

BIBLIOGRAPHY AND ABSTRACTS ON ELECTRICAL CONTRACTS

INTRODUCTION

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The response to the publication of the bibliography on the subject of electrical contacts has been very gratifying. All copies of the original printing of January, 1944, have been disposed of, and many people have been ordering the supplements which have appeared each year since then. Because of this response and the apparent need for such information, the bibliography is being reprinted and brought up to date in all respects. This volume contains all of the references which have been collected up to January 1, 1952.

A bibliography on electrical contacts must necessarily include references on a wide variety of subjects. The effects which take place in the operation of electrical contacts are extremely complicated. They involve the microphysics of the electric arc, the metallurgy of the contact materials, the mechanics of the operating mechanism, the physical and chemical properties of all of the materials, and the ambient conditions. To be practical, however, such a bibliography must limit the information on widely scattered fields to that which is pertinent to the problem involved. The decisions limiting the ranges of titles and subject matter must be made carefully, since the value of this work will be determined by the number of people it will serve. Therefore, it has been considered desirable to include any reference which appears to have any reasonable connection with the problems involved in electrical contacts.

There is one notable exception to the literature concerning electrical contacts which is not included in this bibliography. This is a list of the patents covering the subject of contact materials and other phases of the operation of contacts. This subject, however, is thoroughly covered to the date of its printing in the Silver Producers' Research Report, which is reference No. 737 in this bibliography.

This work is divided into several sections which are designed to make it most convenient for those who use it. The subject index places the bibliography into groups of references on separate problems and details involved in the subject of electrical contacts. The author index will be convenient for those who wish to follow the work of any particular individual. The bibliography and abstract list is placed in chronological order based on the year in which the article was published. The titles of these references are complete, and in some cases are given both in the original language and in English. The abstracts were obtained or prepared of all the articles which are readily available to any one interested in them. Wherever possible, abstracts were taken from *Science Abstracts*, *Chemical Abstracts*, *Battelle Library Review*, or similar publications. If not available there, an abstract was prepared by a member of the committee.

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One important improvement has been made which should help in the use of the bibliography. The subject index had become unwieldy because of the small number of subjects listed. There were so many references listed under each subject heading that it was almost impossible to look at all of them and properly cover the subject as listed. It would be a very difficult job to use all of the subjects covered by the references in this bibliography; however, the subject index has been subdivided far enough to decrease the number of references under each heading to more reasonable proportions.

Most of the headings in the subject index will be self-explanatory. However, some of the headings are so broad that some additional information might be useful. For example, *books* which *include* the subject of electric contacts or *cover* the subject of electric contacts have been listed separately.

Articles which touch many broad fields of contact application but are not specific in engineering and scientific details are included under the subject *Electric Contacts—General*.

Contact materials which are made from alloys, which are handled in the conventional manner in which the material is first formed in a rough ingot or shape, then rolled or drawn to rod strip or wire, are listed under *Contact Materials—Fabricated*. Contact materials which start with powdered metals are listed under *Contact Materials—Powdered Metals*.

Circuit Breaker Design includes those articles on which the design is the important item in the article. The articles listed under *Circuit Breaker Testing* are those in which the main purpose of the article is to report certain tests. When the theory of the electric arc is applied to contacts or where circuits and circuit parameters are considered to be the primary aspect of the paper, the paper is listed under *Electric Arc Theory Applied to Contacts* or *Circuit and Circuit Parameters as Applied to Contact Operation*. The sections covering *Circuit Breaker Design*, *Electric Arc Theory Applied to Contacts*, and *Circuit and Circuit Parameters as Applied to Contact Operation* should in themselves make up the most complete bibliography on circuit breaker application that is at present available.

Contactors or Relay Design is listed separately as being differentiated from a circuit breaker which is a protective device.

Contactors or Relay Testing is considered in the same light as *Circuit Breaker Testing* except covering contactors and relays.

The subject *Stationary or Fixed Contacts* includes bolted connections, brazed connections, bus bars, and any other types of permanent connections in bus bars or other current carrying parts.

The subject of *Sliding Contacts* is broken into *Sliding Contacts—Slip Ring* and *Sliding Contacts—Commutation* to differentiate between the effects which occur on a plain ring and those which are brought about by the commutation of the armature circuits. These two subjects together should provide one of the most complete bibliographies on the subject of sliding contacts.

The heading *Instrument Contacts* covers those papers which have been written specifically with instrument contacts in mind. However, the consideration of this subject with that of *Contact Resistance* and *Contact Wear* would provide a good basis for most of the work which is now available on instrument contacts.

Miscellaneous Special Applications include many things which could not be listed separately, unless the subject index were expanded considerably. Such

devices as contact rectifiers, barrier layer rectifiers, semiconductors, various special types of switches and controls, various instruments for measuring effects in contacts, and similar items will be found under this heading.

The subject of *Contact Resistance* does not by any means cover all of the information on contact resistance which is in the bibliography. However, it does list all of the papers which deal specifically with contact resistance or in which contact resistance is a major part of the work. This subject also includes some references on spot welding and brazing.

The subject *Contact Temperature* should be considered in connection with the subject *Contact Resistance*, since in most applications these two are related.

Electric Arc Theory Applied to Contacts covers those papers in which arc theory has been investigated with contacts in mind or papers in which tests have been run on contact making and breaking equipment, with the idea in mind of investigating the arc. This subject covers most of the practical applications of arc theory to contacts and will include such items as arc temperatures, arc suppression, arc reignition, and so forth.

The heading *Electric Arc Theory* includes work of a more or less theoretical nature which may not have immediate application to practical problems in the contact field but which is basic to the understanding of the electric arc. Any one interested in the background of the applications will find this bibliography quite complete.

Discharges in gases at atmospheric pressure may be divided into five different classifications. The *electric arc* is characterized by a cathode drop of some 12 to 25 volts and a positive column with a gradient of approximately 20 volts per centimeter. The *corona* is a high voltage leakage phenomena at low current, which takes place in the concentrated field at a point or around a small wire. The *glow discharge* is the low current steady discharge characterized by a cathode drop in air of about 300 volts and a voltage gradient in the positive column of approximately 100 volts per centimeter. The *electric spark* is an effect caused by the discharge of a capacitive circuit through an air gap and may contain all three of the above effects to a greater or less extent. The *low voltage arc* is characterized by a cathode drop of from 6 to 10 volts and reversal in the field of the positive column. Each of the above types of discharge is considered separately and references on these subjects are presented.

The subject *Contact Wear* includes contact wear due to the electric arc, material transfer, and other factors which would cause the deterioration of contacts.

The subject *Circuits and Circuit Parameters* includes those papers which discuss the effects of different types of circuits and different types of voltage and current conditions on the operation of contacts. Network analysis, inductive circuits, and capacitive circuits are all included.

This bibliography has now been brought up to date, and it is expected that additional supplements will be issued yearly to cover the new references which are collected. It is suggested that those who buy this copy of the bibliography consider entering a standing order with the ASTM for the supplements so that these may be kept in complete form and up to date. We know that many people who have bought the original bibliography have not received the supplements. Any one who is following the field will certainly want to be kept up to date.

The errors which have been called to the attention of the committee have been

corrected in this volume. However, it is possible that additional errors have crept into the text. The committee would appreciate the help of any person in pointing out these errors to them and in supplying additional references and titles to be included in later publications. This information should be sent to the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania.

Any one who uses this Bibliography on Electrical Contacts can see that there is a considerable amount of work involved in putting it together. It is with considerable pleasure that I express my own appreciation and that of the Committee as a whole to Mrs. Edna V. Miles of the Stackpole Carbon Company for the very excellent job she has done in assembling, correlating, and arranging this material.

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