UNDERSTANDING YOUR BONANZA FUEL QUANTITY INDICATOR SYSTEM

Fuel indicator problems in Bonanzas need not be a source of mystery and frustration. An understanding of the system will allow common glitches to be isolated and cured. Most importantly, it will make the owner far more knowledgeable when he needs to consult a mechanic. The general concept of the system design is explained below. This is followed by a step-by-step trouble shooting and repair procedure which your mechanic might use. The described procedure assumes that eighty gallon tanks (optional) have been installed. However, the forty gallon system (standard) is the same, except for a minor variation. This system was installed in models D-9060 through D-9568, excluding D-9222 through 9390. Although models D-9569 through 9817 have the same system, the circuit board (herin referred to as PC) is not physically attached to the fuel gauge. Straight tad! models had this system installed in CD-1235 through 1304, CE-290 through 470 and CJ-26 through 51. Models CE-471 through 612 and CJ-52 through 104 have the displaced PCs. Excluded straight tails are CE-350 through 408.

The fuel quantity indication system is based upon a method of reading the direct relationship between the actual amount of fuel in the tank and the resistance registered by the fuel quantity transmitter (herein referred to as transmitter). Contained within a single eighty gallon fuel tank are two transmitter assemblies. At the heart of these is a variable resistor. With the fuel tank full, both transmitters register maximum resistance. The registered resistance is varied as the float, attached to a lever arm and riding atop the fuel, causes a contact to move across a resistor winding within the heart of the transmitter. Two transmitters, wired in series, are necessary because of the wing dihedral. As fuel burns, first the outboard float drops, followed by the inboard. When approximately one-third of the fuel burns, the outboard float rests on the bottom of the tank, thereby registering no resistance. The only remaining resistance is from the inboard transmitter. Continuing fuel burn results in a progressive reduction of the registered resistance as the inboard float falls. When the inboard float reaches its lowest travel, the tank is empty of usable fuel and the cabin gauge displays "empty". The PC is the intermediary between the transmitters and the fuel gauge. The PC drives the fuel gauge and allows calibration of the system. The wire going to Pin #1 on the PC is the point of connection from the inboard transmitter. The other pins on the PC supply current and ground to the PC.

The left and right fuel tanks have identical but separate indicator systems. A properly working fuel gauge and PC on one side can be used to troubleshoot the opposite or non-working side. While this is true for the fuel gauge and PC, it is not true for the transmitters in the tanks. These transmitters, with their attached lever arms and floats, are constructed as mirror images of the contra-lateral side.

The steps described below begin in the cabin at the fuel gauge and end at the outboard transmitter. The example given with each component (fuel gauge, PC, etc.) is expressed as though the discussed component is faulty. When a mechanic is unable to return the system to operation with the isolation, repair or replacement of a faulty component, additional faults can be uncovered by continuing the search outwards toward the outboard transmitter.

A mechanic who installs good quality solderless connectors to the PCs while carefully labeling each wire will make the job considerably easier for himself, because it allows the switching of PCs back and forth to each fuel gauge. It also allows the switching of the PCs to the opposite tank leads and facilitates the replacement of PC components and their subsequent testing.

STEP #1 FUEL GAUGE

Test: With the PCs still connected to the leads from their original tanks, switch the right PC to the left gauge and vice versa.

Indication: The non-working side continues not to work while the initially working gauge continues to read correctly (it reads the quantity in the opposite tank).

Note: If the original problem switches to the opposite side, both gauges are operating properly.

STEP #2 PRINTED CIRCUIT BOARDS

The following assumes that the fuel gauge was OK when Step #1 was performed and that the problem switched to the opposite side.

Test: With the right PC still attached to the left fuel gauge, disconnect the leads attached to the right PC, replacing these leads with those leads coming from the left tank and vice versa. (This isolates the PCs.)

Indication: The problem which was initially on the right side has now switched to the left side.

Conclusion: The right PC is bad. (This is the most common problem.)

Fix: Replace PC (approximately $700) Repair PC: Your mechanic will check for the following:

A. Proper power supply to Pin #4

B. Proper ground to Pin #3

C. Replacement of any defective working part(s) if PC is in good shape. (These parts consist of three resistors, one diode, one transistor, and a variable resistor.)

D. Reinstall the PC on its original side, test and calibrate. (Since the mechanic carefully marked which lead came from which tank, he will have no problem reestablishing the proper connections).

STEP #3 WIRES AND CONNECTORS FROM INBOARD FUEL TRANSMITTER TO PIN #1.

Test: Connect one lead of ohmmeter/continuity tester to Pin #1, the other to the lead on fuel transmitter which goes to Pin #1.

Indication: High resistance or discontinuity. Determine if the problem is corrected by running a shunt wire between these same terminals (the fuel transmitter and Pin #1 on the PC).

Conclusion: Connector(s) corroded if resistance is high. Broken wire or connector if discontinuous. (Connectors are in wheel well.)

Fix: Replace defective part(s).

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STEP #4 INBOARD FUEL TRANSMITTER

Test and Indication: With fuel transmitter removed and an ohmmeter connected between the two terminals and while moving the float arm very slowly, the resistance changes in a

non-linear pattern from 76 ohms to zero. Any increase in resistance during this process reveals corrosion on the resistor winding at that position. It is this corrosion that will cause the fuel gauge to flicker toward "full" position whenever that point is reached on the winding.

Fix: Spray the inside of the rheostat assembly with electrical contact cleaner, work vigorously back and forth and retest. If not absolutely linear and regular, replace the transmitter.

STEP #5 CONTINUITY OF WIRE FROM INBOARD TO OUTBOARD FUEL TRANSMITTER

Procedure: Same as in Step #3 above.

STEP #6 OUTBOARD FUEL TRANSMITTER

Procedure: Same as in Step #4 above, but maximum resistance is 43 ohms.

Note: With standard (40 gallon) tanks, a single transmitter is used. This transmitter has a resistance of 160 ohms at maximum.

STEP #7 CHECK GROUND FROM OUTBOARD FUEL TRANSMITTER

Procedure: Clean connectors and surface. Replace if necessary.

The above described procedure will allow your mechanic to localize any problem and, at the same time, identify more than one problem (if more exist) in the fuel indication system. While there is some physical and financial hazard to looking over the mechanic's shoulder, the reassurance that your system is tested thoroughly and that any replaced component will definitely cure the problem will give the owner much peace of mind.

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ELECTRICAL PROBLEMS

In this month's column I am covering some common electrical problems that ABS members have asked me about over the years.

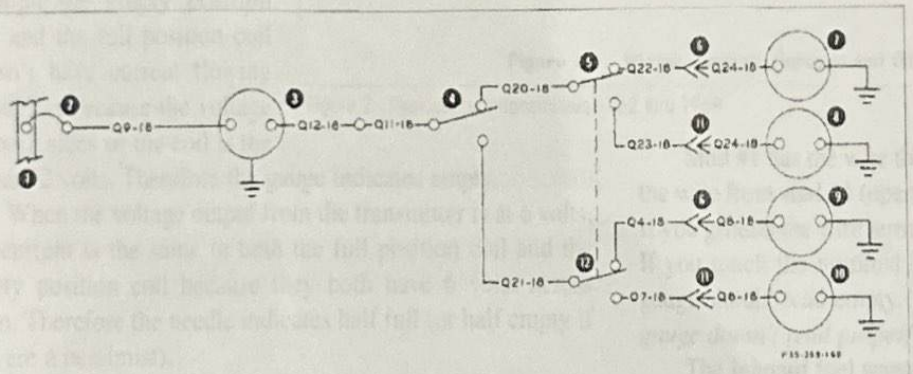
Troubleshooting fuel gauge(s) & associated components

Warning: First, an important caution is in order. The electrical system has changed so many times over the years, often within model years, that *any specific advice must be based on the serial number of the aircraft.* There are different theories of circuit operation as well as wiring interconnection that must be understood to troubleshoot a problem. I found 19 different fuel gauge circuits just for the V-tails, with a slightly lower number for other models.

Documentation: Beech has documented the wiring diagrams in the shop manuals for the early models, and in separate wiring diagram manuals after 1975. All the wires that came from the factory have identifying numbers in the following format: FNNWZZS where F is a letter identifying the circuit function area, NN is the circuit number, W is the wire segment, ZZ is the wire size and S is the suffix.

An example of a wire in the fuel gauge circuit for my 1968 V35A D8663 is Q8A18. Q is the designator for fuel and oil circuits, the circuit number is 8, the wire segment is A and the wire size is 18. There is no suffix.

With the proper wiring diagram handy, one can locate the wire, even if it is in a bundle, and know exactly what it should attach to if you refer to the wiring diagram. So if you disconnect a wire and don't mark it, all is not lost.



1. Bus bar
2. Fuel quantity indicator circuit breaker
3. Fuel quantity indicator
4. Tank selector switch (main - auxiliary)
5. Auxiliary tank selector switch (left - right)
6. Right wing break connector
7. Tank transmitter unit (RH auxiliary)
8. Tank transmitter unit (LH auxiliary)
9. Tank transmitter unit (RH main)
10. Tank transmitter unit (LH main)
11. Left wing break connector
12. Main tank selector (left - right)

OPTIONAL AUXILIARY WING FUEL QUANTITY INDICATOR CIRCUIT
Airplane Serial No. D-3999 thru D-5330

Fuel gauge circuits: There are three types of fuel gauge circuits found in the Bonanza, Baron and Travel Air. But not all variations are covered in these descriptions. I have discussed the most common systems, so you need to *verify the specific wiring diagram for your aircraft before you jump into troubleshooting the system.*

Common to all systems, good connections—especially to ground—is important and should always be checked.

Early systems: The early systems are based on a resistive potentiometer-like transmitter that is wired to a gauge that reads current through the transmitter—the higher the current, the lower the indication. Most of the transmitters are of the 30-ohm variety. When the tank is full, the transmitter will read 30 ohms to ground. When the tank is empty, the transmitter will read close to zero ohms.

On aircraft with aux tanks, there is usually a switch to select the tank indicating on the gauge and some of the earliest aircraft share a single gauge with the left and right tanks. Some of the aux tanks have two transmitters that are wired in series. For dual transmitters, each is about 15 ohms, adding to 30 ohms when full and zero ohms when empty.

To troubleshoot the system, remove the inspection panel above the fuel transmitter. Remove the wire from the transmitter that goes to the gauge. The gauge should read over full. If you short the wire to ground, it should read empty.

The fuel transmitter should read 30 ohms when full and zero when empty. You can purchase a 30- to 50-ohm wire-wound potentiometer and connect it to the wire going to the gauge and vary the resistance between 0 and 30 ohms to check gauge calibration. At 15 ohms the gauge should read half. At 7.5 ohms the gauge should read 1/4, and at 22.5 ohms it should read 3/4.

To be within specification, the gauge needle should touch any part of the E mark when empty and any part of the F mark when full.

The only adjustment in the system is by bending the arm on the fuel transmitter to obtain a better result.

1962 thru 1969 models

These models use resistive potentiometers as transmitters to provide a voltage divider function to a center-tapped gauge with two movement coils. The transmitters

are connected in series, with the high end of the inboard transmitter connected to +12 volts as a reference. One gauge movement coil pulls the needle toward the full position and the other pulls it toward the empty position.

The gauge-full position coil is attached to 12 volts through a circuit breaker. The empty position coil is attached to ground. The two position coils are connected together and are attached to the transmitter variable voltage output. *Refer to Figures 1 and 2 for the following description.*

When the voltage output from the transmitter is at zero volts (ground), all of the current flows thru the full position coil and the empty position coil doesn't have current flowing through it because the voltage on both sides of the coil is zero. Therefore the gauge indicates full.

When the voltage output from the transmitter is at 12 volts, all of the current flows through the empty position coil and the full position coil doesn't have current flowing through it because the voltage on both sides of the coil is the same, 12 volts. Therefore the gauge indicates empty.

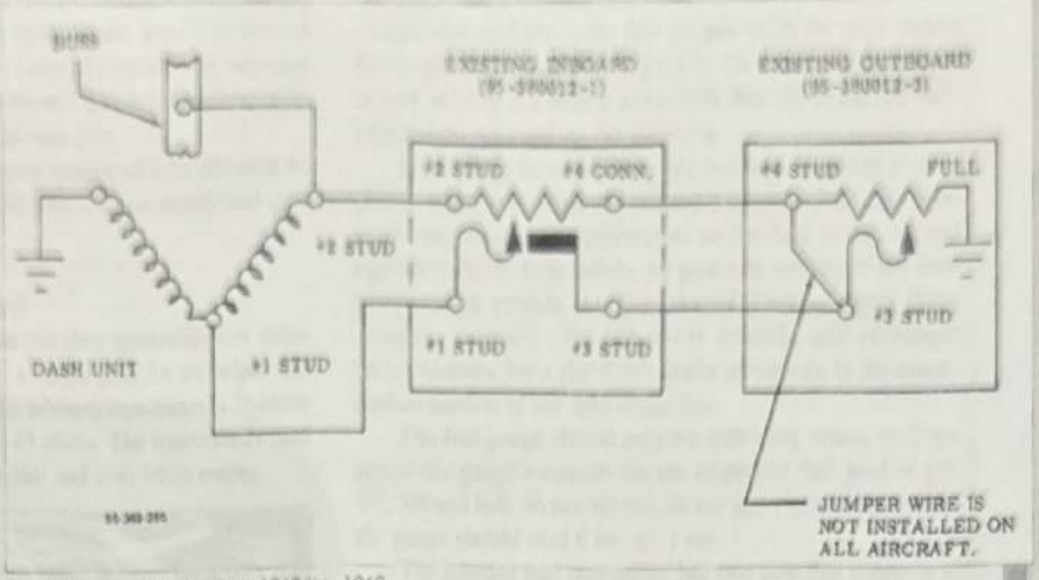


Figure 1 - Original transmitters 1962 thru 1969

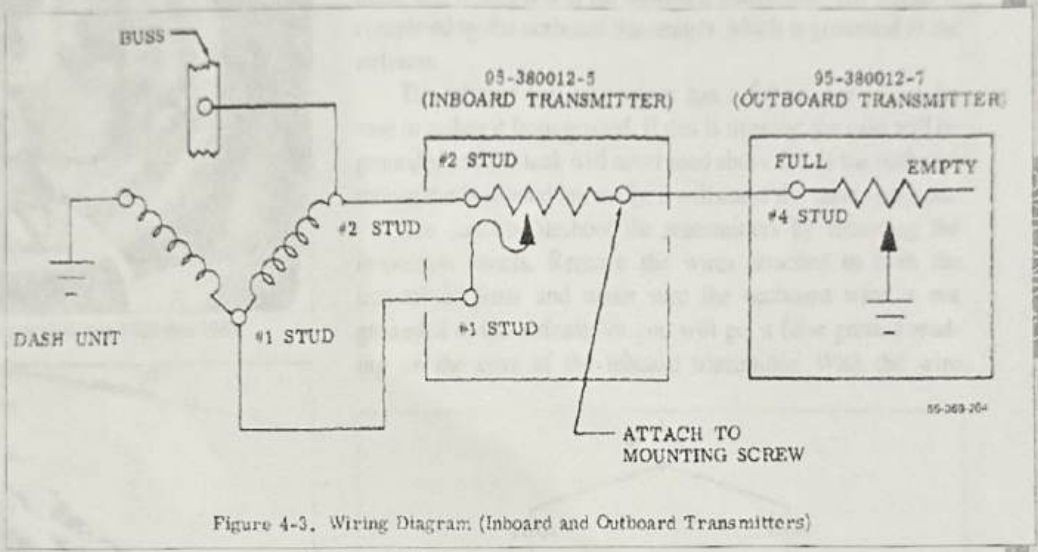


Figure 4-3. Wiring Diagram (Inboard and Outboard Transmitters)

Figure 2 - Replacement transmitters 1962 thru 1969

When the voltage output from the transmitter is at 6 volts, the current is the same in both the full position coil and the empty position coil because they both have 6 volts across them. Therefore the needle indicates half full (or half empty if you are a pessimist).

There are two vintages of transmitters and they can be intermixed. The *original transmitters* have four studs (inboard) and two studs (outboard). The *replacement transmitters* have two studs (inboard) and one stud (outboard).

To troubleshoot the system, remove the inspection panel above the inboard fuel transmitter. With the master switch on, verify that you have +12 volts on stud #2 of the transmitter.

Stud #1 has the wire that goes to the gauge. If you remove the wire from stud #1 (open), the gauge should read half-scale. If you ground the wire terminal lug, the gauge should read full. If you touch the terminal lug to the #2 stud (+12 volts), the gauge should read empty. Turn off the master switch. *If your gauge doesn't read properly, have it overhauled.*

The inboard fuel transmitter case should be isolated from ground by a felt washer (Figure 3). If it is not, the gauge will read full until the actual fuel level is close to 2/3 and then will move the rest of the way faster than the change in the fuel level, although it will read correctly when the tank is empty.

Remove the wire attached to the case and that connects to the outbound fuel transmitter. Verify that the case is not grounded. If the case is grounded, reseat or replace the felt washer.

With the wire from #1 stud and the case still removed, the resistance between the #2 stud and the case should be around 76 ohms. The transmitter wiper (stud #1) should vary between the full resistance value (when empty) and zero, reaching zero well before being topped off (around 2/3).

The outboard fuel transmitter measured between post #4 and the case should be about 43 ohms when empty and zero when full.

1970-and-after models

The later 40-gallon systems use dual transmitters in series with one another. There is only a single post for the wiper and the case is the other terminal. The inboard transmitter is 76 ohms and the outboard transmitter is 43 ohms. The transmitters read 119 ohms added together when full and zero when empty.

Figure 3 - Inboard fuel transmitter - replacement style 1962 thru 1969

Figure 4 - Printed circuit modules 1970 and later

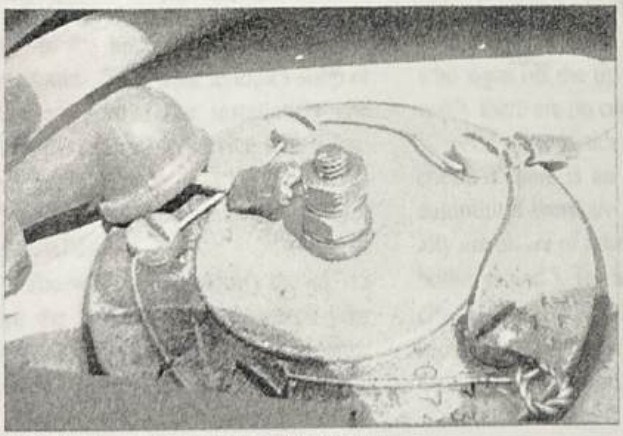


Figure 5 - Inboard fuel transmitter 1970 and later

Each side's transmitters are attached to a printed circuit module mounted above the fuel gauges under the angle mount for the glareshield support (Figure 4). On the rear lefthand side of each module is a slotted adjustment that allows the full indication to be adjusted on the indicator.

If the gauge becomes flaky and bounces around or is completely dead, it is often the printed circuit module. It is relatively easy to swap the connectors on the back of the left and right modules to help isolate the problem module. If the fault goes with the module, it is time to send it out for repair. Birks Aviation Products (309-686-0614) rebuilds and exchanges these modules for a flat $430. Birks advertises in the classified-ad section of the *ABS Magazine*.

The fuel gauge should read the following values +/- 2 mv across the gauge terminals for the respective fuel load of 1/4, 1/2, 3/4 and full: 36 mv, 60 mv, 86 mv and 103 mv. For empty, the gauge should read 6 mv +/- 1 mv.

The inboard fuel transmitter has one post that connects to the printed circuit module (Figure 5). The case is the other terminal and is attached to the outboard transmitter. The circuit is completed by the outboard transmitter, which is grounded to the airframe.

The inboard fuel transmitter has a felt washer under the case to isolate it from ground. If this is missing, the case will be grounded and the tank will never read above 2/3. If the outboard transmitter is shorted internally, it will cause the same symptom.

You can troubleshoot the transmitters by removing the inspection panels. Remove the wires attached to both the transmitter posts and make sure the outboard wire is not grounded to the airframe or you will get a false ground reading on the case of the inboard transmitter. With the wire

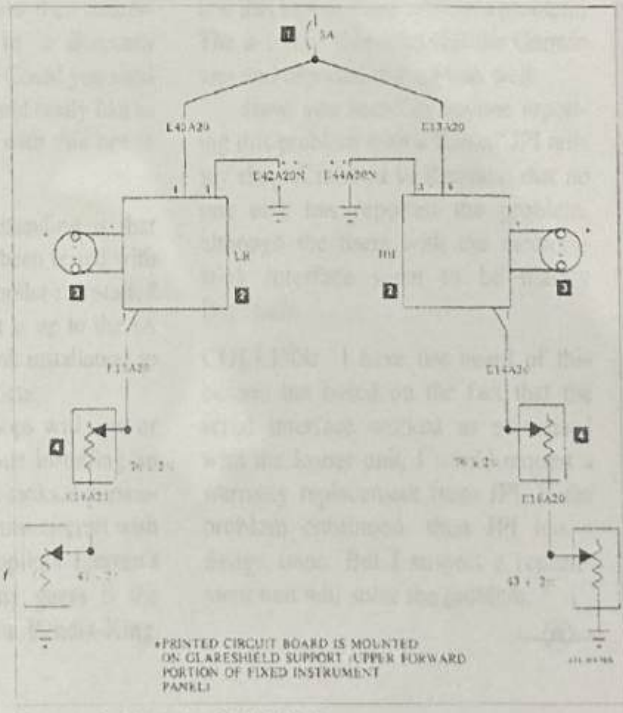


Figure 6 - Fuel indicating D9569-D9817

removed from the inboard fuel transmitter, the gauge should read above full. With the wire shorted to ground, the gauge should read empty.

When the tanks are full, measure the resistance of the inboard transmitter from the post to the case and verify it is close to 76 ohms. Verify the case is not shorted to ground; if it is, verify the felt washer is installed and isolating the case from ground.

Verify the outboard transmitter is close to 43 ohms, post to ground. If you remove the transmitters, they should smoothly vary in resistance between zero and the maximum value as they are moved through the float arm range.

If one or both of the fuel transmitters or a gauge needs to be overhauled, Airparts of Lock Haven (1-800-443-3117 - http://airpartsoflockhaven.com/) is one company that can perform the overhaul. There are other companies that provide the same service.

In future columns, I will offer troubleshooting tips for electroluminous panels (EL panels) and false alternator-out indications.

John Collins, Charlotte, North Carolina, owns a 1968 V35A. He is a commercial pilot with more than 4,000 hours, has a BS in electrical engineering and has worked as an engineer and software developer for IBM and for his own technical business. John owned and operated an FBO, with avionics shop, for six years.

AVIONICS Q&A

ABS MEMBERS SEEK ANSWERS FROM JOHN COLLINS TO THEIR AVIONICS QUESTIONS

JAMES DEVANY, Joyce, WA, is installing a KLN-94 with an NSD 360 for IFR operations in his G35. He explains that he has had a VFR KLN-89 prior to this. His question:

Do you know of an STC I can use as a reference on the POH supplement? Or is a better plan to get a Field Approval for POH and FAA Form 337 purposes?

COLLINS: All the information you need is available free on the Honeywell Bendix-King website, but you need to have your dealer download it. My dealer will do it free when the documents are on their website and are available for free download, as is the case for you. Your local dealer should also be able to get it for you free. Ask for a copy of the latest install manual that has an appendix with the Sample AFMS and it references an STC on a Mooney.

Follow any of the relevant instructions in the install manual for an IFR installation. Then your avionics shop or IA can approve the installation and return the aircraft to service with a logbook entry, a placard stating the GPS is VFR only and an appropriate 337 for the installation.

You will need to modify the AFMS from the install manual to match your installation and submit it with a separate 337 to your FSDO requesting a field approval. Once it is returned, you can remove the VFR-only placard and replace it with one called out in the manual.

The shop or the IA returns the aircraft to service for IFR by signing the field-approved 337.

MICHAEL LEBLANC, Orangeville, CA, noticed on the May 2008 *ABS Magazine* cover that Jim Greene had tip tanks installed on his Bonanza and mentioned he had an S-Tec 30 autopilot installed. He says:

I was told by my avionics people that S-Tec would not allow their autopilots to be installed in a Bonanza equipped with tip tanks. Could you shed some light on this? I would really like to upgrade my 1952 C35 with this newer autopilot.

COLLINS: My understanding is that the S-Tec's STC hasn't been tested with tip tanks. Often the autopilot is installed before tips are added. It is up to the IA who signs off the tip tank installation to verify there are no conflicts.

Not all avionics shops will care or check if there is an issue installing an autopilot if there are tip tanks. I personally am aware of numerous aircraft with both tips and S-Tec autopilots. I haven't checked into it, but my guess is the same would be true for Bendix-King, Century and Garmin.

JEFFREY QUIN, Camarillo, CA, installed a new JPI EDM 760 last year in his 1977 95-B55 and reports that he is still having problems with the Garmin 400 interface. He says:

Using takeoff power, the RS-232 interface between the EDM 760 and GPS 400 goes down. The JPI unit has the memory stick download. I assume the higher fuel flow causes the issue. When power is reduced to a cruise setting, the interface starts working again.

I used a loaner unit with the standard download interface (not a USB) and this unit worked without a problem. The avionics shop checked the Garmin unit and reported that all was well.

Have you heard of anyone reporting this problem with a Baron? JPI tells my shop (Cruiseair in Ramona) that no one else has reported the problem, although the users with the memory-stick interface seem to be mainly Bonanzas.

COLLINS: I have not heard of this before, but based on the fact that the serial interface worked as advertised with the loaner unit, I would request a warranty replacement from JPI. If the problem continued, then JPI has a design issue. But I suspect a replacement unit will solve the problem.