Overhauling the S-1200 Magneto

by Fred Mackerodt

NOTE: Back in December, we talked about how a magneto works and why it's designed the way it is (see "Understanding the Aircraft Magneto," Dec. '87). At that time, we promised a closer, hands-on look at the inner workings of the magneto. This article is a followup to our previous discussion. We encourage all owners to read it—even those who own something other than Bendix S-1200 magnetos.—Ed.

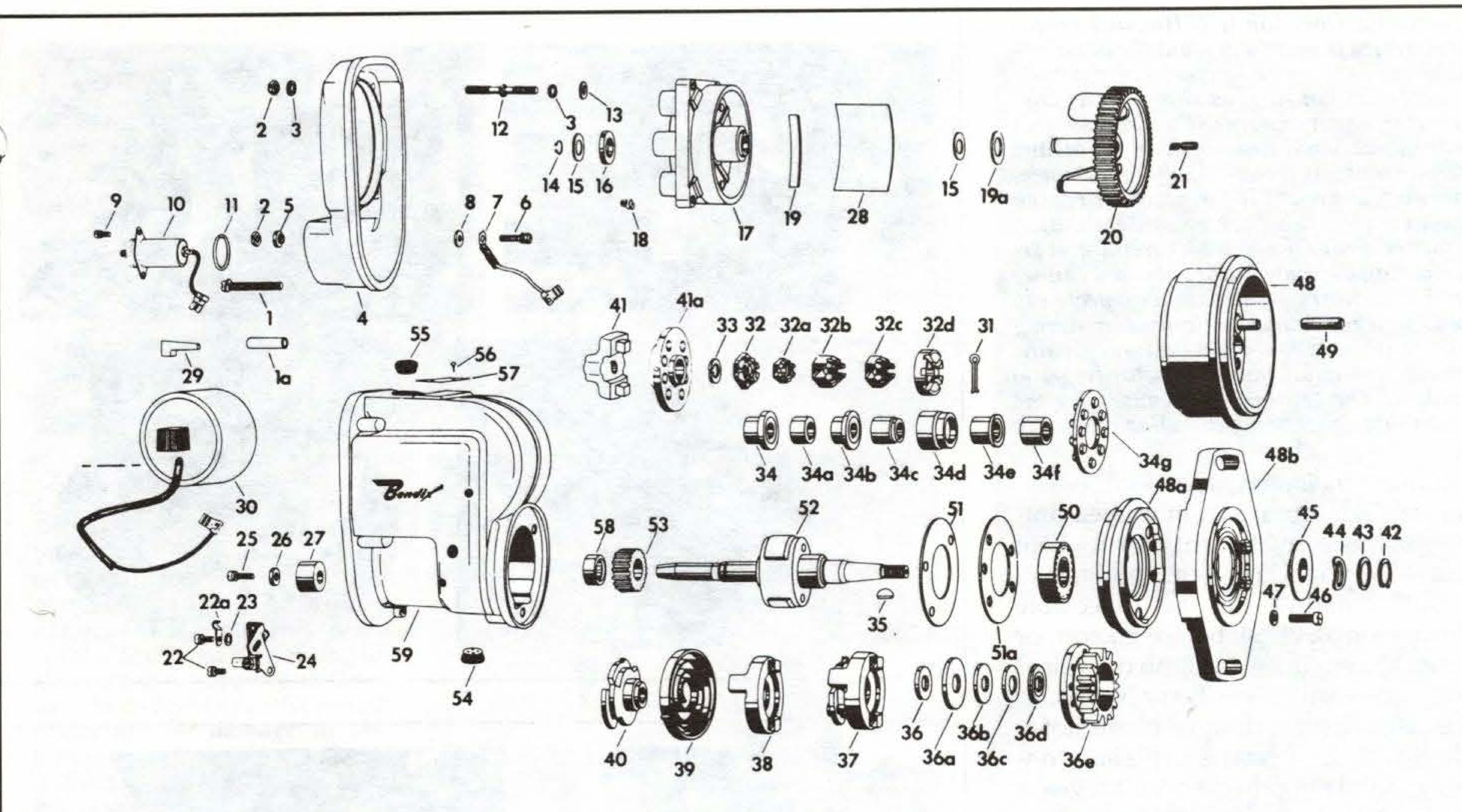
Aircraft Systems, Inc. occupies a neat hangar on the Greater Rockford Airport in Rockford, Illinois. The company specializes in rebuilding magnetos, alternators, generators, starters, fuel pumps, prop governors, and other accessories (even starter-generators for turbine aircraft). The firm is owned by Terry Norris and his two sons, Jerry and Terry, Jr. The elder Norris got his start in aviation in 1956 with Schneck Aviation, where he ran the famous engine shop's accessory-rebuild division. He also worked for Woodward Governor for several years before striking out on his own in 1970 with Aircraft Systems.

Most of Aircraft Systems' work comes from FBOs and engine overhaulers, but—as I found out recently—the company will also take on accessory rebuilds for aircraft owners. When I visited the firm last September, I brought with me a boxful of Bendix S-1200 magnetos out of a Turbo Aztec. All four needed 500-hour inspections.

An increasing number of the mags that Terry Norris sees, it turns out, come in for 500-hour inspections (i.e., routine look-sees) and not because they're giving trouble. While magnetos don't carry a formal TBO (recommended Time Between Overhauls), they do have published inspection intervals (500 hours for most models), which owners are generally ignorant of. Most pilots will only think of having their mags inspected under two circumstances: when it's Underwear Time at Altitude, or when the mag drop falls into the low four digits during pretakeoff runup. Otherwise, the "if it ain't broke don't fix it" system of maintenance prevails.

Unfortunately, while aircraft magnetos are marvelously simple and (for the most part) trouble-free devices—and seem to have the potential of going to the engine's TBO without much trouble—the experts we checked at Continental, Lycoming, Bendix, and Slick concur on a figure of 500 hours as the maximum time between IRANs (inspect and replace as necessary). This is especially true for pressurized mags and mags on turbocharged engines. (The former are subjected to more heat flow than most, and the latter have critical duty-cycle demands in that high-altitude flying brings with it a risk of ionization and crossfire.) In some cases, the 500-hour inspection is mandated by A.D. to check impulse couplings.

In any case, a 500-hour inspection is a good idea (for *any* kind of mag) not only to reaffirm the mechanical integrity of moving parts (rotor, distributor electrode, gearing, impulse couplings, cams, points, cam follower) but also to check for cracks in housings and coils, clean up dirt and grease, and in general assure that everything is as it should be. It's also an opportunity to make electrical checks of the capacitor (condensor) and coils, perform any updates that need to be performed (in accordance with service bulletins), replace worn bearings, oil the cam follower, and—of course—set the internal timing (adjust E-gap). *[If any of this terminology sounds unfamiliar to*



1.	Screw w/ lock washer	16.	Washer	30.	Coil	44.	Washer
1a.	Tubing	17.	Block	31.	Pin	45.	Slinger
2.	Nut	18.	Spring	32.	Nut	46.	Screw
3.	Washer	19.	Strip	33.	Washer	47.	Washer
4.	Cover	19a.	Washer	34.	Bushing	48.	Flange
5.	Bushing	20.	Gear Assy.	34g.	Grommet	49.	Stop Pin
6.	Screw	21.	Brush	35.	Key	50.	Bearing
7.	Lead	22.	Screw	36.	Washer	51.	Plate
8.	Washer	22a.	Clip	36e.	Gear	52.	Magnet
9.	Screw	23.	Washer	37.	Impulse Coupling	53.	Gear
10.	Capacitor	24.	Contact Assy.	38.	Body	54.	Ventilator
11.	Packing	25.	Screw	39.	Spring	55.	Plug
12.	Stud	26.	Washer	40.	Cam Assy.	56.	Screw
13.	Washer	27.	Cam	41.	Plate	57.	Plate
14.	Ring	28.	Strip	42.	Ring	58.	Bearing
15.	Washer	29.	Wedge	43.	Washer	59.	Housing

EXPLODED VIEW OF THE BENDIX S-1200 MAGNETO

you, be sure to read "Understanding the Aircraft Magneto," LPM, December '87.—Ed.]

Needless to say, these checks are not considered pilot-performable "preventive maintenance" under FAR Part 43; but they *are* worth taking a personal interest in. After all, this is your *ignition system* we're talking about.

Sources of Misfiring

Offhand, you might not think magnetos would get very dirty inside, being as well encapsulated as they are. But mags *do* suffer from contamination, both from moisture and other atmospheric glop, *and* from oil. *[The atmosphere inside the magneto is also high in ozone and other ionization products, which is why they must be vented.—Ed.]* Oil mist inside the mag comes from moving parts which have to be lubricated—and from the engine itself, if crankcase pressure is high (due to, for example, broken rings)—and this mist gets "fried" by the spark jumping across the distributor electrodes, turning into carbon dust in the process. Now as you know (if you've ever looked at what commutator brushes in motors and generators are made of), carbon is a fine conductor of electricity. A problem arises if a coating of carbon dust is allowed to build up on components like the distributor block, since such a coating could easily provide a different, more favorable route for current to follow rather than its appointed one. Air tends to insulate electrode fingers from distributor towers, and at altitude, where atmospheric pressure is low, crossfiring can happen as electricity seeks a path of lesser resistance across the block. The crossfir-

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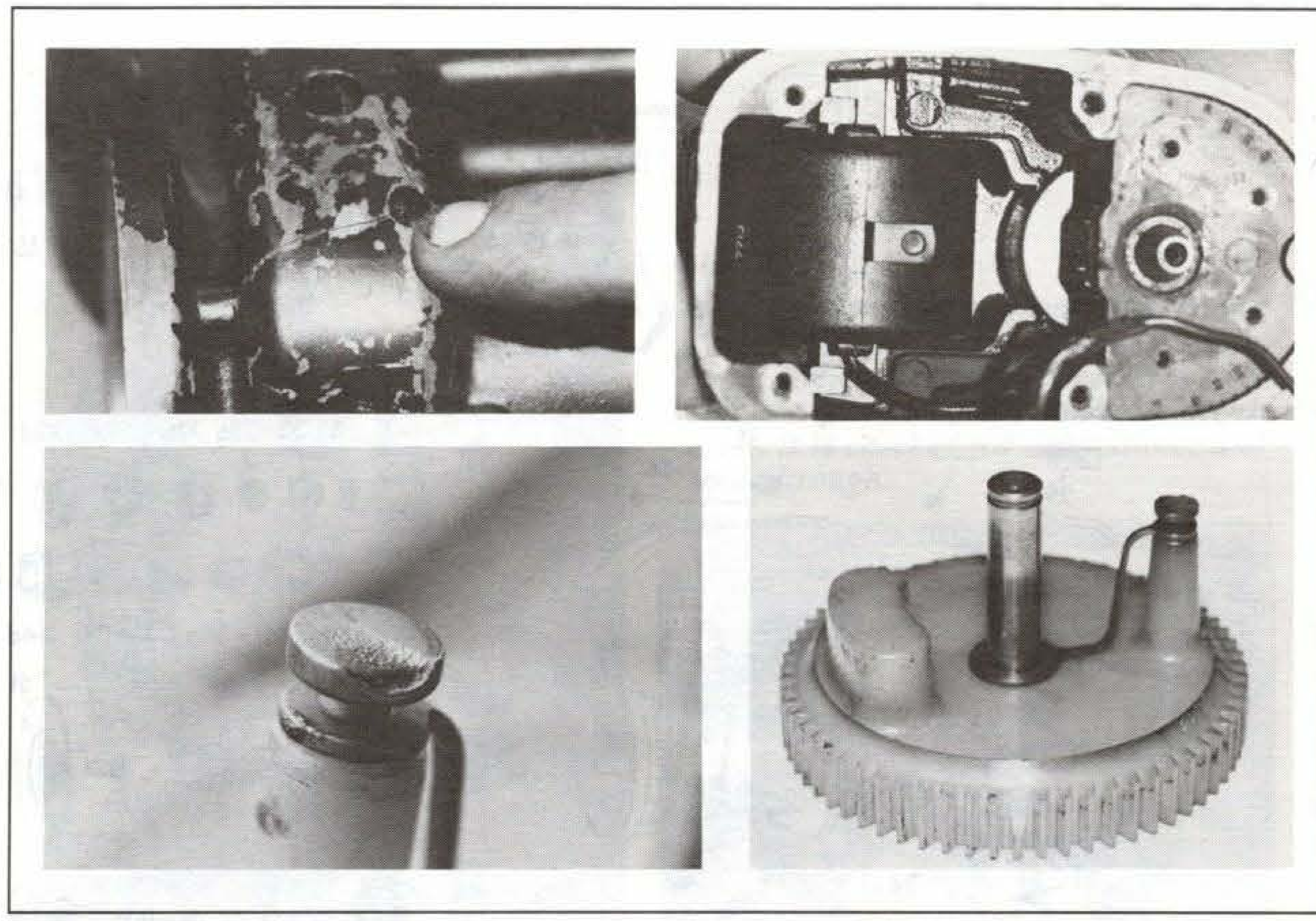

Clockwise from top left: Housing cracks are a rarity in most mags, but the Bendix S-1200 series is prone to cracks of the cast-magnesium housing, as shown here. Distributor end removed, it's obvious this mag has accumulated considerable oil and carbon dust inside. (A 500-hour housecleaning is needed if for no other reason than to keep this sort of contamination under control.) If you look carefully at six o'clock on the distributor gear, you can see that a tooth is gone; this was probably caused when a mechanic used a timing lock to install the mag. In the final picture, severe erosion of the distributor finger is evident. The erosion was caused by the distributor gear being installed one tooth off.

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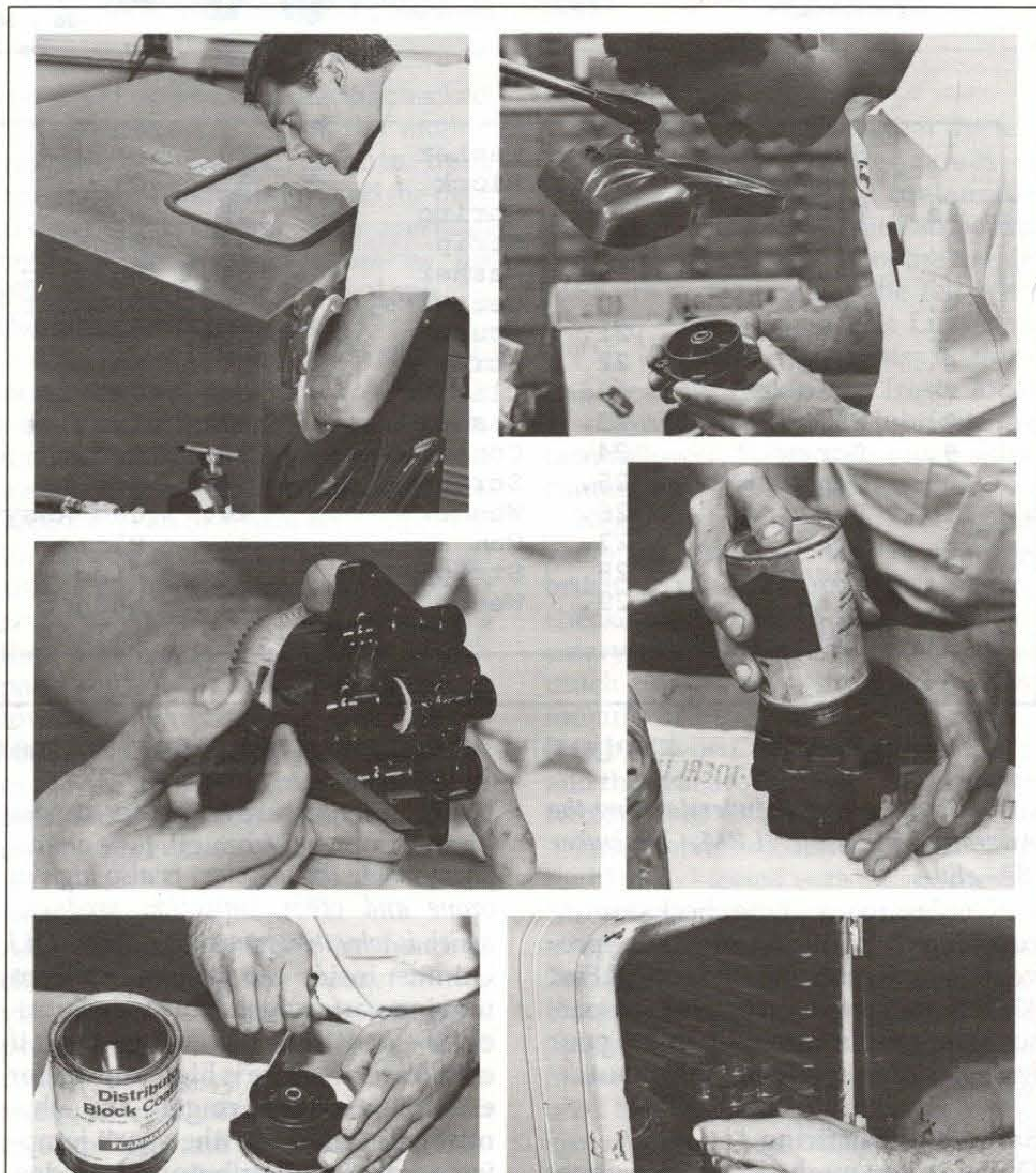
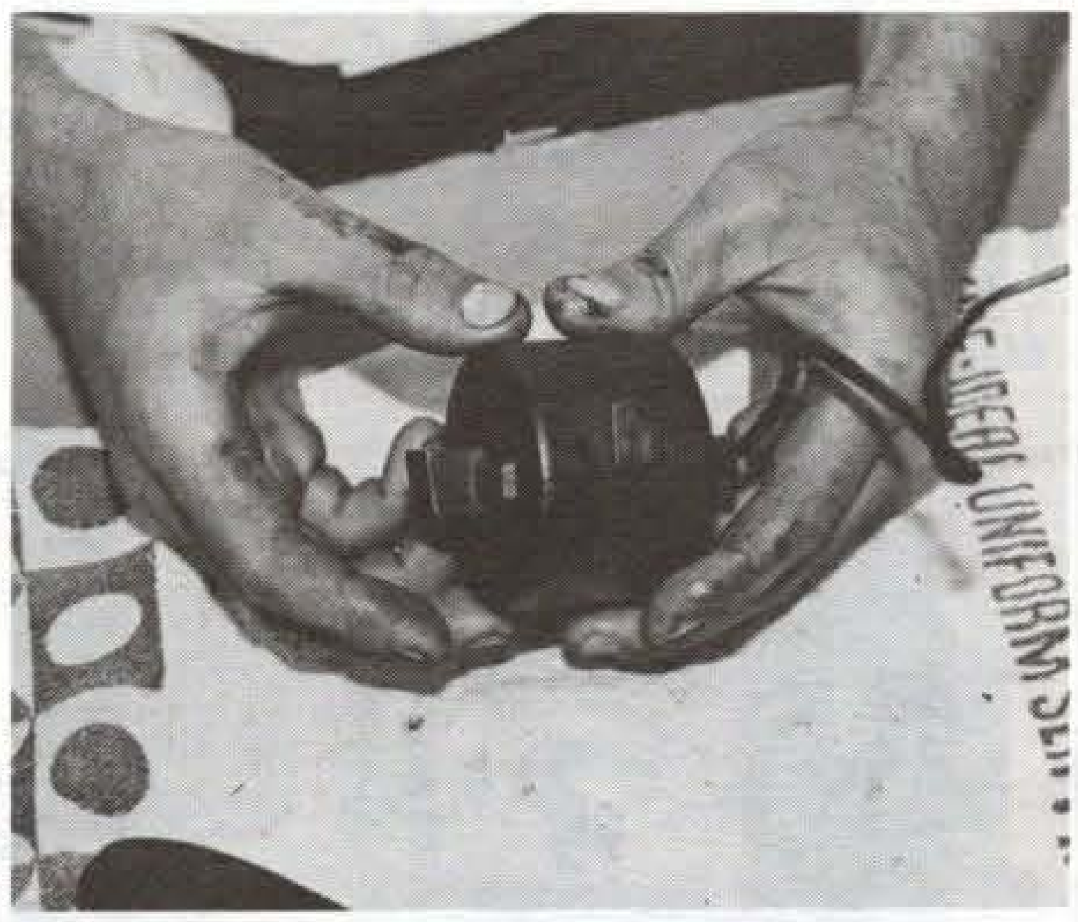
ing, in turn, can result in unpleasantness in the form of burnt pistons, bent con rods, blown jugs—things like that.

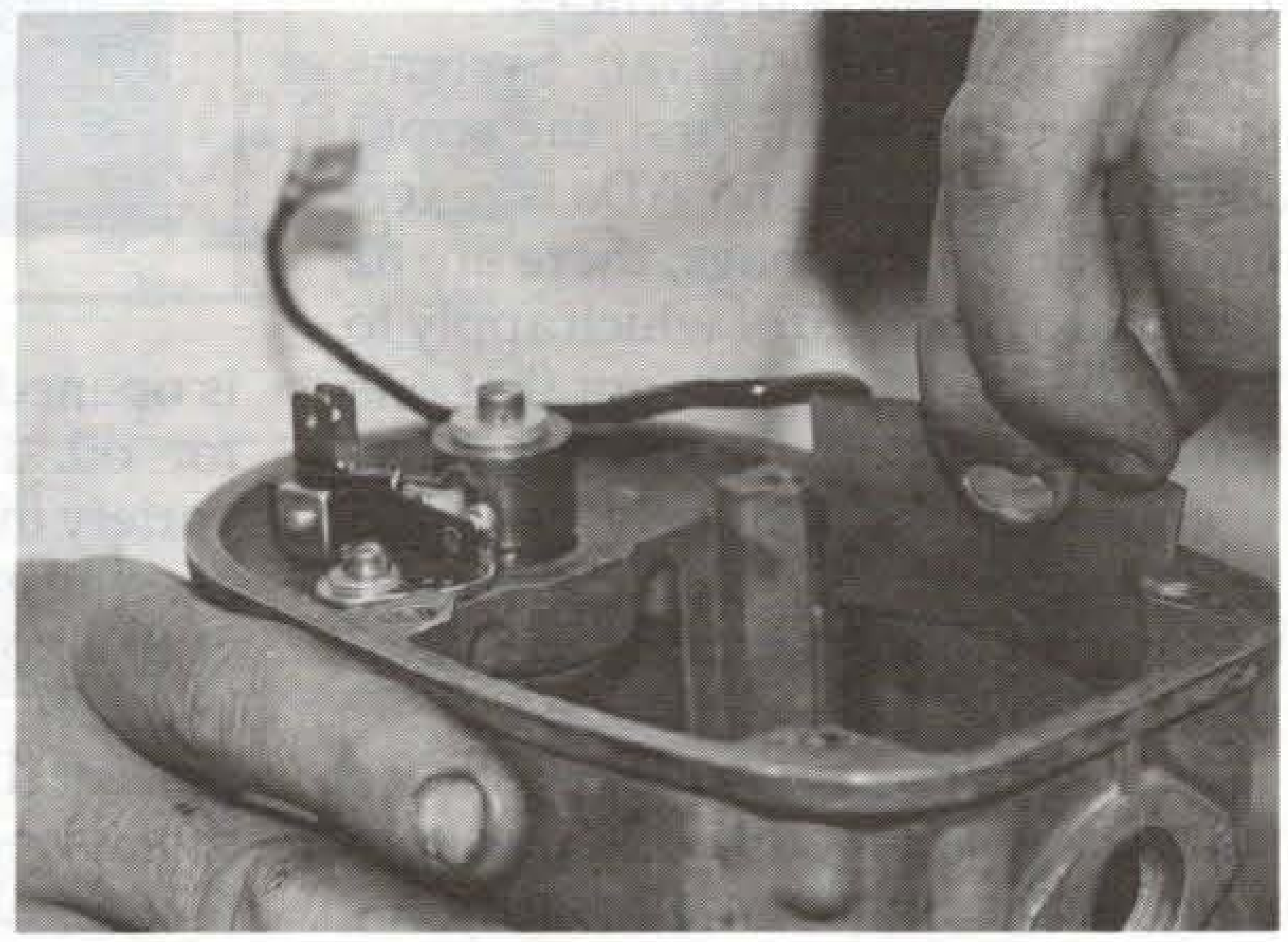
But wouldn't this be detectable during a mag check before takeoff, or when the engine is in climb or cruise? Not necessarily, says Terry Norris. In the case of a turbocharged plane, not at all. "At times," Norris explains, "on-the-ground mag checks won't reveal a problem that's waiting to show up at altitude—sometimes altitudes as low as 5,000 feet. You're climbing along, and then *pow*, it shows up." (On planes with constant-speed props, it's impossible to check the mags for an rpm drop in cruise, due to the governing action of the governor.)

Unless the pilot is completely in tune with his or her airplane, some cases of out-and-out misfiring will go unnoticed even when it happens, even in high-speed cruise. "Engine mounts in today's aircraft tune out vibrations so well," Norris remarks, "misfiring that can lead to detonation is pretty much undetectable." Norris refers to this kind of misfiring as a subtle "thump-thump-thump." The end result can be a condition called (half-seriously) "holy pistons," which in the least will be a truly religious experi-



Clockwise from top left: Terry Norris subjects a distributor block to plastic-media blast-cleaning. Care must be taken not to damage the block (newer brown-colored blocks cannot be blast-cleaned). After cleaning, the block is checked carefully for cracks. Then one end is corked and the center cavity filled with special distributor-block lube, and the unit baked in an oven to get the oil to soak into the oilite bushing. Finally, the block gets a coat of special distrbutor sealant (which will insulate the block and cause moisture to bead up rather than wet the surface). If it needs it, the distributor gear timing marks are then repainted on.

Clockwise from top left: In the S-1200, the coil is held in place by wedges. To remove the coil without damaging it or the magnesium housing, heat (from a torch) is applied very judiciously to expand the housing so the coil can be popped out. Once out, the coil gets a careful visual inspection for damage to the wires and/or cracking of the potting compound. Then checks are made of the primary and secondary coil resistances. (The primary and secondary coils are potted as a unit. So even though we speak of "a coil," we're really talking about two coils.) Fish paper is used to keep coil wires from chafing; and a hammer and drift are used to wedge the coil back into place in its housing.

ence and at the worst will put you in direct communication with your Maker.

"Once a pilot has seen a piston with a big hole in the middle caused by detonation," says Norris, "he becomes an instant convert to 500-hour inspections."

In a turbocharged aircraft at high altitude, everything has to be up to snuff because of the fact that air (which is insulating) is only half as dense at 18,000 feet as at sea level. Depending on how badly a magneto is contaminated, the misfiring point can occur anywhere between 5,000 feet and the airplane's ceiling (or higher). Big mags like the Bendix S-1200 are less apt to misfire at altitude, simply because the distance between distributor towers is greater than in a smaller mag. The spark is thus more apt to go to the correct tower.

In some high-altitude aircraft, the tactic of pressurizing the mags is used (to make up for the lost dielectric of the thinner air), but these come with their own problems, says Norris—problems having to do with heat (it's the turbo compressor that supplies the air) and forced introduction of intake-system contaminants. Inline filters take care of most such contaminants, but heat is impossible to filter completely. Norris showed us a couple of examples of where some magneto components actually melted from heat. "A lot of mags used in high-altitude operations weren't designed for that kind of duty," says Norris. All the more reason to do a 500-hour inspection.

Repairs As Needed

One of my pet peeves is the "exchange" scam perpetrated by the aircraft industry. If a component gives trouble, the FBO—rather than simply fix it—will exchange the item out (for an overhauled unit) in kneejerk fashion, ensuring that the customer pays the most possible money for the job, since exchange prices are based on a "worst case" scenario. The overhauler expects to get a bad core in return, so he factors that in. Send him a unit that needs a complete rebuild, and he makes a fair margin. Send him a unit that needs little or nothing, and he makes a killing.

Aircraft Systems' Terry Norris doesn't work that way; he's from the "only fix what needs it" school of aviation mechanics. If a component needs reconditioning or repair, it gets it. If it doesn't, it doesn't. The customer, in turn, pays only for work that was necessary.

The four mags I brought with me to Aircraft Systems Inc. had varied histories. They weren't (properly speaking) good subjects for a typical 500-hour check, because they all had much more time on them than that. Three of the mags originally belonged to a Turbo Aztec that went off the end of a runway at Buffalo; I bought the en-

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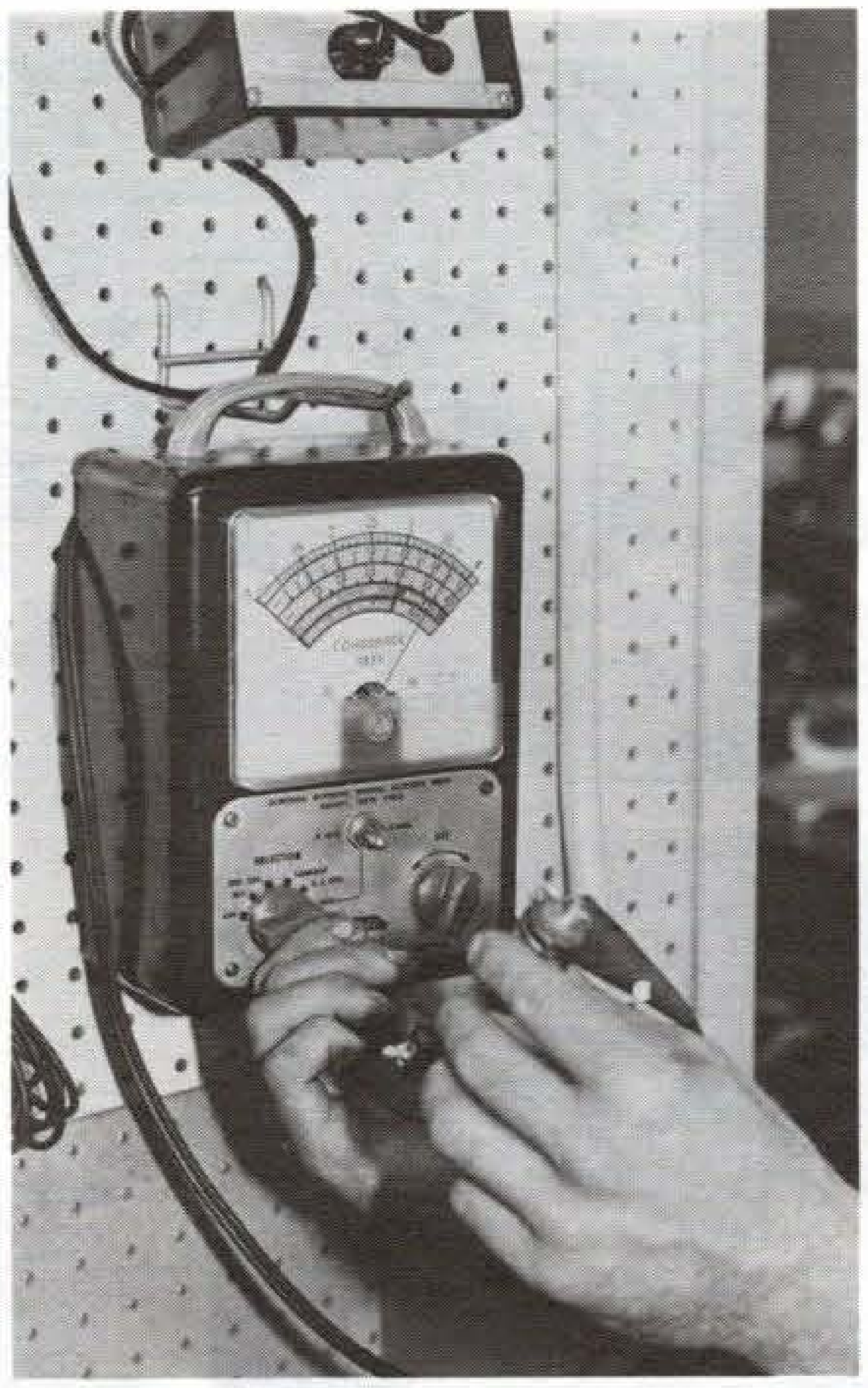
gines off this plane as spares for my own Turbo Aztec, which is now reaching 1,400 hours on the second go-around of its Lycoming TIO-540-C1A powerplants. Two of the mags I brought to ASI were off the right engine of the Buffalo plane, which had 1,780 first-run hours. The log on this engine indicated that no particular attention was paid to the magnetos beyond routine on-condition maintenance. The third mag came from the left engine of the Buffalo Aztec, which had only 160 hours since Van Dusen major. This mag had been completely rebuilt at overhaul. The fourth mag was from my own T-Aztec. It had begun showing 300-rpm drops on runup after 1,300 hours SMOH.

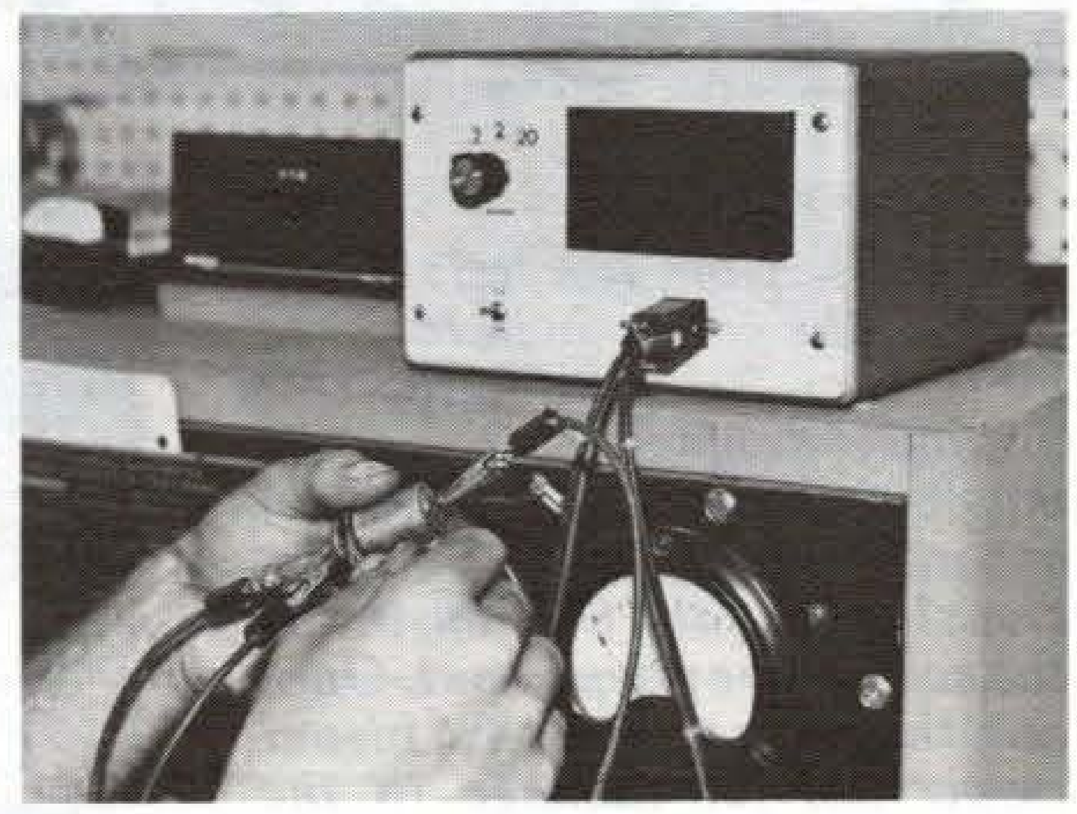
Here's how the Aircraft Systems mag inspection went: First, the applicability of bulletins and ADs is determined. For Bendix mags, there are 62 bulletins to check, 20 of which apply to the S-1200. Norris points out that one should never assume that just because the equipment is relatively new and the AD is relatively old. He tells of checking a brand-new mag and finding a five-year-old AD undone.

The next step is a quick check for major, obvious problems like cracks in the housings, which are a rarity for most magnetos. It turns out that the Bendix S-1200 series mags wind up with cracks in their magnesium housings 25% of the time, according to Norris. Luckily, all four housings I supplied were free of cracks. (Not all cracks mean junking the housing; Bendix Service Bulletin No. 533A, in fact, details with photos just which cracks are okay and which are not.)

If cracks are found, Norris stops the inspection right there, because at the price Teledyne charges for a new housing, the customer is better off sending the mag back to the manufacturer as a trade-in on a rebuilt unit. This is ASI's standard policy. If it ever becomes evident, at any stage of the inspection, that the cost of parts will exceed the price of a rebuilt ($371 in the S-1200's case), Aircraft Systems will button up the mag, charge the customr $20 for the inspection and handling, and suggest you buy a rebuilt. (If you buy one through them, the $20 is credited towards your purchase.)

When no cracks are found, the mag is opened up and the interior checked for oil. Excessive oil of the engine variety means that the seal on the front bearing isn't doing its job, and the mag at this point is in for a major overhaul because the bearings must be replaced. (If oil is of the residual variety, the inspection continues.)





Left: Condensors (or capacitors) can be reused if they meet electrical specs. Here, the condensor is checked for series resistance and leakage. Right: Here, it is checked for capacitance and feed-through.

It's really at this point that the decision is reached whether to overhaul or not. Aircraft Systems has two prices for labor: $57 for a routine 500-hour inspection, and $102 for an overhaul. That's it. If an overhaul *isn't* indicated (i.e., bearings don't need replacing) and no parts are needed, the entire job will cost you $57 for labor, and that's that. On average, an overhaul with parts will go $150 to $350 (tending toward the low side for most magnetos; the biggest Bendix models are the ones with the most expensive parts). A 500-hour inspection runs about $100, on average, with parts.

Internals

After turning the shaft by hand to check for binding, the breaker cam is visually checked for wear; then the points are removed and checked for condition. If they're fairly new, the technician will simply check them on an ohmmeter and reinstall them. Otherwise, if they've gone 500 hours or more, Norris recommends they be replaced 100%. (In the case of an overhaul, the rules say the points *must* be replaced.)

Terry Norris maintains that the felt lubricator on the breaker points is often the source of point contamination. That's why he washes all points (even new ones, fresh out of the bag) in MEK, then relubricates the felt with Bendix/TCM Breaker Felt Lubricant (P/N 10-86527) and blots it thoroughly until it takes ona frosty look. That leaves enough oil to lubricate the cam follower, but not so much as to contaminate the points.

Next, the distributor block and gears are removed, and the carbon brush at the bottom of the gear is checked for wear and replaced if necessary. Terry can pretty well tell how much time is on a magneto just by looking at how much of the carbon brush is worn away. Both the block and the gear are thoroughly cleaned in two types of solvent.

After solvent cleaning, the distributor block is blasted with plastic media, carefully controlling the pressure so as not to allow the block to be damaged. This is done to completely clean the block so as to reveal even the smallest crack. (Norris cautions others not to attempt to clean the new brown-colored blocks under pressure, as it will erode them.) After this, the block is washed again in solvent and carefully examined under a 10X magnifying glass, after which it gets placed in an oven (briefly) to evaporate off any solvents.

Since cleaning removes all lubricant from the oilite bushing in the center of the block, it's necessary to relube this portion. The bottom end of the block is simply sealed with a small cork while Bendix/TCM Distributor Block Lubricant (P/N 10-391200) is carefully poured into the top to fill the cavity; then the distributor block is placed back in the oven and baked at 190 to 210 degrees Fahrenheit for two hours (which helps the lubricant flow into the pores of the oilite bushing).

With the lubrication done, the block is then coated with a special Bendix/TCM Distributor Block Coating (P/N 10-391400) and allowed to air-dry. This shiny coating makes any water that contacts the surface "bead up" as on a freshly waxed car. It prevents the water from sheeting and the spark from following that continuous sheet of liquid to a point where it's not supposed to be. The key to lubing and coating the block is to make sure the oilite bushing oil doesn't get on the block, and the block coating doesn't get on the oilite bushing.

Electrical Checks

At this point, the shaft is spun and the magnet checked for strength. (Believe it or not, magnets are found with low field strength from time to time.) If needed, the rotor can be remagnetized with a P/N 11-1362 Magnet Charger (Bendix-Scintilla) or a Weidenhoff Model D-818.

Next, the coil is removed (see photos for explanation) and it and the capacitor are checked electrically—the coil for primary and secondary resistances (1.0 to 1.5 ohms for primary; 17-23,000 ohms for secondary), and the capacitor for series resistance, leakage, and capacitance (0.30 to 0.45 mfd).

If need be, the bearings are replaced at this point and then all components reassembled in the repainted housing. (Separate inspection procedures apply to impulse couplings; that's a whole article in itself.)

After the points are adjusted and internal timing is set at the proper E-gap (15 degrees plus or minus two, for 4- and 6-cylinder S-1200s), the mag is mounted on a test stand and its sparking performance checked. The test stand gap (in lieu of a spark plug) is set fairly wide to simulate operation at 25,000 feet. Spark output is checked at up to 5,000 rpm, but special attention is given to how the mag functions at 300-400 rpm also. According to Terry, "Low-speed operation is toughest on mags."

Post-Mortem

How did my mags work out? The one that gave up the ghost while on my Aztec was a basket case. It was in pieces. The post-mortem revealed that one tooth had broken off the distributor gear. Terry surmised that this must've happened when a mechanic attempted to hold the internal timing with a "mag lock" while installing the mag on the engine. (Norris advises against using mag locks.)

In addition to this, the drive end flange was worn from the bearing race spinning in it. The bottom line for this mag: $219.62 (including a used replacement flange), for both parts and labor.

The mag off the 160-hour Van Dusen engine was a surprise: We'd expected it to be in top condition, given its low time, but there was a lot of internal corrosion. Apparently, the mag had been in water at one time—perhaps from the ditch the Aztec went into at Buffalo. Both main and retard contact point assemblies had to be replaced (at $26.54 for one and $30.36 for the other) plus the bearings, and

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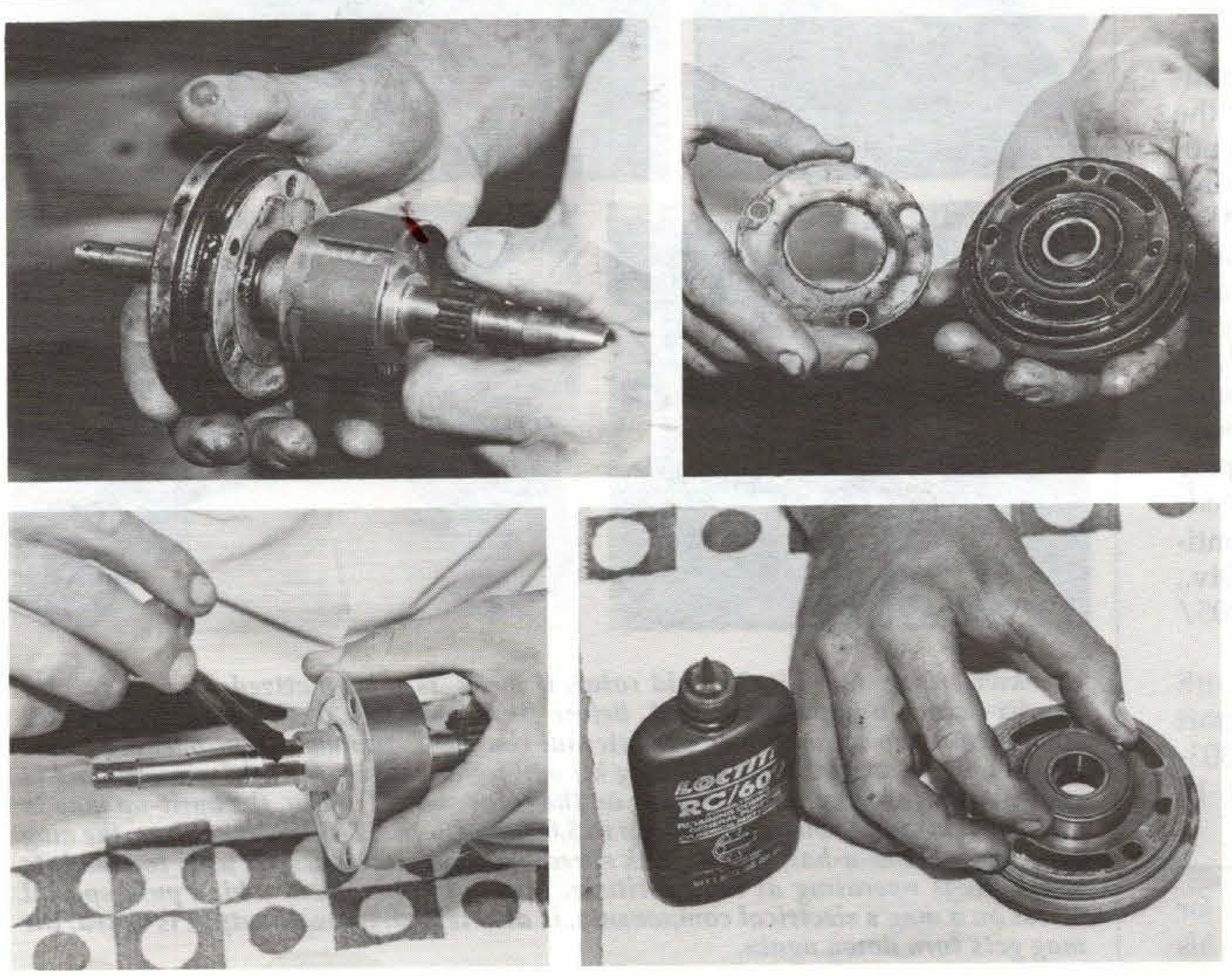

Clockwise from top left: The front bearing on this magneto was definitely passing oil. To get at the bearing, a spacer is removed, the old bearing is pressed out, and the new one is pressed in (using Loctite RC609 to keep the outer race from spinning). A little Loctite is also used on the rotor shaft, to keep the inner race of the new bearing from spinning.

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miscellaneous small parts. Overhaul cost: $182.26.

We didn't know what to expect when it came to the mags off the runout right engine of the Buffalo Aztec. We quickly found out. The first mag was in pretty bad shape; it had originally been set up improperly, the distributor gearing meshed one tooth off. This eroded the finger on the gear, but the resulting arcing also ate holes in the distributor block tower. Replacing the gear ($38.22), block ($61.94), main points ($26.54), retard points ($30.36), and miscellaneous small parts brought the overhaul cost to $278.22.

The second runout mag from the Buffalo plane's right engine was surprising for what it *didn't* require. Because of the number of hours on it, it was overhauled, but most of the components were serviceable, so the final bill was quite reasonable at $154.94.

My bottom line? I'm going to get these four mags on my Turbo Aztec as soon as possible and get the ones on there off. And I'm definitely going back to Aircraft Systems every 500 hours for a mag check.

For More Information

Obviously, the information in this article is for educational purposes only and shouldn't be considered the final authority on Bendix S-1200 (or any other) magnetos. Teledyne Continental (which now manufactures the Bendix line of ignition products) publishes an Installation/Operation/Maintenance manual for the S-1200 as well as an Overhaul Manual (and also a Parts Catalog); each is $5.00, and each is the FAA-accepted authority on maintenance of these mags. *[The Ignition Systems Master Service Manual containing all Bendix bulletins, overhaul manuals, etc., is $85. Add $10 shipping within the U.S. or $50 shipping outside the U.S.—Ed.]* Write: Teledyne Continental Motors' Aircraft Products Div., P.O. Box 90, Mobile, AL 36601 (205/438-3411).

Anyone wishing to get in touch with Terry Norris should contact Aircraft Systems Inc. (FAA Repair Station 303-17) at 5187 Falcon Rd., Rockford, IL 61109 (phone 815/399-0225).

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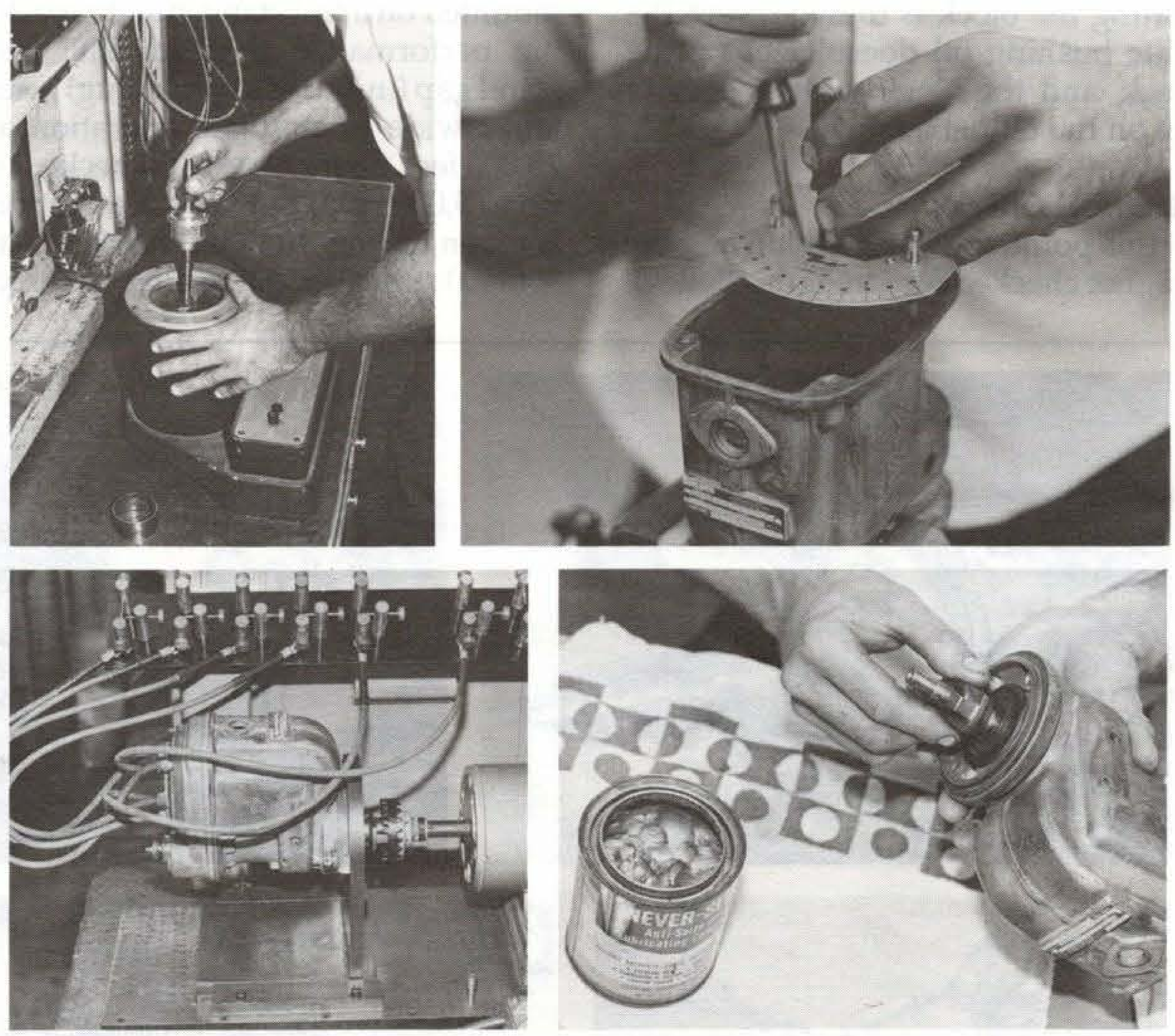
What's in a Name?

Magnetos for aircraft come in two brands: Bendix (*nee* Scintilla) and Slick (formerly J.I. Case Tractor Company Magneto Division). Bendix's product line is the oldest (Scintilla mags were used on the Wright Cyclone, circa 1930) and some would say the best-trusted. (Slick Electro's aircraft mags didn't come on the scene until the late 1950s, and many mechanics still see Slick as "the new kid on the block.") Bendix's magneto business was bought out by Teledyne Continental approximately 18 months ago. Slick is now owned by Unison Industries.

Bendix mags in current production include S-20, S-200, S-1200, D-2000, and D-3000 series models. The S-20 and S-200 series are compact, lightweight units which differ in that the S-20 mags utilize impulse coupling drives, while the S-200 mags employ "shower of sparks" circuitry for starting. The heavy-duty S-1200 (notable for its large, bulbous coil housing) is physically larger than the S-20/200 and is found mostly on higher-performance aircraft. The D-2000/3000 is the so-called "dual mag," wherein two coils, two sets of breaker points, and two distributors are operated by one cam and one four-pole magnet driven by one shaft. Some D-2000/3000 mags are pressurized (and painted dark blue); others are unpressurized (light blue). Only Lycoming engines that have a 'D' in the last digit of the model designator use the "dual mag": e.g., O-320-H2AD, IO-360-A3B6D, TIO-540-J2BD, etc. (No Continental uses this type of mag.)



Clockwise from top left: The old rotor, if weak, is remagnetized using a special Bendix-Scintilla apparatus. Next, before final assembly of the mag, the breaker compartment is set up for proper internal timing (E-gap and point opening tolerances) using a special Bendix timing kit and feeler gauges. Anti-seize compound is used when installing the drive gear on the rotor shaft. Finally, the built-up mag is put on a test stand, where it is run up to 5,000 rpm. (On six-cylinder engines, the mag turns at one-and-a-half times crank speed.) Special electrodes are used to simulate spark plugs operating at high altitude. Low-rpm operation, which puts special stress on a mag's electrical components, is also tested. If weak output is noted, the mag gets torn down again.