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WHERE ENGINEER AND ORNITHOLOGIST MEET: TRANSMISSION LINE TROUBLES CAUSED BY BIRDS

WITH FIVE ILLUSTRATIONS

By HAROLD MICHENER

IT LONG has been recognized by engineers that birds are sources of transmission line trouble because of their making contacts between conductors and the supporting structures or between two conductors. In such cases, which are not very numerous considering the numbers of birds that perch on the wires and supporting structures, the offending bird is usually killed by the arc it has caused. Of course, from the point of view of injury to the birds, any overhead wires and wire fences are bad because the birds kill themselves by flying against the wires.

During the last few years a slightly different type of transmission line trouble has been very definitely proved to be due to birds. The following deals with this class of troubles, which are usually called insulator flashovers, as they have occurred on the Big Creek lines of the Southern California Edison Company between Big Creek, about seventy miles northeast of Fresno, and Los Angeles. These lines operated at 150,000 volts from the time they were built in 1913, until May, 1923, when the voltage was raised to 220,000 volts.

For some reason, unknown until about six years ago, an arc would be established across an insulator. This arc would persist until the voltage was lowered sufficiently to cause it to break, which also would usually cause the power load to drop off and sometimes the lights would go out entirely. Many theories were advanced to explain the cause of these flashovers. One of the earliest was that the accumulation of bird droppings on the insulators decreased the surface resistance to such a degree that the normal line voltage could establish an arc across the insulators. But this theory did not meet all the facts satisfactorily.

The favorite refuge of the electrical engineer was called upon, namely, voltage surges. According to this, high voltage surges were produced in some way, by switching of lines, or perhaps by lightning, these voltages being high enough to cause an arc across a string of insulators in normal condition. But the occurrence of flashovers did not coincide with line switching or with storms. However, to make doubly sure that this was not the cause, instruments were developed and measurements of these surge voltages were taken. None was found of sufficient magnitude to cause an insulator flashover.

Another theory was that of "rivers of ions" which might be pictured as currents of air heavily laden with ions. When one of these "rivers" would envelop an insulator string, the ions would cause an electric current to be conducted around the insulators and a flashover would result.

Another was that spider webs possibly caused these troubles. Particularly during certain parts of the year large numbers of streamers of spider webs can be seen hanging from the towers and from the conductors. It was thought that these might become sufficiently conductive under some moisture conditions to start an arc over the insulators. Further study showed this to be highly improbable.

Still another theory assumed that the voltage stress at sharp points on the hardware at the lower end of the insulator strings caused the air to be ionized there and under favorable conditions these ions would form a conductive path around the insulators and cause a flashover. These sharp points were covered with smooth

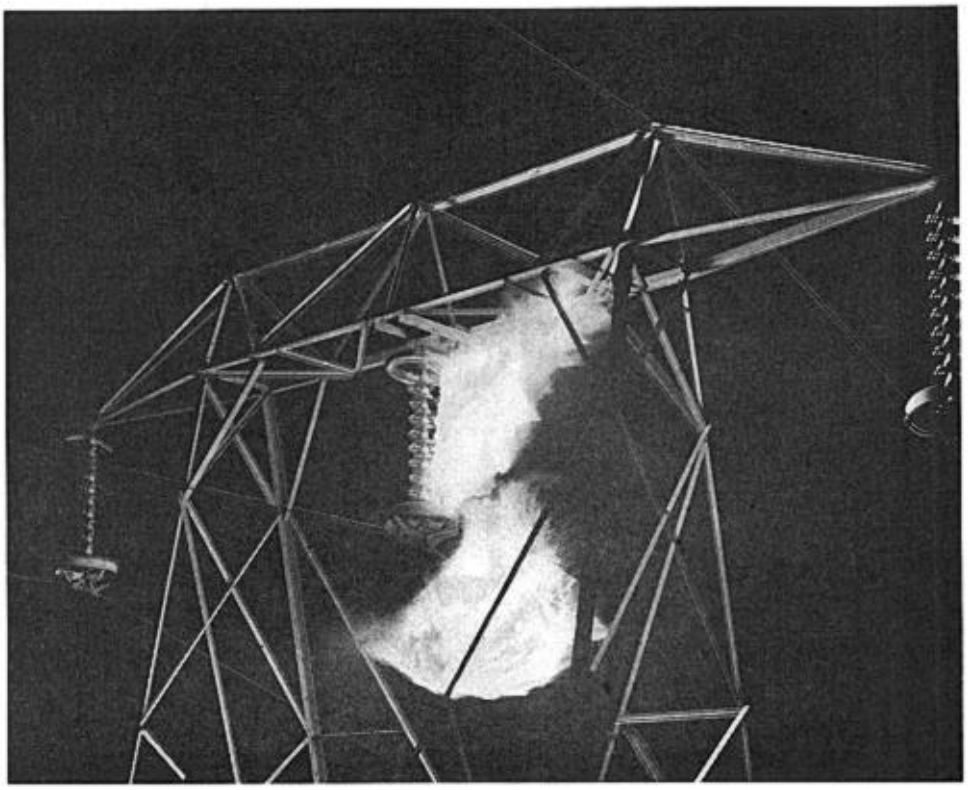


Fig. 63. TWO SEPARATE INSULATOR FLASHOVERS CAUSED INTENTIONALLY BY FINE WIRES. THE UPPER ONE IS TYPICAL OF THE CONCEPTION OF THOSE CAUSED BY BIRDS.

copper balls on thirty-five miles of line. An unusual number of flashovers occurred in this section soon after the copper balls were installed, thus showing that their presence was not helping matters any.

These theories were not promulgated by the lowly, but by some of the very best minds in the profession. The question was becoming more and more serious because the time required to get back to normal operating conditions after a flashover became greater as the size of the system increased. Also the increase in the operating voltage and the concurrent addition of the shield rings twenty-eight inches in diameter at the conductor end of all strings of insulators seemed to cause a marked increase in the number of flashovers. Since these flashovers were prac-

tically the only troubles being experienced on the lines, it became imperative that their occurrence should be stopped or at least materially reduced.

A year or two before 220,000 volt operation was begun, one of the men in charge of the lines saw a bird, just as it was leaving the tower, drop a stream of stringy excrement which extended from the tower member above the insulator to a point as low or lower than the conductor. The observer feared a flashover would occur, but the stream fell clear of the tower without coming in contact with, or within arcing distance of, the conductor. The bird was reported to have been an eagle.

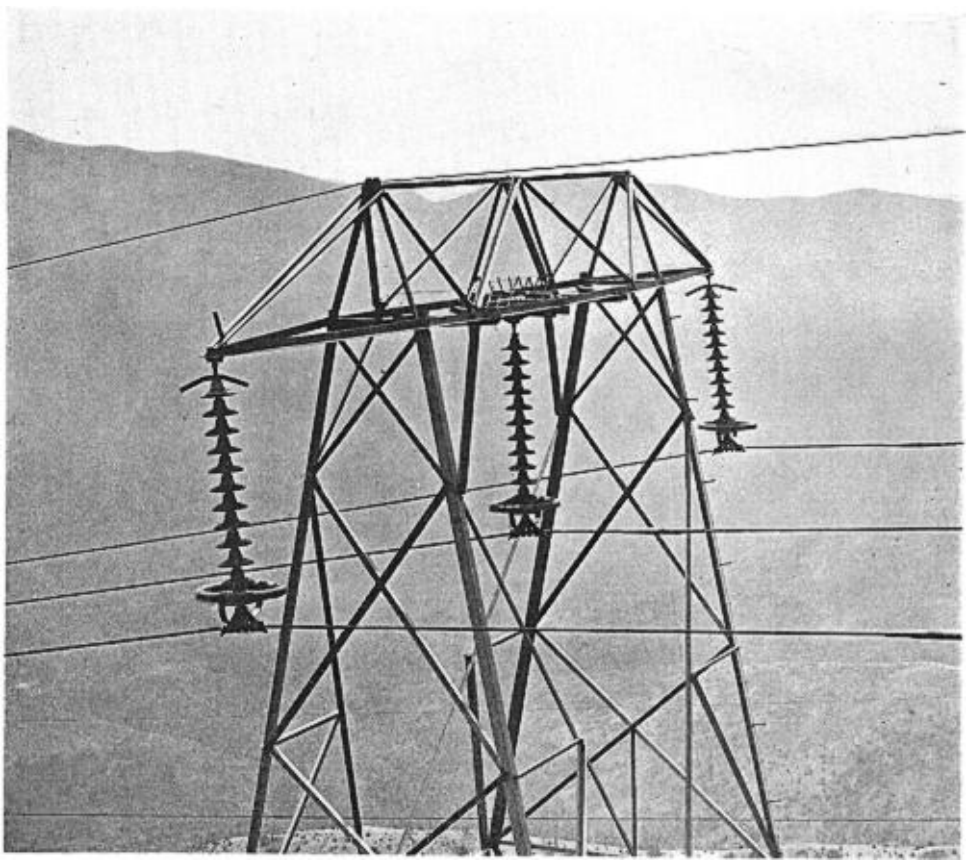
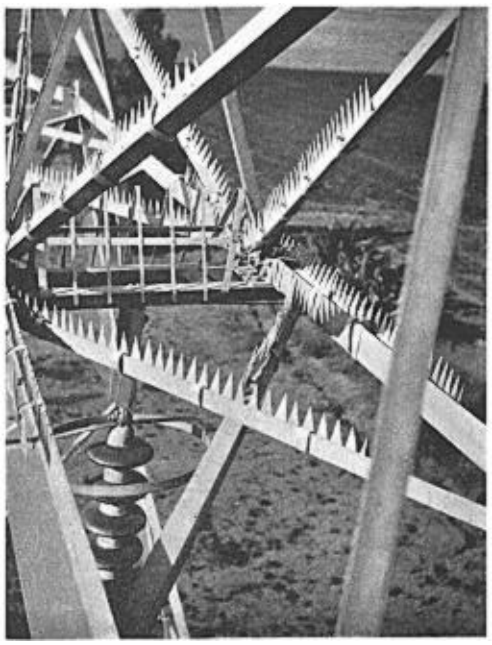


Fig. 64. BIRD GUARDS AS FIRST DESIGNED FOR THE 220000 VOLT LINES OF THE SOUTHERN CALIFORNIA EDISON COMPANY. THIS WAS PRIMARILY AN ATTEMPT TO KEEP THE LARGE RAPTORES FROM ROOSTING ABOVE THE CENTER STRING OF INSULATORS.

At nearly all the towers where flashovers have occurred since that time, direct evidence that the stringy, semi-liquid excrement of a bird was the cause has been found. Sometimes a white streak from one to three inches wide and the whole length of the insulator string would be left. Sometimes only a white spot on the tower and one on the shield ring could be found, and at still other times one or the other of these white spots would be missing. If the bird were perched some distance to windward of the insulator, the wind would blow the lower end of the

string of excrement against the shield ring, or near enough so that the remaining air gap would break down, and the arc would be established along the string of excrement. (The normal voltage will cause an arc through about thirteen inches of ordinary air.) Then the wind would blow the arc across to the other side of the string of insulators, the top end of the arc wandering along the lower side of the tower top, and the lower end of the arc traveling around the shield ring. Many times the evidence of this performance has been found: a white spot on the tower



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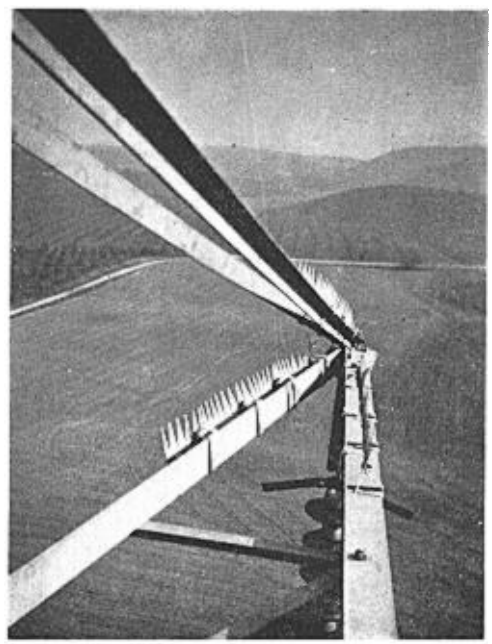

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Fig. 65. ANOTHER STAGE IN THE DEVELOPMENT OF BIRD GUARDS AROUND THE SUPPORT OF THE CENTER STRING OF INSULATORS. EVEN THIS ARRANGEMENT WAS NOT ENTIRELY SUCCESSFUL IN KEEPING THE BIRDS FROM ROOSTING THERE.

Fig. 66. SAW-TOOTH BIRD GUARDS AT OUTER INSULATOR SUPPORT.

and one on the shield ring, each coinciding or nearly coinciding with a burn in the metal; a series of burns along the lower side of the tower top extending from the white spot to a considerable distance on the other side of the insulator; and a series of burns on the shield ring from the white spot to the opposite side.

Large hawks and eagles are believed to be the worst offenders, but there have been a few cases where the evidence pointed very conclusively to a Sparrow Hawk, and undoubtedly herons sometimes cause the trouble. It is believed that a Sparrow Hawk cannot cause this trouble unless the insulators are already wet by fog. The length of the insulator string is approximately five and one-half feet.

Figure 63 herewith shows two separate flashovers that were caused intentionally. The upper one was caused by dropping a fine wire from the tower to the lower shield ring and is of the supposed form of those caused by birds. In this case there was no wind to blow the arc across to the other side of the insulator string. On the next attempt the wire became detached from the tower above the

insulators and started the arc from the conductor to the tower members below it, causing the flashover as shown below.

One thing that made it so difficult to accept this bird theory was the fact that no dead birds were found at the places where flashovers had occurred. It was thought that a bird could not cause such an arc and get away. A few injured birds have been found, however, but not until after the theory had been generally accepted. In one case a heron was found, walking around on the ground at the foot of the tower with most of its feathers burned off. In another case a Sparrow Hawk with most of its tail and back feathers burned off, but still able to fly very short distances, was found at the tower where a flashover had occurred two or three days before. This was on the plains in the southern end of the San Joaquin Valley where it seems quite impossible that this Sparrow Hawk could have had any other mishap that would have left it in this condition.

As a laboratory check it was demonstrated that, with normal line voltage ap-

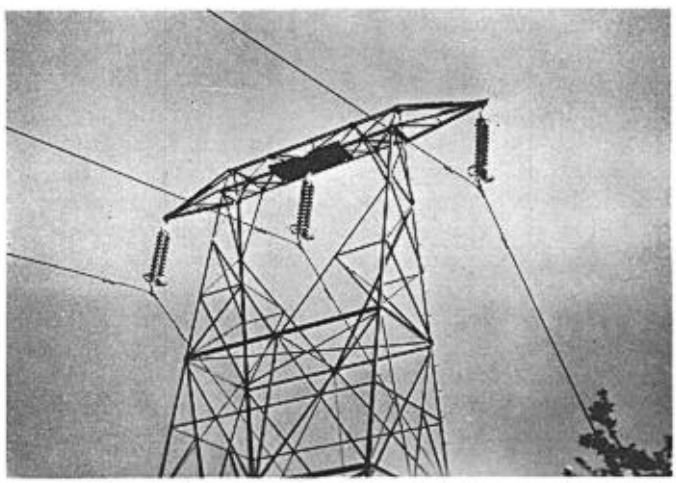

Fig. 67. LATEST DESIGN OF BIRD GUARD ON 220000 VOLT LINES OF SOUTHERN CALIFORNIA EDISON COMPANY. A SHEET-IRON PAN ABOVE CENTER INSULATORS AND SAW-TOOTH GUARDS ABOVE OUTER INSULATORS. BECAUSE OF THE LARGE VERTICAL ANGLE ON THIS TOWER, DOUBLE INSULATOR STRINGS ARE USED.

plied to the insulator string, one or two ounces of a starch-salt solution released from a ⅜-inch tube at the top of the insulators would cause a flashover both when allowed to flow down over the insulator surface and when allowed to fall freely through the air near the insulator but without touching either the insulator or the energized parts at the bottom of the insulator.

At the time the voltage was increased to 220,000 volts these lines were in the eyes of the electrical engineers of the world, for they were the first commercial lines to operate at more than 150,000 volts. When the numbers of flashovers per month ran 6, 5, 12, 14, 9, 10, 8, 1, 4, 3, 3, 0, 0, 1, from May, 1923, to June, 1924, inclusive, all these engineers were intensely interested. If the higher numbers which prevailed during the summer of 1923 had continued, the operation at 220,000 volts would have been pronounced a failure, the consumers could not have

endured such frequent interruptions, and not only this project, but high voltage transmission in general would have received a severe set-back. The decreasing numbers after September, 1923, were a great relief. This decrease was largely due to efforts to prevent the birds from roosting above the insulators, and through these efforts it has been learned that a hawk is just about as persistent as a sitting hen.

Since the greater number of flashovers occurred over the center insulators, the first attempt to keep the birds away consisted of placing an inverted "V" grillage of steel straps on the tower members which supported these insulators, and which formed the favorite roosting places, and in stretching heavy wires about four inches above the other horizontal members for a distance of four or five feet on each side of the center. Also above each outside insulator string, a single spike was placed so that it interfered with a large bird perching there. (See fig. 64.) These guards were put on the greater part of the lines during May and June, 1923, but the flashovers, instead of decreasing in number, increased appreciably. The indications were that the birds, having been forced out of their accustomed places, were perching on the top shield ring of the center insulators and thus causing more trouble than before. This top shield ring was made of a one-fourth by two inch steel strap, was twenty-seven inches in diameter and was placed around the top of the insulator. (See fig. 65.) They were removed during September, October and November of 1923, and the number of flashovers decreased considerably, but still continued at a lesser rate partly due to the persistence of the birds in crowding into their old roosting places, and partly to the fact that no guards had been placed on the towers in some of the less troublesome parts of the line.

Because the flashovers were continuing, even though at a diminished rate, sixty miles of line were equipped with galvanized iron pans in the crossarm above the center insulators. They were about four by eight feet, with the centers above the insulators. These were installed in February, 1924, and only two or three flashovers have occurred at the insulators protected in this way, and these are believed to have been due to Sparrow Hawks. When these pans were installed a space about two and one-half inches high and twelve inches wide was left under the pan and over the tower member that supports the insulator. No attention was paid to this space because it was supposed that no bird small enough to go in there could possibly short circuit an insulator five and one-half feet long. But when the flashovers occurred under the pans, investigation showed that Sparrow Hawks were nesting in those small spaces and occasionally caused flashovers when the insulators already were wet by a heavy fog. These spaces were then filled with blocks of wood and no trouble has since occurred in these locations.

These bird pans seemed to be effective in stopping the flashovers on the center insulators, but they were expensive, costing about $12.00 per tower, and they did not give any protection to the outer insulators. To meet these objections, saw-tooth guards were cut in four-foot strips from thin sheet iron. These teeth were about three inches long and one and one-half inches from point to point. These were held to the tower members by sheet iron straps. (See figs. 65 and 66.) They were first placed on all the horizontal members of the tower top for a distance of four feet to the side of the insulator supporting points on a considerable portion of the towers which were not already equipped with the pans. They helped but did not prevent all of the flashovers. Some of the evidence showed that birds perching more than four feet to the side of the insulator supports were sometimes

causing flashovers, and it was also evident that some of the birds were braving the long saw teeth and finding a foot-hold above the insulators.

After many months trial, it was decided that the saw-tooth guards by themselves were not good enough and that all the towers should be equipped with the bird pans over the center insulators and with saw-tooth guards on the ends of the cross-arm to a point six feet from the outer insulator supports. (See fig. 67.) This has been done, with beneficial results on the parts of the lines where the Raptores are most common; and when the remainder of the lines are so equipped it is expected that a flashover will be a very rare occurrence, though they probably will not be stopped entirely. It is known that Sparrow Hawks sometimes perch on the upper parts of the insulator and that Herons and the larger Raptores may sometimes perch on the outer ends of the cross-arm in spite of the saw-teeth. Although the mileage of 220,000 volt lines has been increased about fifty percent, the means employed for protection from birds has reduced the numbers of flashovers from those cited above to less than one per month. This gives a measure of the results obtained.

This amount of protection from birds has been obtained at a cost of approximately $100,000. In addition to this, most of the approximately 500 miles of 66,000 volt circuits that are carried on steel towers have been equipped with bird guards of some type designed to prevent the birds of the Sparrow Hawk size and larger from perching above the insulator supports. The insulators on these lines are four to six units in length, two to three feet, depending upon the location. In at least one case, the Sparrow Hawk apparently got its feet caught in the bird guard. It was found caught there, dead, and with the feathers of its tail and back burned off.

This effort to prevent the birds from causing insulator flashovers has been well worth while in spite of its high cost. Already it has made the difference between rather poor electrical service and very good electrical service to nearly all of southern California.

Pasadena, California, January 26, 1928.