THE WEISSFLUHJOCH RESEARCH INSTITUTE

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Origins

Snow has been a serious obstacle to the advance of modern civilization into the alpine valleys and mountains. In particular, early efforts to limit the devastation caused by avalanches have often been ineffective. Accordingly, following upon the pioneer work of J. Coaz, F. Fankhauser, E. Hess, M. Oechslin, E. Eugster and other engineers, the Swiss Forestry Department in 1931 appointed a Commission on Snow and Avalanches with the intention of bringing together the various groups interested in the matter, with the object of laying the theoretical and practical foundations of avalanche defence.

An attempt was first made to gain insight into the behaviour of the snow cover by observations at different stations in the mountains. However, a study of the abundant data collected over a number of years proved that owing to extreme variations of external influences, such as wind, temperature, radiation, precipitation and terrain, observations in the field alone could not establish the desired general principles. Here, then, as in many other fields of endeavour, systematic scientific research was seen to be indispensable. The Commission sought and obtained the collaboration of the scientific institutions of our universities in a project for a combined field and laboratory investigation into the principles governing the behaviour of the snow cover. In 1934, the scientific examination of that most peculiar substance—snow—was initiated on the basis of our experience in soil mechanics. Preliminary experiments in this direction made by R. Haefeli proved that the pertinent properties of snow could be determined, but also made it clear that we were not faced by a purely mechanical problem, but also with one in crystallography. Thanks to the great interest for the latter problem manifested by Professor Paul Niggli, Director of the Mineralogical Department of the Swiss Federal Institute of Technology and his assistant H. Bader, it was possible to demonstrate the constantly changing nature of snow conceived as a crystalline aggregate.

In order to characterize clearly the various kinds of snow, it is necessary, as in the case of other aggregates, to examine both its separate particles and their relations to one another. The age of a snow sample is best seen in the form of the single crystals, those of freshly fallen snow showing a finely branched formation, which, as metamorphosis proceeds, becomes more and more granular. This change is not only a function of time, but is also in a high degree dependent on meteorological conditions. It takes place more quickly the nearer the temperature approaches the melting point.

Amongst the most important experiments are those which determine the change in the plastic properties of snow under the influence of external forces and of its own weight. Extensibility, compressibility and shearability have become important concepts in snow mechanism. The coefficients of deformation can be experimentally determined, but for the clarification of the important influence of temperature, special facilities are necessary. By examining a large number of samples it is possible to determine certain average values and then to compute the distribution of stress within the snow cover. This work is of decisive importance as a basis for the design of avalanche defence structures.

The scientists engaged in snow investigation, all enthusiastic mountaineers and skiers, soon extended their activities beyond the confines of the Weissfluhjoch laboratories which are kept continually at temperatures below freezing point. In the course of several winters they have systematically observed the development of the natural snow cover. The evaluation of the measurements

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recorded periodically on a horizontal field of observation to show so-called "time cross-sections" gives an instructive picture of the state of the snow cover in dependence on weather conditions. It becomes evident that each winter has its special characteristics and that snow conditions in a given region can only be appreciated after observations extending over a number of years. Several stations of various altitudes and orientations give us interesting records for purposes of comparison. The measurements of snow pressures, which have been made for some years, have proved to be of great practical importance. By means of apparatus set up in the field, the forces exerted on structures on steep slopes by the slowly creeping snow cover have been measured, and in this way the statistical foundations for the statics of economic construction of avalanche defence structures are being established. As structures of this kind previously erected were of purely empirical design, it should be possible, now that we know the stresses to which they are exposed, to effect considerable saving in their construction. Practice, however, has the last word, and it would, at this early date, be a mistake to formulate generally valid conclusions on the basis of incomplete data obtained from specially situated experimental stations. The design of avalanche defence structures depends first of all on the character of the local snow, and requires detailed observations over a period of years. There can therefore be no standard solution of the problem. Just as in bridge design one must have information on water, cross-sections and building materials, so terrain, site and snow conditions form the computational basis for the snow engineer.

The artificial release of avalanches by means of detonations was adopted in 1936 and brought us into close contact with those already interested in the practice, in particular with the Parsenn Safety Service under the experienced control of C. Jost. This new method for the prevention of avalanche accidents has been developed into a useful service and has been made generally available for military and civil purposes.

Closely related to the question of avalanche defence structures is the study of snow drifts, a matter of importance in keeping open the alpine highways in winter. Second only to avalanches, snow drifts are the principal causes of interruptions of traffic during the cold season. By exercising care in the choice of the routes and by means of deflecting surfaces, it is possible to avoid excessive drifting.

One of the main tasks of our organization is the dissemination among the ski-ing public of information of the state of the snow cover and the part it plays in the development of avalanches. Of late years winter sports have gained enormous impetus, so that it has become necessary to carry on a systematic campaign to acquaint skiers with the dangers to which they may be exposed in the mountains.

The New Institute

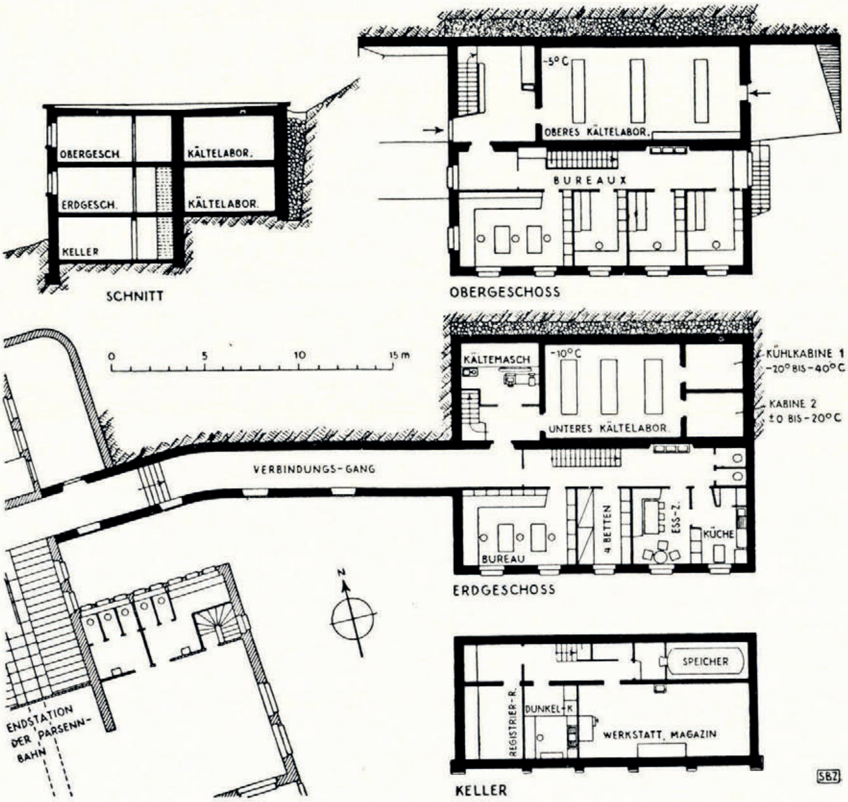
Although a number of the phenomena observed in the changing state of the winter snow cover have already been explained, the programme of research to be carried out had to be greatly extended. As a result of the demands made by scientific and engineering circles, the idea of establishing a permanent centre for the investigation of snow and avalanche problems ripened. After careful consideration of places and projects, the Federal Government approved the proposals made by a committee of experts to build a permanent institute in place of the old Weissfluhjoch station which had worked with makeshift equipment; in a few months a fine new building was completed.

Simple in design, coloured slate-grey to fit into the scene of its mountain surroundings, the Institute now stands amidst the glistening snowfields. As if it had grown from the rock, but modern in its architecture, it harmonizes with the nearby Weissfluhjoch station of the Parsenn Railway. There is no ostentation; the façade of stone and wood make a modest yet defiant impression. The difficulties of construction at such a height above sea-level have long been forgotten. Forgotten, too, the cold, sleety days when the work of excavation had just begun, the wind whistling through the scaffolding and framework. Masons, carpenters and mechanics all did their best to make this, one of the latest seats of scientific research, a pleasant place in which to work.

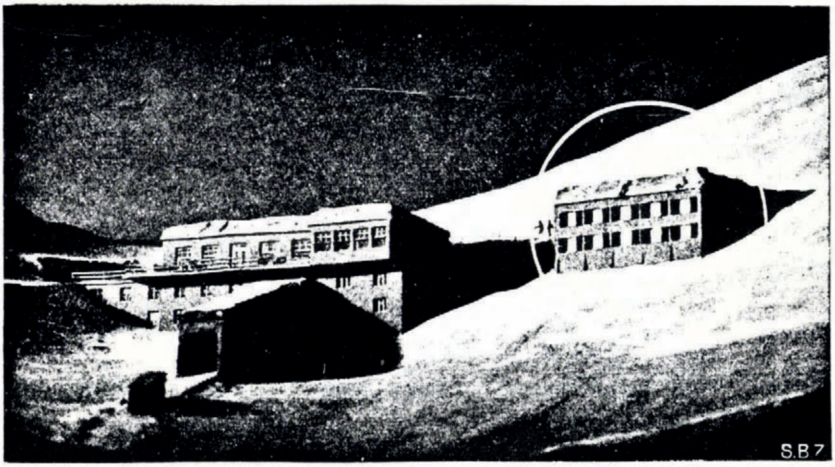
There are two large and two small refrigerated laboratories. There are facilities for the rapid taking of photomicrographs of the crystals deposited from the air, for they are but transitory. In obedience to inner forces their surface becomes smaller as they mature, a process confined to the life of the inorganic world. But many phenomena are related to this metamorphism. Their explanation must be found by laboratory methods before the secrets of snow can be revealed even approximately. Here is research work for meteorologists, crystallographers, physicists and engineers. A workshop in the basement permits the construction of instruments for field and laboratory work and the adaptation of such apparatus to the many divers demands made on it. There is also a dark-room for developing photographs.

In the offices, panelled in light natural wood, a glance through the south windows reveals a magnificent panorama of snow-covered mountains and provides a stimulus towards the practical application of the results of scientific research.

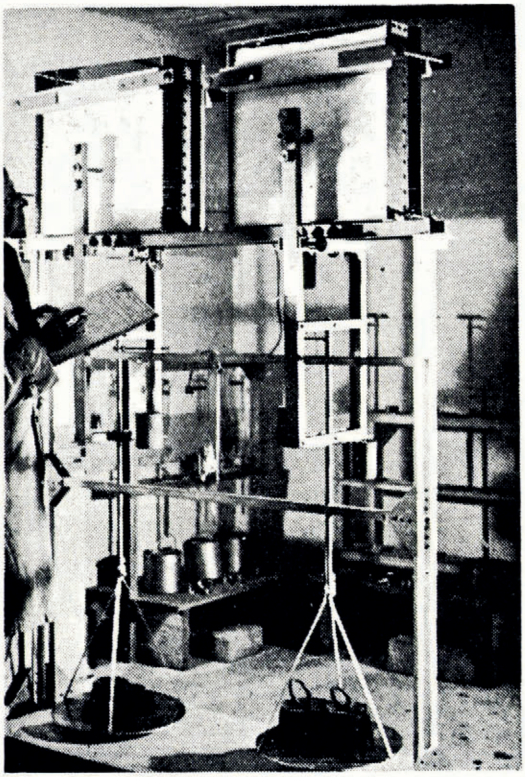
The difficulties and cost of transportation of fuel, be it coal, wood or oil, to 2700 m. above sea-level make the use of electrical heating apparatus essential. An electric hot-water storage tank of 4600-litres capacity permits the use of relatively cheap night power. An 80-kilowatt heater brings



Weissfluhjoch Research Laboratories
Sectional Elevations and Plans



Model of the Weissfluhjoch Funicular Terminus with Research Institute (*ringed*)



Apparatus for measuring plasticity of snow

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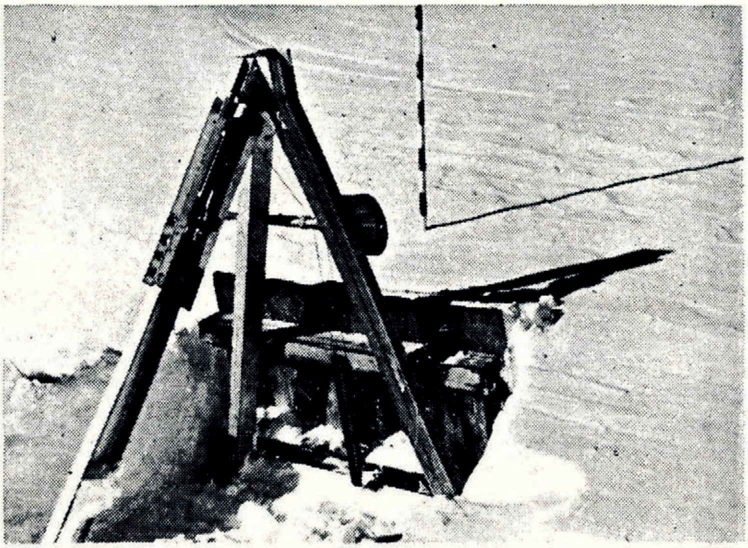
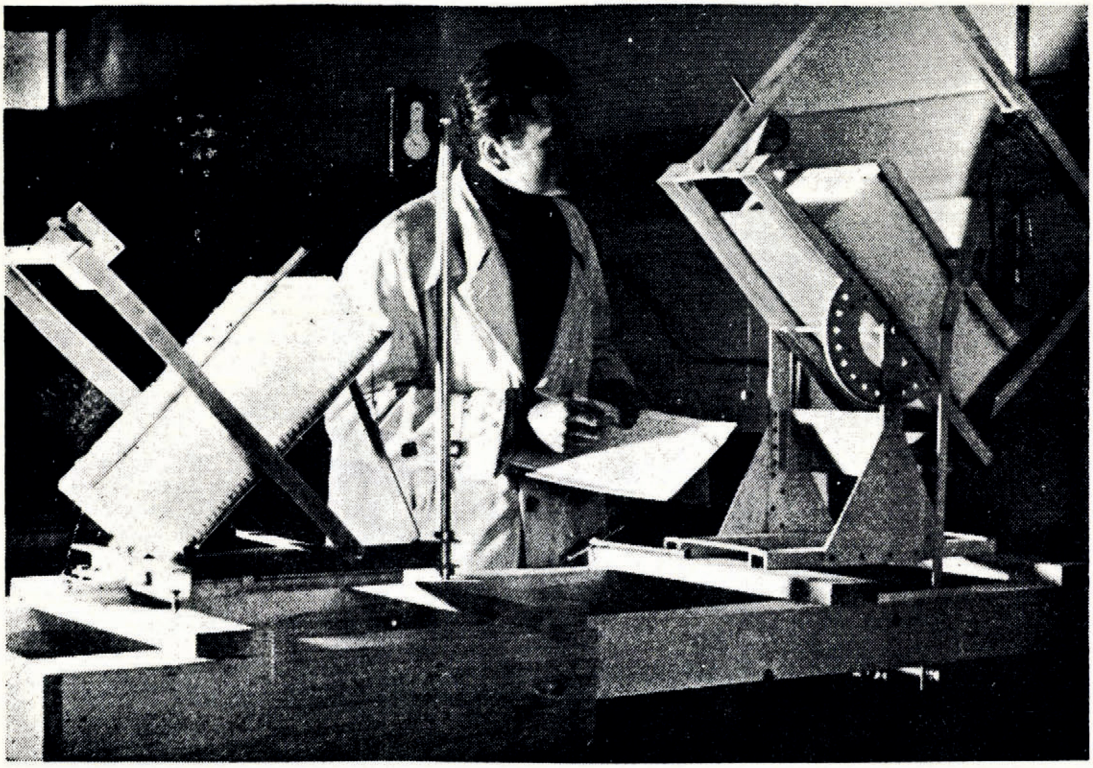


Apparatus for measuring the pressure caused by snow creep in the field



Dr. E. Bucher with laboratory apparatus for measuring snow creep

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the water temperature up to a maximum of 100° C. between 10 p.m. and 6 a.m. To gain space by the elimination of radiators and pipes in the offices a heating system by radiation from the ceilings was adopted at the suggestion of the firm of Sulzer. A system of hot-water pipes is embedded in the concrete and helps in its reinforcement.

The refrigeration of the four laboratories is as follows: A centrifugal ammonia compressor "Frigoroto Sulzer" of 8200 kg.-cal./hr. cools a large tank of brine to −24° C. The heat is dissipated into the air outside the building by a ribbed condenser. The brine is pumped through pipes suspended from the ceilings of the two large laboratories (−5° and −10° C.), the rate of flow being thermostatically controlled. The two smaller low-temperature laboratories are cooled by separate two-stage refrigerators "Therma Kühlautomat" to −20° and −40° C. respectively. Here there is no brine storage, the freon evaporators being inside the cabins. The two evaporators are fed from a single condenser immersed in the brine tank cooled by the large Sulzer refrigerator. The two-stage refrigerators are small and economical owing to the low condenser temperature. The temperature control in all the laboratories is fully automatic, giving a variation of approximately 2° C. During the cold midwinter days the laboratories will soon be capable of being cooled by the admission of outside air. There will also be an installation for defreezing in order to remove the hoar which accumulates on the refrigerating system.

GLACIER FLUCTUATION

Dr. P. L. Mercanton's report on the fluctuations of the Swiss glaciers during the year 1946 shows that although the general trend is one of strong recession, several glaciers are still advancing. The Prapioz and the Scex-Rouge Glaciers which were receding in 1943–4 had in the next two years advanced 64 and 87 m. respectively. Out of 76 glaciers observed, the following are the percentage figures for the years 1945 and 1946 :

	Advance	*Stationary*	*Recession*
1945	6 per cent.	5 per cent.	89 per cent.
1946	13 ,,	7 ,,	80 ,,

The full report is published in *Die Alpen*, Vol. 23, 1947, pp. 313–20.

EUSTATIC RISE IN SEA-LEVEL

In the *Geographical Journal* (Nos. 1–3, Vol. 109, 1947, p. 157) Dr. R. W. Fairbridge gives details of slight rises of sea-level on the coast of Western Australia. These, as he suggests, can doubtless be correlated with the general recession of glaciers which has definitely been established in the northern hemisphere and of which there is accumulating evidence in parts of the southern.

In the succeeding issue (Nos. 4–6, p. 288) Dr. C. Teichert supplements these remarks with evidence on which these conclusions had been based. He concludes "Western Australia . . . provides a natural eustatic gauge, equipped with a sensitive recording material. More intensive studies of the coastal physiography of Western Australia such as are now being ably prosecuted by Dr. Fairbridge are bound to result in a better understanding of eustatic movements during the Late Quaternary, especially the Recent, period."

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