particles. As a result of these collisions a range of small-sized particles would be formed, and those with dimensions of the order of 10^{-5} cm. would be driven off from the comet by the sun's radiation pressure; in this way a comet would produce tails indefinitely at each return to perihelion.

One important effect may be mentioned. Differences of period in the particles must result in their distribution around the orbit of the comet, and in some cases these particles are responsible for meteor streams. In addition, collisions could lead to a resistance which would have effects similar to the Poynting–Robertson effect, though differing quantitatively, thus decreasing the perihelion distances of comets and accelerating their velocities.

This is described in a paper by H. P. Robertson, under the title, "Dynamical Effects of Radiation in the Solar System"[3]. Poynting showed that the absorption and re-radiation of solar radiation by small bodies produced a tangential drag, decreasing the angular momentum of the particles and causing them to spiral inwards towards the sun; and Robertson examined the problem from the point of view of relativity. He obtained expressions for the retarding force which differed from those of Poynting and Larmor, and he admitted that the values caused by the drag could not be reconciled at the same time between the various elements. Lyttleton suggests that the further mechanism provided by his theory, combined with the Poynting–Robertson effect, might partly solve the difficulty that Robertson met in dealing with Encke's comet. It is hoped that Lyttleton will pursue this important subject later.

[1] *Mon. Not. Roy. Astro. Soc.*, **111**. 3 (1951).
[2] *Mon. Not. Roy. Astro. Soc.*, **108**, 6 (1948); see also *Nature*, **164**, 119 (1949).
[3] *Mon. Not. Roy. Astro. Soc.*, **97**, 436 (1937).

ELECTRONIC TELEPHONE EXCHANGES

A TELEPHONE exchange is basically a switch or aggregate of switches, by means of which two subscribers are connected together for the conduct of a telephone conversation. A manual exchange system is one in which human operators carry out the interconnexions between the subscribers; but the idea was conceived some sixty years ago that this work could be conducted automatically by means of electromagnetic switches operated by impulses sent by the subscriber initiating the telephone call. This conception has been developed notably in the past thirty years or so; and about half a dozen systems of automatic telephone exchange have achieved large-scale use in different parts of the world. During this period of development the thermionic valve amplifier, or repeater, has also been applied and has become a normal piece of equipment in any trunk or long-line telephone system. More recently, attention has been given in Great Britain and other countries to the possibilities of automatic telephone exchanges constructed with electronic switches, in order to determine whether exchanges cheaper and more reliable than the present types using electro-mechanical switches may thereby be produced.

At a meeting of the Institution of Electrical Engineers on March 13, a very interesting paper entitled "Electronic Telephone Exchanges" was read by T. H. Flowers, of the Post Office Research Station, Dollis Hill. The author approached his subject in a broad manner, and did not merely limit his theme to a simple problem of replacing a number of electro-mechanical switches by the corresponding valve assemblies carrying out the same individual functions. The paper considered the problem of line interconnexion anew from first principles, and then discussed some of the practical forms which electronic exchanges might take, the possibilities and characteristics of such exchanges, and—very briefly—the questions of cost and reliability. The multiplex switching arrangements required can make use of carrier-frequency or pulse techniques to obtain frequency- or time-division systems respectively. At the reading of the paper a demonstration was given of the operation of a model three-line exchange using trains of pulses for interconnexion, line-signalling and speech transmission between the subscribers' installations. Speech frequencies of 300–4,000 c./s. can be transmitted with a pulse-repetition frequency of 10 kc./s. for the trains of pulses. For a switch dealing with a hundred channels, the time-spacing between the channels is then 1 μsec., and a pulse width of 0·3 μsec. is desirable. As Mr. Flowers points out in his paper, transmission gain and loss, variation of loss, and distortion are features of electronic connector switches not found in existing types using metal-to-metal contacts; but, on the whole, better speech transmission could be given by electronic systems using the connector switches described in the paper.

In the discussion, which followed the reading of the paper, several speakers emphasized the need for caution before too hurriedly adopting these new techniques, since cost and effective life are major items for consideration. A modern telephone exchange is expected to last for at least twenty-five years, and, as Mr. Flowers pointed out, it would be necessary to guarantee at least a five-year life for the components, including the valves, if the effect of failures on the service and the cost of replacing faulty parts are not to be prohibitive. The meeting provided a very useful introductory outline on the possibilities of electronic automatic telephone exchanges, and, whatever may be the outcome, there appears to be enough encouraging evidence to justify proceeding with the development of such exchanges.

COSMIC-RAY EXPEDITION TO THE HIMALAYAS

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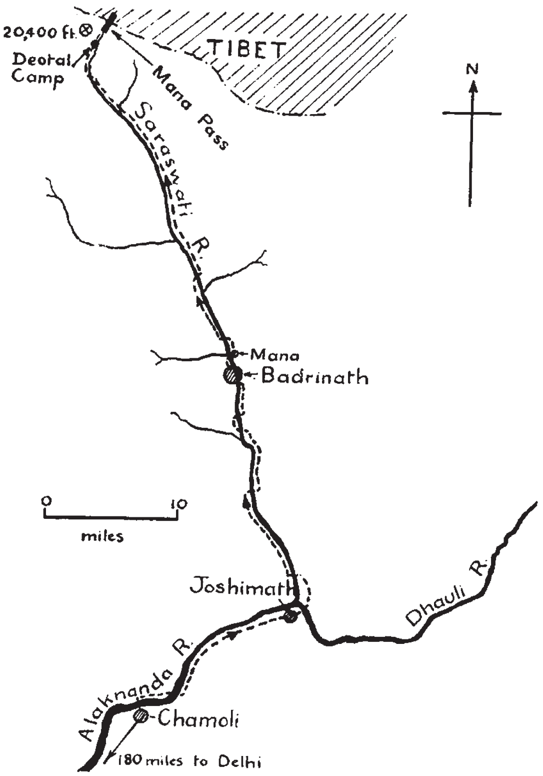
THE University of Ceylon recently sponsored a cosmic-ray expedition to the Garhwal Himalayas. Early in 1951 various high-altitude experiments were designed by Dr. V. Appapillai and me, and a grant from the research committee of the University was obtained to enable these to be carried out. Accounts of the experimental work will be published in due course as the results become available. The purpose of the present note is to communicate some general information concerning the expedition, which, it is felt, will be of interest to cosmic-ray physicists and perhaps to others.



The scientific equipment was limited to photographic plates of the nuclear-research type. There is no doubt that electronic equipment could have been taken over the entire route; but the much greater weight to be transported (due particularly to the necessity for carrying a diesel-electric set) was not within the scope of our budget. Approximately two hundred plates were taken, some of them in aluminium boxes evacuated before leaving Colombo to minimize fading, and the remainder in air. These were placed at various heights up to 18,400 ft. (The highest point, 19,150 ft., was reached by the expedition on the return trip to recover the plates; during the first ascent we were hampered by a snowfall and were forced to place the plates in the valley rather than on the peaks adjacent to it.) The exposure time was fifteen days at the maximum height, and longer for lower altitudes. During the period of exposure the expedition returned to Badrinath at 10,400 ft.

Garhwal, a district of the Kumaun Division of the United Provinces, is bordered on the north by Tibet. The site selected for making cosmic-ray exposures was the Mana Pass, one of the highest passes between India and Tibet. It is situated at approximately lat. 31° 5′ N., long. 79° 26′ E., and has an altitude of 18,400 ft. at its highest point. The Pass is accessible by a 28-mile goat trail from the town of Badrinath (see map), which is in turn linked by a 56-mile foot-path, maintained by the Public Works Department, to Chamoli, which is the terminus of the bus route from the rail-head at Kotdwara.

Badrinath is one of the holy places of the Hindu religion and is visited annually by a large number of pilgrims. There is, therefore, ample catering and accommodation available, and, as the town itself is at 10,400 ft. in the heart of high country, it provides an excellent base for sallies among the surrounding mountains. The actual route followed by the expedition is indicated by the dotted line on the map. There are no villages up the Saraswati valley beyond Mana; but there are camping sites used by Tibetan shepherds and traders who cross the Pass with their flocks during the season. From Badrinath to the Pass the trail climbs steadily and requires about four days.

Coolies were drawn from Chamoli for transport to Badrinath. These men are Dotials, well built and willing, and carry more than 80 lb. for Rs. 3 or 4 a day plus an issue of rice. However, they are unaccustomed to extreme cold, and we replaced them by Bhotias from Mana village, two miles beyond Badrinath. These carried 60-lb. loads to the highest camp-site (Deotal, 17,900 ft.).

There has been a considerable amount of discussion concerning suitable sites for high-altitude laboratories, and the Himalayas seem to have received less than their merited share of attention. Certainly they have attracted all too few scientific expeditions. One of the incidental aims of our expedition was to explore the possibilities of this area of the Himalayas for serious cosmic-ray work. We felt that the average physicist is something less of a mountaineer and is unlikely to conduct prolonged dispassionate investigations while clinging on a crumbling crag. Important requirements of a good site are accessibility and safety as well as high altitude.

After correspondence with a number of Indian physicists, surveyors and government officials, we concluded that Sikkim and Garhwal contain the most promising sites either for an expedition or a semi-permanent cosmic-ray station. Both offer reasonable access to heights around twenty thousand feet without demanding special mountaineering skill or imposing undue hazards. Sikkim is at present closed to travellers, and hence Garhwal, in our opinion, offers the best opportunity.

The site adopted by us may seem remote, being some eighty-four miles by foot or pony from the bus terminus; but it should be noted that the general level of land rises as one proceeds farther into the Himalayas, facilitating the attainment of a high altitude. For example, the head-waters of the Saraswati River are in the valley adjacent to the Pass, that is, at about eighteen thousand feet. Moreover, the snow line rises as the general altitude advances. During the summer season, the Pass is free from snow.

While making the approach-marches up the Saraswati valley we observed at least half a dozen flat-topped peaks easily accessible by gentle slopes from the trail, and all estimated at well over seventeen thousand feet. Immediately west of the Pass itself, and within a mile of the Tibet border, is a peak rising to 20,400 ft. with a spur to the east at 19,150 ft. Both can be climbed readily, had only a light snow covering even late in October and would present no serious obstacle to laden coolies.

The caution must be added, however, that in Garhwal the choice of season is very important. Our expedition was there during September and October, and it is our opinion that some two months earlier would have been preferable. The region is then much wetter but free from snow. By November the Pass is closed and Badrinath deserted until April of the following year.

We acknowledge our thanks to Mr. M. A. Straus, of the University of Ceylon, whose experience in Colorado, United States, made him invaluable in the planning and conduct of the expedition.