found. The drillers' bits now probed the rock formations of the Eocene and Oligocene ages; soon wells were being drilled to 12,000 ft. To-day, in the United States alone, ninety-seven wells are being operated at depths below 15,000 ft., of which twenty-two were drilled last year.

Difficulties increase, and costs multiply, with greater depths. (A 15,000-ft. well is three times as expensive as one of 10,000 ft. It may cost anything up to £400,000 to drill.) The strains imposed on rigs at a depth of two or three miles are vastly greater than with more shallow wells. Derricks have to be of much heavier construction to take the weight of the drill pipe and to hoist it up out of the hole. The heat at 15,000 ft. seriously interferes with the effectiveness of the normal drilling muds. Bits wear out more quickly owing to the greater density and hardness of the deep rock formations. Pipe that is fully adequate to drill to 5,000 ft. will twist at double that depth and drill crooked holes. The recent use of diamond bits for deep-hole drilling has eased the problem.

The world's deepest well had reached 21,482 ft. a little time ago when it was halted by a core stuck at the bottom and the drill pipe stuck at 12,000 ft. The core will reveal whether the well has reached formations of the Oligocene age. If it is still in shales of the lower Myocene age, drilling may be discontinued—with no oil found.

One of the most interesting of recent developments has been the adoption of directional drilling, the process whereby the direction taken by the bit can be changed while drilling is in progress—or the well can be drilled from the start at a chosen angle from the vertical. By this technique it is possible to deflect a hole from an unproductive to a productive part of an area and so save the time and cost of drilling again from the top; the hole can be deflected around particularly hard and difficult underground formations; a fire at a well can be brought under control by drilling a slanted relief well into it; by the same means one can drill under the sea from dry land.

The angle of drift is effected by means of a tool called a whipstock; this is a 'cone' which is lowered into the hole base first with its apex pointing upwards. A drilling bit will always follow the line of least resistance and, when it encounters the apex of the cone, it is naturally deflected from its vertical path at an angle, the angle being dictated by the shape of the whipstock used. Normally, the full angle to which it is intended to deflect a hole is made by a series of whipstock operations, the drift being increased 2–3° every hundred feet until an average angle of 10–45° has been obtained. Directional drilling programmes have been known to achieve a drift of 80° to a vertical depth of 8,000 ft.

Drilling practice is never static. The direction of advance has been and will be towards the automatic rig. The most difficult task has always been the racking of the drill pipe as it comes out of the hole in sections of ninety feet or more. Steel arms at various heights have now been evolved to do this automatically. Unscrewing the pipe joints also taxes the strength of the operators. Chains on winches have been used for twisting the pipe, but power-driven 'tongs' have done this by the push of a lever. To speed drilling a jet bit has been produced.

The greatest depth at which oil has been discovered is 17,895 ft. It is hoped that much more will be discovered below 20,000 ft.

SELECTION OF SUPERVISORS

IN June 1948, the National Institute of Industrial Psychology's Foremanship Research Group conducted an experimental selection procedure in a large heavy-engineering works in Scotland. Two different selections for promotion to supervisory positions were made from a field of 110 candidates, obtained by advertisement within the firm. The first selection was made by management by their customary method of review and nomination; in the second, from the same field, systematic methods were used, including biographical history sheets, recommendation forms, intelligence tests, interviews, group discussion sessions, and a final selection panel. The latter procedure was carried out by members of the management with the advice and assistance of a member of the staff of the National Institute of Industrial Psychology.

After two years a check was made and gradings by the selection panel for the 44 men regarded as worth serious consideration for promotion correlated 0.68 ± 0.08 with assessments made on these men by their managers two years after the original selection. This was an encouraging result in comparison with the poor prediction, 0.23 ± 0.14 , obtained by management's normal procedure. Another check has now been made by J. D. Handyside and D. C. Duncan some four years and five months after the original selection experiment*.

Two criteria were available against which to assess the efficiency of selection: first, ratings by managers who were in a position to assess the performance of the men concerned; and, secondly, whether the men had been promoted twice, once, or not at all during the four and a half year period.

Management's customary method of selection consisted of short interviews by the candidates' managers and discussion among managers who could be expected to know the men reasonably well. The results of the experimental evaluation of this method indicated that it was defective to a startling degree.

It appears from this experiment that a combination of existing, fairly elementary, selection techniques permits prediction of supervisory success—as measured by management criteria—just about as well as the uncertainties of the criteria allow. Nevertheless, there is a need to improve the economic efficiency of the selection methods.

* *Occupational Psychology*, 28, No. 1; January 1954.

GULMARG RESEARCH OBSERVATORY

By PROF. P. S. GILL

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WITH the development of the subject of cosmic radiation the need for stations at various heights and in different parts of the world has become increasingly important. Previously, the high-altitude research stations were used for astronomical, astrophysical, meteorological and terrestrial magnetic measurements; but during recent years these stations have become mainly associated with the work in cosmic rays. In the Americas, a number of high-altitude research stations have been established through the efforts of cosmic-ray investigators, some of which—Mount Evans, Echo Lake, Climax, Mexico

City and Huancayo—are well known; in Europe, too, there are a number of stations, the best-known being the Jungfrauoch in the Alps.

Within the past fifteen years, cosmic-ray studies in India have been initiated in a number of institutions, and naturally the need for establishing a station at a height where it is convenient to work throughout the year has been felt. The Meteorological Department has a station at Kodaikanal (about 7,000 ft.) in southern India, close to the geomagnetic equator. The geographical position of India for the study of cosmic rays is of special importance, because one can go from the geomagnetic equator to about 25° N. within a narrow range of longitude. The effects of the earth's magnetic field are strongly felt in this part of the world, for the intensity of cosmic rays varies rapidly with geomagnetic latitude within the intermediate latitudes.

Aligarh Muslim University was one of the institutions in India where work on cosmic rays was initiated in 1949. The cosmic-ray group thought it necessary to establish a station in the Himalayas at a convenient height, and, after considering various sites, it was finally decided that such a station should be located at Gulmarg in Kashmir. The Government of Jammu and Kashmir provided ample facilities for the opening of this laboratory, and a formal agreement was signed with the Government in the year 1951. The observatory was officially opened this year on April 4 by Prof. A. H. Compton, chancellor of Washington University (see *Nature*, May 1, p. 805). Spacious accommodation at Gulmarg has been provided to house the laboratory, its staff and visitors. The research observatory is run jointly by Aligarh Muslim University and the University of Jammu and Kashmir under a managing committee consisting of representatives of both these institutions. The decision to establish the observatory at Gulmarg was based on many factors, one being that Gulmarg is one of the finest hill stations in Kashmir with a very fine golf course, and another that it is easily accessible and, if need be, it is possible to keep the observatory open for the whole year. In the words of Prof. A. H. Compton: "The height of 9,000 ft. is as great as persons unaccustomed to altitude can work without discomfort, and is adequate for many types of study that cannot be performed effectively at sea-level. The altitude is comparable also with that of most of the high-altitude laboratories elsewhere with which it is important to compare results, for example, Mexico City (about the same magnetic latitude) at 7,500 ft., Huancayo, Peru, at 10,500 ft., Echo Lake, Colorado, at 10,000 ft., and Jungfrauoch, Switzerland, at 11,300 ft. The location is also suitable as a base station for work at higher altitudes, up to 11,000 ft. at Khillan Marg, one hour distant, and up to 14,000 ft. at Apharvat, three hours distant. These locations are as high as any stations at which high-altitude research is now regularly being done".

The research observatory is easily accessible, and a 'jeep' can go right up to the gate of the observatory. To get to Gulmarg, one can fly from Delhi to Srinagar, the capital of Kashmir, the flight lasting three hours, and from Srinagar Gulmarg is twenty-eight miles away. Alternatively, there is a train service up to Pathankot, from where one can take a bus to cover the 275 miles to Srinagar. A good road goes from Srinagar to Tangamarg, which is within four miles of Gulmarg, and this road is now being extended for 'jeeps' and trucks right up to Gulmarg. The proposed

tunnel under the Banihal Pass will keep the road open to Srinagar throughout the year.

The physical details of the observatory are as follows: altitude, 9,000 ft.; geographic latitude, 34° 03'; geomagnetic latitude, 24° 36'; geographic longitude, 74° 24'; average barometric pressure, 707 mb.; maximum temperature, 80° F.; minimum temperature, 30° F.; and average temperature, 60° F. At present the electric power is not satisfactory, as the supply only allows for 5 kW. and the load is such that the voltage fluctuates considerably; also, the alternating frequency is 25 c./s. The Kashmir Government intends to instal a new generator which will give 220 V., 60 c./s., within a few years. During the working season, Nedou's Hotel remains open to visitors, and there are also a number of small hotels and eating places. There is a market for buying provisions. Horses, ponies and labourers are available in abundance at fairly reasonable rates.

The resources of the observatory are meagre, as the two co-operating universities are unable to provide adequate funds at present. It is hoped that in due course a small workshop will be installed. The managing committee of the observatory has empowered the director to allow Indian and foreign investigators to carry out work at this altitude and latitude, if such requests are made. It is intended to develop the observatory into a general-purpose high-altitude laboratory; though it is not meant solely for the cosmic-ray studies, this is the main field in which work has been in progress.

SOCIAL FEEDING BEHAVIOUR OF BIRDS

AUSTIN L. RAND, of the Chicago Natural History Museum, has published a paper with the object of illustrating how certain behaviour patterns in birds may have originated out of general tendencies and evolved from simple to complex patterns (*Fiedliana: Zoology*, 36, No. 1). Social feeding habits of birds, outside the breeding season, are considered from the point of view of possible stages through which the more complex patterns have evolved. Behaviour patterns are examined and compared, and arranged according to their similarity in organization and usefulness. This discloses a number of series, each starting with the simple and becoming more and more complex.

Intraspecific social behaviour is examined first, as it is simpler, and the factors involved tend to be more easily seen. Gregariousness is very pronounced in birds, and seems to be the main starting point for these associations. This flocking could be a disadvantage when food is limited; but various modifications or organizations of the flocks exist that not only cancel out such disadvantages, but also make a position in the organized flock more advantageous than solitary feeding. The most obvious of these are: spacing out of the flock to reduce competition; the leading of some individuals to food by others going to it; the beating or driving of coverts, which flushes prey into accessibility; combining of individuals to capture, kill or otherwise secure food already sighted.

The feeding associations of birds transcend species limits, and many are concerned with animals other than birds, including man and his extensions such as ships. The bird seeking the association is often the