PREFACE

This work is an account of investigations carried out in a period of five years, 1955 to 1959. On account of the research facilities that had to be availed at different laboratories, the observations were made only on slightly interconnected topics. The work is therefore an humble contribution to the subject. For this writing, most of the published material has been recompiled with additions made from unpublished reports prepared while the work was in progress. The various chapters have been written on individual subjects preceded by an abstract and followed by the conclusions. Some of the material required for ready reference, and not directly concerned with the topics under discussion, has been given in the Appendices. Unless required for the purpose of discussion, an attempt has been made to avoid inclusion of material found in literature. References to original papers and books have been given wherever necessary.

The subject matter may be divided broadly into investigations on cosmic radiation and on particle physics. The work on cosmic radiation concerns mainly the study of the soft component (Part.I) and that on particle physics is based upon the study of the decay products of artificially produced K*-mesons, (Part.II). Some subsidiary work on scattered topics in cosmic radiation (Part.III) has been included in the form of published papers.
(ii)

Part.I. An investigation on the soft component of the cosmic radiation.
(Carried out independently by the author)

This work was started with a view to compare the observed number distribution and the energy spectrum of electromagnetic showers with that predicted theoretically by the cascade theory and to find out the contribution of the trident process in the development of the soft component. The aim was to study the problem of anomalous showers (Chapter.I) the published reports on which were responsible for this investigation. It appeared of interest to utilize the experimental data to find the energy spectrum of the bremsstrahlung photons in order to detect, on the cross section at low energies, any possible influence of the density of the medium (Chapter.II). In view of the controversy with theory, regarding the experimentally observed larger cross section for direct pair production by fast electrons, it had also been planned to find the mean free path for trident process (Chapter.III) and compare it with the theoretical predictions. The details on experimental procedure and data; an outline of the cascade theory; on the method of energy estimation developed and used in this investigation, and the discussion on an individual event, have been relegated to the appendices.

The following conclusions have resulted:

1) The growth of electromagnetic showers is in fair agreement with the predictions of the cascade theory. The showers having an apparently anomalous growth have fluctuations of the same order as observed for other samples of cascades.
The fluctuations are in general not very much larger than those expected for a Poisson distribution.

2) For primary electron energies up to $5 \times 10^{11}$ eV, the energy spectrum of the bremsstrahlung pairs has been found to be in accordance with the Bethe-Heitler theory. No marked influence of the density of the medium has been observed.

3) The mean free path for trident production is of the same order as that theoretically predicted. Evidence on this has been obtained for the energy region from $10^{10}$ eV to $10^{11}$ eV.

Part II. Decay Characteristics of Artificially Produced $K^+$-mesons.

(Carried out jointly with J.K. Bøggild, K.H. Hansen, J.B. Hooper and M. Scharff).

The work reported here is based almost entirely on the manuscript of a paper under publication in Nuovo Cimento. The present author's contribution to the problem was the participation in the programme of work done at the Institute for Theoretical Physics, University of Copenhagen, Denmark, during the period August 1968 to November 1969. Unpublished work other than this has not been included here.

$K^+$-decay events in a large block of emulsions were studied, mainly by following the charged secondaries to the end of their range. The aim of the experiment was to determine the branching ratios for the known modes of decay and to obtain an unbiased information on the high energy end of the $K^+\mu^+3$ spectrum and to
search for rare modes of decay, such as \( K^+ \rightarrow \mu^0 + \mu^+ \), and to find out if \( \pi^+ \) secondaries of energy greater than the maximum for the \( K^+ \) were present. The following results were obtained:

1) The branching ratios were obtained in an unbiased manner.

2) The energy spectrum of the \( \mu \)-meson from the \( K^+ \rightarrow \mu^0 + \pi^+ \) decay was found to be in agreement with the phase-space spectrum.

3) The branching ratio for the decay mode:
\[ K^+ \rightarrow \mu^0 + \pi^+ \text{, if it existed, was estimated to be less than } 5\% \text{. No positive evidence for the existence of the } \mu^0 \text{-meson was found.} \]

4) No secondaries of energy between 53 and 61 MeV were observed in a sample of 464 \( K^+ \)-decays. This gave a negative result on the presence of a neutral particle of mass \( \sim 500 m_0 \).

The measured scanning efficiency in the experiment was 99 \%.

**Part III**

Some subsidiary work, carried out while the investigations mentioned above were in progress, has been attached in the form of preprints of three papers, concerned with the interaction phenomena produced by cosmic ray particles.