## INFORMAL REMARKS BY IRVING P. KRICK

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My comments relate primarily to Mr. Bishop's evaluation report. Our group was responsible for operations during the period under study. Also, I may be able to clarify questions raised by Dr. Dennis and others.

We began our investigations into the possibility of hail suppression in the early fifties following discussions with Irving Langmuir and his associates at General Electric. We approached the matter from the standpoint of the atmospheric physics involved as related to our extensive background in the ongoing development and application of a unique weather prediction technique which had evolved over an interval of several decades.

The first field work was done in northern Colorado in the area that is being studied currently by the National Science Foundation. We started seeding individual cells with aircraft, using a solid type fuel -- fusees, we called them -- simply because we hired a company in Denver that made railroad fusees to add our formula of silver iodide and a powdered coke mix to their product. We found this satisfactorily reduced hailfall when working inside clouds. However, we soon learned that the moment we stopped seeding, hailfall resumed, probably from feeder cells entering the main system. We then added a ground-based generator network to the system and by 1952 we felt we were getting useful results because there was less hail observed in our operational area than in upwind and surrounding regions.

We therefore ventured to suggest commercial operations to fruit growers in California and Oregon; and I guess that's when people here in Alberta began to hear about our program. They asked that we look at this area in 1956. We studied available data and, of course, observed that the hailstorms were awsome; hailswaths 15 miles or more in width and 100 miles or more in length. The damage from such hailswaths was virtually complete all along their trajectories.

Our philosophy in approaching this problem seems different from that described in the discussions listened to yesterday. We feel that control measures must be initiated before one gets an indication of potential hail from radar echoes. We regard hailstorm development similar to any other divergent phenomenon in nature. Thus we seek to alleviate the possibility of hail, in order to prevent the storm from reaching such a stage that one becomes like a mouse trying to kill an elephant. In other words, we are after hail prevention, not merely hail suppression. We subscribe to the old adage: "An ounce of prevention is worth a pound of cure". Such control measures require the accurate assessment of hail days at least 18 to 24 hours in advance. As a safeguard against forecast failures we established a westward extension of the ground generator network far upwind of the contract area. These are automatic units that are activated every day, irrespective of whether or not we are predicting hail. Thus there is always a flow of silver iodide from this upwind area toward the project region. On a hail day, early in the morning, as the situation clarifies, additional units within the total network are activated.

We didn't reach a full operational status applying this technique coupled with aircraft until about 1961. As mentioned by Dr. Dennis, Stan Sifferman was up here as our controller in 1956, 1957 and 1958. He did an excellent job, effectively handling the predictability and treatment of most storms. He was aided by special instrumentation we have developed. It measures atmospheric electricity and detects potential thunderstorm development prior to the occurrence of radar echoes and is used as a backup to the forecast material prepared from ongoing surface and upper air data.

As Dr. Dennis pointed out, we seemed to experience a setback in 1959. This was indeed the case. In that year we assigned two men from European projects to Alberta. They were not familiar with hail suppression work, and came up here without sufficient indoctrination -- a serious lapse on the part of management. In assessing what was done, we determined that invariably control measures were initiated late, particularly in the use of the full ground network. It was a disastrous year. In early 1960 I reported these findings to our client group and indicated that we would send Stan Sifferman back. By 1961, because of personal problems, Stan had to move to Seattle and is now an executive of the Boeing Commercial Airplane Company.

Therefore in 1961 the task was undertaken by Newt Stone, whom many of you know. He was associated first with our group at the California Institute of Technology in the thirties and has subsequently been active in the development and application of our forecasting techniques as well as much of the pioneering work in weather modification which we conducted during the late 1940s and early 1950s, when violent controversies surrounded every phase of it. From 1961 Newt continued as our controller through 1968. The pieces began to fall into place, and results remained consistent throughout this period, as Mr. Bishop reported. From 1961 onward for eight years, hail losses in the target were about one-third of those recorded prior to these operational years.

Those interested in the full story of our program may read the article appearing in the WEATHER MODIFICATION ASSOCIATION JOURNAL (Vol. VII, No. 1), reproduced herein. This paper reviews the 13-year effort, which may be the longest operational project to date carried out under the supervision of a single organization.

We have learned a great deal from this program and feel that the time may be at hand to amalgamate the productive aspects of the early work with that of others.

I have two slides I'd like to show. The first (Figure 1) is the ground generator network which we set up. It varied during the years from about 100 to 150 units. Just having a ground generator network <u>per se</u> is not enough; the generators must have special qualities in hail suppression work. Firstly, there must be no deterioration in the effectiveness of the AgI crystals in ultraviolet light. Many times the material is released at night and in the early morning hours when temperature inversions are present. This is deliberate, in order to provide for lateral dispersion. Such measures assure the complete coverage of target and upwind areas before the first appearance of small cumulus over either the cloud-breeding area or the target. In this way any convection will effectively treat all developing clouds with AgI. A continuous output from the ground network is essential during hail days to maintain this action.

Extensive tests on all types of generators we use on this project have been conducted by independent laboratories and confirm that no deactivation in sunlight takes place. The dry crystals produced by these units may be a vital characteristic.

The stars on the map are the locations of the generators -- there are about 150 of them. Note those extending north and south from Golden. This is back in British Columbia; the front ranges and the cloud-breeding areas lie between that group of generators and the main network. Another unit installed about 1964 is situated still farther west, at Revelstoke, B.C. Those generators are all operated automatically each day. They are activated by time clocks, turned on every night regardless of whether or not there is a hail threat. Additional units within the main network are activated at appropriate times when a real hail threat is apparent.

The target area that we were concerned with is shown in Figure 1. An additional control area is identified to the north. It was used in some of the evaluation studies. In addition to the ground generator network, many times line seeding by aircraft is done along the cloud-breeding areas early in the day to provide additional AgI drifting into the target area. As mentioned earlier, our thesis emphasizes the principle of early AgI availability, before any clouds form, so that the slightest puff of cloud anywhere is treated in its initial state and continuously thereafter. Thus all of the tactics described are aimed at fulfilling this objective.

I'm inclined to agree with the statement Dr. Dennis made yesterday concerning the possibility that the enhancement of natural rainfall by seeding helps in reducing hail. This is another facet of our program that is considered important. There is always a rain increase phase coupled with the hail suppression effort. This phenomenon is confirmed by Mr. Bishop's figures, in which he points out that historically in Alberta hail is a maximum during wet years and a minimum during dry years. Surprisingly, however, during the cloudseeding era discussed in his paper, hail was reduced to less than a third of the historical average, while rainfall was maintained at normal or above, resulting in record crop yields.

I'll show you one more slide (Figure 2) which illustrates a simple way used to evaluate our project. We tabulated the Alberta Hail Board loss to risk insurance data for the target, both before and during hail suppression, to try to determine any significant variations which might be noted. The average loss to risk from 1938 to 1955, before cloudseeding, was about 12.3%. During the period of 5 years from 1956 through 1960, large variations in the loss to risk figures were evident. This was an interval when we were trying to determine the best combination of equipment, fuels, operating procedures and personnel. The controller emerged as the key to success. One can have all the sophisticated apparatus in the world, but if the controller can't handle it properly so that seeding materials are always available at the right place at the right time (which Dr. Dennis cited yesterday as a prime requisite), you're just out of luck.

In 1956 we didn't accomplish too much because the program was in effect for only a partial season. But in 1957 and 1958, things were looking quite good. This was under Stan Sifferman's control. In 1959, everything fell apart. When we assessed it, we felt our controllers must have been at fault. In 1960, we noted some improvement. When Mr. Stone arrived in 1961, we moved the control point from a trailer near Didsbury to an office at the Calgary Airport. We also increased the efficiency of the aircraft support of the ground units. All of these changes seemed to help. The successive years from 1961 on showed a loss to risk average of about 3.5%, or something less than one-third of what it was before hail suppression. Thus this simple type of evaluation, which may not be appealing to a statistician, is understandable to the farmer who has purchased hail insurance for years.

As Joanne Simpson pointed out yesterday, one must try to express evaluation material in a form understandable to the client. When weather modification is successful and the magnitude of either rain enhancement or hail reduction is substantial, evaluation is possible in forms quite acceptable to both client and statistician.

I must again emphasize the key nature of the controllers' role. If they are not dedicated people who know what they're doing, one may not have much to show for the effort, and evaluation becomes elusive.

In conclusion, I would like to point out that when our group started work in the late forties and fifties, most of the scientific community and government groups were spending their time trying to discourage any attempt at weather modification. Those who followed on and were engaged in operational programs of a commercial nature were obliged to endure a prolonged interval in which controversy over such programs were rampant. Negative views were exported from the U.S. to every country where constructive efforts were in progress. Although many have weathered this storm, it has been a deterrent to rapid progress.

Finally, may I submit that, in my view, the WMA is attaining a stature which can contribute substantially to the development and application of weather control as it may benefit future generations on this planet. I urge all of us working in this field to join forces to bring about a rapid attainment of important objectives -- economic, social and political.

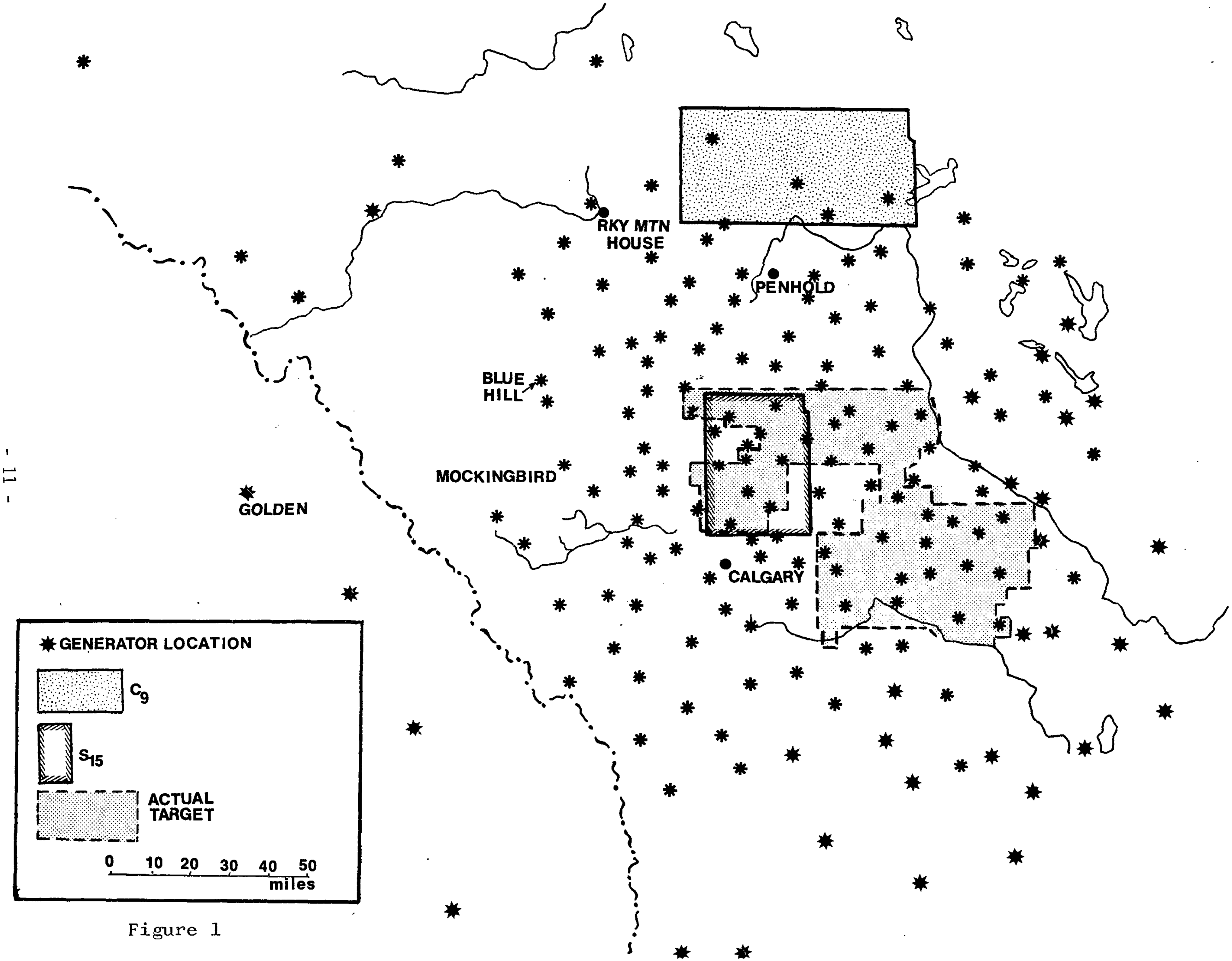
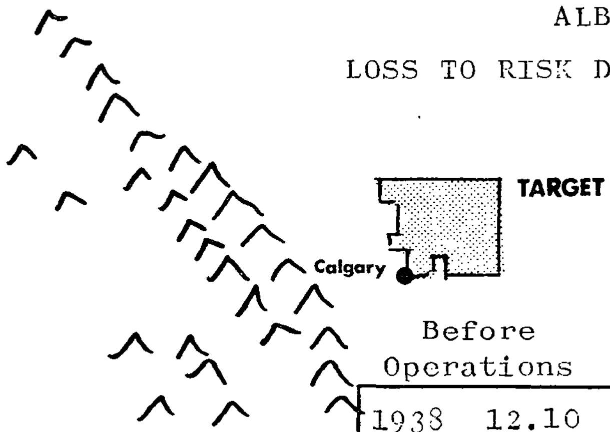

RKY MTN
HOUSE
PENHOLD
BLUE
HILL
MOCKINGBIRD
GOLDEN
CALGARY
GENERATOR LOCATION
C9
S15
ACTUAL
TARGET
0 10 20 30 40 50
miles

Figure 1

## ALBERTA HAIL INSURANCE BOARD

## LOSS TO RISK DATA FOR HAIL SUPPRESSION TARGET AREA*




Before Operations

| | |
|---|---|
| 1938 | 12.10 |
| 1939 | 7.67 |
| 1940 | 6.51 |
| 1941 | 12.68 |
| 1942 | 4.60 |
| 1943 | 10.99 |
| 1944 | 15.34 |
| 1945 | 14.37 |
| 1946 | 9.51 |
| 1947 | 7.69 |
| 1948 | 9.46 |
| 1949 | 15.65 |
| 1950 | 5.12 |
| 1951 | 29.31 |
| 1952 | 4.62 |
| 1953 | 25.01 |
| 1954 | 25.45 |
| 1955 | 4.80 |

Research & Testing Period

| | |
|---|---|
| 1956 | 15.47 |
| 1957 | 8.82 |
| 1958 | 0.15 |
| 1959 | 27.82 |
| 1960 | 12.25 |

Operational

| | |
|---|---|
| 1961 | 4.08 |
| 1962 | 3.33 |
| 1963 | 5.72 |
| 1964 | 2.83 |
| 1965 | 4.03 |
| 1966 | 2.87 |
| 1967 | 3.95 |
| 1968 | 1.01 |

3.5 Average Loss to Risk

12.3 Average Loss to Risk

AVERAGE REDUCTION IN HAIL DAMAGE **71%**

Hail suppression operations performed by Irving P. Krick Associates of Canada, Ltd.

*As used by Prof. Petersen in a restricted report 25 September 1970

Figure 2