Switching equipment for power control

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Title: Switching equipment for power control

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SWITCHING EQUIPMENT
FOR
POWER CONTROL
McGraw-Hill Book Co., Inc

Publishers of Books for

Coal Age • Electric Railway Journal
Electrical World • Engineering News-Record
American Machinist • Ingeniería Internacional
Engineering & Mining Journal • Power
Chemical & Metallurgical Engineering
Electrical Merchandising
SWITCHING EQUIPMENT
FOR
POWER CONTROL

BY

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FIRST EDITION
SECOND IMPRESSION

McGRAW-HILL BOOK COMPANY, Inc.
NEW YORK: 370 SEVENTH AVENUE
LONDON: 6 & 8 Bouverie St., E.C. 4
1921
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PREFACE

Switching equipment for power control forms a very essential part of any plant for the production or distribution of electrical energy. This equipment has been aptly described as the "brain" of the electrical system as it performs all of the duties of direction and control that are so vital to the proper functioning of the system.

Information on the subject of switchboards and switching equipment can be found in very condensed form in certain electrical handbooks, and specific data on definite appliances can usually be obtained from manufacturers. Articles in the technical press also furnish a certain amount of data on this subject, but there has been no American book dealing with the general subject.

Demand for a book on this subject has lead the author to undertake its preparation basing it largely on his own articles which had previously appeared in the switchgear and control sections of the "Penders Handbook for Electrical Engineers" and in the Electric Journal, Electrical World, Southern Electrician, Electrical Age, etc. These have been partly re-written and brought up-to-date.

Manufacturer's publications have been consulted freely and some of their descriptive matter utilized bodily or reworded to adapt it to this book. The attempt has been made to select such information as would be of the greatest use to the largest number of readers and that would embody standard practice rather than special applications.

Thanks of the author are due to various publishers for their permission to utilize his material previously published, and to the various electrical manufacturers for the data they furnished. Grateful acknowledgment is also made to the author's many friends and associates for information supplied and suggestions as to subject matter and arrangements of material.

The main object of this book is to furnish the actual switchboard operator the information that will help him to keep the equipment in his care in the best operating condition, by explaining what should be expected of the apparatus and equip-
ment. It will also assist him in the selection and installing of new material.

The secondary object is to help the student of electrical engineering in a technical school to get a better understanding of this branch of the art and to appreciate how the switching equipment ties together the various generators, transformers, feeders, etc., that make up the component parts of a generating and distributing system.

Consulting engineers and others will find enough of the theoretical features to give them an understanding of the functions and limitations of the various devices. Such an understanding will facilitate specifying equipment that can be readily obtained and that will operate satisfactorily under actual conditions.

The arrangement of this book has been based on the idea of first describing the switching apparatus, approximately in the order in which the various devices were developed. This is followed by considering the main connections desired in a power plant and the means for carrying out the connections so as to obtain the maximum amount of security and flexibility with the minimum outlay. Switchboard panels, control desks, etc., are considered next with the location of breakers, bus structures, etc., and the general arrangement of the part of the power plant devoted to switching equipment.

Description of apparatus has been confined almost exclusively to present day standards to keep the subject matter down to a reasonable length, but a few references have been made to some of the older types of apparatus to show the progress of design.

American practice forms the basis for the descriptions and most of it is the practice of the largest electrical manufacturers. The attempt has been made to include descriptions of apparatus of other important builders, but it has been impossible to describe all of the apparatus of all the builders. The data has been obtained from various sources and the most readily available material has been used.

Stephen Q. Hayes.
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SWITCHING EQUIPMENT FOR POWER CONTROL

CHAPTER I

SWITCHES

KNIFE SWITCHES

Definition.—Switches may be considered as devices for mechanically opening up an electric circuit and their design is based primarily on the following features: They must, when closed, carry their rated current without excessive drop or excessive heating and must take care of the overloads met in practice; they must, while being opened, be designed to prevent or render harmless any arcs that may be formed; they must, when open, insulate all live parts for maximum potential in a permanent manner.

Early Types.—The earliest types of switches consisted of metal plates mounted on wooden blocks and connected together by a plug inserted between them. The weakness of this first design was the proximity of the plates and the tendency for an arc to hold on when the plug was withdrawn. The next step was to increase the distance between the two stationary contacts and to use a movable plate attached to a handle for bridging the gap between these stationary contacts. To avoid losing this movable plate, the next step was to hinge it to one of the contacts and from this beginning the present knife switches have been developed.

Underwriters Rules.—The rules of the National Board of Fire Underwriters relative to knife switches state: "All switches must have ample metal for stiffness and to prevent rise in temperature of any part of over 30 degrees Centigrade at full load, the contacts being arranged so that a thoroughly good bearing at every point is obtained with contact surfaces, advised for pure copper
blades, of about 1 square inch for each 75 amperes." As the result of many tests the Underwriters settled on certain minimum spacings between points of opposite polarity for various currents and voltages of 250 D.C. or 500 A.C. and for 600 D.C. Most switches are designed to meet these requirements as to temperature rise, contact surface, spacing and other recommendations.

**Multiple Blades.**—Up to about 1200 amperes in capacity knife switches are usually made with single blades, while for larger capacity two or more blades per pole are supplied in order to secure sufficient contact surface without making the blades and jaws of abnormal width.

**Quick Breaks.**—"Auxiliary breaks" or "quick break attachments" are furnished in many cases so as to make it impossible to draw a dangerous arc by opening the switch slowly. These quick break attachments are made in many forms.

**Current-carrying parts** of a well-designed switch consist of a high grade of drawn copper of guaranteed conductivity. The sectional areas and contact faces of all sliding and stationary parts are calculated in accordance with the best practice, and a liberal allowance is made for overloads.

**Temperature.**—The current-carrying parts adjacent to the contacts will carry their full-rated current continuously with a maximum temperature rise of either 20 or 30 degrees Centigrade above the temperature of the surrounding atmosphere, depending on the class of service.

The rear connected switches of 1200-ampere capacity and larger are given a lower rating for alternating current than for direct current and are not guaranteed to carry more than their rated current.

![Typical knife switches](image)

**Fig. 1.**—Typical knife switches.

**Momentary Current.**—The maximum momentary current passing through knife switches should not be greater, owing to mechanical and electrical limitations, than 50 times their normal 60-cycle 20-degree ampere rating. If the switches will be sub-