it is correct. The only difficulty lies in the losses set up in the iron core, and they were not great. But if anything happened to tip the instrument or to shake the switchboard, of course the calibration was all off. We did not know much about calibration in those days. We set up a thing that we thought was right, and then took as gospel truth whatever it said. Fig. 2

The only difference between volt meter and ammeter lay in the winding of the solenoid and the addition, back of the instrument, of a supplementary resistance. A watt meter? We had none. We did not need any. We did not know what watts were, and we would not have known what to do with them. (Laughter). That is literally a fact. During the early days of alternating-current work, volt amperes were a measure of power; and if anything happened so that the power did not get into the volt amperes-- well, that must be the manufacture's fault; nothing to do with us. Nobody raised any questions, and nobody answered any. (Laughter).

That is an improved form of instrument, either volt meter or ammeter, a form put out, I think, by the Weston Company. The difference lies in this, that it is a little more delicate. It does not require as much energy to operate it, and therefore the core may be small. The core is merely a piece of iron wire, bent into the arc of a circle and working in a solenoid, also formed as an arc of a circle. Fig.3

A good many of these old instruments were to be seen around the country, even fifteen or twenty years ago. They were not half bad so long as the central spring retained its characteristics. (Laughter). Of course it all remained in the spring.

When I look at the expensive glass plates which you build in your power houses now, and through which the conductors lead in or out, I think sometimes of our early efforts. The only thing we had to use in the way of a wall bushing was a piece of glass tubing cut to the requisite lengths and prepared by heating and bending the ends over. Through that we ran a piece of wire, insulated as well as might be. Fig.4

You are very familiar with high-grade insulated wire. You now have conductors good for twenty or thirty thousand volts; in fact, I recently saw a piece of rubber-covered conductor tested up to sixty thousand volts; and it was not any larger than some wire we used to have and called good for ten. Back in those days there was just one concern in the United States which pretended to make a rubber-covered wire that would stand more than one hundred volts; that is, there was just one concern that made high-voltage wire, and that was Clark; but there were two manufacturers -- Okonite and Habirshaw, which made house-wiring wire good for one hundred volts. That was rubber-covered, even then, but they would guarantee that only for one hundred volts, because standard voltage for house-wiring in those days was fifty-two volts.

There was one concern in Cambridge or Boston, Massachusetts, which made a very high grade of wire, a very fine wire; but the electrical manufacturers could not afford to use much of it, though in special places they would use it. It was known as Clark wire; and when one wanted something especially fine for an experimental laboratory, or in the construction of machines, he would go to the extravagant length of using Clark wire. Clark wire was built in a little old shack of a place, under the supervision of this man Clark. Peace to his ashes! He has gone, long before this. He did not know anything about rubber. He did not know anything about business. He had been a farmer; but he had loaned some money to a man who had been making some kind of a rubber product, and he had to take over the works to get his money out of it. He had in his employ a big buck darkey who had learned, somewhere, to handle rubber; and this big buck darkey, as foreman of his shop-- a shop of about ten hands-- was turning out Clark wire. It had no braided covering, but it had pure rubber insulation. Compare that with the product which the General Electric furnishes us now for any purpose, from underground cable, or underwater cable, to insulation and the highest grade of wire which we may use for any purpose whatever. We have all varieties.

Referring to the circuit-breaker, Fig. 1 that loop of conductor hanging down there was considered a rather formidable sort of thing to be so familiarly hanging in sight where it can be touched. So, in addition to a piece of Clark wire it had slipped over it a piece of ordinary rubber tubing. It was a pretty good tubing, it is true; but how much do you suppose that tubing would stand electrically? I haven't an idea, but I doubt very much whether it was good for five hundred volts; but that was the best we knew and the best the Westinghouse people then knew, at the time when that great commission was sitting at Niagara Falls, discussing this grave question of the best means to transmit the power to Buffalo, whether by wire rope or by electricity.

We had faced our little problem in the mountains of Colorado. We did not have the money for a commission. We did not want the commission, anyhow. We were not built that way; but we used our best judgment and made our best guess.

Continuous current for our transmission, or D. C. as it was then known, entirely, was estimated to require $33,000.00 of copper for the transmission. That estimate was made by the man who had the reputation of being the wisest "guy", on that sort of thing, in the United States-- Mr. Ayer, Chief Engineer of the Electric Railway system of Saint Louis. I might say that he was not as big as it sounds; that is, the Electric Railway System of Saint Louis was not as big at the time as the name might imply. It would not strike you now as being very much. I think they had six or eight cars; but they did move by electricity-- when they moved. (Laughter).

The $33,000.00 looked pretty big to us. We had it, but it was about all we did have; and we did not want to put it into copper. We would not have had anything left with which to buy our apparatus. We decided to accept a proposal made by the Westinghouse Company to put in alternating current apparatus, and give it a trial. Now, alternating current had no motor. What were we going to do? That question was asked of us, and we were laughed at, for presuming to use alternating current, when we had no motor.

I wonder how many of you appreciate the process through which the induction motor of to-day has gone and what its origin was. You might find it interesting. You know, the problem of a motor to operate by alternating current was approached from the angle of experience with D. C. In D. C. you, in effect, split a circuit into two, carrying one circuit to the field and the other to the rotor through a commutator, by which the rotor is kept in step. But, they said, you cant commutate alternating current successfully; so how could alternating current be used for this purpose?

The alternating current motor of today is attributed to the mathematical imagination of Nikola Tesla. I will try to tell you something, not of the technical process but the point of view, the angle, from which the problem was approached.

Those who are electrical engineers will recognize the familiar phase curves above. Below, we have a rough representation of an eight-pole machine, or what it is intended to be is a four-pole machine similar to the way in which D. C. machines are now frequently made. Fig.5

The exterior of an early D. C. machine produced a magnetic field in which the interior, or rotating portion revolved. The point of view from which the problem was attacked was this: If alternating current, applied to four poles, produces an alternating magnetic field, then between such a time as that and that of a cycle, two adjacent poles will reverse their polarity, or rather each pole will reverse its polarity; and if this pole be between a positive, at this time, then at that time this pole will be a positive. In other words, while the alternating current produces alternating magnetization, it is progressive in the sense that a positive magnetization here at one-half of a cycle becomes a positive here at the next half. Tesla reasoned that the solution of the problem lay in rotating the magnetic field. In D. C. the magnetic field is stationary; and the rotating portion is driven by the effect of the commutator. Tesla reasoned that in alternating current you have that rotation. You do not need any commutator, and you can't use it anyhow. Therefore the magnetic field should not be made to rotate, and drag the rotor around with it. If, now, a second phase be employed, like this, and that phase, that is, another circuit, a second circuit in that circuit, be used to magnetize the intermediate coils, as the positive magnetization of this coil, we will say, reduces, the positive magnetization of the next one rises; so that the positive magnetization of this coil is moved over to that, and you have the start of a rotating magnetic field. That is, essentially, the fundamental fact of the induction motor of to-day. There are other problems in the interior rotor, between the squirrel-cage winding and various others; but this is the fundamental difficulty met in the development of the alternating motor.

Now, two phases meant two circuits, four wires;

and they could not believe that the young giants of electricity could stand the handicap of four wires to a circuit, being accustomed to a two-wire circuit, only. It is a rather strange thing that for ten long years the business of electricity balked at the use of more than two wires in a circuit.

Therefore, Tesla's whole effort, his dream, his vision was of the second phase being produced by splitting the fundamental phase. In other words, he wanted to take a single circuit of alternating current, and by splitting it into two circuits and introducing into one of them a combination of inductance and capacity, to shift the phase of the current back approximately 90 degrees. He never succeeded in doing it. I think some of you will understand why. You may shift the phase of the current by the addition of capacity and inductance, but we have never yet learned how to shift back the actual watts or energy of the circuit. The watts will remain in their fundamental relation.

Over there in the window is a bit of a curiosity. It has been, for twenty years, stowed out of the way, where it cost nothing to keep it. It is one of the little motors with which Nikola Tesla labored with his own hands. When it was given me, twenty years ago, I was told that he probably worked on it steadily for several months before giving it up. The end plates were taken off frequently and the windings changed in the experimental work. Even the core was removed and a number of new cores put on. It is merely a good, old piece to put in the museum somewhere; but it is a relic of a day which will never come again. It is a day which will be of great interest to the future historian who will write of the development of the science.

I want to say another word before leaving the motor. We had a simple, single transmission. We were interested in driving just one mill. Therefore, our apparatus consisted of two identical machines, nominally one-hundred horse. It sounds a little funny now—— one hundred horse-power generator, one hundred horse-power motor. We still say horse-power for motor; but then it was horse-power for generator. Why? As I explained, a minute or two ago, we did not know what kilowatts were. We had not made their acquaintance, yet. So everything was in horse-power.

These two machines were operated at the opposite ends of the transmission; one driven by a Pelton water wheel and the other driving the mill. They were identical, interchangeable, and twelve-pole, iron-clad, tee-tooth armatures—— an invention of his Satanic majesty. (Laughter). You dont see them any more. The reason is that generators will break down, once in a while; and when they do, you want some chance to repair the winding, some chance to put in a new coil. It is practically an impossibility with a tee-tooth machine; because the coils must be wound at the factory. They are highly insulated, and it is practically impossible to get them into a machine without so distorting them as to break the insulation.

We had no transformers because, without commutators, it was possible to generate at a sufficiently high voltage for our purpose, three thousand volts; and that voltage was handled directly on the machine. It was rather nervy. It was three thousand volts that we broke with the automatic circuit-breaker. (Laughter).

Ours was a great country for lightning and a great location for lightning. One point was at an altitude of nearly thirteen thousand feet; the other at an altitude of seven thousand feet. That difference in altitude has a bearing on the atmospheric disturbance. We did not know it was atmospheric disturbance, in those days. That term had not been invented. With us it was just plain lightning, (Laughter); but it came along with great frequency; I might almost say with great regularity, when we were using the original equipment. We did not have anything like these recent lightning arresters.

Do you see anything about that that looks like a lightning arrester? It was a marble box of that shape, with two holes in it, through which pick-axes dropped. The points of the pick were equipped with pieces of arc-lamp carbon. The theory is very simple-- beautifully simple. The explosion of the discharge would kick out the pick-axe and break the arc. (Laughter) Of course it may have had some bearing that there would not be any explosion till there Fig.6

was an arc, and there would not be any arc till the pick-axe lifted. It may have worked sometime when we did not know it. (laughter) Lightning was the bane of our existence. After replacing the generator coils a few times we had a very fine motive for avoiding their breakdown. We took up our generator and motor and placed under them insulating platforms made of 4 x 4 oak pieces, boiled in paraffin.

I have been told a great many times that you cant paraffin oak. You cant paraffin any wood. You can only plaster the paraffin on the outside; but you cant drive it in. We had to drive it in. So our situation was that of the elephant. You have heard the old question: "When does the elephant climb a tree?" "When he has to." We discovered that by running paraffin at a little above the boiling point of water, for twenty-four hours, we could drive out the water vapor from the sticks; and after driving out the water vapor, the other vapors which followed were condensable, and would condense when chilled. Therefore we kept the sticks under the surface of the paraffin, submerged, until the paraffin was cold, until the sticks were cold all the way through. We discovered that the vacuum formed within the fiber of the wood, and soaked the paraffin in to a depth of several inches—— clear through a three-inch plank; and I think that is the secret. At all events, we have had no difficulty in paraffining oak or almost any of the non-fat woods, and do the paraffining successfully. We used that in putting down those foundations under the machines, and it greatly reduced the difficulty from lightning. Still we had lightning, and our ingenuity was taxed to find some means of handling it. This represents the most successful lightning arrester that ever was built. It is a very complex mechanism. It consists, just as you see, of a perfectly plain commutator switch, each terminal of the commutator connected to a fuse. The operation is delightfully simple; but it requires two attendants to operate it, (Laughter), one to stand with a paraffin stick, to push the tongue of the switch along, at every stroke of lightning; the other to follow up and replace the fuse. (Laughter) At one time we were operating sixty points, and we had to put on another operator. (Laughter). Now, that is no joke. It was no joke to the boys, for they had to work very fast, (Laughter); because lightning strokes would come in, sometimes, four or five a minute. Of course, that was not lightning; it was only atmospheric disturbance; but, as I have explained, we did not know the difference. Fig. 7

We tried many schemes to find something which would be automatic, or at least would not require so many operatives. Here is one scheme. It has some merit. This is a half barrel, with a metal plate in the bottom, grounded; a shunt from the line brought down across the gap; and this is laid perhaps 1/64th of an inch into the liquid, which is simply a salt solution. Fig. 8

The theory is that the entrance of the discharge, the spit of lightning into the water, would blow the water away and break the arc. It is a fact that it will work; but it is rather exacting in its disposition. The water must be just at the right height, and to get the best results must contain just the right amount of salt. The exactions are rather annoying, in a very dry country, where the evaporation was sufficient, so that additional water had to be supplied, about four or five times a day to keep the surface just right.

I remember a rather amusing incident. We had one of those outside of the station, down in the flat, at the river, where the grass was growing very luxuriously, and a herd of cattle came down one day. There was one very boistrous old bull who took a fancy to that, and he wanted a drink out of that water. It happened just at the instant that we were having a little thunder storm. The effect on his abdominal muscles or his diastolic action was that the curve was very straight. (Laughter)

It is getting a little late. I dont think I will trouble you with that.

You may be interested to have me explain what I believe is the old grandfather of all of your aerial switches today. The first aerial switch, when a branch line was extended down to the town of Telluride, or rather the main line extended, leaving the mill on a branch, it became necessary, whenever there was trouble on the longer line, to cut it off, so that the mill could operate. We had a Fig. 9

mill-man, George Clements, who was a very ingenious chap, but also rather daring. He got tired of going down to the junction pole to cut off this line; and the lineman and the troubleman got tired of having to go back there and draw that up, connecting it up again; so they set up a second pole, in winter, so that the connection could be made by jumpers. Now that is a very rational sort of thing to do. It is done now, right along; but remember we were feeling our way in the dark. That invention had not taken place at that time. This was the invention.

Well, as Spring came on, this second pole having been set about thirty inches in the ground, the ground thawed out and it became very loose. George got a bright idea. He said: "What is the use of climbing up that shakey pole to open the jumpers?" He twisted the ends of the wire, here, and brought them down so that they would meet in that way-- this one and that one-- and proceeded simply to push this pole up against that. (Laughter) With a pike-pole on either side to steady it, and one behind it, he held it up. George would close the switch by taking the rope in one hand and the pike-pole in the other. He could push this pole up or back against the other pole. If there happened to be current on the line, when the switch was open, it was all right; since the arc could rise through all out-of-doors. No harm done. That actually worked. I think it worked for several years; and the only improvement made in it was to provide a little better contact at that point, because George occasionally would not get the switch completely closed, and the arc would eat off the wires. (Laughter).

Long spans were a problem to us, because we were in a snowslide country, where the divides always involved a considerable slant on either side; and they were practically bare rock, where snow would always slide before melting off. It was necessary in crossing those divides-- and we had several to cross-- to make spans long enough to reach from the two points necessarily free from snowslide interruption. One point was the extreme top, and the other point was near enough from the bottom to be safe from the snowslide. That is quite an undertaking in a mountain range, particularly where it runs up to thirteen thousand feet elevation. We had several spans of twelve hundred to sixteen hundred feet, I believe. I shall have to be a little careful about these figures, because I notice that one of my old friends, and an associate, is listening to me. He might call me down. But as I recall, we had a span sixteen hundred feet. Fig. 10

How were we to support such a span? Evidently, ordinary insulators, on ordinary pins, would not stand the strain; but by slacking the wire down, as it was always possible to do, it was quite feasible to run a span of that length, without exceeding the elastic limit of the conductor itself; yet, not without exceeding the strength of a more or less weakened locust pin. So we conceived this notion. There is a cross-arm with a row of pins, insulators, stuck in it, and a small wire-- Oh, I fancy No.8 or No. 10 copper-- that was used for each one; looped around each of these insulators and brought back to a given point, here. We had these insulators; and the wire had to run that distance and back. By combining those and by pulling them at an even tension, with the bend here, and joining them on to the line wire, we were able to distribute the strain on the line wire, evenly, among all the insulators and pins. Then the cross-arm was carried up an iron armature, up here to a point in line. However, this line should not be there. That is my mistake. This was hinged at this point, so that it was free to move up and down, for the alignment of the span. Some of these were in operation not many years ago. Some of them were in operation for better than fifteen years; and I dont see anything wrong with the scheme; in fact, I would rather prefer that scheme to some of these strained insulators which I see strung out around this country now. I think they are safer, perhaps.

When we got to stone construction it was quite a problem to carry three thousand volts, or as it became, a little later, ten thousand, through a stone wall. We had none of these insulators which you have now. We had no porcelain tubing. It was not made at that time. Glass Fig. 11

was very friable. Often glass insulators would stand on your desk and crack, all by their lonesome, just from sheer internal stresses; but glass was the best we had, for many purposes. So there again we used oak, a 6 x 6 oak piece, with a hole bored through it and paraffined.. You see, boring an inch and a half hole through a 6 x 6 oak piece will give you a little over that, when dressed down, just about two inches, perhaps, of solid oak; and that, paraffined carefully, thoroughly, will generally stand up to something like one hundred thousand volts. We did not know that then, because we did not know what one hundred thousand volts was; but we knew that it stood. Inside of that we put some hard rubber tubing, which was obtainable, and inside the tubing, Clark wire.

To illustrate the ingenuity that we had to exercise, on the occasion of receiving a larger motor, a two hundred horse-power motor, it came without a collector ring, and we had to operate it at once. We had to build a collector ring. We took four or five pieces of oak plank, two inches thick, paraffined, laid them cross-grain, and pinned them together, with oak pins. We put them in a little, old lathe we had, and turned them down to a round, with grooves, wound copper wires in the grooves, flattened them down with a hammer and filled it up with solder; the ends of the wire being as illustrated here; carried out with the machine. That ran so well that we did not bother Fig. 11

to take it off when we got our collector rings. It ran for two years. Wonderful things can be done with a little ingenuity, together with paraffin, oak and patience.

When we started our transmission we received samples of insulators from various sources, among them an insulator designed in two parts-- the lower part a saucer through which the pin came, the saucer to be filled with oil. No provision was made to prevent the oil all soaking up in the pin; but that would have been a small matter if the dirt and bugs had ever permitted it to get into the pin. Fig. 12

It was strange to note the point of view expressed by different authorities as to the proper insulator for us to use; because, of course, such an undertaking as three thousand volts required an expensive insulator. Three thousand volts was something awful. A bill was offered in the Colorado legislature, providing that we must put a fence around every pole. It did not pass, but there were plenty of people that thought it ought to pass.

After a good deal of guessing-- that is all it was-- we decided to try out ordinary Western Union insulators, the little glass fellows, and they worked all right. We did not have, however, as much trouble then as we had later with higher voltages and much more expensive insulators-- something about that size; not the   but the long-distance insulators.

Later, we equipped some of these, but they did not give any better result; and that was a porcelain insulator that was spoken of very highly.

They did not know how to make porcelain in those days. Those insulators would stand on the pins and crack just the same, from sheer onériness.

I dont seem to have one sketch here, that I had in mind to show you.

Afterward, when we went to forty thousand volts, as we did here in Utah, we found it necessary, of course, to go to an entirely different insulator. Prior to that, when we went to ten, we adopted a glass insulator, I suppose that was because glass is transparent, and you could see through it, and if it was defective, you could throw it out. That was the great advantage in glass. Porcelain you could not see through, and the porcelain insulators were sometimes full of defects. That type of insulator carried ten thousand volts without a particle of trouble. The manufacturers of glass insulators, by that time, had learned to anneal them, so that it curbed their vicious temper. They would not stand on your desk and crack, any more.

The next step, to forty thousand volts, stumped us on the question of an insulator; but it appeared to us that the better part of the insulating of pole line construction, perhaps, rested in a good pin. Therefore, we adopted a special, long pin, paraffined, and used at first the same insulator.

When we came to build over some of Salt Lake's salt ground, here, the old desert bed, and got into salt storms, we were met with a very serious difficulty there. The insulator was not adequate, and therefore the poles would burn. The current would leak down over the pins in spite of their paraffined condition. It would get on to the cross-arm, and wherever there was a bit of metal it would burn. It was customary to put on braces, just the ordinary braces, and wherever a brace touched a cross-arm, or the pole, it would burn, become carbonized, and where the cross-arm crossed the pole, or was bolted to it, it would burn.

We have any quantity of pictures taken of various flashovers on poles along on our transmission here on the flats of Utah.

To get away from this trouble we adopted a tall pin construction. I dont mean twelve or fifteen inches; I mean we adopted a construction calling for twenty-four inch pins. They were paraffined; one was set in the top of the pole; the other two in the cross-arm. The cross-arm was mortised through the pole. I thought I had that sketch here, but I haven't. The cross-arm was mortised through the pole, because we could not use braces. That was iron. To get away from the use of all iron, that construction worked very nicely; but it was rather weak. It would not do to string very heavy conductors on such flimsy pins as that. So the last step which we made was the adoption of what is known as the Twelve Tee insulator. I believe the Utah Power & Light Company is still using some of them, now. It takes a shorter, stubbier pin, but its insulating properties are very fine.

It should be recalled, however, that during all these years, the porcelain people were studying porcelain; so that at the end of this period we were able to get porcelain which was really dependable.

Remember, this is a development of the insulator as well as the development of the need for it. I suppose that so far as this subject alone is concerned, one might continue almost indefinitely; but I observe that I have exceeded even that hour, and I said I could tell more than I knew in an hour. Yet, I have kept on talking.

Before closing, I want to give credit to Mr. Buckler for his kindness in assisting me with the illustrations which I wanted in order to make some of my points clear. I want to thank him, publicly, for his kindness; and I thank you all for your courteous patience.

(Extended applause).

AMES SWITCHBOARD - 1890

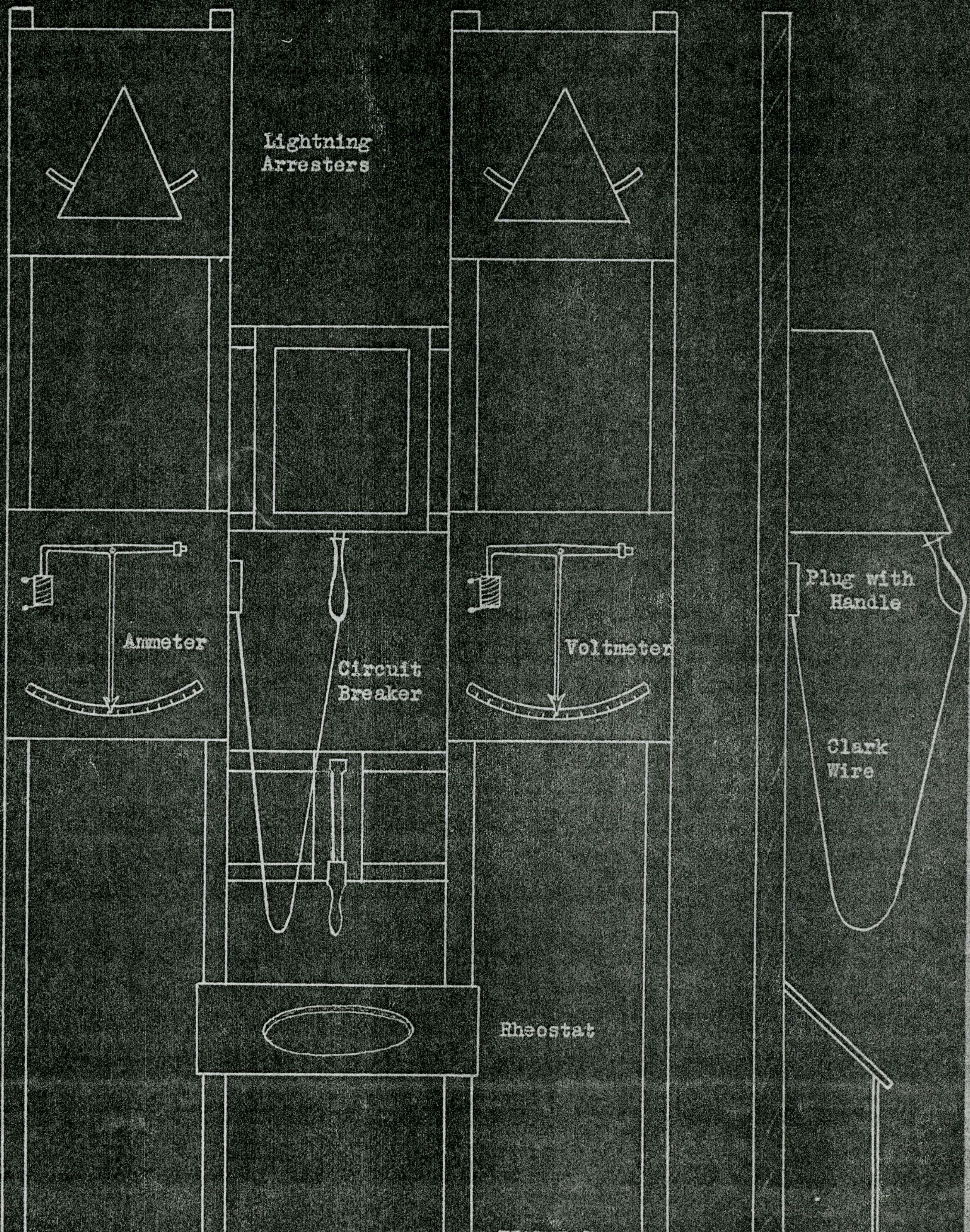

FIGURE 1.

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AMMETER OR VOLTMETER

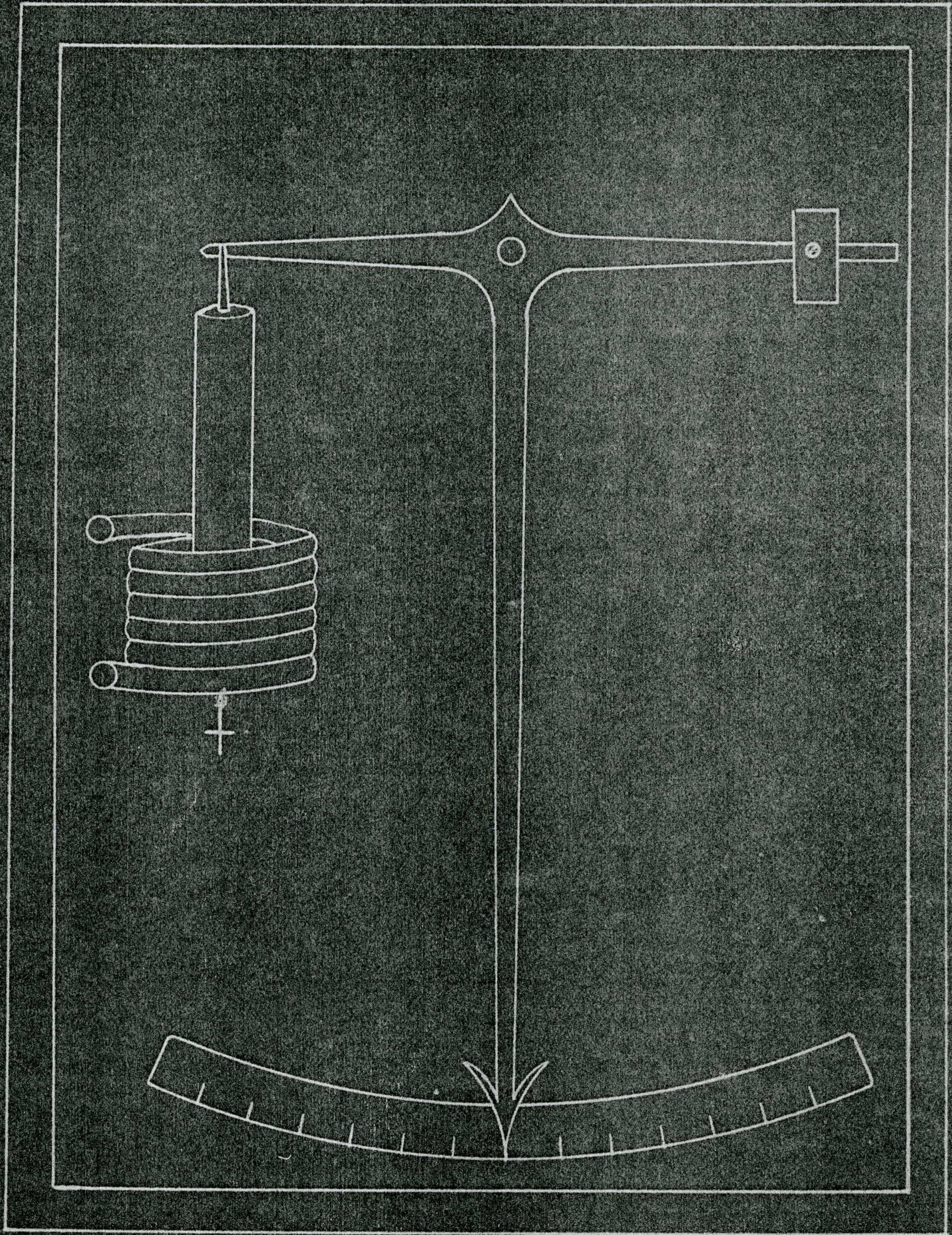

FIGURE 2.

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FSD

AMMETER - VOLTMETER

IMPROVED FORM

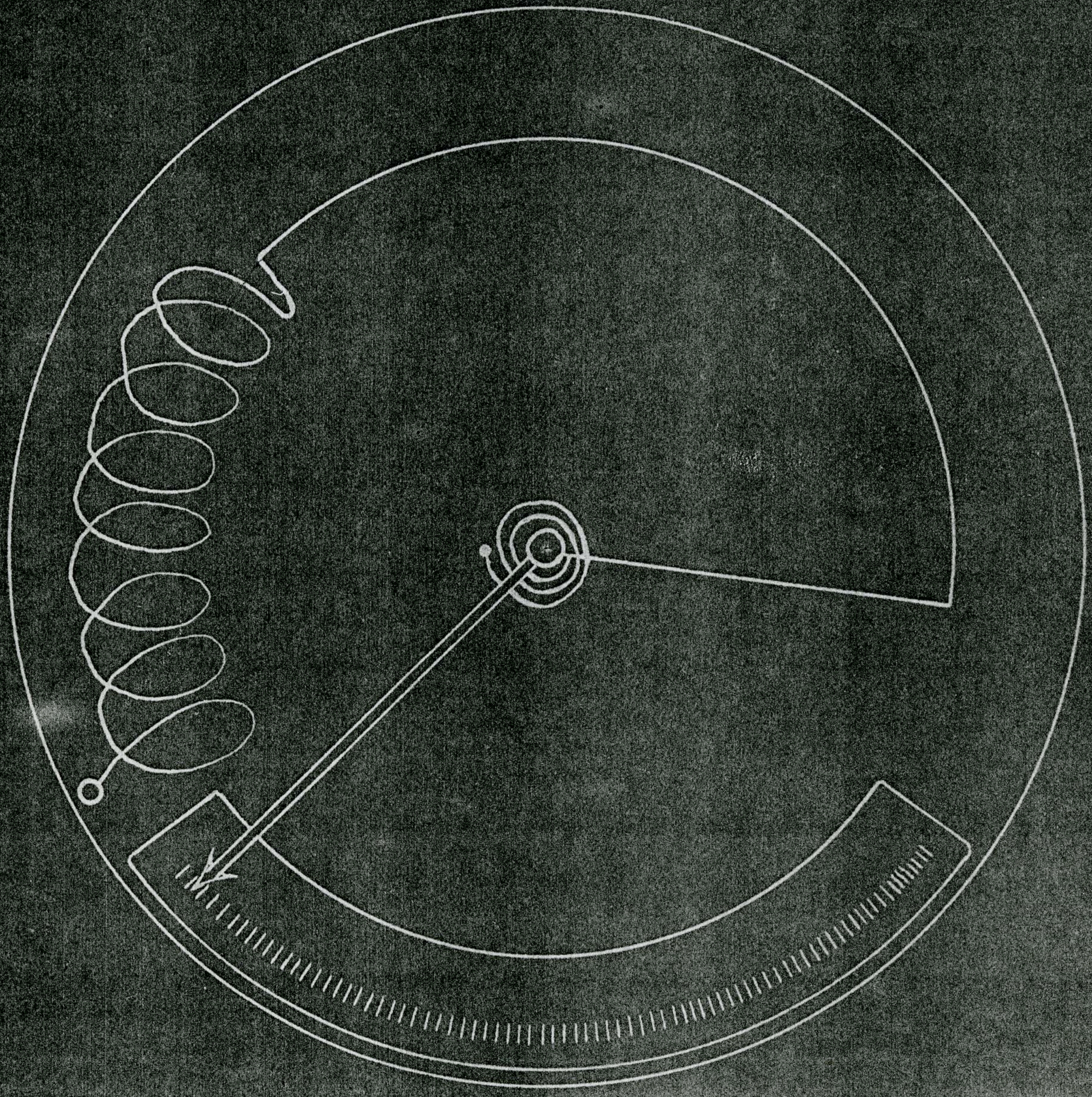

FIGURE 3.

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WALL INSULATOR

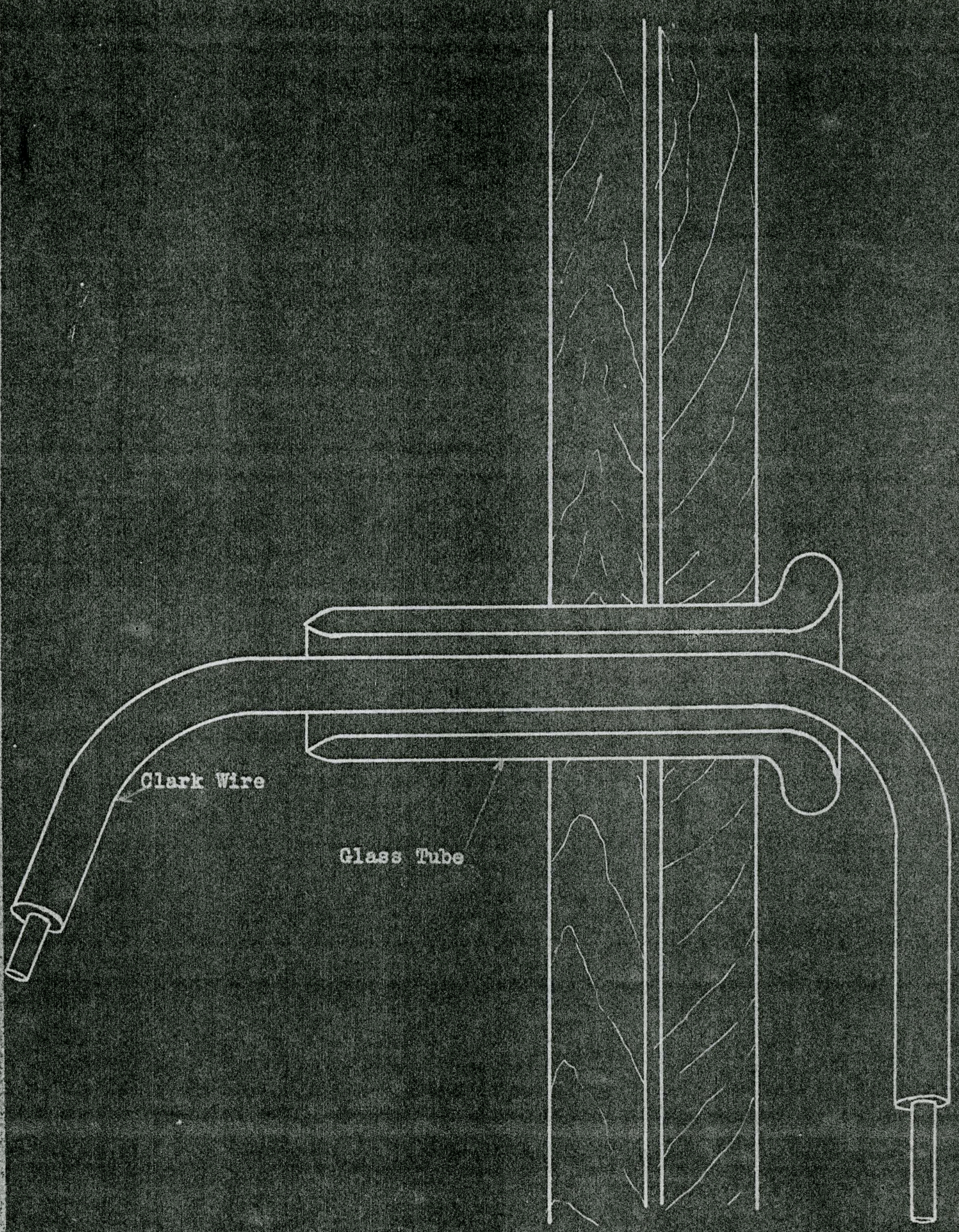

FIGURE 4.

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ILLUSTRATING PRINCIPLE OF ROTATING FIELD

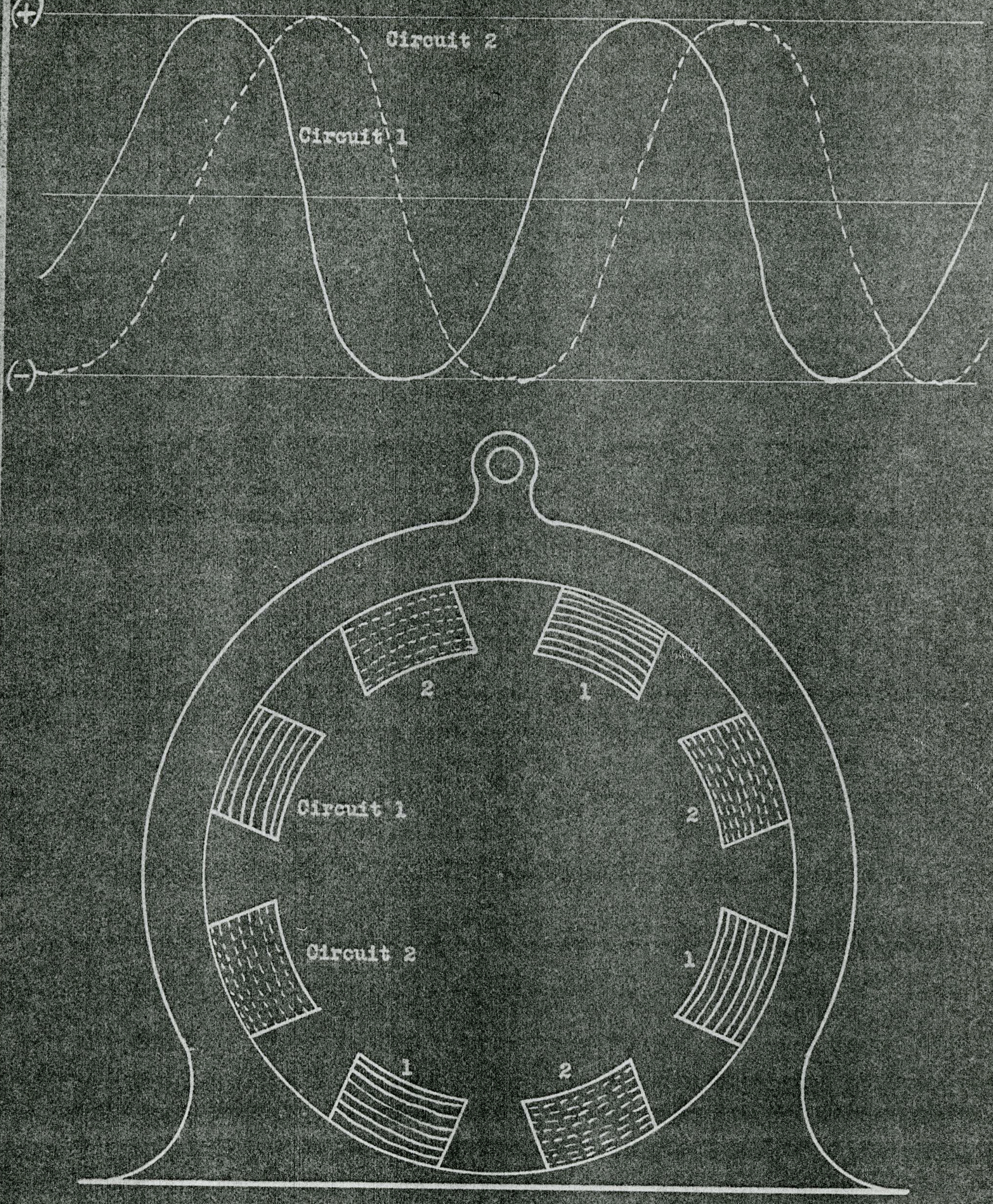

FIGURE 5.

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PICKAXE LIGHTNING ARRESTER

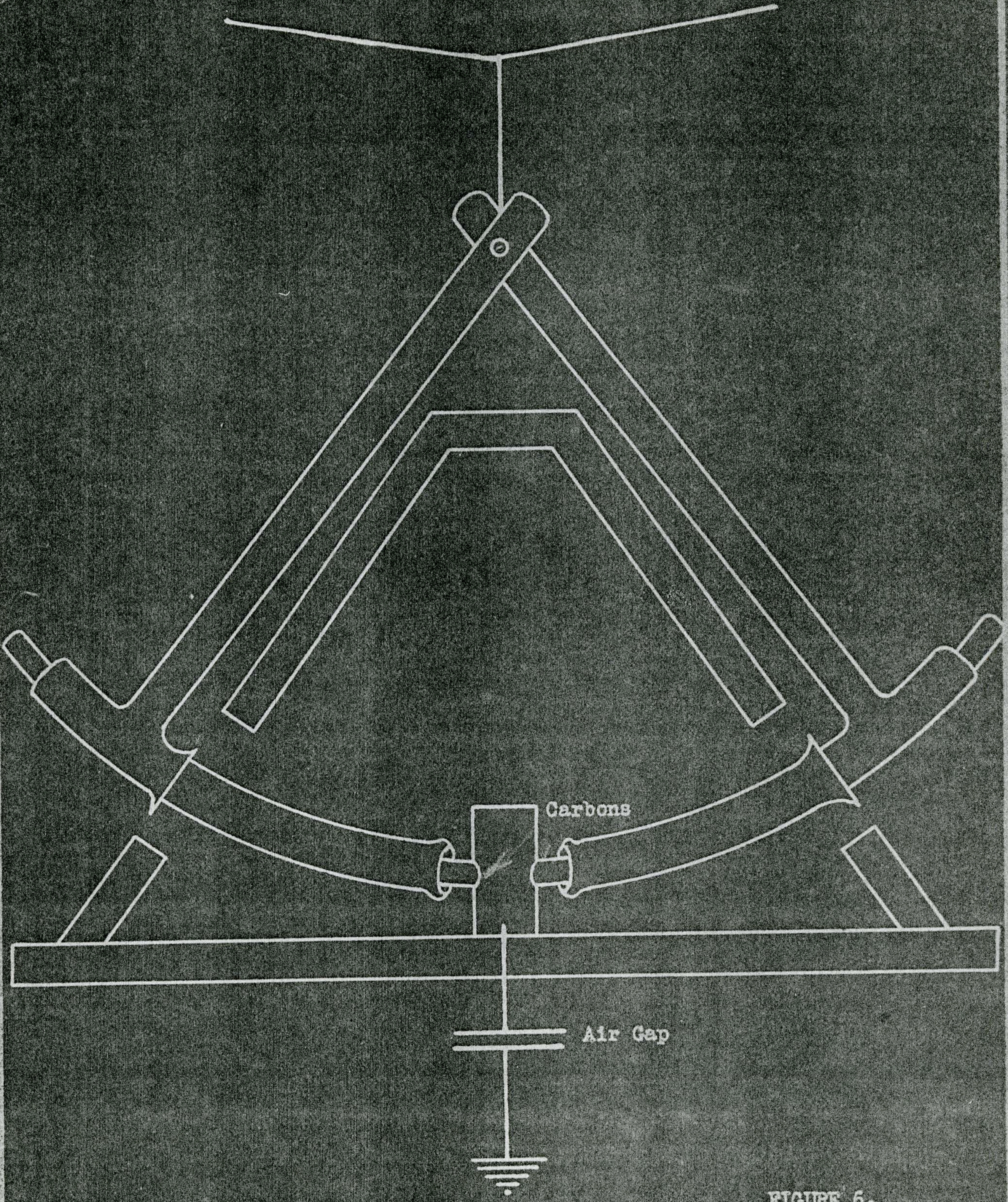

FIGURE 6.

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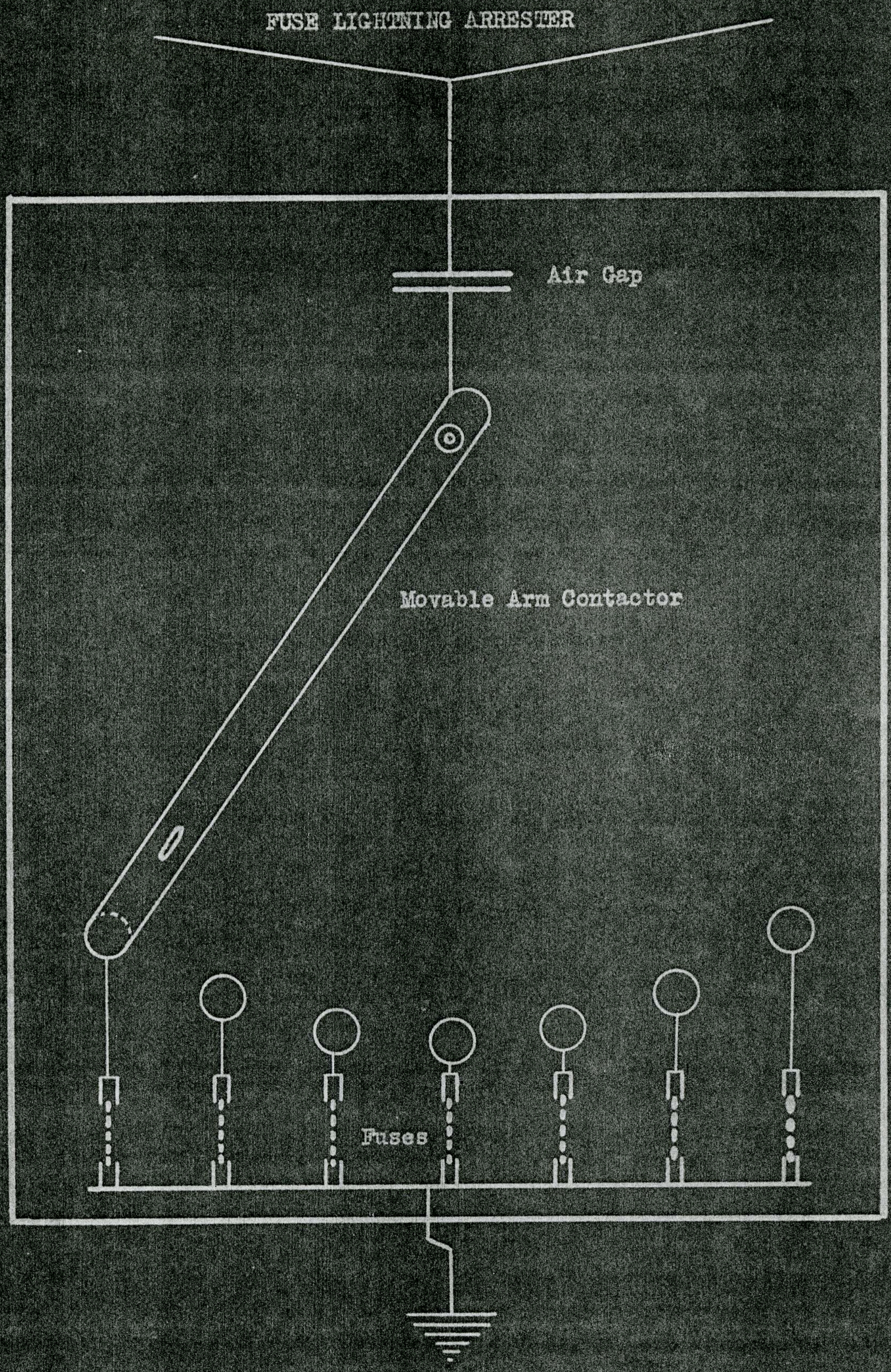

FIGURE 7.

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TUB LIGHTNING ARRESTER

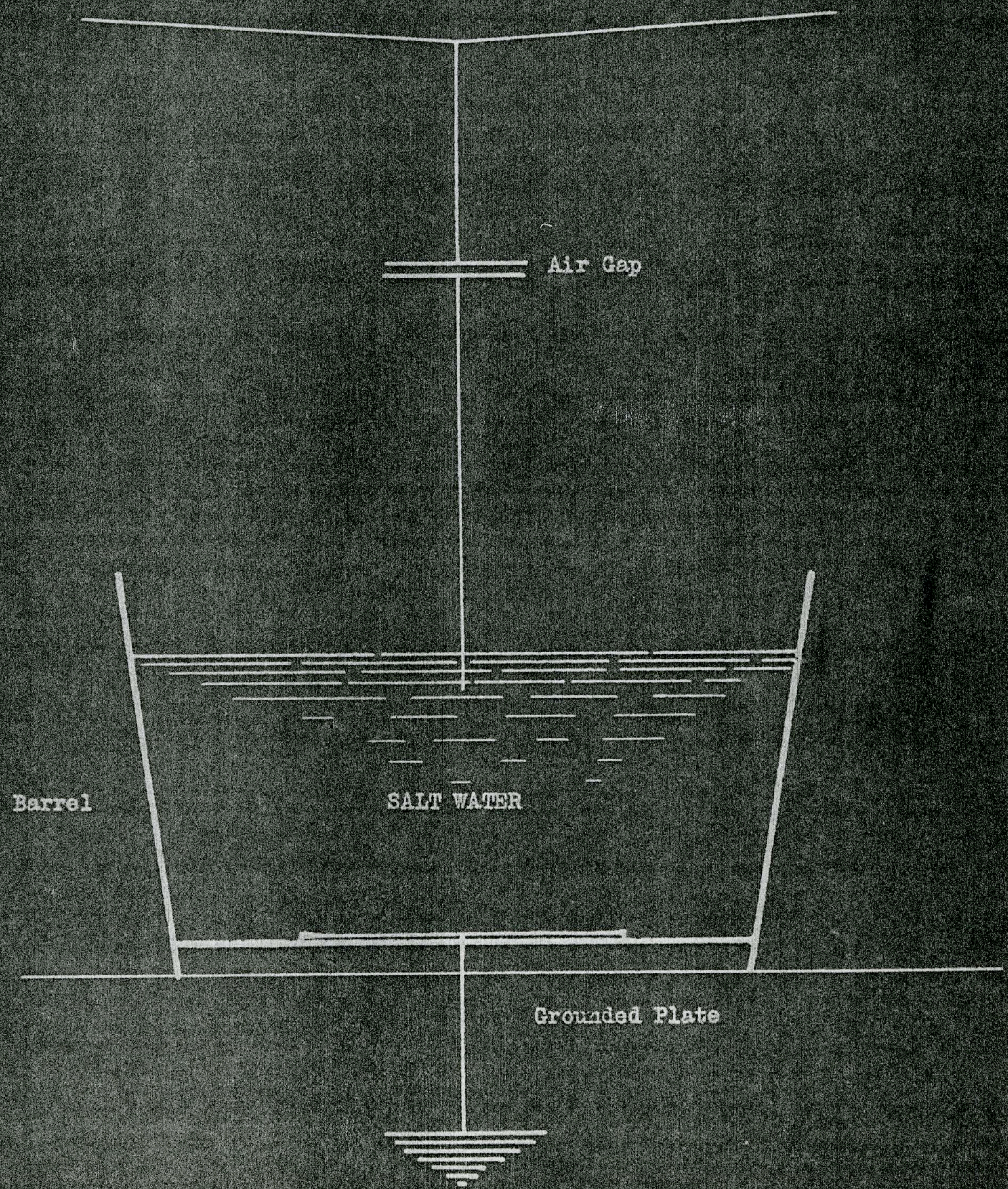
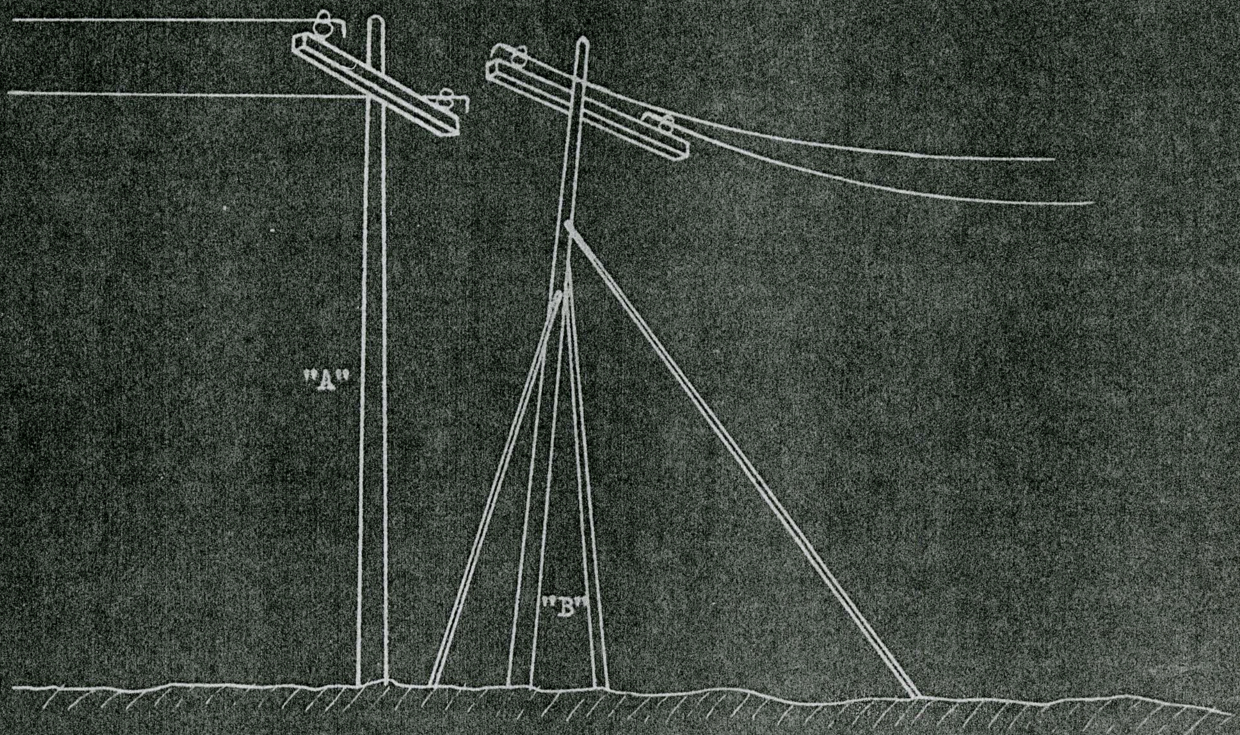


FIGURE 8.

FIRST AERIAL SWITCH
1891



Two poles six feet apart, "A" set firmly - "B" loose in ground and supported by three pike poles.

thus

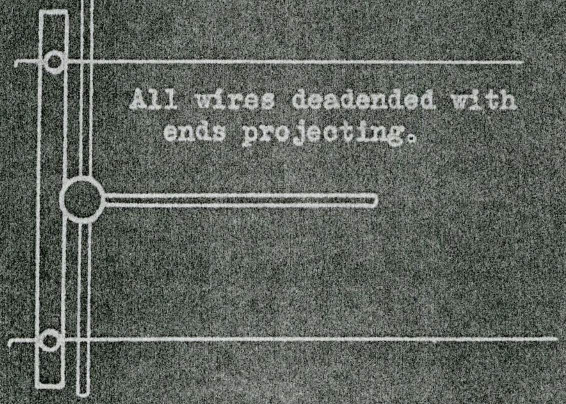


FIGURE 9.

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LONG SPAN STRAIN INSULATOR

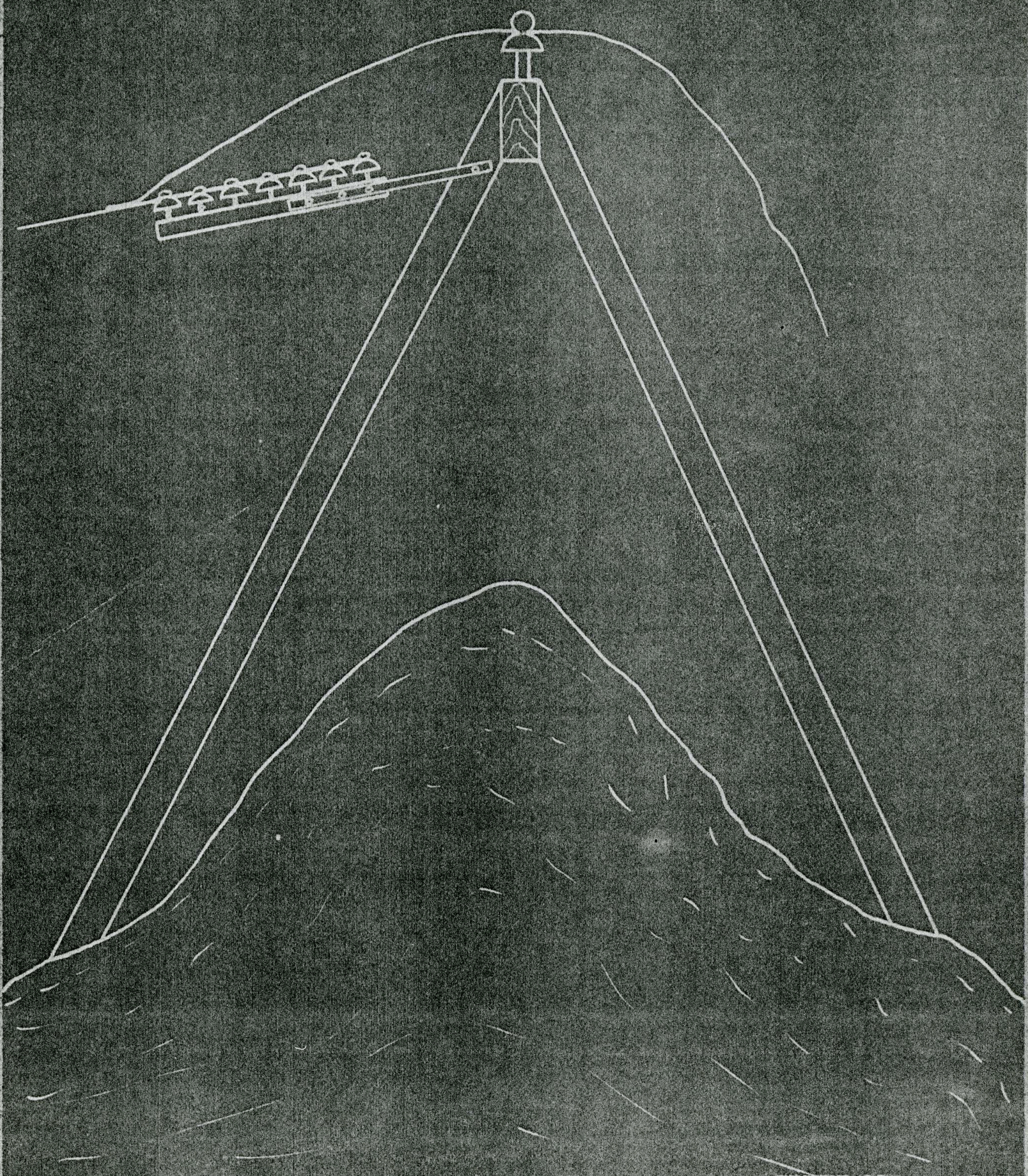

FIGURE 10

F30

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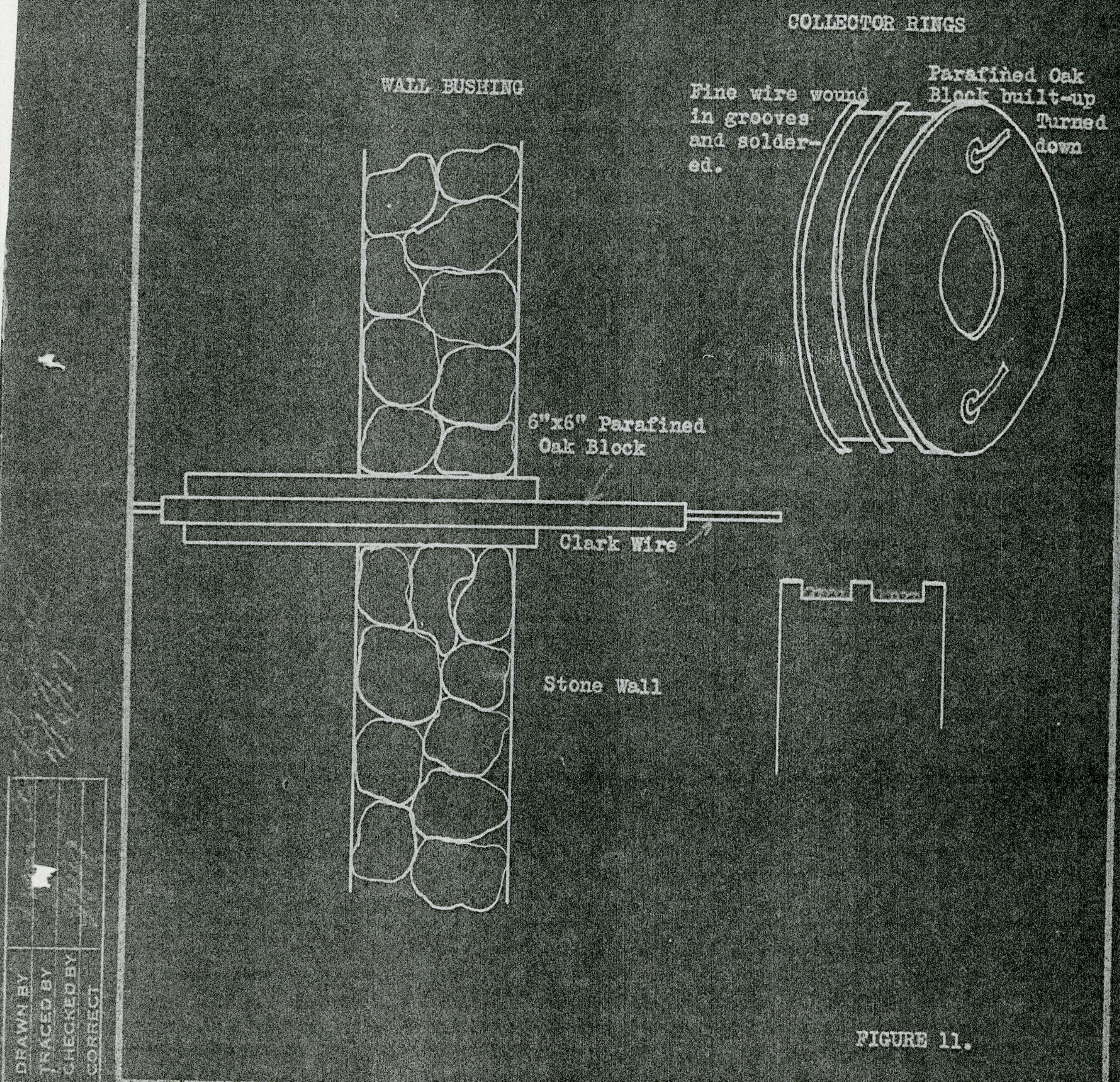

COLLECTOR RINGS
WALL BUSHING
Fine wire wound in grooves and soldered.
Parafined Oak Block built-up Turned down
6"x6" Parafined Oak Block
Clark Wire
Stone Wall
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FIGURE 11.

EARLY INSULATORS

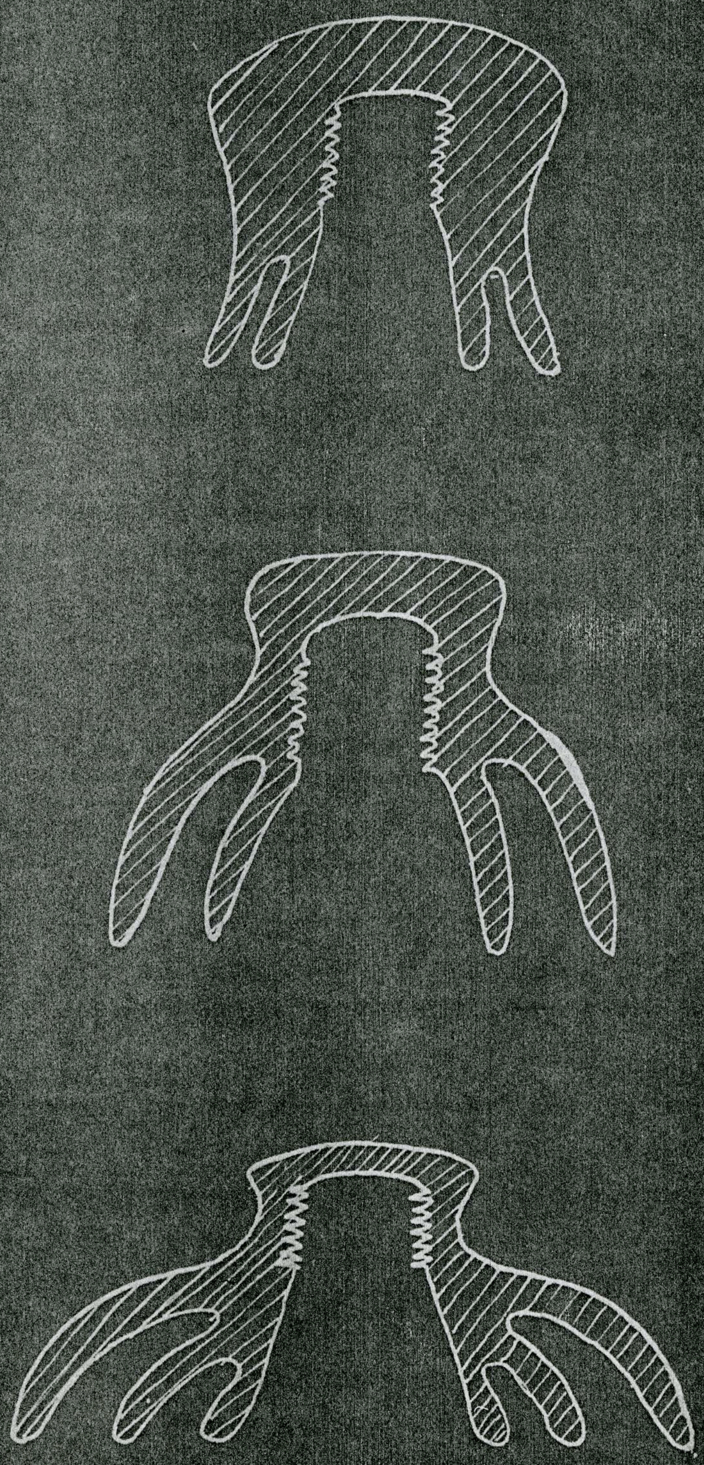

FIGURE 12.

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