Soldering: a Pilot's Primer

by Ed Maher

The aviation industry requires rigid standards for those that assemble avionics and electrical harnesses. If you're flying at 20,000 feet and a solder joint fails, you can't just pull off to the side, park and get out. The correlation isn't quite the same, but the inconvenience and potential failures that develop due to high resistance solder connections can be prevented if you know some of the inside tricks used by the aviation industry.

Two basic types of soldering are used in aviation: one is lead-alloy soldering; the second is silver soldering. Both are used in wiring termination and mechanical connections. Silver is predominantly used on terminations that will endure a higher stress or heat environment, while lead is used for electrical and electronic assemblies. In electronic/electric applications, because the quality and security of the completed joint in each application depends so much on the skill of the operator, considerable practice is needed to develop physical motor/eye coordination skills before attempting to work on sensitive circuitry. GAMA companies require new employees to attend a week or more of schooling before doing any actual gun work.

"Gun work" is actually misleading, since for most jobs, you'll use an *iron*, not a gun. Lead-alloy soldering of delicate assemblies requires a good deal of skill and the correct wattage soldering iron—more so than welding or silver brazing, as very small quanities of solder are used in the average electrical contact and any excess heat can easily damage the very job you're trying to repair.

Remember, the following information is dependent on your personal initiative to actively develop the skills necessary to perform any soldering repairs.

The Basics

There are three very basic steps to effective, quality soldering:

1. Select an iron of ample wattage to perform the work, but not rated so high as to cause damage to the contacts or the surrounding connector. (But also, not so low as to inhibit adequate solder flow into the contact or the strands.)

2. *Clean* and *pre-tin* the iron's tip with solder, wiping excess off on a damp organic sponge.

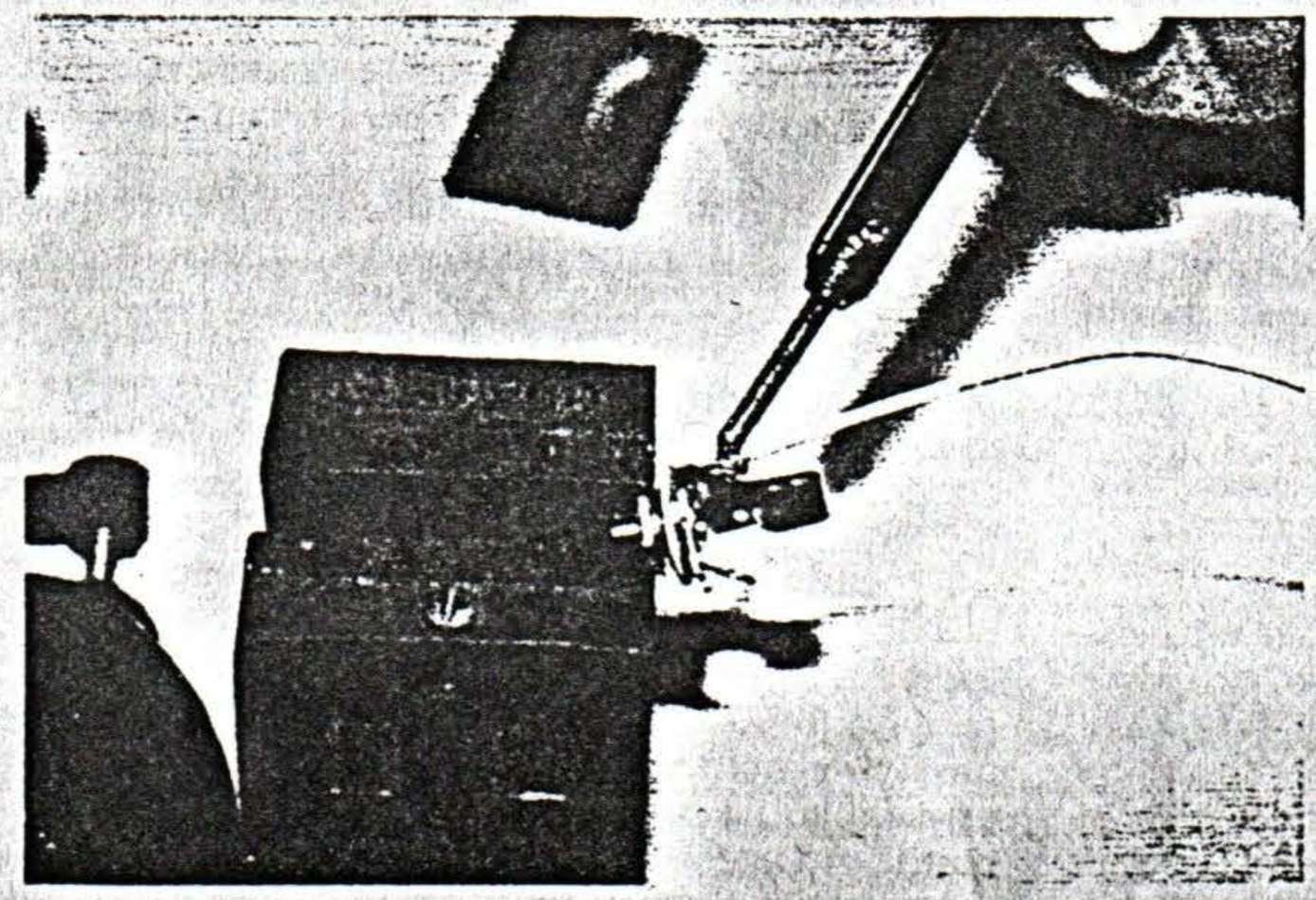
3. The work—connector pins/sockets, etc.—must itself be clean and pre-tinned.

Most repairs or assemblies require only a 30-watt, silver-plated tip, and a 30-watt iron; however, larger contacts—eighteen gauge and above—will require you to use a higher wattage, say 60 watts. I don't recommend the use of trigger activated "gun" unless you have plenty of working room and the tip is appropriately designed for the job. It's difficult to maneuver in high-density connectors and the heat from a gun is usually well over 100 watts, which could possibly result in connector, contact, or wire damage. For most other aggressive applications, a handheld, 90° handle grip, permanent-on, 60-watt iron will do nicely, and it will be easier to maneuver when it's necessary to manipulate tiny pieces in restrictive spaces (or just sitting down at a work bench). DC-operated irons that'll work well on electrical and radio repairs are available from several sources, but the 12 V.D.C. unit can be purchased from Radio Shack.

The hand tools listed below are needed to terminate conductors, strip off insulation, hold the wire during soldering and form any hooks or bends:

1. Aviation style strippers.

2. Heavy duty



Having a vise for a kind of third hand is essential, although well-positioned clamps will often suffice. Start with clean materials, and be sure to pre-tin the termination.

and diagonal electronic cutting pliers ("dikes").

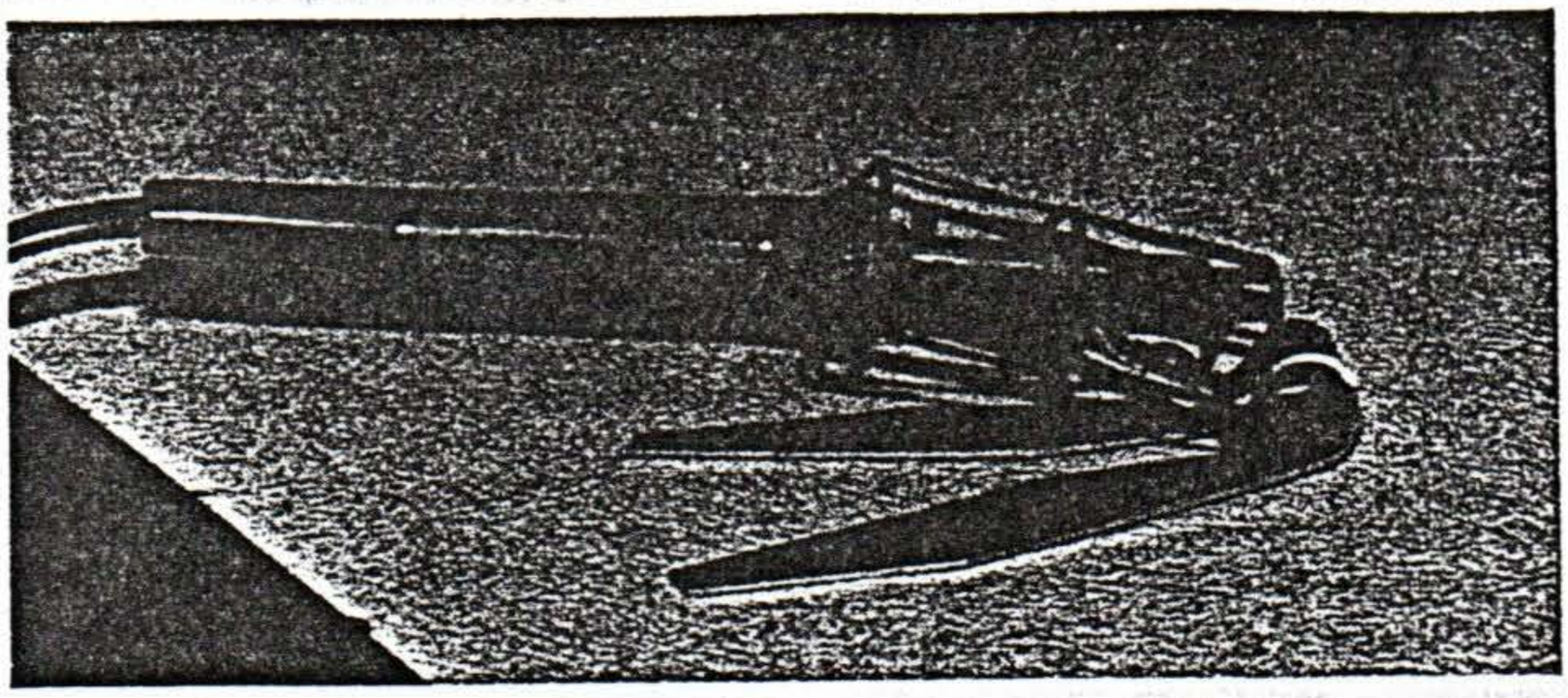
3. Electronics-type needle nose pliers (3-1/2").

4. Solder vise or clamp to support work during assembly.

5. Round-nose pliers (3-1/2").

6. 30- and 60-watt soldering irons.

As for the solder itself: 60/40, mildly activated should be used for all electronic and electrical work, as the more highly activated (MA) types may corrode connections and cause future failures. There are different diameters of solder and fluxes, depending on the work being performed: select the diameter and specifications according to your individual requirements.



Most jobs call for a light iron, not a gun. The type shown here can be bought relatively inexpensively through local sources. Note protective cage.

Practice First

Considerable practice should be done before attempting to solder any aircraft related electrical or electronic connectors. For practice, some miscellaneous parts can be cannibalized from discarded connectors or simulated with the use of solderless terminals. Radio Shack is also a good source for miscellaneous terminals, connector, pins and sockets that can be used for practice.

Conveniently place all of your tools out on your work space, and be sure everything you need is ready. The contact or terminal should be secured in the rubber-protected jaws of the vise to allow easy access during conductor insertion and heat application.

The insulation must be removed from the end of the wire before any soldering begins (the amount varies depending on diameter of connection or depth of contact). The lay of the wire (strands) must be maintained to allow proper insertion into the solder cup, especially when more than two wires will occupy the same terminal/contact. Appearance should be uniform with parallel strands of wire from the insulation to the removed end of the conductor. If, after stripping, with the correct strip die, you find that the individual strands of the conductor have been damaged by nicking from the stripper blades, you must refrain from further use of the strippers until the tool has been repaired or adjusted. If the damaged strands aren't discovered at assembly, they can cause the wire to break at a later date.

When the tip of the soldering iron has reached a temperature that will melt the solder, apply the end of a piece of solder to the tip and rub in a small circular pattern. This is known as tinning and should transfer a small quantity of solder to the working tip, which will prevent oxidation, during the soldering operation. Another method involves wrapping a small quantity of solder around the tip before it heats up. As the tip reaches approximately 700° F, the solder will melt, flowing around the prepared surface. This procedure should be repeated throughout any extended job. If the tip is excessively corroded from previous use or the silver plating has eroded, leaving only the corroded copper, a smooth file should be used to "dress" the tip to a pyramid, tapered, or conical shape, depending on the work to be performed.

When the soldering iron's tip is making as much surface contact as possible, the heat enters the contact, followed by an immediate flow of solder. Failure to properly apply the tip to the work can result in excessive heat reaching the surrounding connector body, causing damage, before the solder flows. Additionally, when the solder does start to flow, it might wick clear through to the opposite side. If a problem arises in obtaining good heat flow, try moving the tip in a small pivotal rocking motion against the terminal, until solder flows freely.

Capillary action is the medium through which liquid solder flows while joining two metals (similiar or dissimiliar); it's critical that the surfaces be thoroughly cleaned of burrs and contamination to allow total distribution of solder to all desired surfaces. This can be accomplished with a liquid or abrasive removal, depending of the application. Liquid solvents do work better in may applications—for example on hook terminals—while abrasive (braided shield stock—Radio Shack) works well to remove corrosion from resistors, diodes, capacitors, etc., prior to installation. Because the insulation on a wire serves to protect, to some degree, the conductor from aggressive corrosion, it isn't always necessary to clean the conductor, other than using the rosin or flux in the solder to perform that function as the solder flows in and around the connection.

Wicking

The inherent strength of a soldered joint is obtained from the wetting action that occurs when the filler metal melts and flows throughout the joint area. The molten liquid metal dissolves and reacts chemically with the surface layers of the base metals, forming a thin layer called the *joint interface*. To enhance this

(Continued on next page)

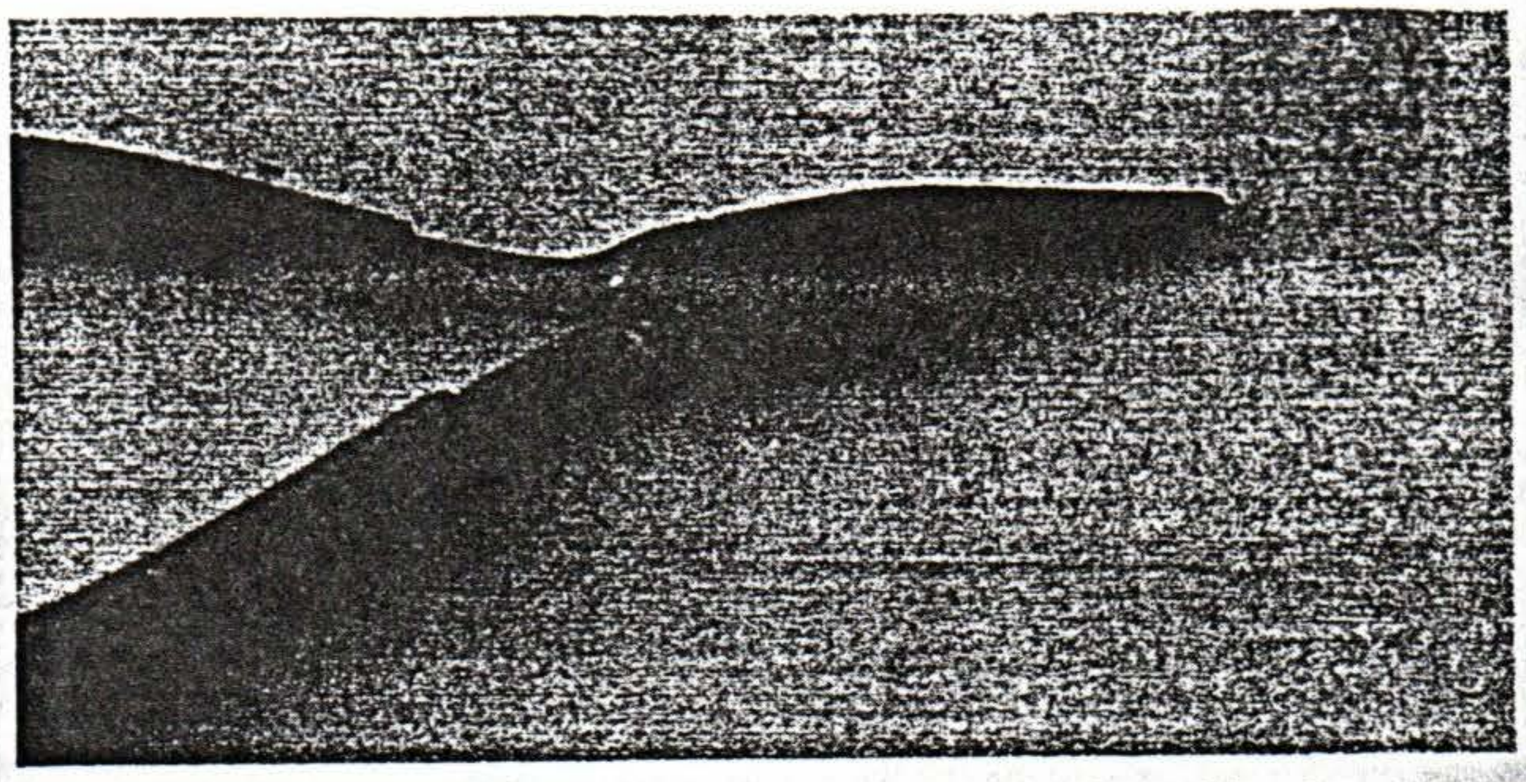
(Continued from previous page)
action, the use of a *flux* which removes and prevents reformation of surface oxides on the base metals is mandatory. Applied just prior and during the heating action, the flux removes the surface oxide barrier that prevents the wetting action upon which successful soldering depends. A small word of advice: Remove any excess rosin or flux, as otherwise the chemical action will continue to work and cause corrosive damage, especially on printed circuit boards.

Pre-tinning of the stripped wire will be the initial test of your iron's ability to properly heat and melt the solder into the individual strands of the prepared wire. Place the tip of the iron one-eighth of an inch from the insulation and apply the solder at the furthest point from the iron's tip. Predictably, the solder will flow toward the heat source, thoroughly saturating the individual strands with liquid solder, forming a homogeneous mass; immediately remove the iron's tip before the solder is drawn or wicked up beyond the recommended 1/32nd of an inch. Solder flow or wicking beyond the insulation point will form a potential stress area of inflexibility. The strands could start to break, one at time, until the wire falls loose, causing a failure.

Before starting each soldering application, reclean the tip of the iron. Lightly brush the freshly cleaned and shiny surface with a new coating of solder. This will establish a new, non-oxidized surface that'll make better contact and greater transfer of heat during each series of soldering operations.

Iron Placement

The iron should always be placed opposite to the solder application. The melting solder alloy will move toward the heat source, joining both the wire and the contact into one unitized, strong electrical connection. If you need to get the solder to flow to a stubborn point, move the solder and perform a rubbing action, but don't move the iron, this may break the heat



Ultra-small needlenose pliers are great for forming hooks and bends.

transfer contact and prevent the solder from flowing to a more distant area of the joint. Each completed solder joint should have a nice shiny, clean, filet of solder between each strand of wire and the cup or terminal.

When each connection is completed, inspect for correct insulation gap, wicking, excessive solder, pitting, chalk-like appearance and a good fillet around each strand, without voids. If you leave your iron on the terminal, three things may take place: one, oxidation of the solder; two, overheating of the surrounding connector; and three, wicking of the solder up the strands under the insulation, stiffening the wire, making it more susceptible to breaking.

Cup Terminals

Soldering of the cup terminal is made difficult because of its design; the surface is curved, reducing the cross sectional area that the iron's tip can contact. This surface area is improved when the iron is prepped with a small quantity of solder which will increase the transfer area by bridging the small areas to the right and left of the terminal-to-iron tip contact area.

Begin by placing the connector in a rubber protected vise with the terminal at a 45° angle to your work table surface. Place your iron's tip at the base of the cup, on the opposite side to the wire insertion point. Fill the cup with sufficient solder to allow for a final fillet that will form concavely between the conductor and the sides of the cup (the solder should not indistinguishably cover the strands of wire). How much pre-tinning? Well, this depend's on the depth of the cup and the diameter of the conductor. You'll have to "learn" this with each type of connector and contacts you'll be working with.

After the pre-tinning operation is complete, on all cups, reapply your iron's tip to the first cup and heat it until the solder liquefies. Quickly insert your prepared wires; the solder should flow smoothly, leaving a shiny finish. Hint: start by first inserting the wire at a slight angle to the terminal cup, placing the end of the conductor into the lower portion of the cavity, then as the wire slides down into the liquid solder, pull back, until the conductor is parallel to and resting against the cup back. Stop moving the wire into the bottom of the cup as you obtain the correct insulation gap between the top of the cup and the insulation.

This procedure should be applied to each and every conductor in the connector, but make sure that you've installed the back shell before starting the soldering operation, as it can be a real disappointment to find that you've overlooked such a simple detail!

Wichita-based avionics consultant Ed Maher has wired many a harness for Beech Aircraft, where he is a senior avionics technician.

ELT Battery Replacement Tips

65F
(.15)

Replacing an emergency locator transmitter's battery pack is so quick and easy, it's hard to imagine that anybody would pay a mechanic to do it (kind of like paying somebody to put air in your tires). If you've been wanting to get started in do-it-yourself maintenance, this is as good a place as any to start.

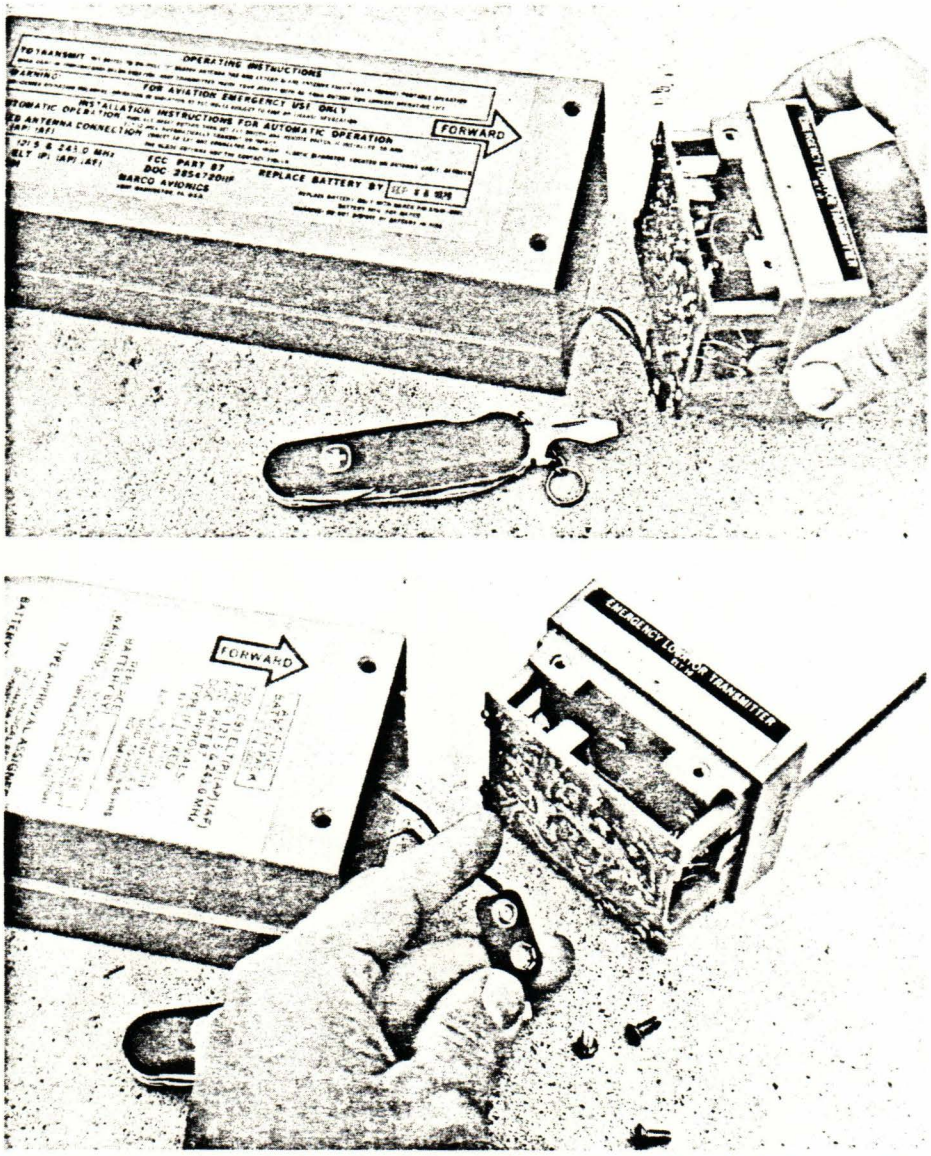
The Narco ELT-10 (shown in the accompanying photos) is among the most popular units on the market. It can be bought, new, for as low as $220 (Kelly Sales Co., 545 W. Allen, No. 17, San Dimas, CA 91773; phone 1-800-368-8684 or 714/592-2021), and —unlike most ELTs—battery packs can be bought in both 2-year ($26.50) *and* 3-year ($49.95) varieties. (Prices quoted are from Independent Aviation Supply, 1816 Delmar, Granite City, IL 62040; 1-800-851-8020 or 618/452-2351.)

Other ELTs for which 3-year power packs are available include the Sharc-7, Rescue-88, Pointer 3000, and Dorne & Margolin. A flat 25-percent discount is available on all ELT batteries from: Aircraft Suppliers Co., P.O. Box 14344, Haltom City, TX 76117 (1-800-468-6900 or 817/589-1688).

The ELT-10 is fairly typical of emergency beacons in general for its battery-change procedure. Always start by disarming the unit (find the "off" switch) and removing it from the airplane. If an external (airframe) antenna is connected—and it should be—disconnect it by untwisting the coax cable and pulling straight out.

Deploy the Narco unit's tape antenna (portable antenna) by pulling it out all the way. (This antenna wraps around the battery pack lengthwise. Deploying it gets it out of the way.) Now look for four tiny, countersunk, slot-head screws at the top of the pack (under the transmitter nameplate; see photos). These screws—two to a side—must come out to liberate the battery. (Set them aside.)

With the retaining screws removed, you can pull the transmitter portion of the ELT straight out of the power pack. You'll notice that the transmitter is quite small (the "guts" fit on one PC board), weighing in at less than half a pound.



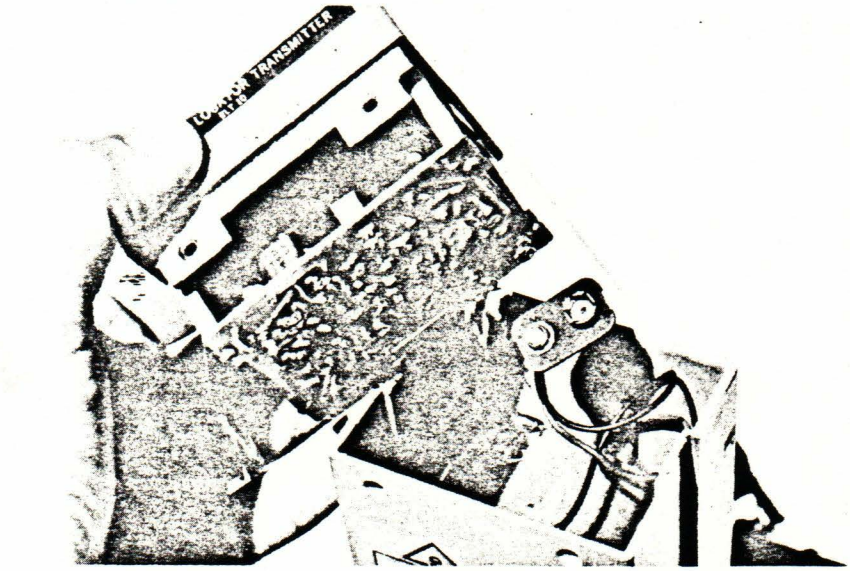
Top photo: To access the transmitter portion of the Narco ELT-10, undo the four small retaining screws at the top of the battery pack, and pull. Lower photo: The battery (large bottom portion) attaches to the transmitter circuit board via a pair of snaps.

Look for a pair of wires (red and black) leading to a pair of snaps on the circuit-board. (These snaps should be familiar to anyone who's ever owned a cheap transistor radio.) Pry the snaps apart with fingertips—then give your old battery pack a decent burial (do not cremate).

Inspect your transmitter, by the way, for signs of corrosion (or other) damage, while you have the chance. If any funkiness is found, return the unit to the factory, or to an FAA-approved ELT repair shop (such as Beuco, Inc., 3308 Cottonwood, St. Charles, MO 63301; phone 1-800-325-6163 or 314/947-0212).

Now. If your new battery comes with a little plastic pouch full of something resembling Vaseline, smear some of this stuff (sparingly) around the edges of the transmitter's case before sliding same into the power pack rim. Wipe off any excess sealant. Then reinstall those tiny slot-

(Continued on next page)



Top photo: Inspect the transmitter PC board for obvious damage/corrosion before snapping the new battery to it. Lower photo: Apply a thin coating of petroleum-jelly sealant to the rim of the transmitter before sliding it into the new power pack.

(Continued from previous page)

head screws that you set aside before. (The jelly gives you ELT a water-tight, gas-tight seal for maximum reliability.)

If you have an airframe antenna, stow the ELT's tape (portable) antenna and check to see that there is a plastic contact guard separating the contact finger of the transmitter from the tape antenna itself (Narco units only). Many ELT-10s were shipped without a contact separator; Piper had a service bulletin on this some years ago. *You want a separator to break contact with the tape antenna while the airframe antenna is installed.* If the portable antenna is hot while the coax is hooked up, the coax is shorted out. (Not really; but the impedance mismatch is bad enough to give you ELT zero range.) If necessary, put masking tape on the inside of the portable antenna at the contact finger.

Now reinstall the ELT in the plane going through the removal steps in reverse. Set the switch to "arm," turn on your main comm radio, and listen (on 121.5, or any nearby frequency) for the familiar "whoop-whoop" sweep-tone of an active ELT. If your ELT is transmitting when it shouldn't be, find out what the problem is, pronto.

Do check the unit's transmit capability at least every 6 months (and at each battery change), by purposely setting the switch from "arm" to "on" while a friend listens from across the airport (or miles away, in flight) on 121.5 MHz. (Don't just listen on one of your comm radios. You want to check the *long-range* effectiveness of your ELT/antenna combination, which is something you can only do with the aid of a long-distance observer.) It's legal to turn your ELT on, for testing purposes, within five minutes past the top of every hour. (Common courtesy dictates that you advise Ground Control of your intentions, if you are based at a busy airport.)

And that's about it, except for the normal log entry (something you can do yourself). Oh, and don't forget to post the battery-replacement sticker in plain view of your mechanic, so that the ELT's power pack won't automatically be changed out at your next annual inspection (as most are).

Narco ELT Calibration

Narco Avionics, under Service Bulletin No. ELT-14, now considers yearly calibration and testing of ELTs mandatory; otherwise, the so-called "lifetime warranty" of the ELT-10 is voided. (The lifetime warranty is also voided by use of any battery other than a genuine Narco battery, but at least one battery maker—Merl, Inc., P.O. Box 188, Meriden, CT 06450, phone 203/237-8811—has said it will pick up the lifetime warranty for ELT-10 users who specify a non-Narco power pack.) According to Narco, a complete system performance check can't be performed without specialized test equipment. Therefore, owners should send their units to ELT Labs, 2825 Laguna Canyon Rd., Laguna Beach, CA 92651 (1-800-ELT-LABS or 714/497-5077) for calibration and testing. ELT Labs is the only Narco authorized ELT-10 service center in the U.S. (Narco doesn't want units sent to the factory). Overhauled/exchange ELT-10s are available from ELT Labs with fresh battery pack for $54.95 (wholesale) or $78.50 (customer list), exchange, with a $100 core charge to ensure return of old transmitters. For more information on Narco's customer service policy, contact James McNabb, Manager, Customer Service, Narco Avionics, 270 Commerce Dr., Ft. Washington, PA 19034 (phone 215/643-2900).

VACUUM SYSTEM SERVICE

Failure to follow the following instructions may result in death, bodily injury, or property damage.

So goes the warning from Air borne Air and Fuel Products regarding the use of their vacuum system products for flight under Instrument Flight Rules (IFR). It doesn't exactly inspire confidence in that $400 dry-air pump affixed to the back of your engine but it does describe the all-to-common result of indiscriminate failures that occur without warning and generally, without apparent cause.

With a 20% increase in the number of active instrument rated pilots over the last 20 years and considering that there are some 18 million IFR operations conducted annually across the United States, it stands to reason that some of the two thousand plus accidents occurring each year in General Aviation, are the result of a loss in aircraft control due to spatial disorientation; That condition which renders the pilot unable to recognize his position or attitude and typically, results in the immediate peril to life and limb.

Vac Sources, Wet, Dry and Static

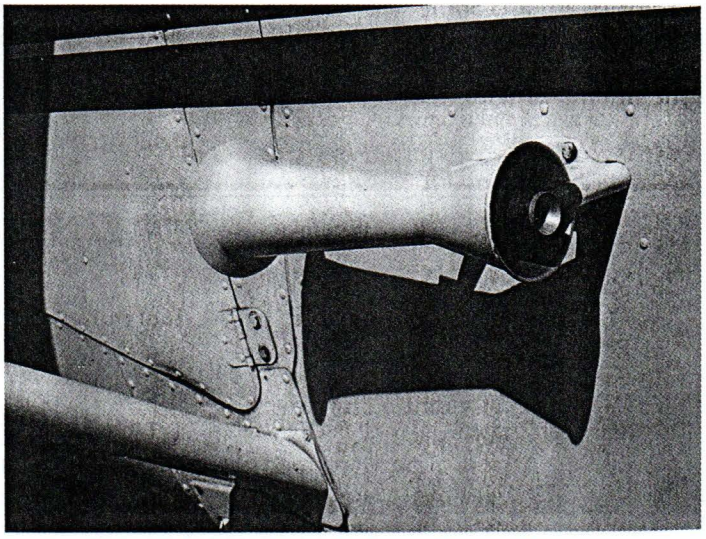
Light aircraft used in the 1940's operated basic gyro instruments with minimal control and limited capacity. Bulky, fuselage-mounted venturis were standard equipment on many single engine aircraft and vacuum performance was a direct reflection of aircraft speed. Plumbing from the vacuum air operated gyros went directly to the low pressure side of the static venturi and as the aircraft gathered speed, a low pressure drop at the venturi source would pull air through the instruments. Ground operation prior to take-off and slow climb speeds would not pull a sufficient amount of air through the heavy instruments and gyro spool-up was slow at best. While simple and trouble free, these older systems fell from grace when the engine driven vacuum pump was introduced in the late 1940's and early 1950's.

The wet pump system could provide nominal system vacuum of 4.5 inches of mercury differential at any engine speed above idle and gyro spool-up was measured in minutes rather than knots. Driven off a standard AN pad on the engine, the wet vacuum pump received a small supply of oil from a galley drilled in the pump drive boss and oil was allowed to dribble into the vane chamber. This oil was primarily used for lubrication but it also helped to form the necessary vane tip seal. An air/oil separator was needed to remove the oil vapor and mist from the vacuum pump discharge air in order to return the oil flow back to the engine. A series of low pressure hoses and fittings attached to the accessory case provided a means of return for the oil and discharge air was released below the separator canister.

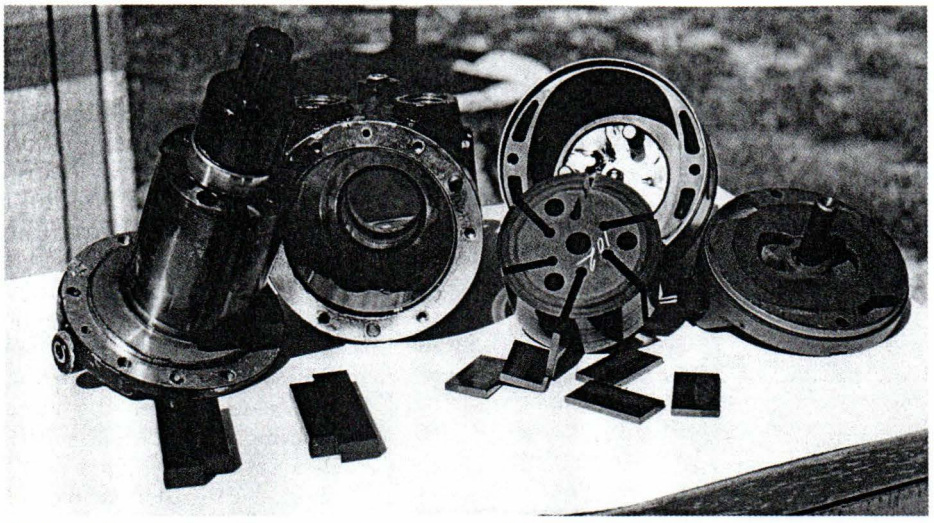
The reliability of the new wet pump system was primarily of question of external plumbing problems and oil separator maintenance. The system worked extremely well and wet style vacuum pumps became standard equipment on most all light aircraft. Their only drawback had to do with the complexity of the design, weight concerns and the mess found with the ever-leaking air/oil separator. Aside from those obstacles, the wet pumps lasted a long time and even performed well when completely worn out.

In the interest of making the wet vacuum pump system less complex and more esthetically pleasing, the wet pump was replaced by a new dry style vacuum pump introduced by the Airborne Company in 1957. This conversion, still offered today, allows for the removal of the wet pump system, along with the related hoses, separators, fittings and brackets. In its place is installed a dry type, vane style pump with only an inlet and exit fitting for plumbing. The new pump sits on the same AN pad with a gasket designed to block any oil flow through the drive area and the inlet to the new pump is connected directly to the vacuum regulator. All other system components and general vacuum system operation remain unchanged.

The dry-air pump is the standard used today for all light aircraft. Simplicity of design combined with clean operation and relatively durable performance make the dry-air pump a desirable alternative to the long lasting wet pump. For aircraft in which an air/oil separator is standard equipment, wet pumps are still used, however, many of the 300 and 400 series Cessnas, the Beechcraft twins and



Fuselage mounted venturi installed on a Cessna 140.



Wet and Dry style pumps. Note: four vanes on the wet pump, six on the dry style.

older production Pipers have been converted to the dry series pumps. All new production aircraft have replaced any wet system with a dry type pump, giving in to the lower life expectancy of the newer pump designs.

Normal Wear and Tear

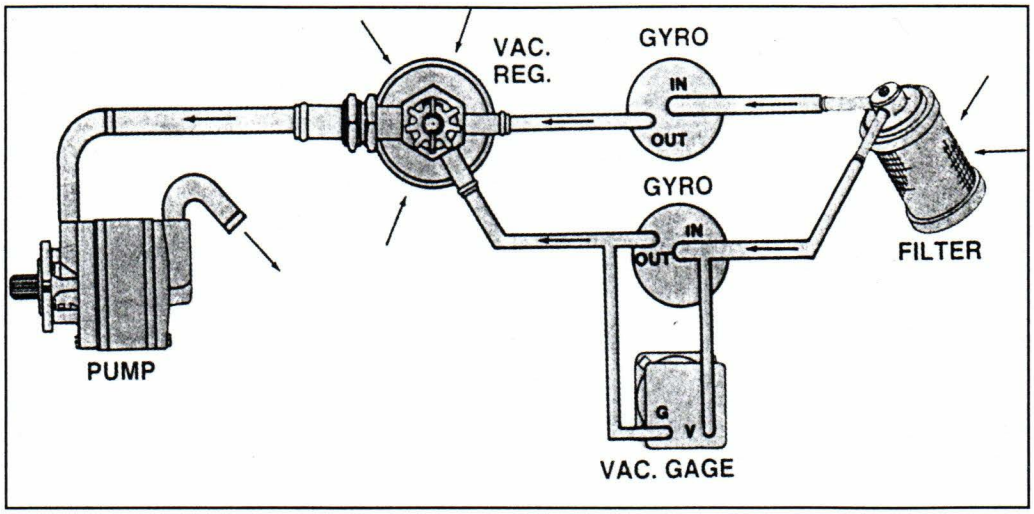
The typical dry vacuum pump is made up of nothing more than a set of six carbon vanes loosely held within a rotor which spins inside a pump housing. The vanes are rounded on the edges with a slight rake against the drive direction. Some pumps are bi-directional and are equipped with vanes that remain straight within the rotor. When the pump turns, the vanes are flung out against the housing and affect a seal against the smooth housing liner. The amount of air flow through the pump is determined by pump RPM and system regulator adjustment. The higher the speed, the higher the vacuum. Many Lycoming engines turn the vacuum pump a maximum of 3500 RPM at take-off power. Some Continental engines are spinning the pump drive at 4050 RPM. While pump wear is related to rotor speed, adverse vane wear and pump life has a direct relationship with the amount of internal heat generated by the pump and inlet air conditions. High altitude and hot pump operation will accelerate vane wear and lessen the life expectancy of any dry type vacuum pump. While pump manufacturers have changed some vane materials to offset the adverse wear characteristics, the limitations placed on the delicate design of the carbon vanes doesn't allow for any excess slop between the vane and the rotor slot. When the vane wears on the loaded face, a powder contaminant is produced. This debris by itself is not cause for immediate concern, however, the wear pattern will allow some shifting of the vane in its slot. When the vane moves too freely in the rotor, catching of the vane and chipping of vane material create large pieces of contaminant that get caught between the vanes and the housing. It is this free-floating contamination which acts to bind the vanes and seize the pump, usually resulting in the shearing of the plastic drive gear and failure of the pump.

If pump life is related to extremes in operating temperatures and high, dry-air environments, then it stands to reason that some pumps installed in turbocharged aircraft would fail more often than their low powered, normally aspirated counterparts. Generally speaking, they do. The Cessna P210 will destroy a new vacuum pump in as little as 400 hours when a Cherokee 180 might get 1000 hours or more on a single 200 series pump. Aircraft equipped with de-ice boots and dual flight panels place additional stress on the vacuum pumps and these systems usually require pumps of larger capacities. Regardless of the installation and the size of the pump, heat generated within the housing, pump speed and very dry air conditions all combine to determine the life of your vacuum pump. Unfortunately, your usually the last to recognize the wear and the first to find the failure.

System Description

The typical vacuum pump system is made up of a central air filter, a vacuum regulating valve, a vacuum pump or source and the necessary lines, fittings and clamps. Other, more sophisticated systems, use in-line filters, de-ice boot valves, sonic venturis, check valves and a variety of isolating devices to keep two or more intermixed systems separate from each other. Regardless of the installation, the principles of operation are basically the same for all.

The engine driven vacuum pump is located at the end of the system and functions to pull air through the vacuum operated flight instruments. Cabin air is pulled through the central gyro filter (the beginning of the system), through all lines and instruments, past the vacuum regulator and finally exits the output side of the vacuum pump. In a pressure system, the vacuum pump becomes a pressure pump and instrument air is pushed through the panel rather than pulled. The principle of operation is the same, however, the order is reversed. In a vacuum system, the central filter cleans the air introduced to the instruments and vacuum pump. The vacuum regulator is equipped with an adjustable bleed valve which can be reset to obtain correct vacuum pressure. This calibrated bleed will control the amount of vacuum applied to the system by allowing air to be sucked into the system from outside the instrument loop. It is usually located underneath the instrument panel (as is the central filter) and is generally located very close to the vacuum pump source. It too, is supplied with a foam filter which cleans the relief air pulled into the system. The central filter should be changed every 500 hours and the vacuum regulator filter should be replaced each 100 hours. Airborne recommends they both be changed at every annual. How often the filters are changed should be based on your environment, both in and out of the cabin. Dusty conditions and smoke particulate clog these filters very quickly and a dry-air pump is very sensitive to any contamination at all. Of course, no filter change is going to mean a thing if the system has developed leaks at lines or fittings. If the



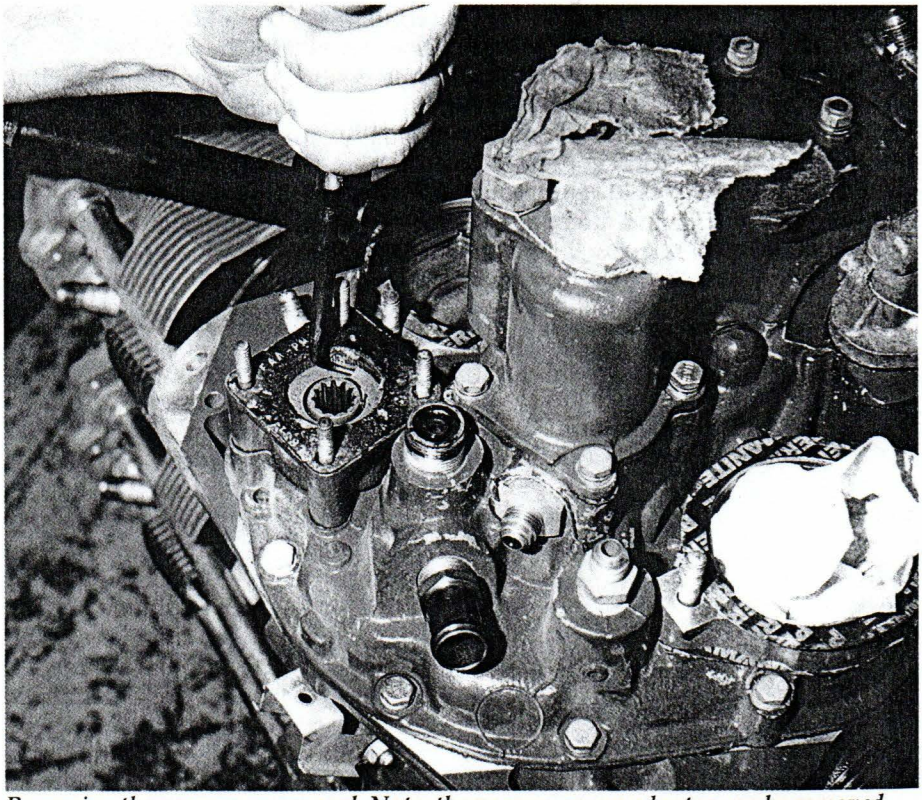
Typical single engine vacuum system.

vacuum gauge indicates a lower than normal reading, check the system for leaks before adjusting the vacuum regulator. Compensating for a leak by jacking up the regulator will allow unfiltered air to contaminate the pump and, ultimately, lead to complete pump failure. Loose clamps, cracked lines or damaged fitting threads all lead to system leakage and should be repaired when found. Also note that all fittings are to be installed dry (or sprayed with silicone and allowed to dry) and torqued only enough to be secure. Don't use any form of thread seal and keep the breaker bar in the tool box. One to one and a half turns on the fitting are enough to keep the fitting secure.

Check closely for signs of vacuum pump drive seal leakage. The drive end of the pump must be clean and free from oil or grease. Any oil leakage from the pad drive seal is reason enough for seal replacement. These Garlock seals can wear the vacuum pump drive gear resulting in a groove cut around the gear circumference and, typically, end up generating oil seepage from the pad. The seal can be replaced by drilling or punching a small hole in the metal part of the seal and gently prying the old seal out of its boss. Be careful not to damage the soft aluminum pad area. After the seal area is completely cleaned of any grease, oil or old sealant material, install the new seal with a small amount of Locktite around the outside of the seal cage (not on the rubber part of the seal) and gently tap in place. A large, twelve point socket will work well to seat the seal and still allow room for the gear to fit inside the socket diameter.

All This and it Blows Up Anyway

Don't be discouraged. Vacuum pumps are very sensitive components and the only sure way to keep one from shearing the drive or otherwise self destructing is to leave it in the box. For those who wish to use their pumps though, expect a failure at some point in life. When it happens, some precautions should be made to eliminate the potential contamination of the new pump by debris from the failure. Flush all lines going to and from the pump with dry, compressed air. Inspect or replace filters and clean the vacuum regulator. Make sure all fittings are clean and not trapping any residue from the vane disintegration. Most often, true vacuum systems don't distribute much in the way of debris through the failed system. However, a pressure system, one that pushes air through the instruments, can blow carbon dust and chips past the in-line filter and clog the small screens installed in the inlet to the instruments. On twin engine aircraft, some of the contamination from the failed pump can make its way to the manifold check valve thereby providing the good pump with the same contamination that destroyed the failed pump. In all cases, regardless of the system



Removing the vacuum pump seal. Note: the vacuum pump adaptor can be removed from the engine in this picture which means that prying the seal out is unnecessary.

design, flush the lines and change the filters as a minimum.

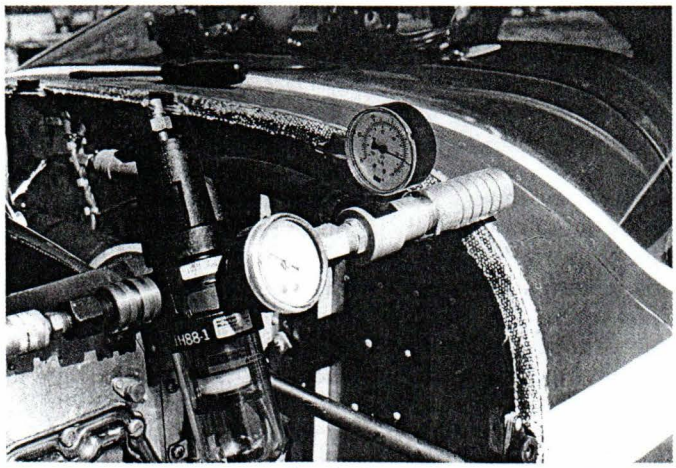
New, Used and Rebuilt

There are several sources for new vacuum pumps and a couple of outfits that supply rebuild kits. Parker Hannifin, parent company to the Airborne Division, Air & Fuel Products, 17325 Euclid Ave, Cleveland, OH 44112-1290, phone: 216-531-3000 and Sigma-Tek (formally Edo-Aire), 1001 Industrial Rd, Augusta, KS 67010, phone: 316-775-6373 are the major suppliers of factory new pumps. Rapco, Inc. 445 Cardinal lane, Hartland, WI 53029, phone: 414-367-2292, supply rebuild kits and overhauled vacuum/pressure pumps for all light aircraft at about half the normal cost for a new Airborne or Sigma-Tek pump. While Airborne does not recognize or authorize the rebuild of any of their pumps and Sigma-Tek maintains that their pumps can't be overhauled, the rebuild process continues to flourish. Unlike the Piper Seneca owner who acquired a Rapco kit and rebuilt his Airborne pump on his living room table, some rebuilt units go beyond the 16 minutes of operation found with the Seneca effort. To say the rebuild is a delicate matter is an understatement. If your flying is strictly VFR and your vacuum operated flight instruments are basically filling the holes in the panel, then acquiring a Rapco kit or similar FAA/PMA replacement can be had for around $115. For the not-so-daring, a rebuilt vacuum pump can be purchased for just under $195. Aircraft frequently operating in IMC conditions will probably insist on going with a factory new pump with all the normal precautions during installation. Pricing for new Airborne pumps run in the $400 to $500 range with Sigma-Tek selling slightly lower in price. Regardless of the pump option you buy, a cooling kit can extend the life of your pump well beyond normal expectations. Rapco provides cooling kits for most models of pumps for under $60 and while installation can take longer than the directions lead you to believe, the work involved will pay dividends down the road.

Loaner Airborne Test Kit 343 .

System Adjustment and Testing

The set-up and adjustment of the typical single-engine vacuum system consists of insuring that the pneumatic loop is clean and secure and setting the vacuum regulator to the prescribed system pressure. The vacuum regulator is adjusted with a jack screw held in place by two bend tabs. Move the tabs away from the screw handle and turn the adjusting screw in to increase the vacuum and out to decrease the pressure. The vacuum regulator is usually mounted underneath the instrument panel, close to the firewall or it may be installed in the engine compartment. Where appropriate, the regulator can be adjusted with the engine operating in a cruise configuration, however, some installations make this a hazardous practice. When in doubt, adjust the valve with the engine off and then check your setting at cruise RPM.



Regulator P/N 1H88-1 is plumbed to the system replacing the vacuum pump source allowing for system troubleshooting.

Airborne test kit #343 provides an easy means to replace your engine operated vacuum pump with a box designed to supply system vacuum and pressure on demand. This kit will easily check the setting and operation of the vacuum regulator as well as identify restricted filters and fittings. While it won't clean the system or tighten loose instrument connections, it will locate sources of trouble and allow for quicker troubleshooting of the system. These test boxes can be purchased from Airborne for around $600 but a call to the Airborne Technical Service Hotline (1-800-382-8422) will get you a loaner test kit and instruction manual for use on your troublesome vacuum system. In addition to finding the source for plumbing leaks or restrictions, setting the system with this kit will allow you to verify the strength of your vacuum pump, which is something you can't do without the box.

While safety warnings and liability waivers will remain intact for aircraft operating in IMC conditions, especially those without a back-up vacuum system, in-flight pump failure can be avoided and system performance can be enhanced by visiting annually with the various components of your vacuum system. It's not a guarantee, but piece of mind comes at a price for all and the simple vacuum system demands its share.

Cockpit Chatterboxes

Built in or portable, intercoms offer the best solution for cabin communications

by Gary Picou

Good, clear and efficient cock pit communications are vital to safe flying. In addition to the safety factor, a comfortable environment for the ear enhances the flight experience and protects your hearing. Headsets and a good intercom are important accessories in any airplane. Still, not every intercom works as well as it should and for a variety of reasons. Sometimes the unit isn't up to the task but often enough, it's shoddy installation that deprives you of all the benefits of your newly purchased intercom. In this article, we'll address the different types of portable and panel mounted intercoms and we'll cover some of the installation practices while offering things to look for when the system doesn't perform up to par.

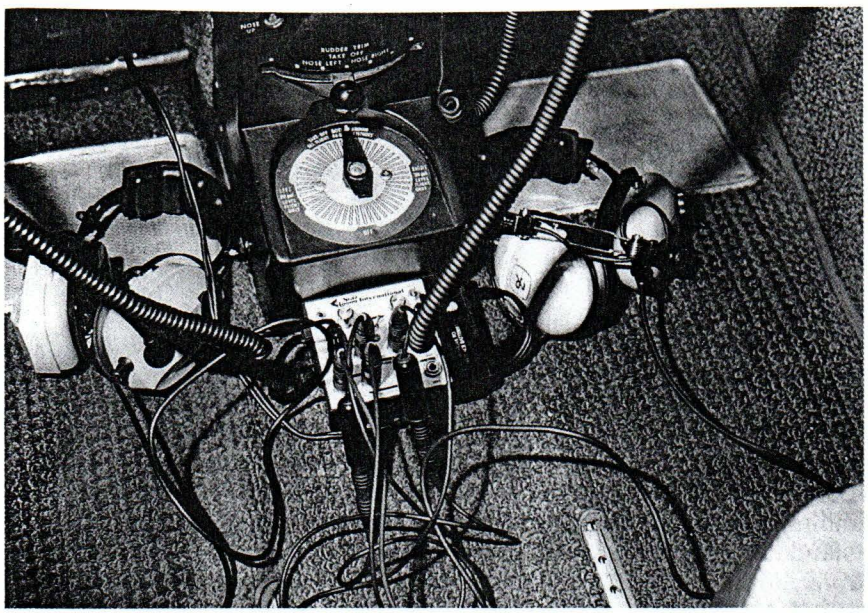
The intercom system consists of a unit that connects two or more headset/microphone stations together. It will be equipped with an amplifier capable of boosting mic signals to headphone levels. Most systems on the market today are VOX, or voice activated systems. They will have a squelch circuit that chops out the background noise between conversations. The squelch control is designed to adjust the threshold for different ambient noise levels, voice levels, and microphone types. Because we only have one set of ears, the intercom must accommodate radio traffic, too. It must, at the proper time, direct incoming radio audio to the headset. It must also connect the microphone of the designated talker to the radio for transmissions. As important as intercom conversations are, they can't compare to the air traffic control transmissions. So, your intercom always needs to pass these signals on as a priority. Whether portable or built-in, intercoms must have a failsafe feature which will pass comm audio if they are malfunctioning or if the power is removed. Most intercoms have an auxiliary or entertainment input. This can be a portable tape player or perhaps some other installed music source. When the intercom is in use or if there is radio traffic, the entertainment source will be overidden. Some systems mute it completely while others reduce the volume to half or less, automatically. When selecting or installing the system, you need to understand the functions and options available. Some systems, like the David Clark DC 200 allow the user to control how quiet the music becomes. Others, like the Flightcom 403mc, can be strapped during installation to mute the radio or intercom signals, as desired.

Carry-On or Fixed

Intercom systems fall into three catagories: Those basic systems found in comm or audio panels, a portable type that can be carried from airplane to airplane and a full-featured panel mounted intercom system installed as a separate unit. Many avionics components have a built in rudimentary intercom system and are a natural feature for a comm radio or audio panel. With few exceptions this intercom is too simple to be much good. They are not voice activated systems and as such, require additional switches to be used on each station. Audio panels often require the user to switch out of comm mode manually. This means you must remember to switch the mic back to Comm 1 or Comm 2 in order to talk with ATC. The resulting confusion almost invariably means you transmit to the wrong ears occassionally. "ATC idiots!, Make ME do a 360 for an ultralight will ya!" Yet, as with all technological aberrations, this is slowly changing. Bendix/King has had a VOX audio panel for years, the KMA 24H. Unfortunately the space required for the intercom meant that the marker beacon receiver got tossed overboard. Today, Terra makes a VOX intercom with a marker receiver, and PS Engineering's new PMA 6000M audio panel incorporates a full-featured intercom, complete with stereo entertainment inputs. Look for this intercom integration to proceed into the next generation of avionics, like the AlliedSignal stuff in the new Cessna 172's.

A portable intercom system has many advantages. It can be moved from aircraft to aircraft which can be ideal for renters. They are less expensive, don't incur installation labor costs and many are expandable. As you move from a Musketeer to a Bonanza, you can add expansion modules to accommodate the additional seats. Since there're not permanent, failure of the unit simply means unplugging the thing and continuing the flight. There are disadvantages too. Wires strung all over the cabin like miles of ticker tape with headset jacks plugged into various floor and panel mounted recepticles. It's easy to confuse the mess and a very real possibility exists of finding yourself cross-connected and unable to talk to anyone but yourself. While some systems might have a power connection to the cigar lighter plug, others will be powered by batteries. It should noted that batteries are engineered by the manufacturer to quit at the least op-

The Filghtcom 403mc will mute radio and intercom signals during priority transmissions.



Portable intercoms are convenient, but they are plumbed with a tangle of wire.

portune moment. (We can't prove it scientifically, but experience shows that it must be that way.)

Since the portable units have wires strewn thither and yon, there is an excellent chance that airframe noise will get into the system causing whines and buzzes. Just the sort of fatiguing noise you sought to eliminate with the intercom. Any portable system is just a good compromise in performance versus versatility. For reliable intercommunications, nothing beats a panel mount. The panel mounted system has the big advantage of a more consistent power supply (as long as the ship's electrical system is working). The system is permanently interfaced to the radios, hopefully correctly, using quality aircraft components and techniques. There are no wires to pull out or break, nothing to connect before each flight and the intercom is always there, waiting to be used. Back seat passengers aren't climbing in over wires and their headset stations are available and easy to understand. Even for the novice aviator. With a good quality unit, the controls are set for your preferences and can be ignored in a routine flight. Naturally, panel mounted intercoms cost more than their portable counterparts. The price differential isn't much on the units themselves but the installation labor can more than push the total system cost. Consider the steps involved in the installation of a sirnple four place system. First, you should nearly gut the airplane by removing seats, interior panels, instrument panel overlays, etc. You can work around them if you wish but it often takes more time that way. Since the intercom will be interfaced to the audio system, the panel jacks and avionics stack need to be exposed so they can be worked on. The panel unit needs to be installed which involves cutting holes in the panel. The copilot jacks may need to be installed and the rear jacks have to be mounted in the back. Like anything, you get what you pay for. A typical four place intercom can be installed in four hours and it'll look like it. Jacks screwed into plastic trim pieces and wires strung loosely throughout the cabin. Poor grounding and slap-dash power connections will make the system noisy and unreliable. Even at a mere four hours (at $50 per hour), the installation cost can easily exceed the unit price. A more reasonable installation time might be eight hours. Naturally, if the intercom installation is concurrent with other installations or routine maintenance, the cost drops. Annual time is a good intercom time.

Selection and Output power

How many people will use the intercom and what positions shall have access to the radios? It is not as easy a question as it may seem. Sometimes, you can be content with a"listen only" station or two. The determining factor in intercom selection is not headphones, but the number of microphones. Microphones depend on voltage, called bias, to operate correctly. This mic bias doesn't like to be subdivided. Therefore, each mic input to the intercom is usually on a separate pin, while many headphones are paralleled together. At installation you will have to decide if the copilot can talk on the radios and who will have priority. Usually the pilot side will override the copilot but depending on wiring and the unit itself, it may have a first-come first serve priority. This is useful in primary instruction aircraft.

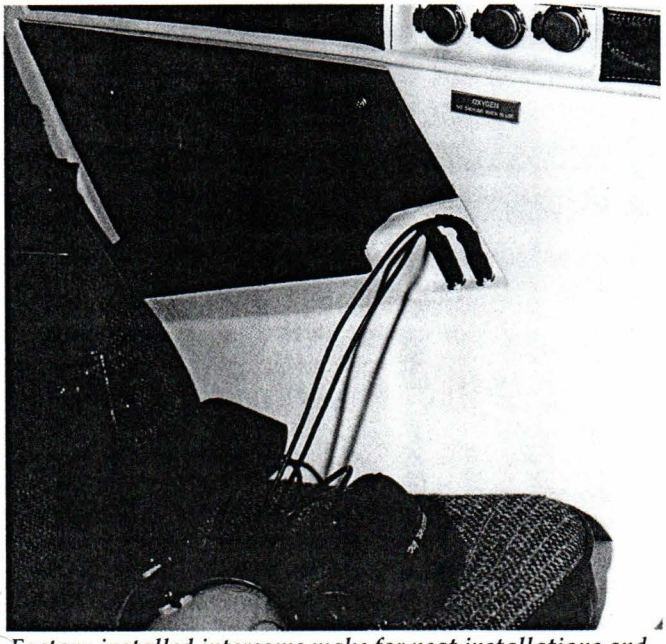
When shopping for an intercom, there are a few other specifications to look at besides nurnber of places supported. In addition, there are some that don't matter. The most important of all specs is output power. This can be expressed as total output or as output per station but the important point is that more is better. More audio power will efficiently overcome aircraft noise, reduce distortion and drive more headsets. In low power systems, the volume drops as more headsets are plugged in. Beware of a company that doesn't list an audio output specification. In tests conducted for other publications, total power ranged from a low of 50 milliwatts for the Sigtronics SPA-400, to over 400 mW for a Northern Airborne Technology AA80.Some systems make claims of low distortion. Come on, it is an airplane for heaven's sake. Even if you drag along your portable CD player and listen to Beethoven's Sixth Symphony with some of the customized headsets now available, the difference between 5% and 1% distortion won't be noticeable. A low distortion figure is meaningful as an indicator of quality only if coupled with other features like power and individual mic circuits. In the better intercom systems like David Clark, Northern Airborne Technology, PS Engineering, QuietFlite and Telex, only the microphone that is spoken into is active. In other systems, like Flightcom or Sigtronics, when one person speaks, all the microphones are "hot ". That means all of the noise in the back seat gets passed through the system. This can be intolerable in noisy airplanes and when the kids in the back seat get restless. Getting a good intercom is only a small part of the battle. A

low-end intercom will work fine in a good installation, but even the most expensive system will be a bad investment it not properly installed.

Grounds, Shielding and Noise

Should you use shielded wire? Always and without question. Noise is the biggest problem in any audio system and the intercom is extremely susceptible to the slightest leak. Electrically, there is little difference between alternator noise and the spoken word, so it can't be easily filtered out on the output. The best course of action is to keep it out completely so a filtering device isn't needed. A common place for noise to affect the intercom is the power input. An AC noise signal rides along on the DC power and essentially modulates the power supply. The aircraft electrical system shouldn't be too full of noise if the alternator and regulator are working properly. A quality intercom will filter out "normal" power noise but sometimes an alternator filter is required. To prevent airframe noise from further contaminating the power leads, avoid bundling them (or any intercom wires) with high current wiring like alternator cables, heater or blower wires and rear motor leads. Also, avoid bundling them with or near the transponder, DME or ADF antenna coaxes. Why ADF? Because many direction finder systems use a chopper signal in the loop circuit which makes a cool buzzing noise. Something you don't want in your headset.

The purpose of shielded wire is to control noise. If you want to keep noise in the circuit, ground the shield at both ends. This is commonly done to alternator field wires. To keep noise out of the wiring, ground the shield at only one end-preferably the source of the signal. This way noise roaming around will fall into the shield and travel to ground where you want it to, without being induced into a signal wire. If the signal wire shield is grounded at both ends, it sets up a ground loop. This can actually create noise by acting as a tiny antenna. One common problem is noise created by a difference in ground potential between parts of a system. The low side of the microphone jack isn't necessarily the same electrical ground as the intercom unit itself. To the intercom's amplifier circuits, it all looks like somebody talking. In an intercom installation, we like to see a "single-point ground." This refers to the fact that all grounds, whether power low or shield termination, return to the same electrical point. We can live with grounds that float electrically, so long as everybody floats together. The single most common noise inducing mistake in intercom installation is grounding the headphone and mic jacks. This often happens unintentionally when the well-meaning installer secures the jacks with metal washers. The proper jack should be isolated from the structure with fiber or plastic washers, available from any aviation supplier, and usually are included with a jack kit. Since the ground side is the outside of the jack, when it touches the metal, a ground loop is created which picks up noise all along its path.



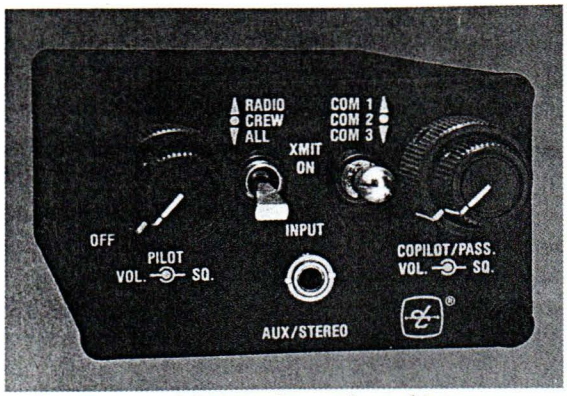
Factory installed intercoms make for neat installations and simple operation, even for the novice passenger.

Besides proper grounding techniques, there are some microphone rules of thumb too. Because microphones are biased, never hang more than one on the same line at a time. That goes for communication radios, intercoms, PA systems or anytime a microphone is used. Never leave a headset unattended. For instance, if you have a four place system, unplug the rear headsets when there isn't a head in thern. It's always a good idea since any headset can pickup and transmit noise. It's absolutely mandatory when you have an intercom that activates all mics during a transmit because any unattended set will create a nasty feedback.

Mics, Jacks and Troubleshooting

Microphone and headphone jacks require occasional maintenance. They can become loose when subjected to repeated poking and pulling and poor connections caused by dirt and debris are common complaints. While a properly constructed jack won't care if it falls completely off the panel (mainly because it doesn't depend on it for a ground), loose jacks can create noise as they make and break contact with the metal panel. They can get twisted around and can short out against static lines, control cables, and any of a thousand potential grounds behind the panel. Contacts can get mashed, bent and squeezed, usually by somebody working in the area and shorting out the whole audio system can be accomplished with one careless move. It's easy to check your jacks for security (they shouldn't move) and if tightening is required, hold the jack carefully as you tighten the attaching nut with a suitable pair of pliers.

What do you do when the intercom starts to misbehave? Perhaps you can see the copilot's lips move, but you can't hear anything? That's a good clue that something isn't working (It doesn't count if it is your instructor saying his Rosary, like mine). The most likely place for audio problems remains in the headset. Generally used and abused, headset plugs are yanked out by the roots from across the cockpit and wires are twisted and wound to impossible angles. If the intercom doesn't work, first, try another headset. It's always good to carry a spare. The next step would be to turn off the



DC-Com model 500 voice-activated intercom.

intercom system. It doesn't matter what the problem is, almost any intercom you'll find has a fail-safe mode. As soon as the switch is in the off position, radio phones and speaker signals are passed straight through to the pilot position headset. If that's okay, you can decide what to do about the intercom at a later date. If you still can't hear anything, and you have switched headsets, it's time to dig out the hand-held. It's unlikely that your intercom is at fault, either, except for one important fact. Many intercoms are in series with the radio audio. Audio goes in one pin, and back out another. If the intercom is unplugged or a wire breaks, the whole system is down, including the comm radio and other headset audio signals. Can you say NORDO?

Troubleshooting noise in the intercom audio is tough. Describing it to your avionics technician is even tougher. With the crackling and popping of an insecure intercom system it becomes difficult to identify a hiss from a buzz and a snap from a sizzle. But listen you must, because it will tell you much about the source of the problem. In case you haven't already been indoctrinated into the electrical sounds of an airplane, here goes. Alernators whine. It is a high frequency whistle that changes pitch as the engine RPM changes. It may become more pronounced as the regulator kicks in or as the paralleling relay activates in the case of a twin. Chances are, unless you have the intercom wires tied to the amp meter cable, this noise is coming in through the power input. It'll have to be corrected at the source, through alternator maintenance or filtered out there. If you notice a popping noise that sounds like spark plugs firing and the noise accelerates with the engine speed, one or more ignition leads are inducing an electrical push into the audio wires. This is usually caused by a bad mag harness or one that is improperly grounded. It is a frequent complaint following new engine or harness installation. It's also a frequent complaint after an intercom is installed, particularly when an active noise canceling headset is used. Why? Before the intercom, all you listened to were the radios, which never set any great standards for fidelity. Now, you're listening to your companions without any radio interface and you KNOW what they're supposed to sound like. In addition, you now have many feet of wire acting as a noise-receiving antenna. With ANC headsets, all of the wind and mechanical noise is gone, leaving only the electrical noise to deal with. The solution is to ensure that the installation of all aircraft components is electrically correct as well as mechanically proper. If it doesn't whine or pop but hisses and crackles instead, it's probably airframe charging. Not the AOPA Gold Mastercard kind but a static build-up that isn't effectively handled by the static wicks. Fixing this problem will require a careful and extensive evaluation of the static discharge system, including wicks, bonding straps and overall airframe grounding.

On the surface, an intercom might seem to be a simple system. There are no antennas, not mystical cable lengths or arcane formulas. Still, the difference between a good and bad intercom can be defined by two factors. Product quality and installation quality. In both cases, price is a fairly good indicator of the kind of performance you can expect. Yet, while competition can lower the cost of even the best of units, you can't short-cut the installation and still expect the system to provide you with the clear, clean communication you wanted from the intercom.

Intercom Suppliers

David Clark Company Inc.
360 Franklin Street
P.O. Box 15054
Worcester, MA 01615-0054
508-753-5827

Flightcom Corporation
7340 S.W. Durham Road
Portland, OR 97224
503-684-8229

P.S. Engineering, Inc.
9800 Martel Road
Lenoir City, TN 37772
423-988-9800

Sigtronics Corporation
822 N. Dodsworth Ave.
Covina, CA 91724
818-915-1993

The David CLark 200 will isolate the driving mic while muting remaining sets.

Pitot/Static Systems

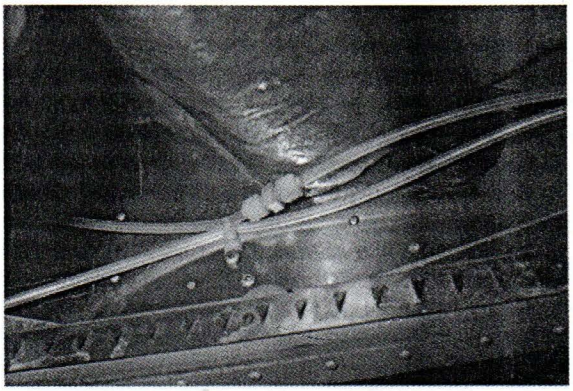
How can a system with virtually no moving parts create such a huge bill every 24 calendar months?

FAR Part 91.411 and 91.413 require that aircraft flying in controlled airspace under IFR have their altimeter system and transponder equipment inspected and tested in accordance with the instructions contained in FAR Part 43, Appendix E and F, within the last 24 calendar months. That's fine. Avionics shops all over the country perform the necessary inspections in a little over an hour, at rates that range from $60 to $125 for the average single or light twin engine airplane. It's not a big burden and the piece of mind goes a long way. Unless there's a problem, of course, and with radio shop rates pushing $75 per hour in many places, it doesn't take much of a problem to produce a bill that creates yet another problem.

Compliance with Part 91.411 is broken out into two separate functions. The regulation states that the altimeter as a unit and any altitude reporting equipment shall be inspected each two years and must pass a series of tests outlined in Part 43, Appendix E. These inspections are to be carried out by appropriately rated individuals or instrument shops approved for such work. The second required inspection is a test and inspection of the static system which includes, among other things, a system integrity test, more commonly known as a leak check. It is this system, not the altimeter, that generally fails the altimeter/transponder check and repairs can be time-consuming and costly. Fortunately, the static leak check can be performed by your local A&P mechanic or, better yet, by you, under the supervision of your local A&P mechanic. Either way will save you a ton of money when "Sparky" comes to hook up his test equipment.

Fittings, Ferrules and Tubes

The average single engine airplane has around 30 feet of plastic, static system tubing, broken by endless fittings, tee's and adapters all designed to create an airtight loop which ties the appropriate equipment to a single ambient static source (or dual port in the case of IFR aircraft). The purpose of the system, of course, is to provide instrument sensing of a change to outside ambient pressures which translate, ultimately, into some altitude diversion. With the exception of an alternate static source, the system has no moving parts. It is simply a loop made from plastic tubes and equally plastic flareless fittings which are supposed to allow flexibility around the back of instrument panels and through fuselage formers and bulkheads. The design of the system requires a water separator to be installed in some low point in the line and the hardware must be of sufficient quality to resist kinking at bends and remain free from corrosion. It's simple, and yet, every other year or so, a new leak is found or some fitting has worked loose due to vibration or who-knows-what.



Static lines are run in the overhead cabin area or along fuselage side panels. Leaks can occur at any of the tubing connections and defects must be isolated by trial and error.

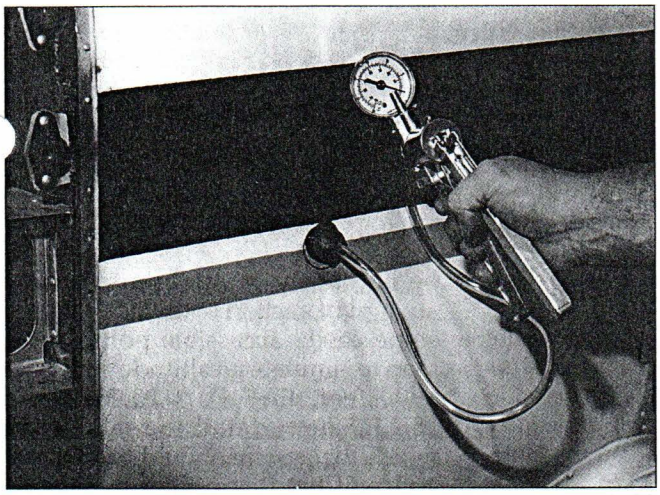
Maybe a carpet screw was driven into a side panel slightly off the mark, drilling the static line tucked behind the forward fresh air vent, or maybe the VSI line worked loose when that airport delinquent who helped you bleed your brakes managed to squirt 5606 all over the back of the panel. Anything can happen. Just ask the guy who mismanaged a static system check and blew the glass out of six different flight instruments in a cabin class twin. It happens, and when it's not mechanically induced, leaks occur when they want and where they want. It is for this reason that checking the static system yourself, prior to getting the altimeter and transponder checked, will save you money, time and aggravation.

Leak Tests and Suction Guns

To leak check the static system, it will be necessary to apply a sufficient amount of suction to the static port or some easily accessible point in the loop to simulate an altitude change of 1000 feet. FAR Part 23.1325 and 25.1325 both detail the manner in which the system should be checked and will list the minimum requirements for acceptable performance. The same information is found in FAR Part 43.13-1A, Chapter 16, Section 4.

Basically, a vacuum is placed on the static system of sufficient pressure to see a climb on the altimeter of 1000 feet. After reaching this point, the vacuum source is sealed off and the system must maintain the existing altitude for a period of one minute. Maximum allowed loss in altitude (and thus a loss in vacuum) is 100 feet. If the vacuum holds, your inspection is finished. If it does not, put the cat out, cancel all your appointments and call for back-up. You'll be here a while.

FAR Part 91.411 (a)(2) states that any time a static system is opened (aside from the alternate static source) a new inspection must be accomplished to test the security of the static system. The regulation only requires that a leak check be done. It is not necessary to have the altimeter and transponder checked again unless they



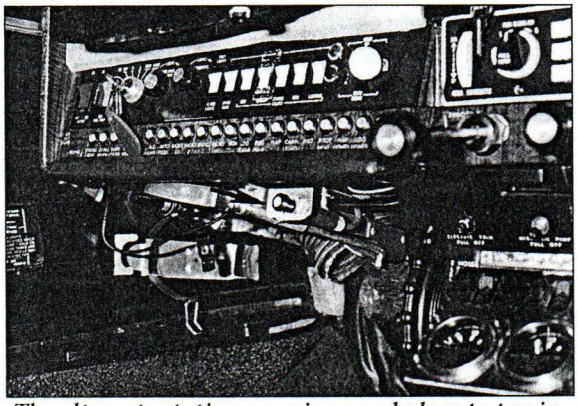
Suction is applied to the static system by using a hand-held vacuum gun. Be sure to plug the second system source for IFR-certified aircraft. Pump shown is a Matco MV4000.

have reached their two year limit. This allows the mechanic to exchange defective flight instruments, replace heated static vents and repair defects in the system without incurring the cost for a new altimeter and transponder check. The check is easily made but does require some specialized equipment.

There are several ways to tap into the static system for the leak check but no matter where you apply the suction, you'll need some device to create a vacuum. Auto shops have long used a hand-held suction gun to apply a vacuum to diaphragm-operated automatic transmissions. Some gun kits come with various adapters and cups to allow a single mechanic the ability to bleed the brakes on cars and trucks without assistance. Whether you purchase a suction gun from Snap-on Tools, Aircraft Tool Supply Co. or one of the many auto parts stores, the most important feature you'll need is the ability to seal off the vacuum applied to the system so that a realistic inspection of the system–and not the gun–can be made. A cheap vacuum pump can be unreliable and, often enough, will slowly bleed the suction off the system making the inspection impossible. For quality and design, we would recommend the Mityvac MV4000, available from your local Matco distributor, or any of the pumps which come with an all-metal casing and silicone type check valves. It's also important to purchase a pump that can be rebuilt with a manufacturers repair kit. Valves will leak over time and the pump ram seals need to be changed occasionally.

Attaching the vacuum pump to the system is easy. Attach a suitable hose to the pump and simply seal the tube to the static source using a lump of putty, sealant, or putty-type gasket material. Modeling clay and other water and dirt-based materials are not desirable because of the potential for system contamination; they're also somewhat difficult to work with. Once attached, the static system can be sucked down while watching the altimeter and VSI. Remember to plug the other static source for IFR aircraft equipped with a dual source. Work the pump slowly and allow the instruments time to react. Tapping on the altimeter will be necessary to overcome any mechanical resistance. Make sure that you don't allow any affected flight instrument the chance to "peg-out" against some maximum, and whatever happens, guard against rapid vacuum loss. If the line pulls out of the putty or your gun should fail, the altimeter will unwind in the blink of an eye and the VSI will automatically reach descent rates unheard of in your airplane.

Once the altimeter reaches 1000 feet, close off the vacuum source and start the one minute clock. If the altitude remains at or above 900 feet AGL for this check, the system is good to go. If the altitude falls or exceeds the acceptable loss rate, isolation of the leak must take place and the necessary repairs made.



The alternate static source is a good place to tap into the system and a prime place for leakage.

Looking for the Leak

Generally speaking, most static system leaks will be found under the panel. Not always, but most of the time. For this reason, when a leak is discovered, the first thing you'll want to do is define the general vicinity of the defect. To do this, simply seal off the static port (or ports) with the putty and tap into a place in the line which will isolate the panel from the rest of the system. Usually, this is done at a place where the line from the static port meets the first component under the panel. On many Cessna aircraft, the line from the port is routed to a low point where the water drain will be located. Tap into the line which will define the panel as a unit and perform the leak check again. Regardless of the outcome of this check, work backwards to the static source and check that line as well.

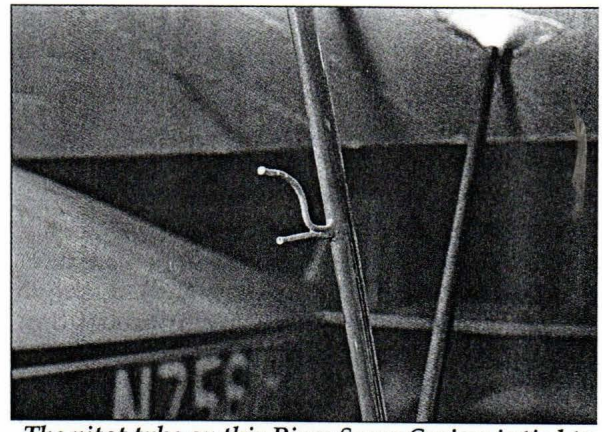
Once the leak is identified in a general way, perform the leak check again and, while a vacuum is applied to the system, gently feel around lines, fittings and unions until a sudden jump in the leak is found. Manipulating the static lines at a weak point will help isolate the offending piece and will identify those areas that could cause a failure in the future. If pulling on lines and fittings doesn't isolate the culprit, a more aggressive search will be necessary. Begin by capping off lines installed at individual instruments and reducing the size of the area to be tested. Note any change in the rate of leakage with each change in the area tested. Don't forget the possibility of instrument glass leakage. A layer of putty around the glass circumference will seal a faulty instrument or eliminate the potential for leakage. Also, check the alternate static source for a seal leak in the valve. While the valve generally won't be a problem, the fittings attached to the valve tend to "work" over time and leakage at these areas is common. It's a time- consuming job and a little

like a game of cat and mouse, but for those who enjoy tedious, intricate work and don't mind working in the bowels of the instrument panel, it can be quite rewarding. Especially when it's about 8:45 in the evening and everyone else has left the airport. You've missed dinner, had to cancel your card game with the boys and your wife has decided to shop for that new car on her own but, you found the leak!

Plugging the Hole

In November of 1957, the Russians launched a dog by the name of Laika into outer space aboard the earth satellite Sputnik II. It is not known whether the Russians were trying to determine if earth-bound organisms could survive a launch into space or if they just had a low opinion of the dog, but it was around this time that aircraft started using a plastic type of flexible tubing for instrument system plumbing. Commonly referred to as Tygon tubing, static systems are held together with this tough, vinyl material using clamps and flareless style fittings for attachment to instruments and "T" fittings. Older aircraft use low-pressure, Mil Spec hose and standard AN fittings for their static systems but the installations are bulky and hardware is heavy.

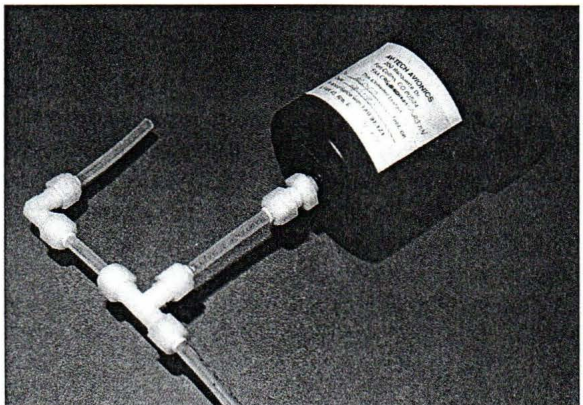
Originally introduced in 1939, there are more than eight styles of Tygon tubing, each made up of materials designed to perform in specific environments. Generally, all are flexible, heat and cold resistant, and will not corrode or otherwise deteriorate over time. Most major parts suppliers provide some pitot/static system hardware but individual pieces and parts for line repair are difficult to find, aside from ordering directly from the manufacturer. One supplier, Skybolt Aeromotive Corporation, 551 North Park Ave,. Apopka, FL 32712, phone: 1-800-223-1963 or 407-889-2613 carries a line of instrument tubing and fitting kits made from Nylo-Seal, a material made of Nylon-11 used extensively in pitot/static installations. They can supply tubing and flareless fittings as well as tees and connectors for any permanent installation or field repair.



The pitot tube on this Piper Super Cruiser is tied to the static line (on top). Note the holes drilled in the side of the static line for proper static reference.

Because repairs to leaking static lines usually involve the cutting out of a defective length and splicing in new material, the use of flareless fittings makes the job quick and easy regardless of your experience level. Simply trim the piece to be repaired, install the "B" nut and ferrule and assemble the new line to a coupling or connector. Tighten the "B" nut two to three turns only. This will force the ferrule into the female side of the connector while it grips the outside diameter of the tube. The fitting and line are now sealed. Don't over-tighten the nut and make sure the line doesn't twist during the installation.

Line terminations at instruments, water separators and alternate static sources are good candidates for replacement as time goes on. Make certain your cuts are clean and straight and position the lines so that no bend radius is less than one inch on 1/4 inch O.D. tubing. Most vinyl and nylon tubing will take tremendous pressures before bursting (compared to what you would see in the static system) but are somewhat susceptible to hardening and splitting with the application of even a little heat. Generally, plastic static lines will remain flexible at -20 F. and will work just fine to around 185 F. Any temperature higher than that will affect tube life and possibly create a hazard to system integrity. So keep the lines away from heater ducts and route with clearance around avionics stacks.



Nylo-Seal tubing and flareless fittings are standard equipment in many aircraft. Over-tightening of the fittings is a common cause of system leakage.

Pitot Lines and Airspeed

Like the static system, the pitot tub and airspeed indicator are connecte by various tubes and hoses, many which are made from the same Tygo or Nylon-11 material used in the cabi While no mention is made of chec ing the pitot system in Part 43 Appe dix E, FAR Part 43-13-1A, Chapter 1 Section 4 does recommend cleanin and pressure testing of the systen Simply plug the pitot tube vent l cated in the back or along the botto of the tube and pressurize the tub with the output side of the suction gu (if yours is one that works that way Otherwise, a regulated pressu source can be used to check the pit system for leaks. Watch the airspee indicator and adjust the needle defle tion to no more than 3/4 scale or 1 knots indicated and hold for or minute. A loss of no more than te knots is considered acceptable. An further loss is reason enough to fin the source of the leak and make th necessary corrections. Again, use ca with the pressure source so as to kee the indicator glass intact and avoid rapid loss in system test pressure.

If cleaning of the pitot tube syste is required, remove the line from th back of the airspeed indicator and us clean, regulated shop air to blow bac wards toward the pitot mast. Any di water, bugs or other varmints will b expelled during the process. For tho who experience pitot system contam nation, it might be a good idea to wra a cloth around the tube before blov ing through the system in order identify the offending debris. Knov ing your enemy is the key to winnir

(Continued on page 24, Pitot/Static)

(Continued from page 3, Engine Clinic)

The bickering from both sides by those instrumental in this issue is repugnant. Our efforts should be directed to the guy flying the airplane: Explain to him the importance of the inspection protocol, ease his mind about needed repairs and reassure him when repairs are not warranted. He's the one looking for answers, straight answers about the health of his engine. To leave him with nagging concerns about the inspection process or doubts about the manner and method employed in the repair is both irresponsible and self-serving. We owe him more than that.

(Continued from page 8, Annual Insp.)

12 months. The combination of correcting all mechanical deficiencies as they occur, complying with AD notes in a timely manner and keeping up with preventive maintenance during the course of the year will leave little to do during the annual but routine service and inspection. In this way, you can provide a safe aircraft, ready to serve at a moments notice, regardless of where you are in the 12 months before the next annual inspection.

(Continued from page 18, Fuel Injection)

sure that any adjustment to the wastegate plug has no deleterious effect on performance.

As always, if an adjustment makes no difference in the operation or if a component will not "dial in" to a target pressure, then the offending component is usually the one being adjusted. Before removing and replacing components, though, make certain that all other potential problems have been eliminated.

Given enough fuel supply and a nominal amount of engine RPM, the simplicity of the Continental Fuel Injection System will show itself in long, trouble-free operation.

(Continued from page 14, Bendix Switch)

you a better pilot, it will allow you more time to concentrate on a take-off roll that doesn't include doubts about whether you're *Left* or *Right* of the centerline.

CONTINUITY TEST
TWIST TO START

SWITCH POSITION	CONTINUITY BETWEEN
OFF	R & GRD
	L & GRD
	L & R
	S & PR
RIGHT	L & GRD
	R & UMK
LEFT	R & GRD
	R & UMK
	GRD & UMK
BOTH	R & UMK
START	GRD & UMK
	S & BAT
	L & BO
	L & LR
	BO & LR

L-------LEFT P-----POWER
R-------RIGHT S-------SWITCH
GRD--GROUND BAT----BATTERY
UMK--UNMARKED
LR-----LEFT RETARD
BO----BOOSTER OUTPUT

(Continued from page 21, Pitot/Static)

the war.

If your altimeter and transponder are due for certification, plan to check the static system a week or so before your appointment. That will allow sufficient time to acquire the necessary parts to fix your leaking system and still give you time to buy that new car.

Postmaster: Please send address changes to Light Plane Maintenance, P.O. Box 420234, Palm Coast, FL 32142.