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V. M. FRIDKIN

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PREFACE TO THE ENGLISH EDITION

In the preface to the present English edition the author would like first of all to thank Professor Berg and Professor Chibisov for their co-operation and initiative in the preparation of The Focal Library edition of the English translation of his book "The Physics of the Electrophotographic Process".

In getting the book ready for translation practically no changes have been made either in its plan or in its basic contents. Nevertheless Chapter 3 has been considerably enlarged by the incorporation of material on the mechanism of the charging of electrophotographic layers and the kinetics of latent image formation in layers, material which was obtained in the Institute of Crystallography of the Academy of Sciences of the USSR and which was published after the Russian edition of the book had appeared in print.

But even the new enlarged version of the book is neither a text-book nor a review of electrophotography. As the author has observed previously, the present book is rather a monograph which reflects the interests of the author and his individual approach to the investigation of the physics of the electrophotographic process. The practical applications of electrophotography are questions which the author has left entirely out of consideration. In this connection two interesting Focal Library publications which have recently been issued should be mentioned — a symposium "Xerography and Related Processes" edited by Dessauer and Clark and the book by Schaffert "Electrophotography" which give a complete coverage of the technological and practical aspects of electrophotography.

Electrophotography, both in the form in which it was discovered by Carlson and in the present existing and developing modifications, is only one of many "non-silver" photographic processes employing semiconductors. The author has no doubt at all that this new photographic process is destined to develop even further and in this connection he expresses the hope that the present book will prove interesting and useful both to specialists in electrophotography and to a wider circle of readers.

Moscow
Institute of Crystallography,
Academy of Sciences, USSR

V. M. Fridkin

PREFACE TO THE RUSSIAN EDITION

This book gives a general account of the studies which have been made of the mechanism of the formation of the latent image in electrophotography — a new photographic process which utilizes the photoconductivity of dielectrics and semiconductors of high resistivity – and is based largely on investigations of the electrical properties of crystals by the author and his colleagues in the laboratory of the Institute of Crystallography of the Academy of Sciences of the USSR. The present monograph also summarizes the results which have been obtained by other workers in this field, and may thus be regarded as an exposition of this subject as a whole. With this object in view we have included a short historical review and have attempted to give a general analysis of the present position in the development of this field of study, and particularly its association with photoconductivity, luminescence and the photochemical processes in crystals.

At first sight the title of this book might seem to be somewhat conventional. The words "The Physics of the Electrophotographic Process" usually imply a wider coverage of the subject than we have given and would be expected to include an analysis of the traditional branches of photography such as development and sensitometry. We have however narrowed the limits to a description of the physical processes underlying the formation of the latent image. Besides this, the book is largely devoted to an experimental investigation of the photoelectret state in crystals — a phenomenon which is of interest in itself and used not to be regarded as having any connection with electrophotography. Nevertheless we consider this incongruity to be only a formal one. Investigation of the mechanism and kinetics of the formation of photoelectrets is the most convenient and systematic method of studying the mechanism of the formation of the latent electrophotographic image, and we are convinced that the latter process and that of the formation or depolarization of a photoelectret are in most cases one and the same phenomenon. From this standpoint this monograph represents a balanced study of these two processes. In this connection we should like to emphasize that the position is analogous to the one which obtains in the ordinary photographic process which is based on photochemical phenomena. In making an analysis of the electronic stage in the formation of the latent image, a study of the photoconductivity of silver halide crystals occupies the same place as that of the photoelectret state of crystals in analysing the mechanism of the formation of the latent image in electrophotography.

This approach to the subject is reflected in the arrangement of the material in this book in that the first two chapters are devoted to a study of the mechanism and kinetics of the formation of the photoelectret state in crystals, and the results of this study are used in the third chapter which deals with the analysis of the mechanism of the formation of the latent electrophotographic image. From this point of view all three chapters form an integral unit since in the first two chapters the methods of investigation are developed, and in the third chapter the results of applying them to existing electrophotographic layers are given. In the fourth chapter a new photographic process which is based on the luminescence of zinc sulphide electrets is described.

It should be mentioned that part of the material which relates to the study of photoelectrets has already been published in the monograph "Photoelectrets and the Electrophotographic Process" (issued in 1960). It would however be incorrect to consider that the present book gives merely the results of a further development of this course of study. As already stressed above, an attempt has been made to combine the investigations on photoelectrets and electrophotography and use this as a basis for studying the mechanism of the formation of the latent electrophotographic image.

The author would like to express his deep sense of gratitude to academician A. V. Shubnikov and Doctor of physical-mathematical

sciences, I. S. Zheludev for their unfailing interest and support in this work, without which this book could hardly have been written. The author is greatly indebted to academician of the Bulgarian Academy of Sciences, G. S. Nadzhakov and his colleagues, to academician of the Academy of Sciences of the Uzbec SSR, É. I. Adirovich, and Professor F. F. Vol'kensteĭn and also to the co-workers and post-graduate students of the Institute of Crystallography of the Academy of Sciences of the USSR and of the Scientific Research Institute of Printing Machine Construction, who have worked all these years with the author. The author would also like to express his great indebtedness to corresponding member of the Academy of Sciences of the USSR, K. V. Chibisov, for his interest in this work and for reading through the manuscript of the present book. P. N. Rudenko and K. A. Verkhovskaya have also taken an active part in preparing the manuscript for printing, and the author would also like to express his grateful thanks to these two colleagues.

V. FRIDKIN

INTRODUCTION

The formation of the electret state in a dielectric is a process in which a state of stable (persistent) electric polarization is set up and then destroyed fairly slowly by the conductivity either of the dielectric itself or of its surrounding medium, and is based on a complex group of different physical phenomena. Thus nowadays several types of electret are distinguished: thermoelectrets and photoelectrets,[1-3] electroelectrets[4, 5] and radioelectrets.[6, 7] However even this classification which is an extremely arbitrary one does not cover all the conditions in which the stable electric polarization of dielectrics is possible. It is sufficient to point out for instance that an electret can be produced during the polymerization of a polar monomer in an electric field[3] or during the vulcanization of polar elastometers.[8]

The idea of regarding an electret as a dielectric possessing stable or persistent polarization is conditional since every electret actually becomes appreciably depolarized in time. Moreover electrets of different nature depolarize at different rates depending on the conditions of polarization and storage. We therefore consider the use of the term "electret state" to be more suitable than "electret". Heaviside, who foresaw the existence of an electrical analogue of a permanent magnet[9] was the first to predict the possibility of being able to obtain electrets. In his first experiments, Eguchi[10, 11] prepared electrets from a molten mixture of wax and resin which was allowed to set in a strong electric field. After the field had been switched off the solid mixture was found to possess internal electric polarization, a negative charge having formed on the surface of the sample facing the anode and a positive charge on that facing the cathode. This kind of charge was afterwards called a heterocharge. After preparation, the heterocharge on an electret decreases within a few days and then remains practically constant since the further drop takes place very slowly. These electrets were later called thermoelectrets.[1, 2, 12-22]

When the polarizing field is sufficiently strong, a change is observed to take place in the polarity of the thermoelectrets of a number of substances: within a few days the original heterocharge falls to zero and then, having acquired the opposite polarity, once again reaches the maximum value. Moreover the surface of the thermoelectret facing the anode acquires a positive charge whereas that facing the opposite way acquires a negative charge. This kind of charge was called a homocharge. The terms "heterocharge" and "homocharge" were first suggested by Gemant.[12] Nowadays the stability of the hetero and homocharge on thermoelectrets is explained satisfactorily by the mechanisms of dipole orientation and the macroscopic displacement of ions.[3]

In 1937 Nadzhakov[1, 2] discovered a new type of electret. While studying polycrystalline sulphur he found that when photoconduction took place in this dielectric, space charges accumulated and these persisted for a long time after the illumination and field had been cut off.

Nadzhkov suggested using the term photoelectret to describe the polarization produced in a dielectric during the process of photoconduction, in analogy to the electrets of Éguchi, which he suggested calling thermoelectrets.[1, 2] Nadzhakov's studies of photoelectrets of polycrystalline sulphur revealed a stable heterocharge: however no change was observed in the polarity of the photoelectret.

It should be pointed out that the phenomenon of the polarization of crystals in the presence of photoconduction had been observed in earlier investigations on the photoconductivity of insulating crystals,[24-37] and, in particular, in some of the work which was completed soon after the discovery of photoconductivity.[23] However, prior to the work of G. S. Nadzhakov, no particular importance had been attached to this phenomenon.