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BATTLE WITH AERIAL GIANTS
(USSR)

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BATTLE WITH AERIAL GIANTS
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V. Belotserkovskiy

Air currents are weak in strati. The precipitation of such clouds falls in the form of mist, sleet, or snow.

In summer, when the earth is thoroughly warmed by the sun, cumulus clouds begin to form. The earth and woods "sweat" beneath the warm rays. Warm air, laden with moisture, quickly rises, reaches cold air layers, and then the moisture begins to condense. A cumulus cloud is born.

Ascending air currents of adequate strength do not arise in a continuous mass above the earth, but only over separate, more warmed up parts of the ground. Thus cumulus clouds seldom completely close off the earth from the sun. The earth continues to "sweat" and the rising currents of warm air continue to fill the clouds with additional moisture. The "heap" grows and is transformed into a tower. The cumulus "bastions," beginning at a point of a kilometer or two above the earth, sometimes rise to a height of 10-12 kilometers, and in the tropics, to 16-18 kilometers, twice the height of the highest peak in the world, Mount Chomolungma /Everest/. Millions of tons of water are suspended above the earth. Thus, while other types of clouds are formed horizontally, cumulus clouds have a vertical development.

And this to a great extent determines their marvelous characteristics. While hot weather is found at the "foot" of a cumulus mountain, frost prevails at the peak.

Heavy cold air flows down from the peak while warm air comes up in exchange.

The velocity of vertical air currents in cumulus clouds attains hurricane proportions: 30 meters a second, over 100 kilometers an hour! If a plane flew near the bottom edge of a cumulus cloud, it would inevitably be drawn into it, as a swimmer into a whirlpool. An airplane in a cloud "pool" is bound to be destroyed: The air currents meeting it would break the machine to pieces.

These currents do not yield sufficiently heavy drops of moisture to fall to the earth in the form of common rain. The drops, jostline and clinging together, are borne up the cloud until they become extremely heavy. When the strength of the ascending air currents becomes insufficient to sustain the drops in the cloud, a downpour begins, or, if the upper part of the cloud is strongly cooled, it hails.

Hailstones in cross-section show a stratified structure. The reason for this is that, before they fall to earth, they are carried for a long time up and down the cloud. The moisture settling on them at the bottom of the cumulus tower freezes on the way up, forming a new layer of ice.

Cumulus clouds are distinguished by their violent and rapacious "character." From afar they are very picturesque and harmless, but within them swarm enormous destructive forces. To draw into themselves a careless airplane, wreck it, and smash it to pieces within their maw -- this is a frolic for them. The energy of cumulus clouds is immense. Electric charges arise from friction of water drops within the clouds. When the clouds attain huge and critical proportions, a thunderstorm begins.

But hail is an even more frightful "weapon" of cumulus clouds than lightning. Hailstones may have the size of large eggs, and, falling earthwards, they not only destroy crops and vineyards, but even kill birds and small animals. And while human beings may protect themselves in some way against lightning, man is still helpless against hail.

Hail inflicts especially severe damage to agriculture in southern countries. There it occurs more frequently than in our latitudes, because cumulus clouds grow taller and their summits are more intensely cooled.

Cumulus clouds bring innumerable calamities to man. Even when they break out in rain, they invariably do so in the form of a downpour, which does more harm than good. And they have been "raging" for so long and so regularly that man has become used to this condition. Therefore, the thought of being able to end hail and thunderstorms in the near future seems improbable.

How can this be achieved, how can man dictate his will to the clouds -- both cumulus clouds and other types -- and consequently to wind and rain and storm, when the energy of these natural processes greatly exceeds our own power?

The Thawing Cloud

We flew up to the site of the experiment. Under us were strato-cumulus clouds. Their thickness approached 600 meters. This is high for stratus clouds.

The plane descended and dived into the clouds. We had to measure their moisture, the size of their d rops, and the temperature. This was the task of the supervisor of the group, Seregin.

When he finished the measurements the plane pulled out of the clouds but continued to fly close above them, sometimes tearing through the higher "waves" of the cloud mass. And at these times the plane always shook a little, as though it were penetrating not a cloud, but an actual wave.

"Well, how are conditions?" I asked Seregin.

"Bad! A strong inversion -- 3° above in the upper edge!"

This was bad because hard carbon dioxide depends upon negative, winter temperatures. On the ground it was actually winter, but here at a height of over 2,000 meters there was a "thaw": instead of the usual drop in temperature with height there was an "abnormal" inverse rise up to 3° above C.

The reason for this strange phenomenon is that during winter in our latitudes the earth often receives less heat from the sun than it itself irradiates into space. This results in a so-called radiant cooling of the earth and, consequently, of the layer of air adjacent to it. And the temperature of this layer is then lower than the layers directly above it.

"We'll carry out the experiment anyway," Seregin spoke angrily. "I think it'll succeed regardless. The temperature is lower inside of the clouds. And on the lower edge it's 3° below. Let's test it."

"Get it ready, Boris," he spoke to Krasnovskiy. "We'll use three thousand grams."

Krasnovskiy opened his "drawer," put in a briquet of dry ice, turned a wheel, and pressed a button. In the compartment a loud crackling and hissing broke out. This was a special cutter, rotating at a speed of 3,000 revolutions a minute, which sawed up the chunk of ice into equal cubes one cubic centimeter in size. The cubes fell into the clouds through a bunker underneath the compartment.

The speed of cutting and, therefore, the release of ice were accurately regulated. At this time because of the unfavorable conditions the release of ice was at the maximum -- 3,000 grams a minute.

Could these insignificant particles, which would scarcely suffice for an ice cream freezer on a mild summer day, be capable of destroying a sea of clouds 600 meters thick?

I looked out the window to see.

"The plane will turn back now and you'll see everything," said Boris, noticing my curiosity.

The plane careened and straightened out again. We were on the return course.

I ran into the pilot's cabin. Seregin and Konstantin Dmitriyevich at once pointed somewhere ahead and below. But I saw nothing except the same endless white waves.

"There, over there! A dark streak eroding the clouds! Do you see it?"

In fact the clouds were getting dark as though before a rain.

"Konstantin Dmitriyevich, fly higher," Seregin told the pilot. "Then we'll see the 'lower sun.' This is the reflection of the sun in the ice crystals. Crystals of ice, a myriad crystals are forming there now!"

"And will we see the ground, Yuriy Alekseyevich?"

"Of course," Seregin laughed. "In about 10-15 minutes. The whole process takes from 20 to 30 minutes. When it ends the 'lower sun' vanishes and the ground appears."

I started to look for the "lower sun." It was there. It shone brightly with silver in a furrow opened in the clouds. Merely because of its silver shine I would have preferred to call it a "lower moon."

But now the furrow was getting ever wider and resembled more and more a thawed patch of ground under snow, as though a pipe with hot water were passing below the clouds at this point. The furrow ended and, turning back over it, we saw a field. The snow of the clouds had "melted down to the ground." To the left and right of us the clouds drifted on as before, magnificent and full of cold power, but underneath us there remained only pitiful wisps and some foggy shreds.

Along a highway there were slowly crawling small black beetle-trucks, which were overtaken by Pobedas looking like lady-birds from above. Beside the road was a village. The sun, a real "upper" sun, shone on toy church cupolas.

The plane resumed its course to Mineralnye Vody. The first experiment was completed. Seregin set to work making notes.

Let us attempt to appraise what has happened.

The Search for a Weapon

Ten years ago it was still a matter of mystery, covered, if not by darkness, by an extremely dense fog. Men had actually attempted to "influence" the weather since the most ancient times. They prayed to God for rain or good weather. They offered sacrificies. But these "methods" proved to have little effect.

The steam age came, then the electric age. Men came to place less hope in God and more in their own strength, but little advance was made in control of the weather.

Scientists studied atmospheric phenomena, but, in view of the immense energy enclosed in them, they were powerless to devise anything.

It is absurd, it was said, to build a dam to the sky in order to block cold air. This is only within the capacity of nature, which has raised huge mountain ranges as barriers to winds. It is impossible also, for example, to construct a gigantic ventilator to help in driving away clouds. The task of regulating the weather seemed insoluble.

But in 1921 Soviet professors of science V. N. Obolenskiy and V. M. Vitkevich, said: "It is possible! It is possible to regulate the weather without building huge dams and ventilators."

The nature of atmospheric processes, they said, is contradictory and unstable. Take clouds, for example. Some forces create them and others try to break them up. Man must act under the principle of "divide and rule"! We must unite our feeble forces with one of the hostile sides, and it will conquer for our advantage! But how is this to be done?

Obolenskiy tried, for example, to apply powerful x-rays to clouds in order to alter the electrical charges of the moisture drops. It is well known that like charges arise on the drops from friction. They repel each other and do not permit the consolidation of heavy drops of rain. Obolenskiy wished to assist the intermolecular forces of attraction.

But he had no success. Possibly he was handicapped by the insufficiently modern techniques of his time. In any case, after Obolenskiy's failure skeptics shrugged their shoulders at the idea of directing the weather.

Afterwards, the war broke out, and the weather was entirely forgotten. But when the war ended enthusiasts again began an assiduous search for ways and methods of influencing clouds. Scientists of many countries went to work. At the end of 40 years their search was crowned with success. And this success is mainly connected with hard carbon dioxide.

We are accustomed to the fact that water freezes at a temperature of zero degrees. At any rate this occurs with water in ponds. But it seems that droplets in clouds do not freeze with the arrival of cold weather. The drop structure of water hinders the formation of ice. Water, it may be said, goes over to a condition of transcooling and can remain in a liquid form down to -40° C!

But this transcooled condition of water in cloud droplets is extremely unstable -- they can freeze quickly. And scientists decided to utilize this instability and use dry ice in the struggle with clouds. Falling through a cloud, dry ice lowers the temperature of the surrounding air below -40° C and leaves a cold strip behind it. The drops in this strip freeze and form light, fine crystals of ice. This is the beginning of the process. In the air around the newly born crystals drops of water are suspended as formerly. Molecules of water evaporating from these drops encounter the ice crystals and settle on them. The crystals grow, turning into snowflakes, while the drops "ail" and become nothing. The weighted snowflakes begin to fall to earth. The cloud "seeded" with dry ice ceases to exist.

Now it is known why dry ice does not produce results in above zero temperatures. It does not form ice crystals in summer.

Thus, by spreading dry ice in clouds, we give only the first nudge and disturb the unstable equilibrium of the hostile forces of nature. The process continues by itself without our interference.

To convert one cubic kilometer of clouds into snow, it is sufficient to use approximately one hundred grams of hard carbon dioxide -- dry ice.

But, of course, in practice everything is not so simple. The difficulty lies primarily in the disage. The principle "butter does not spoil porridge" is not appropriate here. Scatter more dry ice than is needed the the cloud will not disperse. A so-called "over-seeding" takes place. Too many drops will freeze at once, and the snowflakes will scarcely grow, not acquiring moisture from anywhere, since too few liquid drops remain near them.

A certain optimum dose is necessary. And it is very difficult to determine it. It depends on the state of the cloud: its temperature, saturation, and the velocity of the air currents within it. The problem is solved in two ways: by repeated experiments and by theory. But, unfortunately, theory still lags behind practice.

The following figures are a good indication of the extent of applying methods of influencing clouds: every year, with the aim of preventing hail, clouds are seeded in France over a territory of 47,000 hectares, in Italy, 46,000 hectares. In the United States, with the aim of increasing precipitation for agriculture and hydro-electric stations, 47,000,000 hectares are seeded annually.

"The Ground!"

We flew towards the foothills of the Caucasus. But we could not see the mountains. The clouds above them heaved as one gigantic breaker, as in the surf. The crest of the wave curled up, remained suspended, but did not drop.

From the ground came an announcement: The Mineralnye Vody airport was overcast.

The decision was made to uncover the airdrome ourselves and land. We no longer had an experiment, but actual work to do! Our job was complicated by the inversion dogging us and by a strong wind especially insidious in the foothills of the Caucasus. The "window" opened by us could be carried by the wind past the airdrome. All our hopes were pinned on our navigator Robert Lin'kov. He had to calculate accurately where we had to "bomb" the clouds.

Robert Lin'kov completed his calculations, and the plane sought out its target above the clouds. Krasnovskiy's machine crackled and hissed, throwing into the clouds its minature "bombs." The clouds under us began to grow dark, and the disk of the "lower sun" appeared again. After we had unloaded our "bombs" we flew up a way and tensely watched the dark furrows carved in the clouds. They spread apart and joined together. From the ground came the first announcement: "Heavy snow has fallen, visibility has decreased."

"Everything is all right so far," Seregin cheered us up.

But it seemed to me that he was reassuring himself instead. We had already flown twice over our furrows. Thirty minutes had elapsed and the ground still was not visible.

"The snow has stopped!" came an announcement from the airdrome. Apparently, down there they were also worried about us.

"What good will that do us? The clouds are heavy and the temperature is not right," said someone, who had probably lost hope of seeing the ground.

At this time the commander noted that the wind from the mountains was beginning to bear fresh clouds into our furrows.

Would we succeed in getting back to Moscow?

Suddenly from the pilot's cabin came a desperate shout by Seregin:

"The ground!"

Everyone rushed to the windows. There was the ground! True, it was hazy, but we could see houses, fields, and roads.

From the ground they radioed: "The sun is shining in the city area! Visibility has increased to 500 meters."

The airdrom was near the city. The sun would be shining there now.

"Get ready to land," the dispatcher announced.

The instrument bells, which automatically inform pilots on the proper time of landing, rang. Already below us appeared the lighted landing strip. A soft bump -- and we were on the ground.

The next morning we set out to examine the ground equipment for dispersing fog over the airdrome. It reminded one of a small tractor, only without wheels or tracks. It was standing on runners. Behind it lay eight balloons of carbon dioxide, in the middle was a cabin for the motorist, and in front was a sprayer, resembling an automobile exhaust pipe or horn. Moving from side to side, it spews up flakes of dry carbon dioxide.

It is proposed that this apparatus be drawn by tractor or car along the edge of the airport on the lee side to disperse fog above the ground. This would be simpler and cheaper than to send up planes.

Seregin showed us another piece of ground equipment. It was extremely simple -- two balloons. In one there was hydrogen, in the other, a solution of silver iodide in acetone. The latter is mexed in a special small burner and kindled. Acetone burns in hydrogen, and, because of the intense heat, silver iodide, the same compound used in photography, evaporates and, mingled with hot air, rises high into the

fog. Silver iodide operates under a different principle from dry ice. Silver iodide is a crystalline substance. In their structure its crystals resemble the crystals of ordinary ice. And this is sufficient to "fool" water vapor, which quickly begins to freeze on the silver iodide crystals as on natural ice. The further course of events is already known to us: the crystals grow, become heavy because of the adjacent drops, and fall to earth. The cloud or the fog is dispersed.

The silver iodide apparatus for influencing fog is extremely simple, but, on the other hand, silver iodide has one grave shortcoming -- it is expensive.

At present carbon dioxide and silver iodide are the basic weapons for acting on transcooled clouds in winter. But these methods are sometimes applicable in summer against warm cumulus clouds.

An Epoch Has Begun

So far, in discussing the struggle with clouds, we have mentioned only the clearing of airports, prevention of hail and storms, and the increase of snowfall on fields for the benefit of agriculture and hydro-electric stations. These things are already possible to achieve and are being done.

But this is far from all the things that can be done. Before us are vast perspectives that are difficult to overestimate. Clearing clouds from a huge expanse of the earth at once will summon the sun to heat up the layers of air above the earth. This will change air pressure and the direction of air currents. On the other hand, over-seeding of clouds can prevent rain and natural dispersal of clouds, which, in turn, will also change the thermal balance and atmospheric currents.

And if one adds the fact that the climate in different regions of the globe exists in close reciprocity, then it is clear that, conducting similar work, we can control and change world climate on the broadest sclae. In the opinion of many outstanding scientists of the world, all this will be a matter of the near future.

Perhaps, in this century our country will be covered by a network of stations for directing the weather, as it is covered now by, say, meteorological stations.

How will these stations be equipped? Possibly, they will be armed with rockets containing new, highly effective substances, or with aerial balloons automatically spraying these substances (airplanes will scarcely be used), or, finally, there may be specially directed machines

radiating high-frequency currents or any rays influencing electric charges of clouds. Or, possibly, there will be another, a third, or a fourth means, which we cannot imagine today. The completely automatic direction of the different types of "weapons" of these stations will be effected by oblast or all-union central direction points. To such a command point will come weather summaries from every corner of the world. They will be subjected to lightning-fast analysis in special electrical calculating machines in order to work out an accurate prognosis of the weather. And then with the aid of these machines the daily dispatchers will receive accurate instructions on the necessary action to "improve" the existing weather.

This improvement will be planned in such a way that it will be possible to give full satisfaction to the weather "applications" sent in by different organizations of our country or even of neighboring countries. Probably, the necessity of creating world-wide coordination centers will arise, so that improvement of the weather in one country will not lead to deterioration of the weather in a neighboring country.

Thus, in the near future there will spring up a new remarkable type of industry -- the industry of artificial climate!

That small experiment, in which I managed to be a participant, has convinced me of the reality of this bold dream.

FIGURE APPENDIX

The Vanquished Clouds
[Original Pages 2-3]

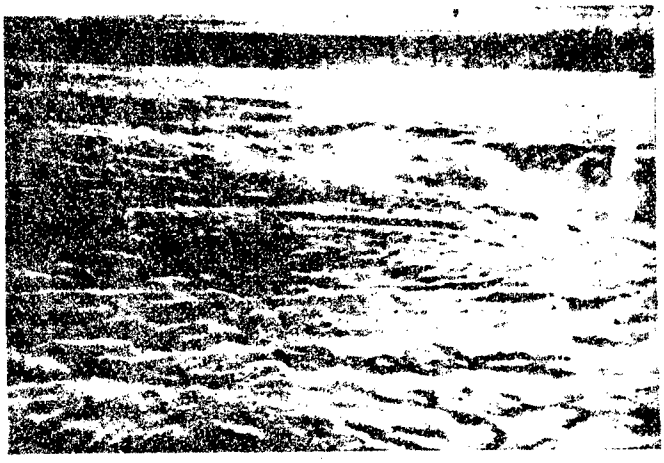

Figure 1. Ten minutes after the airplane seeded the clouds with dry ice. The "lower sun" has appeared...

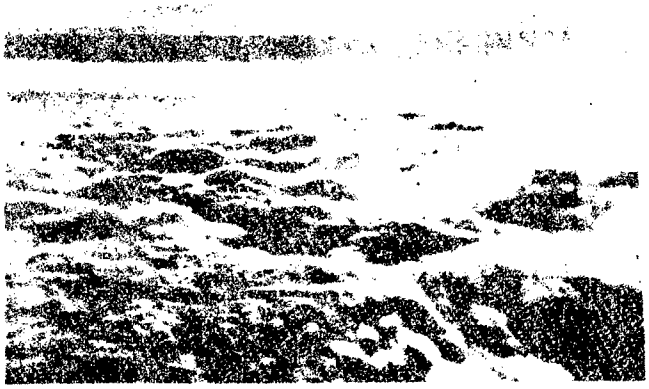

Figure 2. After twenty minutes...

Figure 3. Twenty-five minutes afterwards a dark, wide erosion was formed in the clouds...

Figure 4. A half hour has elapsed. The clouds have opened, but the ground is still covered by fog...

Figure 5. Another five minutes... The ground!

Figure 6. With each moment the horizon expands more and more.

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- END -