DIESEL-ELECTRICS—How to Keep 'Em Rolling

4

Running Maintenance of Commutators*

Only when the purpose of a commutator and its construction are understood, can it receive the kind of attention it must have

THE commutator is a vital part of every d.c. motor or generator. Hence, it deserves the very best of care. The fact that a commutator usually begs for maintenance by showing signs of trouble long before it actually fails is a big help to the maintainer. If you are able to recognize these signs and know what to do, you can often correct the trouble before it gets more serious. The more you know about how a commutator is made, and what it does, the better running maintenance you can give it.

* This is Part I of the 4th of a series of articles on maintenance of diesel-electrical equipment. This article is written by J. W. Teker and J. R. Schreckengost, both of the Motor Engineering Division, General Electric Company, Erie, Pa. Part II on the subject of commutator maintenance will appear in the December 1951 issue of *Railway Mechanical and Electrical Engineer*.

How a Commutator Is Constructed

As shown in Fig. 1, a commutator is made up of alternate copper and mica segments. The copper segments are often called "bars", and the mica segments are usually called "side mica". The side mica separates the bars electrically. The bars are wedge-shaped so that when assembled they form a cylinder. Each bar usually has a riser to form the connection with the armature coil. The bars are clamped between the shell and cap. Tightening the cap bolts moves the cap toward the shell. This causes the jaws to clamp the bars and pull them together to form a rigid cylinder. Mica cones prevent the shell and cap from short circuiting or grounding the bars. The side mica is undercut below the surface of the bars. This is done because mica wears more slowly than copper under the sliding action of the brushes. So, if it were not undercut, it would interfere with the brush contact on the commutator.

We may divide the work of the commutator into three parts. A study of Fig. 2 will serve to make this plain:

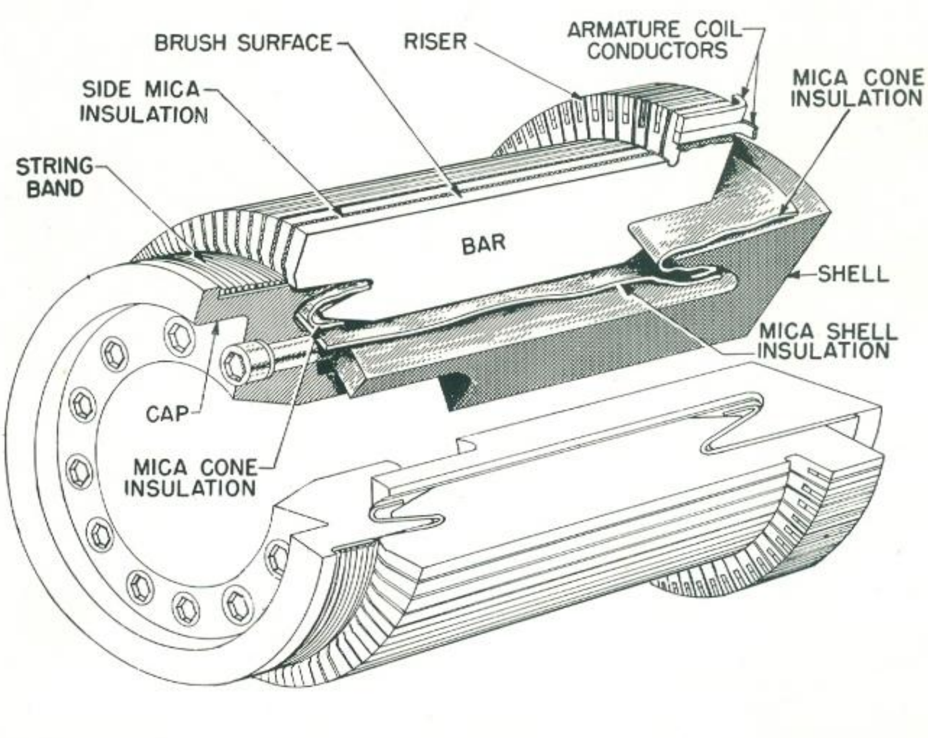

Fig. 1—Cutaway section of a commutator showing how it is put together

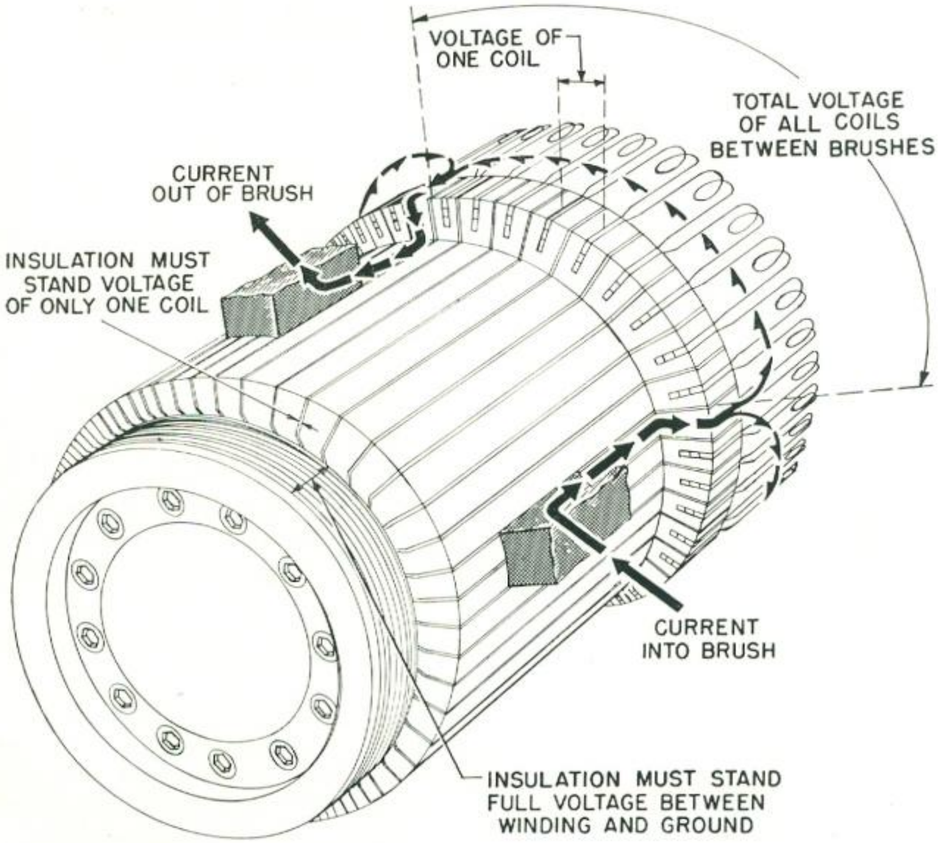

Fig. 2—The commutator must act as a reversing switch changing the alternating currents developed in the armature to the direct current in the exterior circuits

1. It provides the required sliding electric contact between the fixed brushes and the moving armature. Current enters the armature winding through a set of brushes. It then divides and follows two paths. When it reaches the next set of brushes, it leaves the armature. One such path is shown complete in Fig. 2.

2. The commutator acts as a reversing switch. As the armature coils pass the brushes, it switches them out of one circuit into another. This means that all the coils have current flowing through them in the right direction at all times.

3. The commutator also brings to the brush surface the voltage of each armature coil in the circuit. These voltages add up bar by bar between brushes. As a result, the total operating voltage of the machine appears at the brushes.

The All-Important Surface

No commutator can work as it should unless the brushes make good electric contact. This requires a smooth, cylindrical commutator surface that runs true with its center. When you realize that this surface may slide under the brushes as fast as 120 miles an hour, you see why it must be as smooth and true as possible.

Remember that a commutator is not one solid piece. It is made up of many sections of copper and mica clamped between steel parts. All these materials react differently to temperature changes. This means that forces are set up which tend to shift the parts. Also, the parts tend to shift during operation because of centrifugal force. Now you can see why it is almost impossible to maintain a perfect commutator surface. In spite of all that can be done, small variations are usually present. Brushes, being forced against the surface by spring pressure, will follow these variations, *if they are not too sudden*. Beyond that point you start to get into trouble.

It is the maintainer's job to spot a surface that is heading for trouble and correct it before failure results. A knowledge of various surface conditions and how they affect commutation will be helpful. Let us examine the more common ones.

Eccentricity. — Although a commutator surface is smooth, it may be running off center, as shown in Fig. 3A. It is then said to be eccentric. This is one of the most

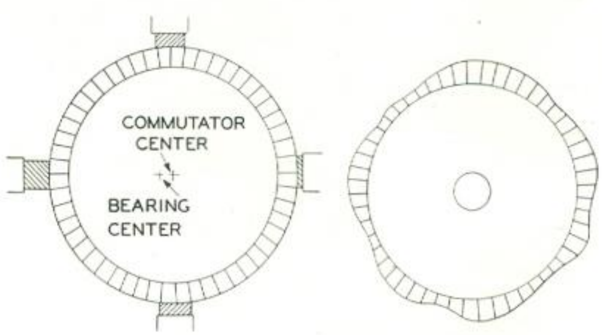

Fig. 3—Examples of commutator eccentricity and waviness, exaggerated for the purpose of illustration

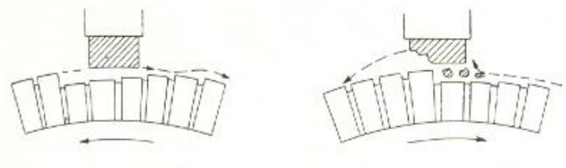

Fig. 4—Depressed bars may have different effects depending upon direction of rotation

common faults. It may result from the shaft being bent, the commutator being machined on bad shaft centers, or the bearings not running true. In single-bearing machines, such as generators, an offset coupling may be the cause.

This is usually the easiest of all surface variations for the brushes to follow. They simply rise and fall in the holders once with each revolution. However, as the speed goes up, this motion becomes faster. Finally, the brushes begin to break contact and gradually burn the commutator surface. As this continues the burning causes still further surface destruction.

Waviness. — The surface may develop waves, (see Fig. 3 B). To follow such a surface, the brushes must move in and out of the holders several times for each revolution. The motion is quicker for a given speed than that due to eccentricity. So, it is harder for the brushes to stay in contact with the surface. At high speeds, they bounce over the low spots like the tires of a car being driven rapidly over a rough road. Then we have sparking which burns the commutator surface and the brushes.

Surface Breaks. — Sometimes a sharp step or break occurs in a commutator surface, as shown in Fig. 4. It may be caused by a bump or blow to the commutator.

Fig. 6—Example of a soft commutator bar which has lifted at high speed

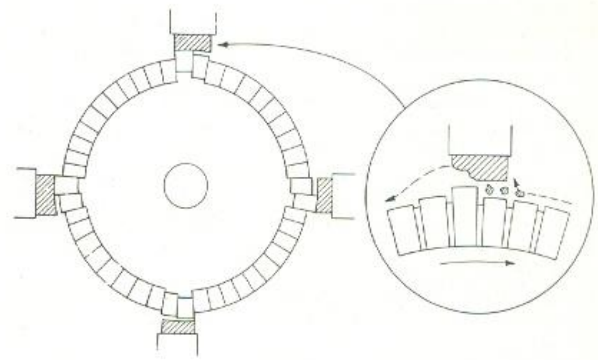

Fig. 5—Effect of high bars on brushes

The change in surface level may be very small, but it occurs almost instantly as the bad spot reaches the brush. For this reason, even a heavy spring load will not keep the brush in contact with the surface. If the commutator turns as shown in Fig 4A, the brushes will "ski-jump" from the high bar. Sometimes you can hear a distinct "click" as the brushes strike the commutator after their jump. If the rotation is as shown in Fig. 4B, the step strikes the brushes and "kicks" them away from the surface. At high speeds, this "kick" may be hard enough to shatter the brushes.

High Bars. — If a motor is held at standstill while the power is on, the commutator bars under the brushes will be overheated. These bars will expand and rise above the others. A commutator surface such as shown in Fig. 5 A is the result. The high bars kick the brushes and arcing and bouncing result, making the commutator surface even

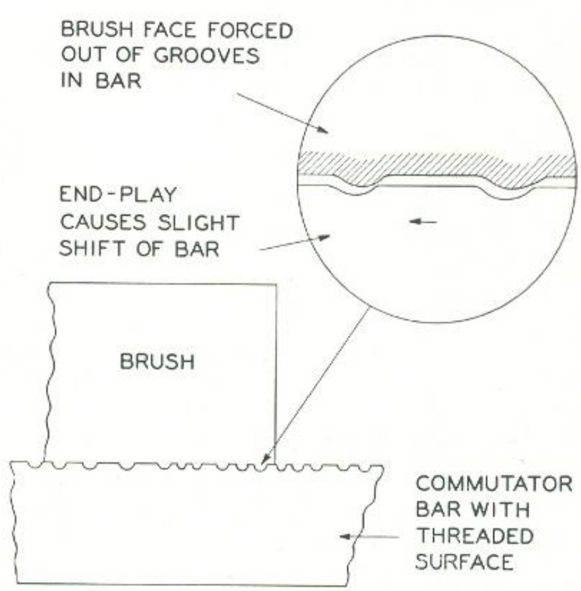

Fig. 7—Threading of the commutator as shown in the illustrations can cause the brushes to have reduced contact area when the commutator shifts due to end play

worse. If this condition is allowed to go uncorrected, the brushes will finally shatter and a flashover will result.

In severe cases, the temperature may get high enough to anneal the copper. The binder may even be burned out of the mica. This lessens the clamping action on the hot bars and they become loose. A commutator in this condition is very troublesome. The soft bars wers differently than the hard ones next to them. Because they are loose, they lift at high speed, as shown in Fig. 6.

If you suspect annealed bars, check them by comparing their hardness with that of adjacent bars. This can be done by the use of a sceleroscope or by some equivalent means. Often annealed bars can be spotted by their discoloration, especially at the ends where the brushes do not slide.

A quick check for loose bars can be made by tapping each one gently with a light hammer. At the same time, feel for vibration between bars with the finger tips.

Poor Surface.—The appearance of a commutator surface will vary. This may be the result of temperature, atmosphere, and the grade of brushes used. These all affect the thin film formed on the commutator surface during operation. A regular pattern of dark and light colored bars may develop. As long as the surface is smooth and polished, such changes in color are no cause for worry. When the surface becomes dull, raw and roughened by burning or abrasive action, trouble is on the way. Under some conditions, copper is pulled over the edges of the bars. This decreases the actual distance between bars. An arc formed at a brush is then more easily carried over to the adjacent set of brushes, resulting in a flashover. This is the commutator's warning that something is wrong. The wise thing is to find the cause of the trouble, and do all you can to correct it.

Looseness.—Glancing back, Fig. 1 shows how a commutator is held together by the clamping action of the shell and cone. Failure of the clamping action may be caused by loose or broken commutator bolts. It pays to check these bolts regularly. If even one fails or works loose, it can cause a serious accident. Overheating of the commutator is another source of looseness. This may be caused by lack of ventilating air, overload on the machine, or sparking. The heat may soften the mica binder. Then the flakes of mica shift away from the pressure areas, and the bars loosen.

Threading.—This is the most common surface defect running around the commutator, crosswise to the bars. It shows as small, thin grooves cut into the surface by abrasive action. The brush face wears to fit into these grooves. When the commutator shifts, due to end play, the brush is lifted out of these grooves, as shown in Fig. 7. The contact between the brush and the commutator surface is disturbed and poor operation may result.

Any of these commutator defects acts like a break in a highway pavement. At first, it is hardly noticeable, but if it is not cared for, it becomes worse and worse, until finally the road must be closed. So, a commutator does not fail suddenly. It gives warning in time for the trouble to be corrected. Bouncing, or shattered brushes, or bad overloads, will cause arcing at the contact surface. When these arcs become severe enough, they will bridge the insulation between bars. This permits the power to spill over between brushes in a burst of flame hot enough to melt metal. This is the commutator's final protest against abuse. Evidence that a machine has flashed over is found in copper splatterings on the surface and ends of the commutator bars. Often these are also found on the brush holders, the surrounding insulation, and nearby parts of the steel frame.

4

Running Maintenance of Commutators*

Resurfacing of commutators requires know-how in order to insure good commutation and long life

"Face-Lifting" or Resurfacing

Commutator troubles may often be corrected by resurfacing. This is the name given to any process which restores a true, cylindrical, polished surface to the commutator.

Polishing.—If the commutator surface is merely smudged, you can clean it by polishing with canvas. When this is not sufficient, crocus cloth or fine (No. 4/0) sandpaper may be used. This should be mounted on a block curved to fit the surface of the commutator.

Stoning.—When only a small amount of copper has to be removed to correct the defect, a hand stone is most suitable. It should have a surface curved to fit the commutator. Also, it should be long enough to bridge the defect to be removed. Otherwise, the stone rides in and

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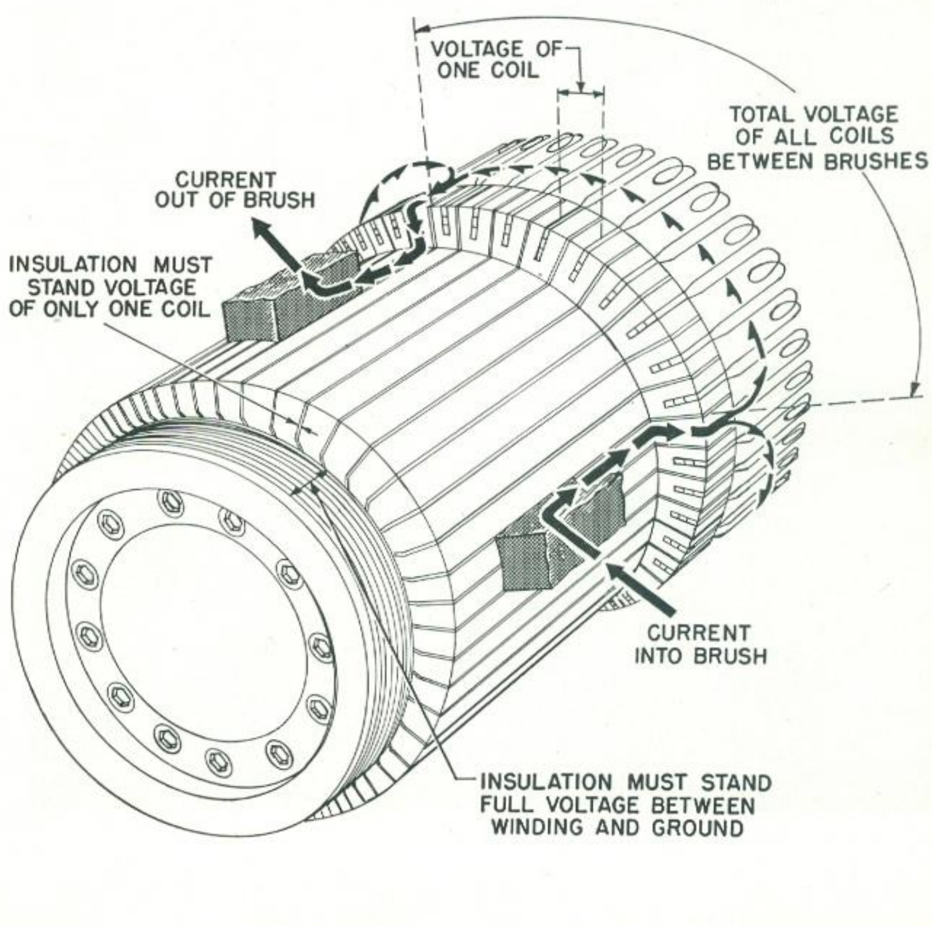


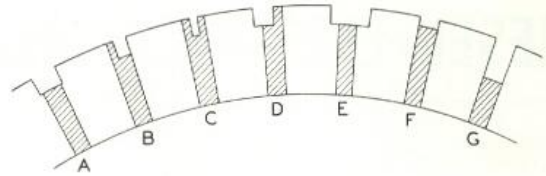
Fig. 2—The commutator must act as a reversing switch changing the alternating currents developed in the armature to the direct current in the exterior circuits

out of the defect and does nothing to correct it. The length of the stone will usually be limited by the space between brush holders. If this is not enough, a holder should be removed to make room for a larger stone.

When a greater amount of copper is to be removed, or the defect is too large to be bridged by the stone; use a jig, mounted on the frame of the machine to hold the stone. This jig has a movable carriage for passing the stone back and forth across the commutator. A feeding device regulates the position of the stone so that it cuts down the high spots on the surface. Jig stoning is faster and requires less skill than hand stoning. It also has the advantage that it will correct a commutator that is eccentric or out of round.

Turning.—If a commutator is badly worn or burned, the resurfacing operation can be speeded up by turning. A tungsten-carbide tipped lathe tool should be used because the speed may burn a tool-steel tip. Remove only enough copper to give a uniform surface. This cut should be followed by a coarse stoning and then a finish polish.

At times it may be necessary to remove the armature and turn the commutator in a lathe. When this is done, the armature should be supported on its own bearings if possible. If it cannot be supported on its own bearings, it must be held in lathe centers, but make sure they are



A. MICA PROPERLY UNDERCUT.
B. UNDERCUTTING TOOL TOO NARROW, LEAVING FIN AT ONE SIDE OF SLOT.
C. UNDERCUTTING TOOL VERY NARROW, LEAVING FINS AT BOTH SIDES OF SLOT.
D. SLOT IMPROPERLY INDEXED, PART OF BAR CUT AWAY AND FIN OF MICA LEFT.
E. TOOL TOO WIDE, PART OF BAR CUT AWAY ALSO.
F. UNDERCUTTING TOO SHALLOW, SHORTENS SERVICE LIFE BEFORE NEXT UNDERCUTTING.
G. UNDERCUTTING TOO DEEP, POCKET COLLECTS CARBON AND COPPER DUST, SHORT-CIRCUITING BARS.

Fig. 8—Some common mistakes in undercutting the mica between the commutator bars

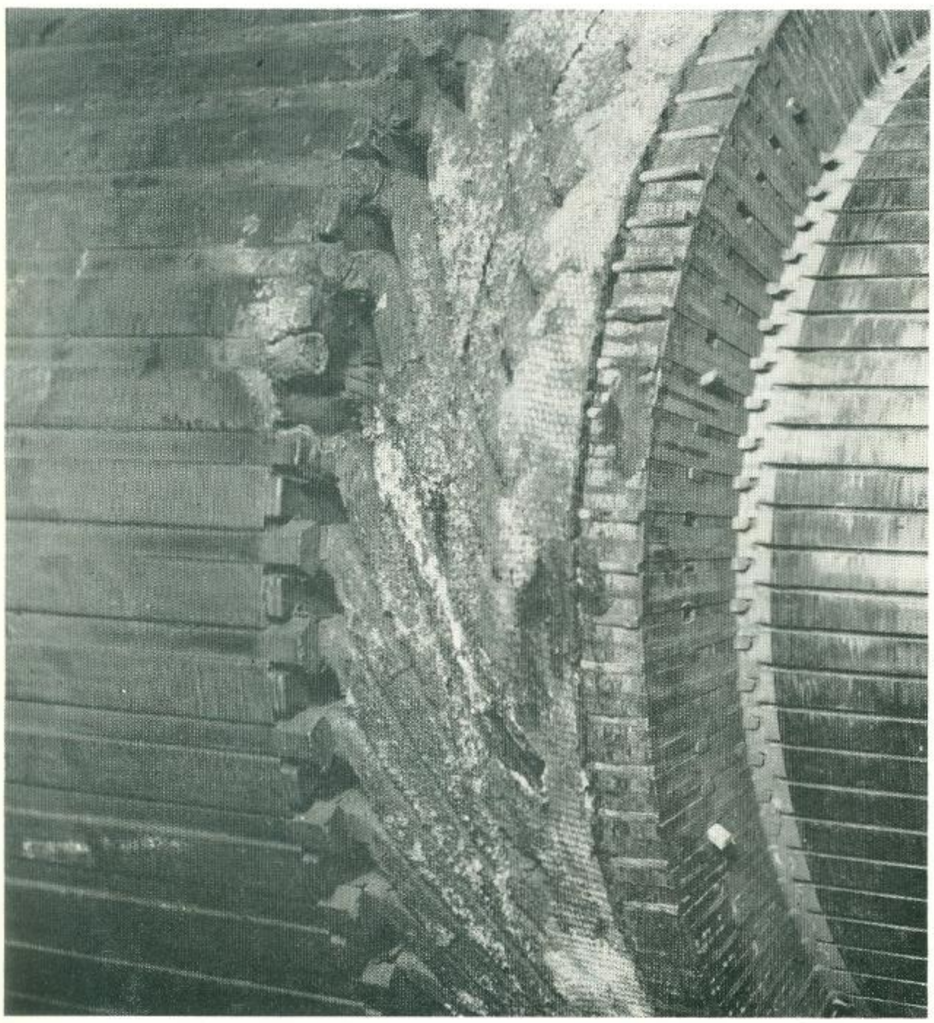


Fig. 9—An example of how molten solder has allowed the leads to shift and has short-circuited the armature coils by collecting under the insulation

true with respect to the bearing seats—otherwise you will end up with an eccentric commutator.

Undercutting.—After a commutator has been resurfaced, check the depth of the undercutting of the mica between bars. If undercutting is necessary, it should be carefully done with the proper tool. Some common mistakes are shown on Fig. 8. Be careful to avoid these. Make sure that no fins of mica project as shown in Fig. 8B, C or D. They will spoil the brush contact on an otherwise good surface.

Air Curing.—Resurfacing usually leaves particles and slivers of copper hanging on the bar edges or lodged in the undercut. These must be removed before the machine is placed in service. Otherwise, they may shift and bridge the side mica, causing a flashover. A special tool or a stiff brush may be used for this job.

After raking and brushing out between bars, the job should be checked by operating the machine at no load. Start out with a low voltage. Sweep a strong jet of compressed air back and forth across the commutator surface midway between the brush holders. The voltage and the air stream act together to disturb and burn loose any copper particles remaining in the slots, and to blow them out. When sparking under the air jet stops, increase the voltage another step. Repeat until top voltage is reached.

This process is called air curing. It can be done easily with a generator by blocking open the power contactors and increasing the speed a notch at a time.

In order to check a motor commutator at full voltage, you must arrange to have the field separately excited. This is necessary to keep the motor from running away at no load and full voltage.

Safety Precautions.—When working on commutators, always wear goggles and gloves as a protection against flying particles, and possible flashover when air curing. A respirator also should be worn during stoning operations to avoid breathing abrasive dust.

Stoning a commutator with the brushes in place will wear them away very rapidly and cause carbon dust deposits on insulation. When working on an engine-driven generator, the brushes that are hard to reach should be removed before the engine is started. After cranking, the rest of the brushes should be taken out. In the case of motors, the good brushes should be removed, and worn ones substituted. Usually one brush in each holder is enough to run the motor light.

Brush holders.—After resurfacing a commutator you should check the height of the brush holders above its surface. If much copper has been removed, you may have to lower them to meet the new surface level. When the holders are too high, the brushes will be cramped and cause trouble by sticking.

Switching Duty or Commutation

We have already seen that the second duty of a commutator is to act as a reversing switch. Just as mechanical defects in the commutator surface interfere with proper brush contact, so electrical defects in the machine will interfere with proper switching action. Now let's look at some of these.

1. Reversed main or commutating field coils.
2. The use of improper shims under pole pieces.
3. The exchange of magnetic for non-magnetic pole-piece bolts, or vice versa.
4. Wrong location of brushes on the commutator.

All these defects will cause sparking at the brushes and overheating. You are most likely to find them after a hasty emergency repair job on the equipment.

Anything that breaks the connection between a commutator bar and its armature coil will affect commutation. This happens when the commutator gets hot enough to melt the solder and allow the ends of the coils to lift out of the riser slots. Such heating may be caused by overloads or lack of cooling air. Hence, solder throwing warns the maintainer to check the blowers and air ducts to be sure that the machine is getting enough cooling air.

A connection not properly soldered, or one that has thrown solder, may oxidize rather than lift out of the risers. When this happens, local heating will cause a blackened or burned area on the riser at the poor connection.

Molten solder can cause serious damage. An example of this is shown in Fig. 9. Here the molten solder, not only allowed the leads to lift, but also short circuited the armature coils by collecting under the insulation.

Insulation

The purpose of insulation is to prevent leakage of the electric current. If leakage occurs across a small area of insulation, it may cause sufficient heat to carbonize the surface. This lowers the resistance enough to cause a breakdown.

Looking at Fig. 2, we see that each pair of commutator bars has the voltage of one armature coil between them. If the side mica is bridged by any conducting material, the bars will be short-circuited. The current flowing across this small area will heat the mica, causing it to carbonize and glow at that spot. At high speed and voltage, this hot spot will form a ring of fire around the commutator which may cause a flashover.

Another cause of short circuits is damage to the commutator, resulting from an accident. Loose objects, such as small bolts, nuts or washers may fall unnoticed into an air duct or a commutator chamber. If such material lodges between a brush holder and the commutator, it will do extensive damage and put the machine out of service.

Not only must the bars be insulated from each other, but the whole commutator must also be insulated from the ground. This insulation has to stand the full operating voltage of the machine. It consists of relatively long creeping surfaces next to the commutator. The string band, shown in Fig. 2, is one example. When these surfaces become coated with dirt or moisture, they are no longer good insulators. As a result, there is leakage of the current to ground. When this leakage becomes great enough, the insulation breaks down and a ground results. Such failures can be prevented by keeping the string band clean.

A flashover may strike across the string band and do varying amounts of damage. If the band is only smoked up, it can be cleaned with a cloth and solvent. If the paint is burned, it can be cleaned with sandpaper and repainted. Be careful not to cut through the string. If it is seriously damaged, a new band must be applied. This is a repair job.

By watching for the warning signs described above, an alert maintainer will be able to correct troubles before costly failures result. The old proverb says, "A stitch in time saves nine", and it is certainly true of commutators. A good job of preventive maintenance will pay big dividends in increased locomotive availability and decreased repair bills.

DIESEL-ELECTRICS—How to Keep 'Em Rolling

5 Brushes and Brush Rigging*

Don't be deceived by the simplicity of a brush. It can cause serious trouble in fourteen different ways if it is not properly cared for

Brushes are simple looking things—just a block of carbon—but this simple appearance doesn't tell the whole story. Actually they do a mighty big job in passing large quantities of current through their sliding contact with the whirling commutator surface which speeds past them at a hundred miles an hour. This job is all done without oil or grease for lubrication.

Carbon is an excellent material for brushes. It handles the heavy currents without fusing or welding to the commutator when sparking or flashovers occur. It is readily molded into the right shape and can be treated to give soft, hard, or tough brushes. When the proper grade of brush is used, a very thin glossy film is formed on the commutator. The brushes ride on this film. The advantage of this is that wear takes place in easily-replaced brushes rather than in the costly commutator.

There's More to It

Having a good material isn't the end of the story. If the hard-working brushes are to do their stuff, the maintainer must watch several things:

1. Grade and type of brush.
2. Commutator surface condition.
3. Brush holders.

Watch Your Grade

This important item is often confusing to maintainers. It isn't always easy to choose the right grade of brush for a motor or generator on a certain locomotive. From long experience, the builder usually recommends what he knows will give good results in most operations. Be very careful about changing that grade, or you may save pennies on brushes to spend dollars on commutator repairs.

A quick look at brush grades will give an idea of the effect of different brushes on your equipment.

(a) Soft brushes are usually very easy on the commutator. They quickly produce and maintain a good surface film. Their friction on the commutator is usually low, tending to keep it cool. Such brushes are recommended wherever they can be used economically. In applications where equipment gets rough service, they break or quickly wear and a stronger brush is needed.

(b) Hard, tough brushes, unlike the "softies," can take a pretty good beating before breaking. "Great!" you might say, "Let's buy hard brushes." Wait! Not only can hard brushes take a beating—they can also give one to the commutator, by bouncing and sparking at high speed.

Naturally, the alert maintainer wants to keep brush mileage high. If wear or breakage increases, he will be tempted to use harder brushes. What he really should do is try to find the cause of the trouble. Some common ones

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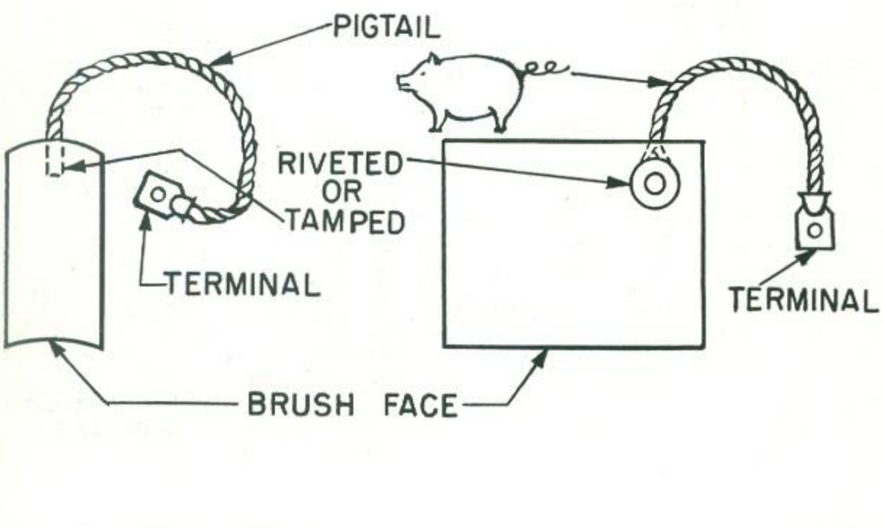

Fig. 1—Solid type brush

are wheel-slip overspeed, stalled motors, or abrasive dust in the air. Changing to very hard brushes might get him out of trouble today, but he would likely have to pay the penalty in damaged commutators later.

The best brush is usually a compromise between soft and hard grades. This gives many of the good features of both and gets away from some of the troubles just mentioned.

(c) Abrasive brushes, also known as "scrubbers," are sometimes used to keep a commutator surface clean. Unusual operating conditions may burn and dull a commutator surface beyond the point of self-recovery. The frequent stoning necessary to keep it in operation would take too much time. Here the mild, abrasive action of "scrubbers" will keep the job going. Of course, you will have higher commutator wear, so use "scrubbers" cautiously, and only as a last resort.

Besides the grade of brush, you must also think of its design. There are two main types: solid and duplex.

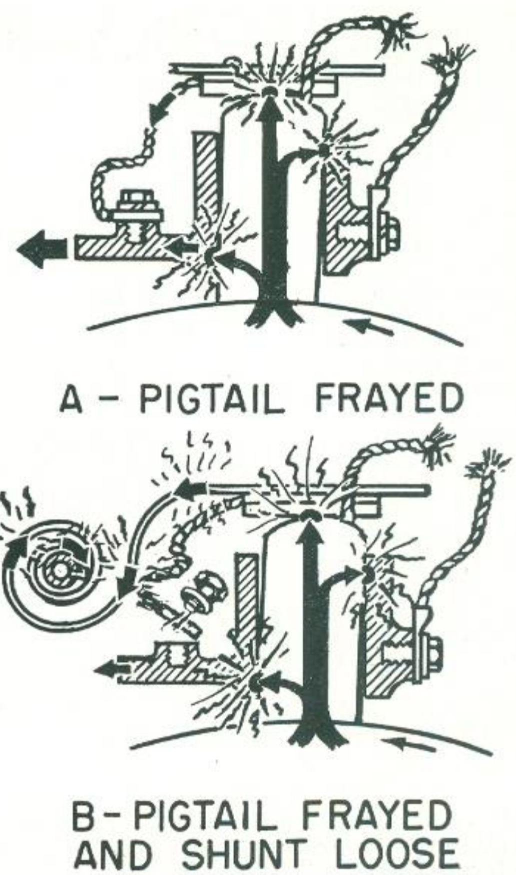

Fig. 4—Results of poor maintenance

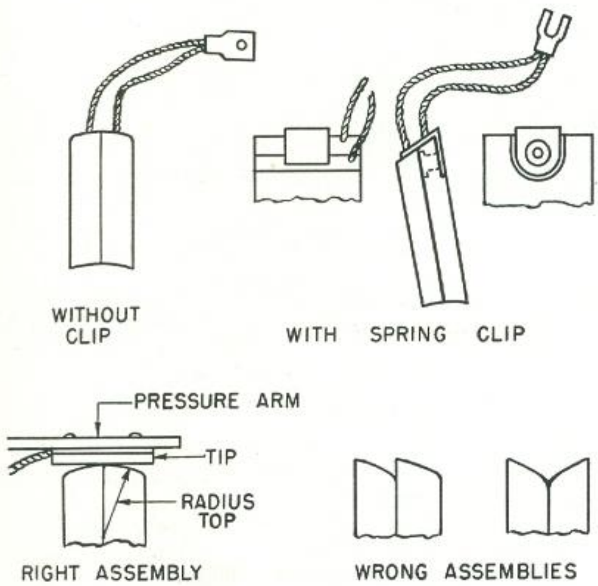

Fig. 2—Duplex type brush

The simpler solid brush, Fig. 1, is used wherever operating conditions permit. It has the advantage of low first cost and easy handling when replacing brushes.

The demand for greater power in a given size locomotive has meant increased duty on all parts, including the brushes. Greater commutator speeds, higher currents,

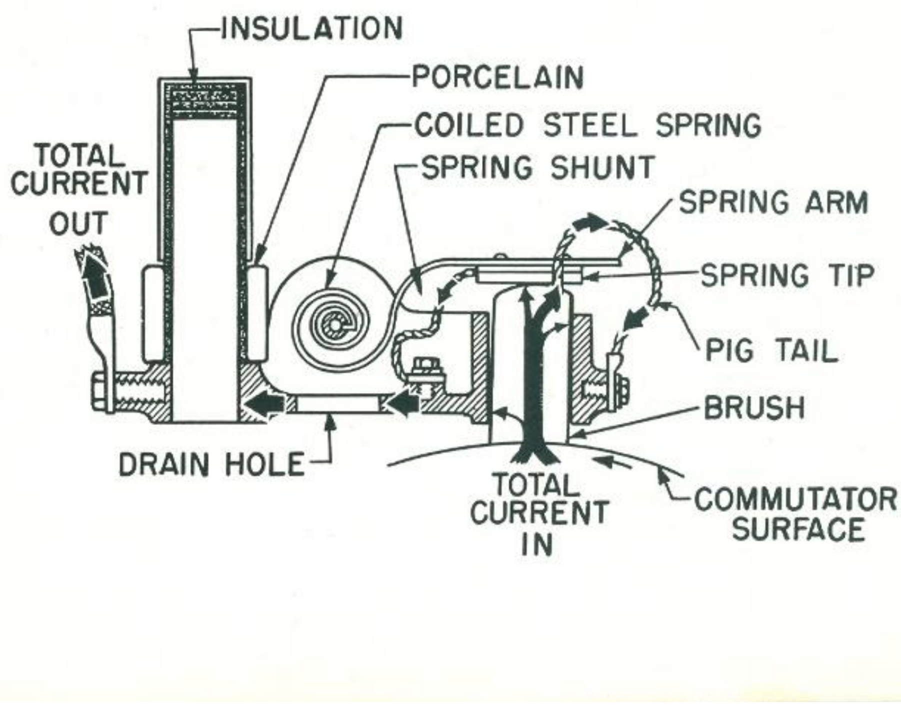

Fig. 3—Typical brush holder

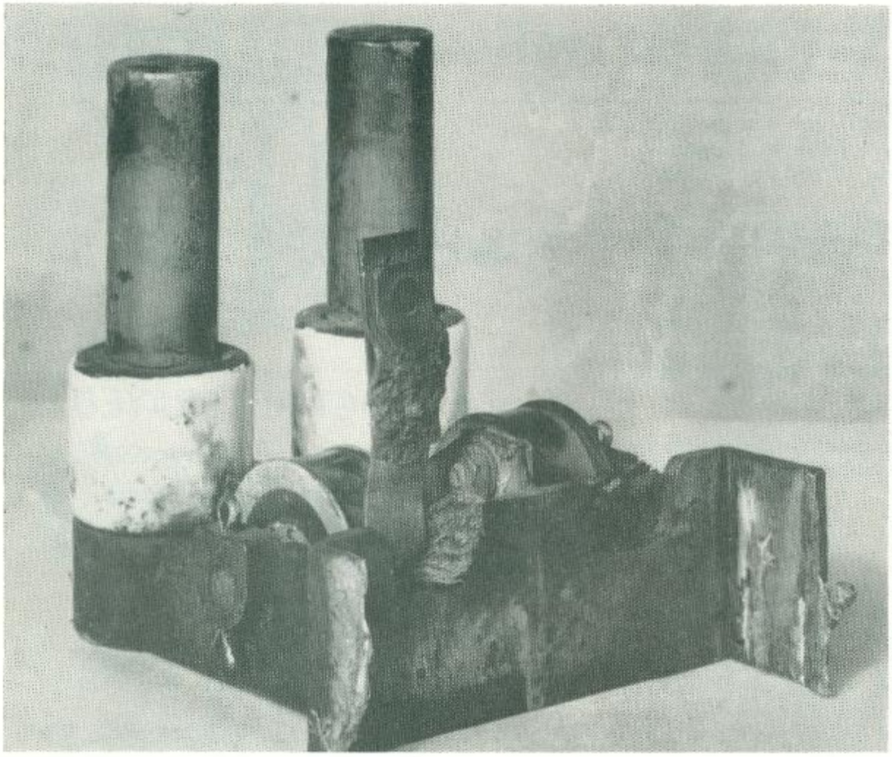

Fig. 5 — Neglect of proper maintenance of brushes and brush rigging may have serious results, as this melted traction-motor brush holder testifies

and tougher service have sometimes reached the limits of the solid brush. When this happens, commutator surfaces become poor and brush maintenance goes up. Here the duplex brush, Fig. 2, proves better.

Believe it or not, cutting a solid brush into two smaller pieces makes it do a better job of riding the commutator and handling the current. The duplex brush has a higher first cost and is a little more trouble to handle. It pays off, though, in lower over-all maintenance and greater reliability in heavy duty jobs.

Where Surface Counts

It's very important to keep the brushes on the commutator at all times. A bouncing brush hammers itself to pieces and gives the commutator and brush rigging a beating. Worse yet, it draws an arc at the commutator surface. This eats away the copper bars and makes matters even worse. Putting it the other way around—to keep good brushes operating properly—the commutator surface must be smooth.

The Rest of the Team

A good brush—like a big league pitcher—needs a team to back it up. The brush holder is this team. Its most important plays are to:

1. Get current into and out of the brush.
2. Keep the brush in the right position.
3. Keep the brush on the commutator.

Let's see how a typical traction-motor brush holder, Fig. 3, plays the game. Normally, most of the current is carried by the pigtail. A small amount may sneak out the side of the brush and get into the holder through the

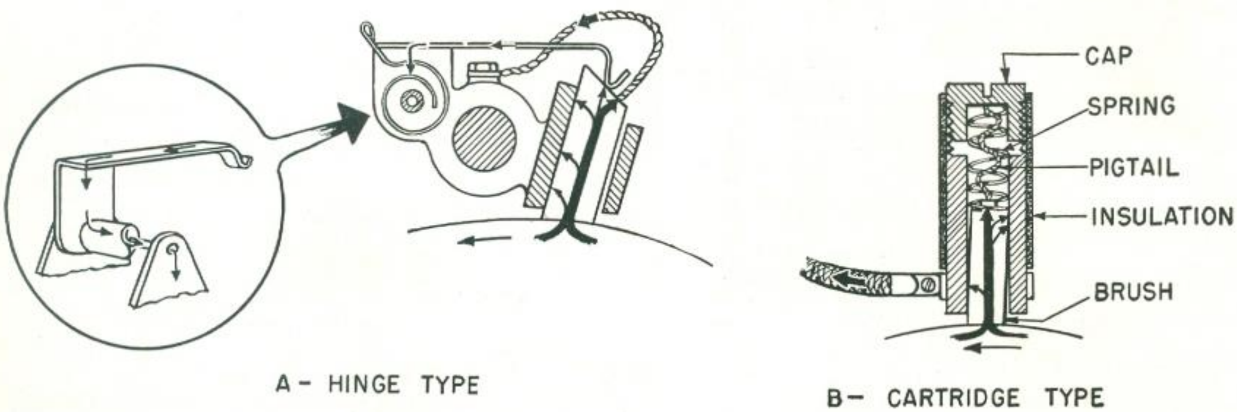

Fig. 6—Two more types of brush holders

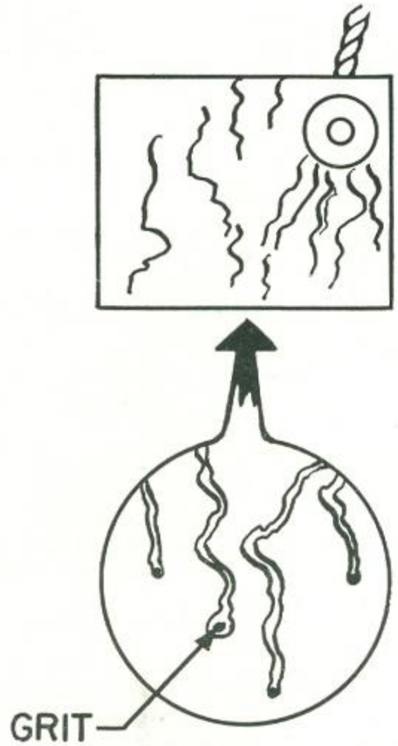

Fig. 7—Brush affected by grit

carbonway. More of it gets out of the brush top through the spring tip and shunt. But the pigtail carries the big load because it makes a good, solid connection between the brush and holder. In contrast, the brush makes only a moving, touching kind of contact with the spring tip and carbonway.

Sometimes the pigtail gets loose in the brush or may not be tightly fastened to the brush holder. Also, it may become badly frayed or broken. When any of these things happen, most of the current is forced to go through the carbonway and the spring tip and shunt. The moving contact of the brush with the carbonway and spring tip is poor and can carry only small currents. In easy service with low starting currents, a brush holder in this shape may get by without much maintenance trouble. But in hard service with heavy train starts, these poor contacts can get glowing hot, see Fig. 4. Giving a brush holder the "hot foot" like this is no good. Wear increases and repairs begin to pile up. Remember—a good pigtail connection is a mighty important link in proper maintenance.

The next most important current carrier is the spring shunt. If anything goes wrong with the pigtail, this acts as a backstop and carries most of the current, as in Fig. 4A. If the shunt stops carrying current, you are in for real trouble. This can happen by the shunt loosening where it connects to the brush holder, or by its getting frayed and broken. Then current will be forced to flow through the spring itself, Fig. 4B. Since the steel in the spring has a much higher resistance than the copper shunt, the heavy current flow makes it so hot that it loses its temper. With the spring out of commission, the brush can bounce on the commutator as much as it likes. This overloads the other brushes until they also fail. Then arcing between the brushes and commutator starts and a flashover may result. Worse yet—when trying to start a heavy train, it can melt off the brush holder, Fig. 5, and burn a hole in the commutator. Then you have a road failure.

You can usually bring a train in, even though a pigtail has failed, when the spring is protected. But if the spring isn't protected, you're in for trouble. Also, a loose pigtail waving around can do a lot of damage. If it touches the frame, it will ground the motor. If it drags on the commutator, it will cause a flashover. So you better see that pigtails and shunts are tight. Also, make sure that they are looped away from the brush spring so they won't wear and fray open.

Two other designs of brush holders are also used in railroad work, see Fig. 6. The first has the lever arm moving on a hinge pin and an independent spring. This arm offers a shorter and better path for stray current than the long, coiled clock spring. The second is the cartridge, or completely enclosed type, used for low power on small machines.

Position Is Important Too

The radial type of brush holder is used on machines, such as traction motors, that operate in both directions. It has a carbonway, or brush box, that holds the brush in a radial position on the commutator. The brush tilts slightly whenever the motion of the commutator reverses. Hence, the clearance between the brush and box must be kept as small as possible. When the box wears, the brush cramps and wedges itself. Not being free to follow the commutator surface, the brush then sparks and chips; the commutator is damaged and brush life is reduced. Electric pitting is one big cause of wear in the brush box, but abrasive dirt can also cause it to get sloppy in a hurry.

Sometimes dirt makes odd patterns on the brush, as shown in Fig. 7. This is often mistaken for electric burning, but actually it results from sand or gritty dirt between the brush and box. This dirt digs a worm-like path in the brush, and also wears down the walls of the box. Once you have closely examined such a case, you will never mistake it for electric action. Rather, you will start looking for a way to keep dirt out of the machine.

Worn brush boxes are not the only trouble caused by dirt. Sometimes oil gets between the brush and box where it mixes with dirt and forms a gum which sticks the brush in the box. The effect is the same as removing the spring pressure, and the brush gets stuck off the commutator and quits working.

One more important point. Be sure to keep the recommended distance between the brush holder and the commutator. Don't fail to check this if you are replacing a brush holder or have resurfaced the commutator. If this

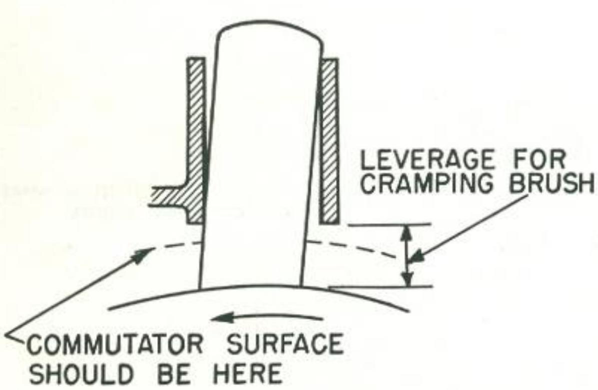

Fig. 8—How brush holder position affects cramping

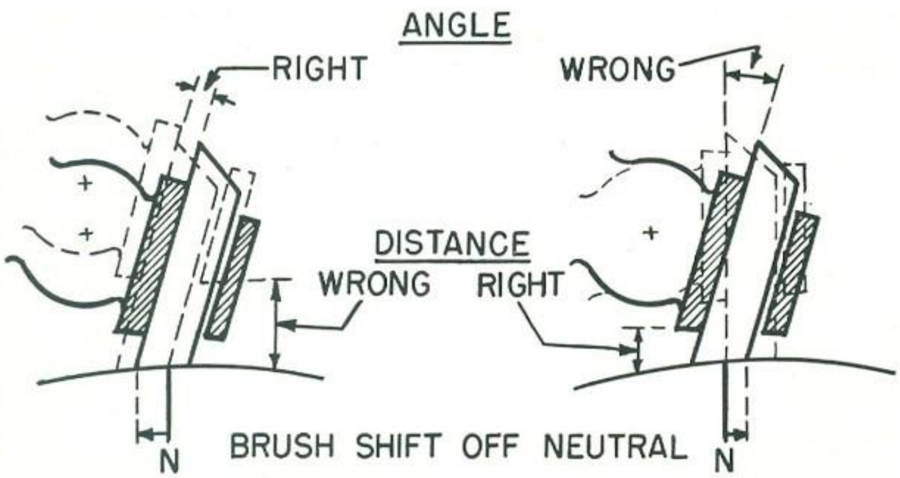

Fig. 9—Reaction type brush holder

distance gets too great, the commutator surface drag will have enough leverage to cramp the brushes, see Fig. 8.

One-Way Running

When, as in a generator, the commutator always turns the same way, it is possible to use the types of brush holders shown in Fig. 9. These hold the brush against one side of the box to keep it from cocking and chattering. In the trailing type, the brush is held against the box by the action of the brush spring and the angle the holder makes with the commutator surface. The stubbing (leading) type, also holds the brush against one side of the box, but directs it against (instead of with) the direction of commutator motion.

The brush box clearance in this type of holder can be quite large because normally the brush touches only one side. This side must be flat to hold the brush steady. If it becomes rounded, the brush will tend to seesaw. This condition may be the result of wear or may be caused by careless cleaning of the brush box with sandpaper or a file. Of course, you cannot get a good contact at the commutator surface if the brush rocks back and forth in the box.

The angle of such brush holders is important. It depends upon the brush grade, commutator speed, spring pressure, etc. The builder fixes the angle to obtain the best brush operation. Whenever you remove brush holders for maintenance, be sure they are replaced at the proper angle.

Hold That Neutral Point

The brush holder angle must be watched for other reasons too. For best operation, brushes should contact the commutator at a definite point called the electrical neutral. Even though you can't see it, this point is a real thing—just like the timing of your auto engine. If the brushes are not at this position, the output of the machine will be affected. A motor will have its speed under load changed, and a generator will have its voltage affected. Brushes set "off neutral" will show up by sparking. This is particularly bad when one set of brushes is out of place in relation to the others.

You can get brushes "off neutral" in several ways. Suppose you set the brush holder too high above the commutator. Because of the angle, the brush will overshoot its proper position, as shown in Fig. 10. The same thing will happen if you let the brush holder twist on its stud. The wrong angle will throw the brush off, even if you get the distance right, see Fig. 10 again.

A jig is usually provided for setting brush holders at the right angle. Sometimes brush holder supporting studs are keyed into the frame and to the holders. Then

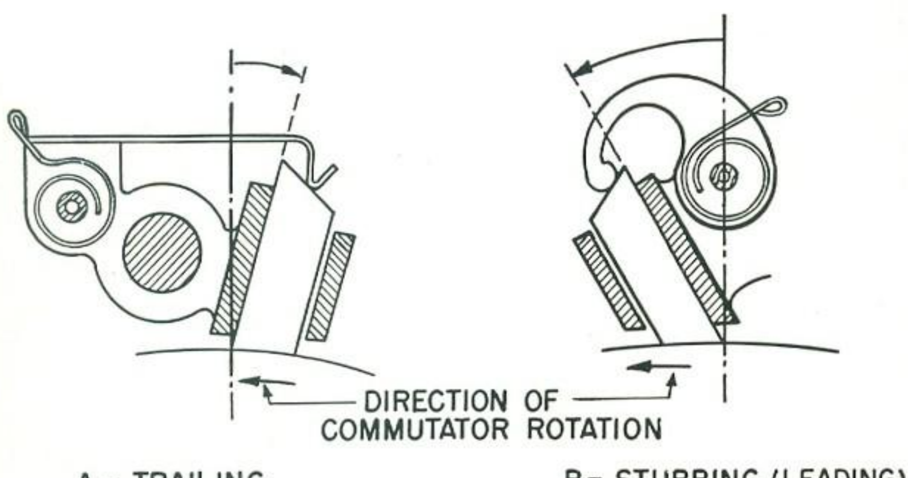

Fig. 10 — Effect of wrong brush holder position

you need only check distance to the commutator. Some machines have the brush rigging on a movable yoke or frame head. You should check this for the neutral mark or key to get the proper position. Many older machines used tramming tools and reference marks for setting brushes. Check this neutral position before you tear anything down so you will be sure to get it back just right.

Be Sure of a Good Fit

If you replace only one or two brushes at a time you needn't sand them in, especially if you are using brushes with faces prepared to approximately fit the commutator. Usually the other brushes will carry the load until the new ones get fitted. But, if you change a large number of brushes at once, you had better fit them, either by sanding or with a brush seater. When sanding, be sure the paper hugs the commutator surface. This will give a sharp fit right to the brush edge. If the machine runs in one direction only, pull the paper that way when finishing the sanding. This may seem like a fine point, but it shows you know the score.

Springs—Handle With Care

Another important thing about a brush holder: keep the right spring tension to hold the brush on the commutator. It should be nearly the same as the tension of its fellow spring in the next holder. If the spring tension in the brush holders varies a large amount, the current collected by brushes will vary also. If the differences are too large, some brushes will overheat and fail.

Tension is affected by wear in the spring mechanism, dirt between the hinge and shaft, and overheating of the spring. It is good to check spring tension occasionally, and to see that the springs are free from dirt or objects that might foul them.

Watch brush length too. If brushes wear too far, the springs will rest on some part of the holders. Then the brushes will be free to bounce on the commutator. Sparking will result that may cause a flashover or damage the commutator and brush holders.

A word of caution: when renewing brushes, either release the spring tension or use a tool for holding the spring. If a spring slips out of your fingers, it can deal a shattering blow to the brush. Even if it doesn't crack the brush right away, this tough treatment may show up later.

One More Play

Supplying the teamwork to back up the brushes is no simple task for the brush holder, but its job isn't over yet. It must keep itself insulated from the frame of the machine, yet be rigidly attached to the frame so that it won't vibrate and cause the brushes to chatter and spark. A megger will serve to check the insulating value of the holders. The only way to be sure they are tight is to get in there with your hands and feel them. Remember, more than once brush and commutator troubles have been caused by loose brush holders.

How it All Adds Up

Now, we've seen what each part does and how the brush and holder work together as a team. You, as the coach, can see to it that each part stays on the job to maintain a good score. Keeping this team running smoothly does much to prevent serious troubles, costly overhauls and road failures. So treat that little block of carbon with the respect it deserves.

DIESEL-ELECTRICS—How to Keep 'Em Rolling

6

Insulation—Its Purpose and Its Requirements*

If insulation is given the care it deserves, the maintainer can avoid a lot of grief and hard work

Why Insulation?

Electricity, like many people, follows the path of least resistance. It is always looking for short cuts to get out of doing work. The material we use to keep it on the job is called insulation. It confines the electricity to a useful path — usually through copper wires. Non-metallic materials like glass, mica, porcelain, wood shellac, and varnish are some of the better insulators. Even dry air is good for this job. Electricity has a tough time getting through or across these materials.

If the conductors of a machine could be bundled up in plenty of insulation, you might think the machine would last forever. But the problem is not that simple. "The more the better" isn't always a good recipe to use with insulation. Remember, heat is generated in an electric machine when it is working. And good electric insulators are also good heat insulators. This means that insulation acts like a blanket to keep the heat in the machine. While not enough insulation will wreck a machine, by allowing electricity to escape, too much insulation will also hurt it by making it overheat. So, to let the heat out, just enough insulation is used to keep the current in the wires.

Another thing, there is only so much space in a ma-

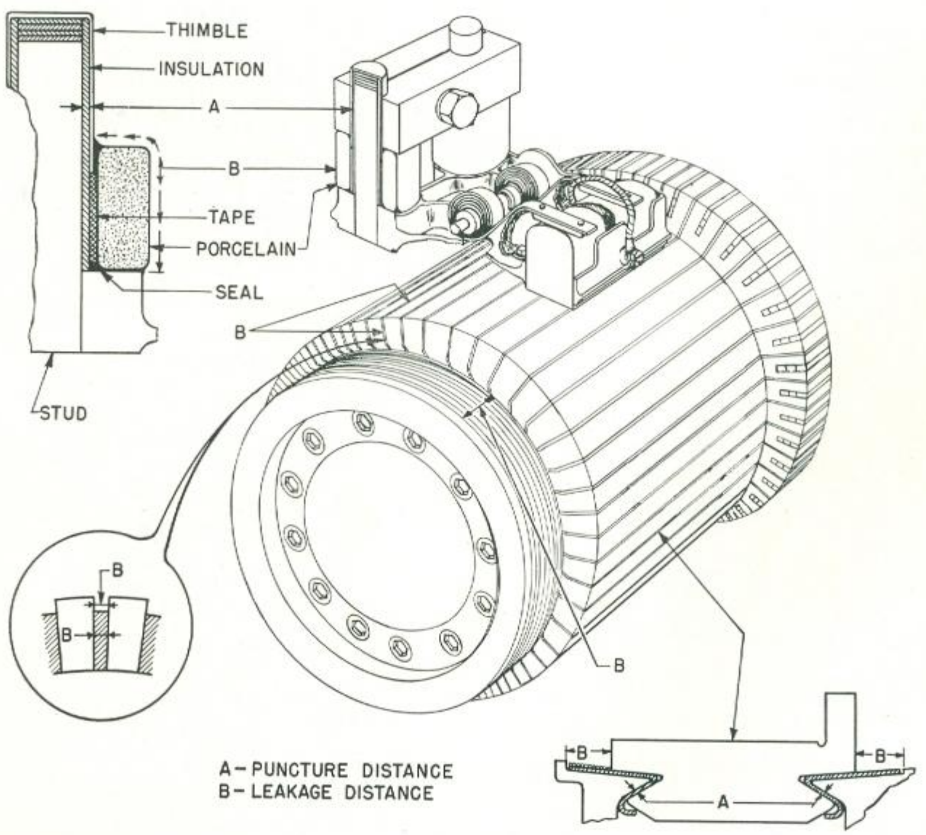

Fig. 1—Details of brush-holder and commutator insulation

* This is the sixth of a series of articles on maintenance of diesel-electrical equipment. This article is written by J. W. Teker and J. R. Schrecongost, both of the Locomotive and Car Equipment Department, General Electric Company. Erie, Pa.

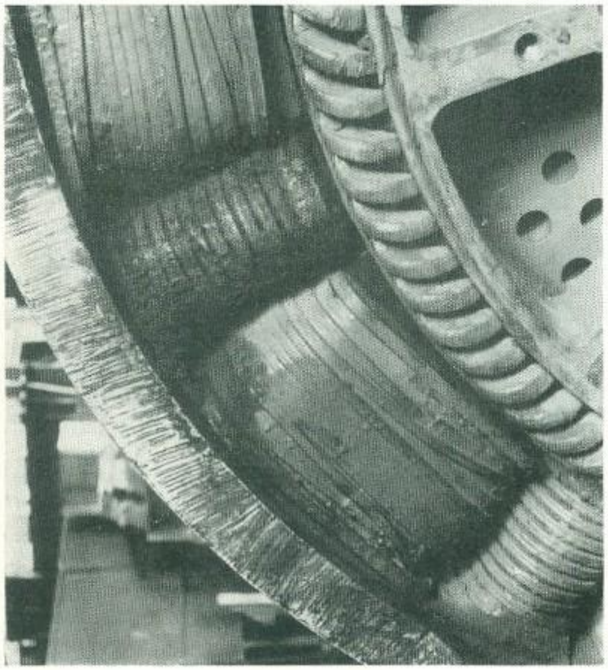

Fig. 2—Accumulation of oil and dirt on generator field coils

chine. This has to be divided between copper, iron and insulation. Since it is electricity that transmits the power to pull trains, we try to get all the space we can for copper and iron. This is another reason for not using any more insulation than necessary.

Although it doesn't take much insulation to hold electricity in, what there is must be o.k. The maintainer's job is to keep this insulation in good condition so it can do its work well. Now, let's look at the job insulation has and see some of the things that may happen to it.

Electricity's Traffic Cop

Motors and generators depend upon the flow of current through their field and armature coils where the work is done. Insulation keeps this current in the circuits leading to these coils. It also separates the turns of the coils so that the current must go around each turn. This makes the current do its magnetizing job. When the insulation fails, the current short-cuts across the turns. Then it doesn't do its job, and we have what is called a "short circuit". If the insulation fails in a way that lets current escape to the machine parts which are not in the regular electric circuit, we have what is called a "ground." This means that current gets into parts connecting with the earth or ground.

What Makes It Fail?

"How and why does insulation fail", you may ask, "and what can I do about it?" The two more common forms of insulation failure are puncture and leakage, and sometimes a combination of both.

Puncture: Insulation has very good resistance to puncture. However, if the voltage (electrical pressure) is high enough, it can break through the insulation just as water or steam can burst a pipe. Good insulation will hold a pressure of several hundred volts on a wall only one thousandth of an inch thick. This is fine, for it allows most of the circuits inside a machine to be completely enclosed by insulation thick enough to hold the electricity in, but thin enough to let the heat out. What's more, today's insulating materials keep their puncture strength for years of regular duty. Then why worry about insulation at all?

One reason is the danger of mechanical damage. Because insulating materials are mechanically weak, the thin layers used are easily damaged. Careless handling of tools, or parts, may cut or puncture the insulation. Loose coils on poles shake and wear their insulation. Relaxed armature bands let coils buzz and wear through. Vibration from bad gearing or a rough engine seeks out and punishes any insulation that is free to chafe. Rough cleaning treatment, or prolonged soaking in strong solutions may be harmful, both mechanically and electrically. Dirty or loose terminal connections get hot and char the insulation on the conductor. Using flame to thaw out steam or air pipes that are near conduits carrying electric wiring may burn cable insulation. From these examples, you can see that damage is a greater enemy of insulation than is puncture by any operating voltage. So if you keep damage off the job, the insulation built into the machine will keep electricity on the job.

Leakage: While most of the conductors in a machine are completely enclosed with insulation, there are certain parts that must be left exposed. An example is the commutator surface and brushes (Fig. 1), which must make sliding electric contact with each other. How to keep electricity from escaping at these exposed places is a problem especially worth understanding. At such points, the current is no longer walled in. Hence, it can leak or "creep" away through any conducting material that

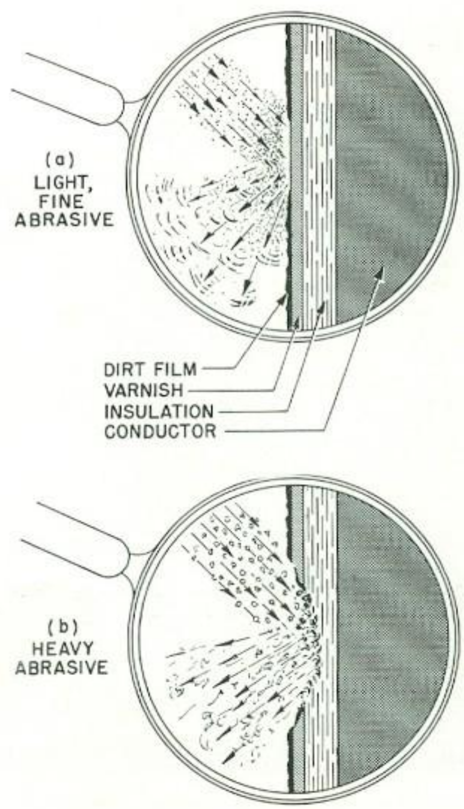

Fig. 3—Good and bad air-blasting practice

does get in. Remember the leakage surfaces during regular cleaning when you blow the dry dust out of the machines. Blow with a purpose, not just to stir up dust. Engine-driven generators and exciters can be kept turning during blowing. In this way, all surfaces can be reached, and the machine fans will help expel the dust.

Beware of Moisture

Solid conducting particles are not all that form escape paths across insulation. Water, with conducting material dissolved in it, will readily carry current. An illustration of this is the way current flows through the acid-water mixture in a storage battery.

When a leakage surface gets wet, the current doesn't have to try to jump through the air spaces between particles. It can get across through the water. In fact, current can then bridge gaps impossible for it to cross on dry insulation. Trouble begins if the film of water is carrying current when it starts to dry up. This drying may be by natural evaporation or by heat, if the path is conducting enough current. The surface does not dry all at once. Tiny dry spaces form here and there between the wet patches. The current easily jumps these little dry spaces as they form, and the sparks char the insulation. If the water doesn't dry off faster than these sparks burn the insulation, a carbonized path will be formed. This will lead to failure unless it is detected and corrected.

Moisture has a way of soaking into tiny spaces that dry dust alone could not penetrate. It seeks out pinholes and cracks to start leakage paths in insulation that would be perfectly safe if dry. That's why you should be cautious about applying power or making high-potential tests on wet machines. The insulation should be dried out first. This can sometimes be a problem.

When a cold machine is moved into a warm shop or enginehouse, it breaks into a sweat. Moisture froms on it just as drops of water collect on the outside of a glass of ice water on a hot day. Or the machine may have run through a severe snow or rain storm and soaked the insulation without being hot enough to dry the moisture off as it came through. If left in the warm enginehouse, the machine may dry out in time. Or a blast of hot air can be blown through it to speed up the drying. A generator can be short circuited with a temporary connection and then driven at low excitation to get it hot. The short circuit will allow a high heating current and, at the same time, keep the voltage low.

Another Bad Actor

Dry dust and moisture are not the only enemies of insulation. Diesel engines and air compressors like to splash and blow around in oil. They have a generous way of sharing it with everything in the engine room—even the insulation of the electric machines. While clean oil is a good insulator, it is also a good dirt collector. Oil fumes, or even solid droplets, in the engine room air deposit a thin film of oil on insulation. This makes the surface sticky, and when dirt particles fall on it, no amount of blowing can get them off. The deposit gets thicker and thicker. It builds up against field coils, in corners and over to terminals (Fig. 2), until a leakage path is formed. Then it settles down to glow and burn, just as in any other leakage failure. Like water, oil has a way of finding and seeping into pin holes and cracks in the insulation.

Such mucky dirt must be washed away with a solvent. The perfect solvent evaporates rapidly, without leaving a conducting residue. It doesn't harm the insulation,

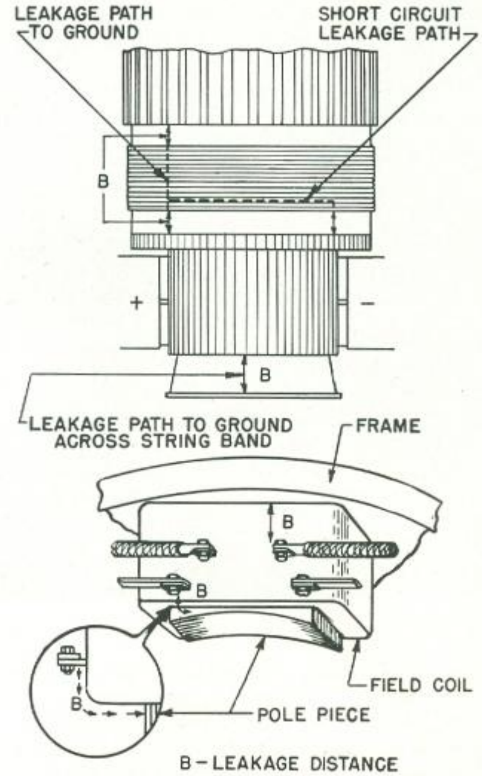

Fig. 6—Typical leakage surfaces on armatures and fields

will not burn or explode, and is not poisonous. No one has yet found this perfect solvent, but a number of good ones are in use.

Carbon tetrachloride comes close to filling the bill, except that it must be used with care. Precautions must be taken to guard against personal injury, especially from breathing the fumes. Perchlorethylene is not as poisonous, but any of these good cleaners must be used with caution—just like fire or electricity. Follow carefully the instructions worked out by your Safety Committee experts for your own good. Do not use more solvent than necessary, and provide good drainage so that it doesn't float the dirt to a place where it will do more harm. Where possible, it may be a good bet to wipe with the solution instead of washing or spraying.

Locomotive "Traffic Film"

Our last trouble maker—and probably the most difficult to remove—is a smoke-like deposit of fine carbon. It does not blow or wash off. It is like the "traffic film" on your car. If you squirt the body with a hose, it looks clean while it is wet, but as soon as it dries, it is as dull and grimy as ever. The only way to get the stuff off is by scrubbing. As you know by experience, you've got to lay hands on it. This is all right as long as you can get at these grimy surfaces. Some, however, are hard to reach, such as the pockets between coils at the end of the armature slots, or behind commutator ears or risers. Here is a good place to use an abrasive blast. Like any powerful tool, it must be handled with caution and full understanding of what it does. Otherwise, you can do more harm than good with it. Heavy, abrasive particles driven by a powerful air jet will not stop after removing the dirt. They will cut through the protective varnish coat and rip the insulation to shreds (Fig.

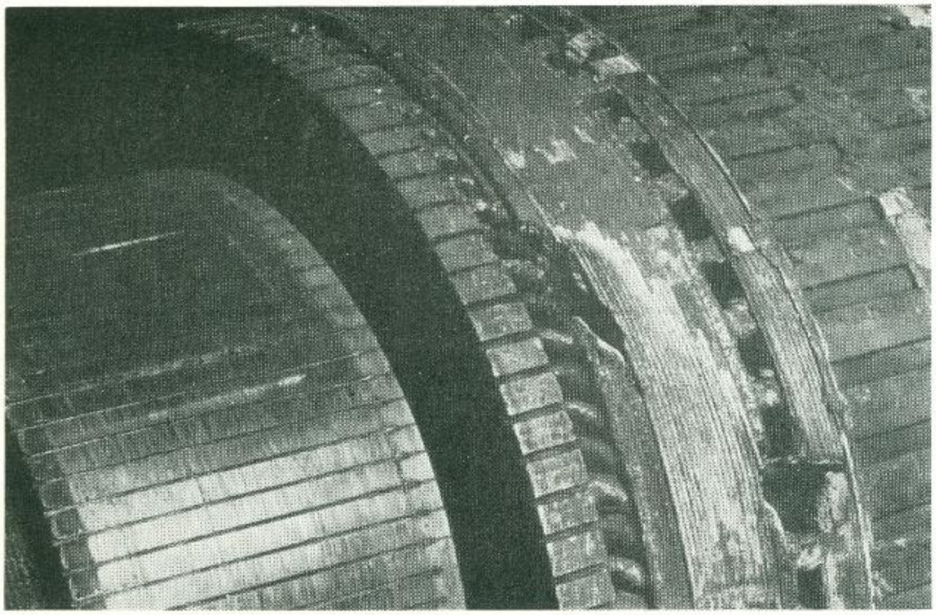

Fig. 7 — Generator armature bands burned by short circuit currents

3b). Heavy, soft, sponge-like pellets driven at high speed will pound a surface. Maybe they won't cut, but they will loosen the bond between the layers of insulation.

Because this dirt forms only in a fine layer, a very light flour-like abrasive is all that is needed (Fig. 3a). Driven at moderate speed with usual shop air pressure (90-100 lb.), it will give a cleaning heat that cuts fast enough to control without doing any harm. Don't make the mistake of blowing a solid stream of abrasive. Cut it down so only a fine, barely visible dust shows. Let the air do most of the work. Above all, study and understand what you are using and what it is doing. Don't think only of the present cleaning job. Remember what effect your present action may have on the future operation of the machine—you don't want to cause a rebuilding job. Protect yourself too; be sure to wear a respirator.

You Can't Cover Up

There is a strong temptation to paint insulation instead of cleaning it. This may make a nice looking job, but it doesn't fool the electricity. Don't think you can get away with it. Painting dirty insulation is the worst possible thing you can do. The layer of conducting dirt is still there, although covered up with shiny, new paint. The current leaks through it just the same, only now with the paint over it no one can get at it to clean it off. The backshop will find you out when they strip the machine down to rebuild it after it blows up.

If there isn't time for a good cleaning job, it is much better to let the machine go without painting. Then you have a chance of improving it next time. Be wary of insulation that looks dirty, but measures good. Don't paint it. Remember that wiping only a small gap across an otherwise dirty leakage surface is enough to give a good megger reading. Such a small gap will fill with dirt much faster than if the entire leakage surface were properly cleaned.

Points to Watch

A machine has many leakage surfaces all of which are important to its proper operation. Let's look at some that you will usually be working with. One is the leakage surface from the machine terminals along the cables to the point where they are cleated. Another is from brush holder terminals along the cables or connection rings to the point where these are cleated to the frame.

The brush holder itself is insulated from the clamp or support that holds it to the machine frame, as detailed in Fig. 1. In this typical case it is done by an insulating tube over the brush holder stud. Note that the puncture thickness of this tube is small as compared with the long leakage distance from the clamp to the brush holder. A metal thimble is slipped over this tube to protect the clamped portion, and a porcelain sleeve is used to protect the exposed portion. Porcelain is used because it has a hard, smooth, easily cleaned surface. The space between the tube and the porcelain must be well sealed to keep moisture out. Sometimes, to get a tight fit, the tube is wrapped with a tape and then the porcelain is pushed over it. If this joint is not thoroughly filled with varnish or if the porcelain is broken, the tape will soak up water like a wick and form a leakage path on the surface of the insulating tube (Fig. 4).

The string band over the commutator cone protects the mica and prevents it from flaking off. Since this is a leakage surface, the string should be tight, be filled with varnish, and have a smooth surface finish. It the band is loose, dirt will collect under it. Then a leakage path will be formed, even though the outside surface looks good (Fig. 5).

Did you ever think of the side mica in a commutator as a leakage distance between segments? Fig. 1 shows it is, and that is why it is so much thicker than required for the puncture voltage. Keep this surface clean.

Don't forget the steel bands on the armature—especially at the commutator end. The current tried to leak along the path shown in Fig. 6, from the riser at one brush holder position across the armature surfect to the band, then through the band and back across the armature surface to the riser at the next brush holder position. If this happens, the short-circuit current can burn the band off (Fig. 7). This will wreck the armature so that it may slide the wheels. Another path to ground is from the commutator riser across the armature surface to the band, and from the band across the short distance to the core.

Not all leakage surfaces are on the armature. Field coils have leakage distance from the terminals across the insulation to the pole piece or the frame (Fig. 6). So it goes, from one part of the machine to another, and all these points are important to watch.

Forestalling Trouble

Leakage and puncture are the long and short of insulation. Don't get them mixed up. You will have a lot more to do with leakage than with puncture. Remember that no matter how thick and strong the insulation is, it fails if there is a leakage patch across it. A strong wall means nothing when you put a ladder against it. Any conducting material is all the ladder electricity needs. Keeping dirt off the job is a fine way to keep your machines on the job. If you think of what insulation is, and what it is supposed to do, you will be able to handle it intelligently. The result will be less work and trouble for you in the long run, and more service from the equipment on the road.