CIRCUIT BREAKERS

MAINTENANCE

[redacted]

Conference Paper

R C Dickinson

Inspection and Maintenance of

MAGNETIC AIR CIRCUIT BREAKERS AND ASSOCIATED METAL CLAD SWITCHGEAR.

R. C. Dickinson
Fellow, AIEE

Westinghouse Electric Corp., E. Pittsburgh, Pa.

and

B. I. Hayford
Member, AIEE

Westinghouse Electric Corp., E. Pittsburgh, Pa.

Presented at Fall General Meeting

October 26 - 31, 1958

Pittsburgh, Pa.

Price: 40¢ To Members
80¢ To Nonmembers

(5¢ per copy additional if first class mailing desired)

Paper No.
58-1350

Inspection and Maintenance of MAGNETIC AIR CIRCUIT BREAKERS AND ASSOCIATED METAL CLAD SWITCHGEAR

R. C. Dickinson and B. I. Hayford

Introduction

The magnetic air circuit breaker has practically become the standard of the industry. With their introduction in 1929, it soon became apparent that the installation, inspection and maintenance problems with the then radically new type power circuit breakers would be much simpler than with the oil circuit breakers of that period. The characteristic cleanliness and relatively small need for maintenance have been very influential in the continuing growth in the popularity of the air magnetic type of power circuit breaker.

The introduction in the early thirties and subsequent widespread use of metal clad switchgear with magnetic air breakers has further decreased the need for maintenance because of the complete enclosure of live parts and their insulation.

However, no one makes the claim that magnetic breakers and their associated metal clad switchgear do not require any maintenance. For most efficient and dependable performance, regular inspection and maintenance as indicated is a must. To a great many engineers this may appear to be unnecessary advice because this has been learned through long years of experience in operating high voltage electrical equipment. Others newer in the field may tend to regard today's switching equipment as something to be installed and forgotten.

When to Inspect

Inspection and maintenance go hand in hand. Inspection shows what maintenance is advisable and indicates whether a maintenance operation should be done immediately or safely may be deferred until the next inspection time.

The circuit breaker manufacturer usually gives recommendations as to frequency of inspection of the products he builds. However, it actually is impossible for him to give accurate recommendations that will apply to all possible service conditions. Some circuit breakers are located in very dirty surroundings where the air carries much solid matter which settles on almost all parts of the equipment. It is obvious that in such cases the breakers should be inspected more often than under cleaner conditions.

Also, some breakers may be operated from several times a day, such as in station auxiliary service, to a hundred or more times per day in certain kinds of industrial service. These should be inspected more frequently than those which operate only a few times per month or year. Other breakers may normally remain closed for six months or a year without being opened.

However, the time to start inspecting circuit breakers is immediately when they are received from the supplier. The manufacturer's instructions should be available before the equipment is uncrated, as it may contain suggestions for easier handling and preventing damage.

The inspection of newly received equipment should have two objectives:

1. To see if damage has occurred from excessively rough handling in shipment.

2. To see if foreign matter or objects have gotten into the equipment.

Storage of New Equipment

Much new apparatus is damaged before installation by being kept, before installation, exposed to construction work. Under these conditions ordinary dirt, cement dust, water, mud etc., gets into the equipment and much labor will be required to clean it. Or it may not be cleaned sufficiently and will not operate properly after installation. Also, there may be excessive dampness or free water near construction work so that the equipment must be dried out thoroughly before being installed. Instances are known where the breakers and other strictly indoor equipment were kept under leaky tarpaulins.

The best recommendation is to store the equipment in a heated building or shed some distance from the actual work. The next best thing is to cover it with leak proof tarpaulins or other covers ventilated to prevent "sweating" and see that it is thoroughly dry before placing in service.

Upon Installation

When installation is complete, and before energizing the main circuits, each breaker should be checked for proper closing and opening, both by hand and electrically. Check all auxiliary devices such as auxiliary switches, control contacts and relays for proper operation.

It is often advisable to check insulation before energizing, due to prior exposure to water, dampness, dirt or all three of these conditions. The insulation should be checked only after it is believed the equipment has been thoroughly dried. A recommended check on insulation is a high potential test, which may be as high as 75% of the factory test in terms of rms a-c voltage. Many users prefer to apply a d-c test as that testing equipment is frequently available for cable testing. For a d-c test, it is recommended that a d-c voltage equal to 75% of the factory test be used. If the factory test is 36 kv, the field test is 27 kv a-c and the d-c test also would be 27 kv.

Inspection Schedule

The manufacturer's recommendations should contain an adequate guide for inspection. However, as the user becomes more familiar with the equipment, he may learn from experience that he may safely go beyond the manufacturer's recommendations in extending periods before maintenance. In effect, he learns more about the operation, care and ultimate limitations of the breakers and equipment than the manufacturer can know. For instance, it is known that some utilities allow some substation feeder magnetic breakers to go for 100 automatic openings before major maintenance. This practice was, of course, not started at once but operations were gradually extended through years of experience.

It is a good general rule for feeder breakers in distribution service, unless or until experience shows otherwise, to give the breaker several "exercising" operations every six months and complete inspection once a year.

Inspection and Maintenance

The circuit breaker is the largest and most complex single piece of equipment in the switchgear. Consequently, it should receive the greatest amount of attention. For inspection purposes, the circuit breaker may conveniently be regarded as having the following categories of parts:

1. Insulation.
2. Arc interrupters.
3. Contacts.
4. Mechanical operating parts.
5. Auxiliary devices.

Insulation

The insulating materials used in magnetic air breakers and their metal clad equipment have been improved during the last few years. Many breakers now being built have insulating materials considerably more resistant to leakage, tracking and burning than the best corresponding materials available a few years ago. In general, the magnetic air breakers have used a considerable amount of organic insulating materials in parts such as bushings, barriers, operating rods, supports or braces. Originally and for many years these materials were mostly phenolic laminates. Subsequently, these materials were rendered flame retardent. More recently glass mat polyester laminates and molding materials have been developed. These materials are now available with a high degree of flame retardence and resistance to tracking.

Even the original phenolic materials in general will withstand a considerable amount of dry dust or dirt without deterioration. Examples are known of some of them becoming black with coal dust in a warm dry location in a steam plant, without deterioration. However, moisture in combination with the dirt encountered in almost any locality, will result in leakage, no matter what the insulating material may be. In extreme cases, flashover may result. Even porcelain will leak and flash over under some conditions found in service. In mild cases of leakage, permanent carbonized tracking may develop in the old types of organic insulation, with long exposure.

The most adequate protection for any insulating material is:

1. Keep it dry.
2. Keep it clean.

Arc Interrupters

Modern magnetic arc interrupters are built with only inorganic materials exposed to the arc. Such materials line the throats of the interrupters in the vicinity of the arcing contacts and constitute the interrupter plates or fins which act to cool and disperse the flame of the arc. No matter what material is used, the arc can melt and vaporize it, as the arc is considerably hotter than the melting and boiling point of any known material.

The arc, of course, also melts and vaporizes the metals of the contacts. These metallic vapors, with perhaps some of their oxides, condense on the insulating surfaces in the vicinity, including the inorganic materials. These deposits will also be melted into the surfaces of the inorganic materials. Metallic vapors also will condense on some of the organic insulating materials near the arcing contacts.

The result is that with repeated arc interruptions the insulation resistance of the arc chutes will decrease, leakage will increase and if carried to the extreme the breaker will fail to hold open circuit voltage.

The remedy is, of course, to clean the flat surfaces in the throat of the arc chute. It is important to sand the sooted organic materials of the arc chamber enclosure to remove all traces of carbon or metallic deposit. Refinish, if advisable, according to manufacturer's instructions.

The affected surfaces of the inorganic materials may be most effectively cleaned with a disk sander using a non-conducting abrasive.

Arc interrupters should be tested by high potential applied to the arc horns or runners. It should withstand at least 75% of the factory test. There may be special precautions to take with interrupters of each make, so manufacturer's advice should be followed.

Contacts

The major functions of a circuit breaker must include the correct operation of the contacts. Most magnetic circuit breakers have at least two distinct sets of contacts on each pole, main and arcing. When closed, practically the entire load current passes through the main contacts. Also, high overload or short circuit current must pass through them during opening or closing faulted lines. If the resistance of these contacts becomes high, such as from foreign material becoming embedded in the surfaces, decrease in pressure from the springs which hold them in contact, or from excessive pitting, they will become overheated. This will also cause excessive current to be diverted through the arcing contacts, with consequent overheating.

Therefore, the general rules for main contacts for all types of breakers are:

1. Keep them clean.
2. Keep the pressure up to normal as indicated by contact spring deflection.
3. Keep them smooth.
4. Keep them in good alignment.

The arcing contacts are so called because, since they are the last to open, the arc appears on them. In circuit interruption, they carry current only momentarily but that current may be equal to the interrupting rating of the breaker. In closing against a short circuit, they may carry momentarily considerably more than short circuit interrupting rating. Therefore, they must make positive contact while they are touching. If they do not, the main contacts may be badly burned in interrupting heavy faults and failure to interrupt may result.

On magnetic air breakers, the arc quickly is moved off the arcing contacts by the magnetic blowout field and on to arc horns or runners in the arc interrupter. However, the arcing contacts are expendable and eventually will be burned enough to require replacement.

Do not allow the arcing contact material to be burned away so much that a few more interruptions would burn through the arcing tips and into the base metal.

Mechanical Operating Parts

The purpose of the mechanical operating parts is to open and close the contacts. This usually is done by linkages connected, for most power breakers, to a power operating device, usually a solenoid, for closing and which contains one or more small solenoids or other types of electro magnets for tripping. Tripping usually is accomplished mechanically independently from the closing solenoid, so that the breaker contacts will open even though the closing device still may be in the closed position. This combination is called a mechanically trip-free mechanism.

After closing, the primary function of the operating mechanism is to open the breaker when it is desired, or whenever the tripping coil is energized at above its rated minimum operating voltage.

Therefore, on operating mechanisms and the entire linkage system:

1. See that the parts operate freely when tried by hand and electrically.

2. Again, keep it clean. If dirt or other foreign matter accumulates around pins, in bearings, latches or other movable parts, they will not work freely.

3. All movable mechanical parts are subject to wear. Long-wearing and corrosion-resistant materials are used by some manufacturers. Also some wear can be tolerated before improper operation occurs. Additional wear may be caused by high speed of operation or where unusually heavy moving parts are involved. Wear usually results in loss of travel of the breaker contacts and either too hard or too easy operation of latches, i.e., they may stick or they may slip off and prematurely trip the breaker. Adjustments are provided for wear in certain parts. In other parts, replacement is the remedy.

Stationary Switchgear Structure

The item of cleanliness applies equally to the stationary portion of the switchgear structure. In fact, it is almost the entire item of maintenance on this portion of the switchgear. Since there are relatively few moving parts associated with the switchgear, other than the circuit breaker and its mechanism, the item of wear is almost negligible. The control relays and control switches should be checked periodically. Protective relays should be loaded to check for actual operation and time settings on a regular schedule. This will insure that they will function when called upon and that the time setting is correct to give proper selection with other relays in the system to minimize the power outage incident to any abnormal condition by tripping only the circuit or circuits in trouble.

For reliable operation and service continuity, the bus supports and bus insulation must be kept clean and dry. In addition, all bus supports, control wiring, instrument transformer mountings and other devices should be inspected for tightness at regular periods.

Conditions at individual locations will vary so that it is not possible to recommend any schedule which will apply in all cases. Under normal atmospheric conditions, a thorough inspection and maintenance check should be made once a year. Abnormal conditions will require checking more frequently and it may be permissible to go for longer intervals under unusually good conditions and relatively easy service. It is best to start with a shorter period than seems necessary and gradually extend it if it is found that the equipment is remaining clean for the period selected. It is a safe rule to at least look at it once a year.

Under extremely bad atmospheric conditions, such as salt spray along the coastal areas or in locations adjacent to chemical processes or where the air may be laden with carbon or graphite dust, or corrosive chemicals maintenance expense and service reliability will warrant some form of air conditioning or air cleaning for the switchgear room.

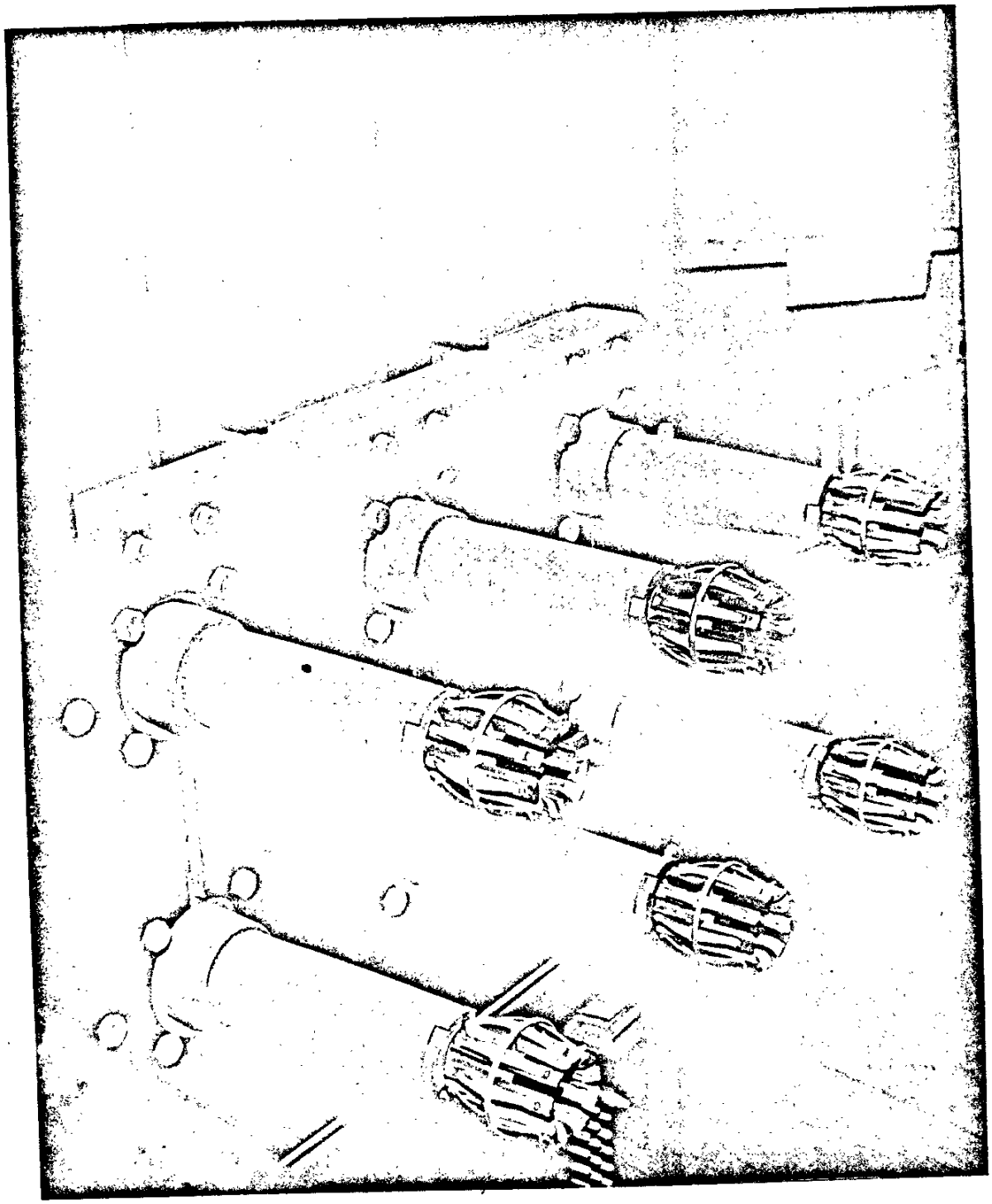

FIGURE 1 (PHOTO 360609)

Dust on the breaker in this photograph is the accumulation of about 1 year in a manufacturing plant making heavy machinery. It contains a wide variety of substances such as coal dust fine metallic and metallic oxide particles. It also contains minute quantities of ionizable salts. None of these substances have any appreciable damaging effects when dry. Even a small amount of moisture, such as condensation caused by a sudden increase in air temperature and humidity will cause electrical leakage over the surface. It is advisable to keep this type of equipment cleaner than illustrated here.

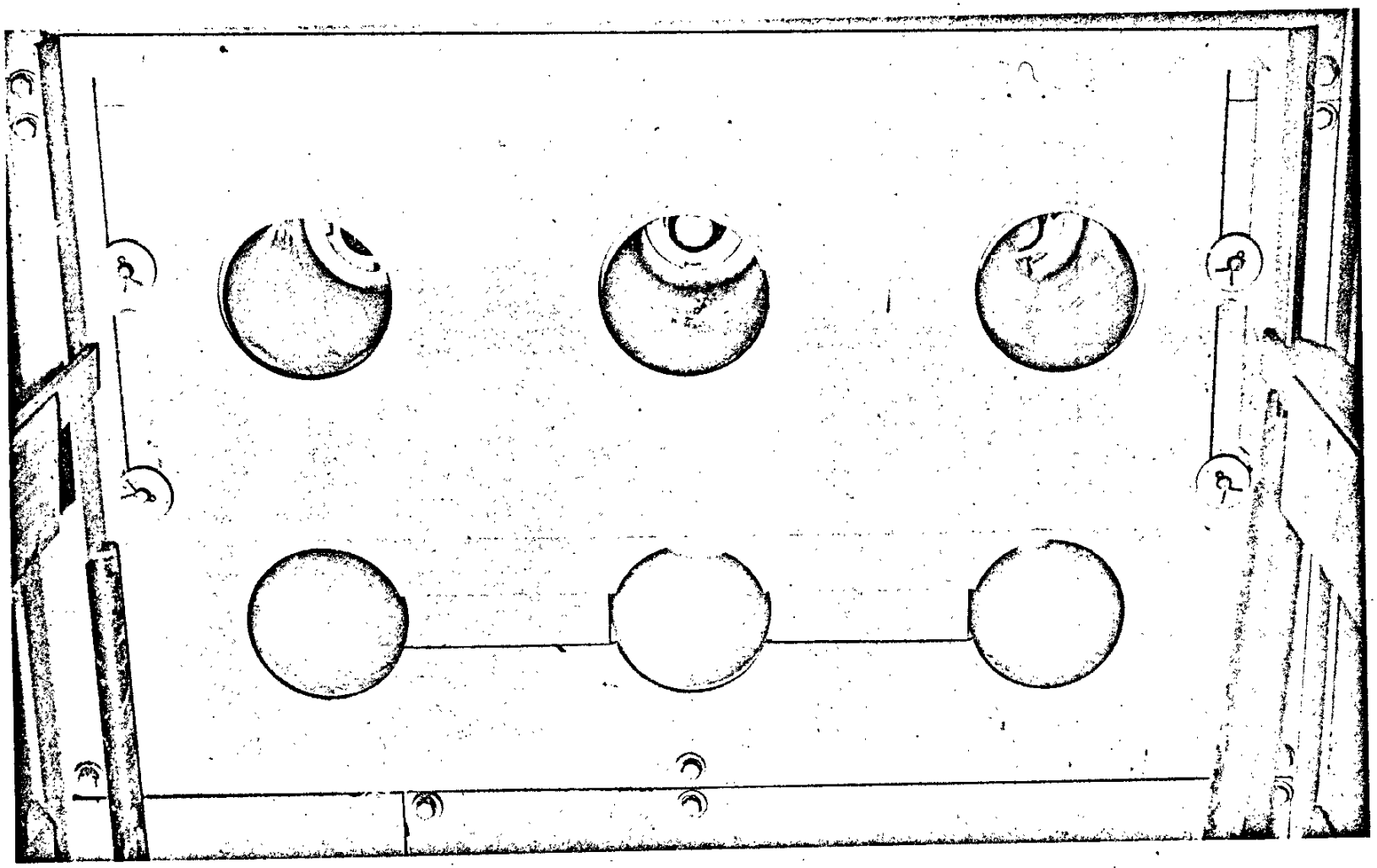

FIGURE 2 (PHOTO 360608)

Dirt will accumulate in supposedly inaccessible places, over a long period of time. Consequently, such insulating surfaces as the interior of these stationary contact supports for horizontal drawout switchgear should get regular inspection. Obviously the contacts should be de-energized before cleaning.