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Aircraft Batteries and Electrical Systems

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In-flight Problems

Airborne, VFR

Electrical failure when VFR should not be too big a deal. If the alternator quits and some battery power remains, conserve it by shutting everything off. If the system shows low voltage, and the alternator is still working (and ammeter/voltmeter readings are not alarming), lighten the load as much as possible, but don't shut the alternator off, because you might not be able to restart it if the battery is really cooked.

If you lack handhelds, or if their batteries die, navigate by good old pilotage and dead reckoning, both of which still work remarkably well! When you find a place to land, bring the radio on briefly if possible to announce intentions. If you're fully nordo, stay away from airspace requiring a transponder or clearance to enter, unless it's real emergency. If you do approach a controlled field, use the procedures described in the AIM. Don't forget to cancel a VFR flight plan, flight following, or radar service.

Airborne, IFR in or near VFR Conditions

This should not be a big deal, either. If you have a transceiver or cell-phone, get busy with it (see list of numbers attached), but don't expect too much. Handhelds are weak; cell-phone calls from the air sometimes get rejected or dropped by the cellular systems, batteries die. The IFR rules and the AIM say what to do. If you can't complete the flight per your clearance as last updated, land VFR right away somewhere and cancel.

Airborne, IFR in real IMC Conditions

With a failure in tough en-route instrument conditions, or in the midst of an approach being conducted in actual IMC, you have a much bigger problem. Don't just fly on, hoping you will make it in before everything quits. While airline crews with stone-dead electrical systems have been known to complete flights to major cities and make letdowns and landings without the passengers being any the wiser, accomplishing this assumes reasonable ceilings and visibilities down below, plus a fair amount of skill. If you won't have decent conditions, or if your blundering on might require clearing metro airspace during rush hour, everybody will be much happier if you divert to someplace with good VMC (which you should be able to reach with watch and compass alone, if need be!).

Some Things Not to Try

Sure, use your handheld, your cell-phone, or your portable GPS, but short of the kind of emergency you should never be caught in, *don't* try to fly instruments or make an approach with these gadgets. It ain't legal, but mainly, it ain't safe. You have no

assurance at all of accuracy or battery endurance, you can't crosscheck indications, and you're probably not practiced. Then too, the gadget you're using might get smashed on the control wheel in turbulence and spill its batteries (this has happened!). Using portable gadgets to help with an ATC supervised letdown to MSA could be contemplated, but you don't want to bet the farm on being able to follow some obstacle-filled approach course with them. Neither do you want to try to execute a PAR approach on a handheld, except in dire emergency.[2]

Carrying an auxiliary battery in a satchel to plug into the aircraft bus (like some old-time pilots apparently did) is not a wonderful idea, either. Sure, it might give you a few extra minutes of radio, but a carting around a loose, live, lead-acid battery with jury-rigged connections is asking for a fire, a spill, or a smash, and it would be heavy. Much the same goes for dry batteries, which would be very expensive, besides.

The triangle-flying described in the AIM is a holdover from the ancient days. It could be tried, but it is said that it's more or less useless. Know where you're going to run to, and then go there.

AOG Situations

In electrical AOG situations, there are many more options than there are in the air. It's best to let the mechanics do the work, in their time-proven, standard ways, if possible. If you do get involved, be careful. Also do not be "excessively creative" or too clever by half. Aircraft batteries and jump-start power supplies can do bad things, and the prop is a murderous cleaver just itching for a victim.

Weak Battery Discovered in Airplane

When starting with a known or suspected weak battery[1], use a good starting procedure to make the most of what you might have left. Preheating the engine will definitely help. Warming the battery will help (but not as much). Especially with our current Cessnas, it should never be necessary to grind and grind with their starter.

If the engine can't quite turn over, tie down, put someone knowledgeable on the brakes, and put the keys in your pocket, then pull the prop through many times, perhaps leaving it in position where the next compression stroke will not one of the tougher ones. Untie, get back in, and use the starter motor to rock the prop against compression. All you should need is for one blade to make it through the spot where the magneto impulse coupler clicks. Properly set up to fire, the engine will always go right away.

If the battery is basically OK, but has been ground down from too much cranking, give it a rest. Go have a cup of coffee. Any gross flooding of the engine by excess gasoline will dissipate, and the water formed down in the battery plates will diffuse out and be replaced by fresh electrolyte. The plates themselves will depolarize a bit, leaving the battery ready for another crank or two (but that's about all you'll get!). Limber things up and set the engine set up to fire instantly. Maybe you will be lucky. It's worth a shot!

As described in the battery material, the heavy charging the alternator will do after a hard start is rough on the battery, and perhaps on the rest of the electrical system too. If the battery does get discharged, slow recharging with a battery charger is much better for it.

After getting a start, always check right away for starter-motor disengagement (no ring gear noise, no wonky meter readings). Also, after a hard start, make sure the alternator stays on line during run-up and takeoff. The heavy charging current being drawn may make the voltage regulator think there's trouble, and shut the alternator down.

Jump Starts [See Hazard Precautions in Battery writeup]

If the battery is not frozen, some places you can call the line-men and their battery cart for a jump start (or line up a pair of 12-volt automobiles, or use an automobile plus an extra 12-volt battery, or two 12-volt batteries, or a spare 24-volt battery) -- but be sure you know the full jump start drill.[3] If using two automobiles, it may be best not to run the car engines, but to use passive battery power alone. The automobile alternators can put out a lot of poop, and may cook the aircraft battery if its voltage is down.

Always supervise any jump start attempt closely. Make sure the right voltage as well as the right polarity is about to be connected! A 12 volt cart will not be able to start a 28-volt airplane. On the other hand, a 24-volt battery cart could burn things out in a 12 – 14 volt airplane. (The ordinary battery charger can't crank an engine at all.) Ignorant line-boys may not have a solid grasp of these fine distinctions! They will cheerfully hook up anything to anything.

Be sure the avionics are off! Use the auxiliary power plug and observe the POH-mandated sequence for inserting and extracting the plug and switching the master on and off. Disconnecting a plug or shutting off the master in wrong sequence can produce a nasty inductive kick that can walk right through the electrical system and wipe things out.

When doing a jump-start, be sure everyone involved knows exactly what's expected of them, and knows what to do if things aren't working out (e.g. fire, sudden need to shut down, etc.). Never let passengers or other unqualified people help! Make any such people stay far away, or get inside with you.

Don't trust that naïve passengers, children, automotive types, girlfriends, bystanders, or inexperienced people will have actually absorbed much of anything that you may have told them about the danger from the prop! (See API material on propeller discipline.) Even holding the brakes may be beyond them (as the famous video clip of a starting accident shows, where the passenger obviously didn't realize that she needed to hold the brakes with *both* feet.)

After a successful jump start, leave everything connected. Do not allow anyone to go near the turning prop! Even experienced people have been known to walk right into the invisible propeller disk when reaching for the power plug or the wheel chocks. Run the

engine at 1000 rpm until it has warmed up and the battery has taken on enough charge to crank the engine again. Then shut down and unplug everything in safety, peace and quiet. You and anyone helping you must absolutely not screw up! You really, really don't want a prop accident!

Hand-Propping

The same remarks apply to hand-propping. Most places won't allow their line-people to have anything to do with it, for very good reason. Never hand-prop and engine unless you are fully checked out to do so! (And even then, it's not a great idea!) As for you yourself, DO NOT PROP unless you absolutely know and can follow the full drill, with a qualified person both inside and outside. Use a good cold start procedure, so that it takes only a twitch to set the engine running. Never trust the inside guy. Push on the nose to check the brakes, and make him show you the keys. Don't be in there bellying up close to the prop to pull it through, and never hook your fingers over the blade!)

Even if you do manage to get the engine started this way, you may still not like the result. If the battery is really down, the alternator may not "catch", leaving you a crippled bird to ferry with no electric instruments and no avionics. Far better to remove the battery and take it (and yourself) somewhere to get warmed up and fully charged.

Removing the Battery to Put It On Charge

In cold weather, if you're stranded with a dead or dying battery, if you haven't already tried to start the engine (which will take care of the problem), it's useful to use the battery's last gasp to briefly engage the starter motor on the airplane before removing the battery, so that the bendix gear will be engaged and ready to crank the engine when you return with the battery all charged up.

As noted in the battery writeup, when removing the battery, be careful to avoid shorts with tools and jewelry. Remove the ground strap first. Don't let the stiff and heavy battery leads fall back down on the terminals after you have disconnected them!

Ideally, the battery should be taken to an aircraft maintenance shop for charging, but in a pinch, it can be taken to a gas station for a slow (2 – 3 ampere) overnight charge. Unscrew the caps so that the explosive gases can easily escape from the cells. Avoid letting dirt or contamination of any kind get into the cells! At the gas station, you may need to intervene forcefully to prevent ignorant auto mechanics from trying to give it a quick-charge! One of those 100-ampere automotive quick-chargers will almost instantly boil all the electrolyte out of the battery and set off an explosion!

If possible, check the charging process from time to time to make sure cell temperatures haven't become excessive, and watch for the onset of gassing and specific gravity increase that says the battery is reaching full charge.

Wear eye protection, and keep your face away from open cells. [See battery writeup for full safety precautions.]

Charging the Battery While It Sits in the Airplane

Follow POH instructions for connecting the charger to the battery via the auxiliary power plug cable. That way you will have the protection of Cessna's built-in circuit features that will counter mistakes like connecting up the wrong polarity.

Some chargers have their own protective circuitry, which can get tripped off when it encounters the protective circuitry aboard the aircraft. In that case, resist the temptation to connect the charger directly across the battery as it sits in the airplane. You may blow the 5 amp battery contactor fuse. Sparks and shorts of other varieties may occur if the clips jump off the terminals. You don't want any arcs or sparks to occur in a confined space like the aircraft battery compartment!) Remove the battery and charge it away from the aircraft.

Some "Creative" Things Not To Try

Batteries can be charged from any source of DC current that can develop a high enough voltage to force current back through the cells. (With an uncontrolled source, the current will generally need to be limited with a suitable resistor.) Some of these sources, though, can be pretty dangerous. No unorthodox source should be used with the battery sitting in the airplane!

Out in the boondocks, at truck stops, or at certain shade-tree establishments, charging batteries with DC arcwelders, plating rectifiers, MG-sets, or jury-rigged circuits is not unknown, but don't let anyone do such a thing around the airplane.

In the case of arc-welders, if circuit continuity is lost, there will be a substantial arc. Welder open circuit voltage will rise to maybe 75 volts (risking another big spark upon reclosure). If someone forgets and leaves the welder's RF arc-initiation circuit on, the powerful spikes will cause an arc down inside the battery and blow it up. The typical arc-welder's controls won't go as low as 2 or 3 amps. Even though charging with an arc welder through a current limiting resistance will work, *don't* let anybody use an arc welder on an aircraft battery!.

Charging with anything connected without isolation to the AC line is very dangerous too! An example would be a 50-watt light bulb or other resistor in series with a diode plugged into the house current. Yes, it works, but contact with the hot side could kill anyone touching ground at the same time. Also, accidentally getting house current across the battery would be disastrous.

Using two 14-volt automobiles in series with their engines running to charge a 24-volt battery (again, with the battery removed from the airplane!) might work, since the automobile batteries and voltage regulators would tend to limit the total voltage, but as

noted above, car alternators can put out enough current to cook an aircraft battery. The setup would need to be checked carefully to be sure that excessive current would not flow, particularly with a flat battery. A current limiting resistor (~ 1 ohm, 25 watts) might be necessary. Without exact knowledge of what will happen, or a way to measure current, aircraft battery charging with automobiles is not a good idea.

While a 24-volt aircraft battery could conceivably be charged one 12-volt section at a time from a 14-volt automobile or battery charger, this would require gaining access to the cell plates or tie-bars at the midpoint of the 24-volt aircraft battery. Doing this would be extremely hairy, and would require drilling into the battery case to contact a tie bar, or reaching inside a cell with a (chemically-pure lead!) conductor to make a secure contact that must never be allowed to spark. Such things must *never* be attempted! Don't drill into the tie-bars, don't reach inside the cells with anything except a cell-tester, avoid doing anything that would result in an internal spark!

In a similar vein, the poor-man's stunt of strapping out the dead cell in a dying car battery and running the car on the remaining good ones has no merit whatsoever. Yes, it would probably work[4] but the maximum-output alternator current that would be commanded by the voltage regulator would soon fry the remaining cells or do bad things to the alternator and regulator.

Short of trying to escape from imminent atomic attack, maneuvers like any of the foregoing really have no place at all in Airplane Land! The only reason to describe them here is to warn of their existence, and head off their ignorant or ill-considered use.

Notes

1. If the battery is fully charged, and can run the lights and radios, but can't crank, the problem may be loose or corroded connections. This problem can occur with elderly automobile batteries in hot, humid weather. It shouldn't happen with the more carefully sealed and protected terminals of aircraft batteries, but even so, it may pay to check tightness and cleanliness of battery connections, including all current-carrying grounds, every great once in a while.

2. As a backup for lost comm, handheld transceivers are weak, and their nav capabilities (if any) are notoriously inaccurate and hard to use You will often hear it said that contacting ATC or an FSS via cell phone is a more successful ploy than using a handheld transceiver. That may be true. Cellphones, however, can be refused service if the signal hits too many ground stations at once, which can happen at altitude. If you do use a cell phone to dial an FSS, use the local area-code number of the FSS you are trying to reach. Using a Boston-based cell phone to dial the universal 800-number will only get you Bridgeport, no matter where you are in the USA (and the 800 number won't work at all in Canada). I suppose Bridgeport could relay messages to ATC somewhere in the hinterlands, or dig up their number for you to call directly, but things would get complicated. Best to have a table of US local-area ATC and FSS numbers with you.

3. When charging or jump starting, the positive (red) auxiliary power cable connection goes to the positive (red-identified) terminal of the jump-power source. The negative side similarly: black goes to black, or if using an automobile, black goes to engine-block ground (assuming negative ground).

Do it the other way around, and you will be about to short out the (up to) 48 volts resulting from accidentally connecting, in series, the aux source and battery to be jumped. (Even though discharged, the battery to be jumped may still be capable of considerable output! In any case, it will still have a low internal resistance, meaning that large short circuit currents can flow.)

In the airplane, a protective relay between aux power plug and battery forestalls this unfortunate eventuality, but there is nothing to prevent it if the power source is connected wrong way around directly to the battery to be jumped. If you mistakenly go ahead and do this, the result will be a very energetic, high-amperage, short-circuit "Kaplow!" This you don't want!)

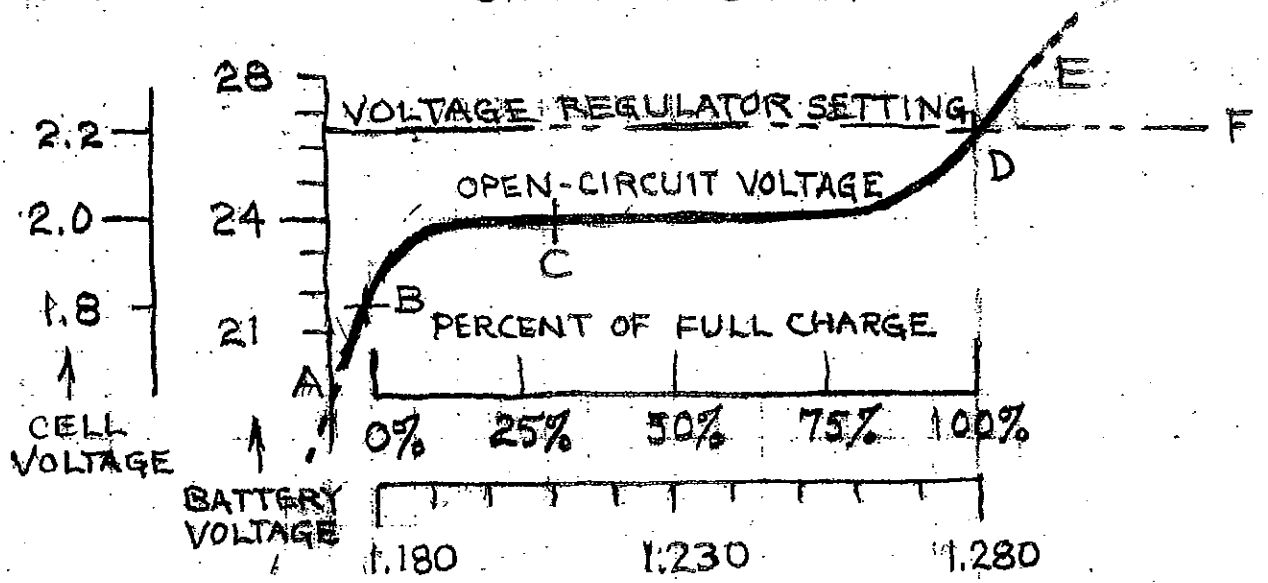
If connecting two 12-volt batteries in series to get 24 volts, then you *do* want to put the 12-volt batteries in series before hooking them up to the discharged 24-volt battery. Just as it is done in a flashlight, the series connection is made by connecting the positive terminal of one source battery to the negative terminal of the other source battery (with just one single-wire cable, going to just one terminal of each battery -- only!). Then, to make the jump-start (parallel) connection, the remaining two 12V battery source terminals (one positive, on the one battery; the other negative, on the other battery) are connected to the corresponding positive and negative cables of the auxiliary power plug, or to the corresponding terminals of the battery being jumped, as described above.

Similarly, if connecting two automobile-installed 12-volt batteries in series in order to jump-start a 28-volt airplane, negative (ground) side of one car goes to positive (hot) side of the other car. (Both cars are assumed to have the same (negative ground) polarity, and they are assumed not to be connected to one another in any other way. Bumpers, for example, must not touch). Note that actually trying to charge an aircraft battery this way with the automobile alternators might be too "creative," as discussed above.

4. Running an old jalopy on a 12-volt car battery with a dead cell strapped out was one of several scungy, money-saving measures taken by its college-student joint-owners many years ago. The remaining cells could easily start and run the car and its radio. (The lights worked too, but were a little dim until you got the engine going). Charging rate was limited by a resistor; and the battery had to be nursed a bit, but the thing passed state inspection and survived all through a Boston winter, and even made successful (daytime) runs to NYC and Philadelphia. (Such stunts, of course, have absolutely no place in Airplane-Land!)

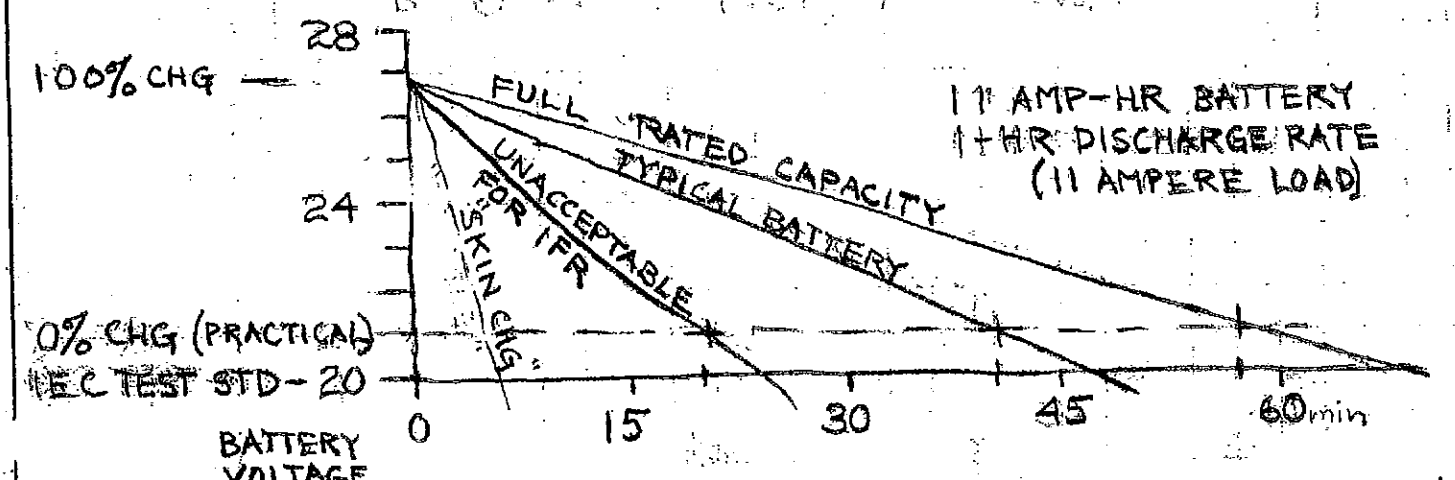
SOME IMPORTANT BATTERY CHARACTERISTICS

STATE OF CHARGE

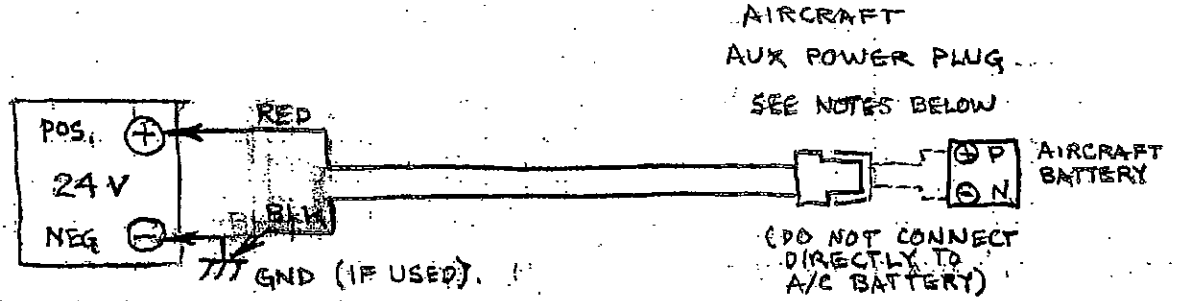


A. BATTERY LOW OR FLAT, RISK OF SULFATION
B. BATTERY DISCHARGED, NEEDS PROMPT RE-CHARGE
C. BATTERY IN NEED OF MAINTENANCE-CHARGING
D. BATTERY FULLY CHARGED
E. BATTERY OVER-CHARGED, CONSUMING WATER
F. VOLTAGE LEVEL SET TO PRODUCE FULL CHARGE

BATTERY CAPACITY TEST, VOLTAGE vs. TIME UNDER LOAD



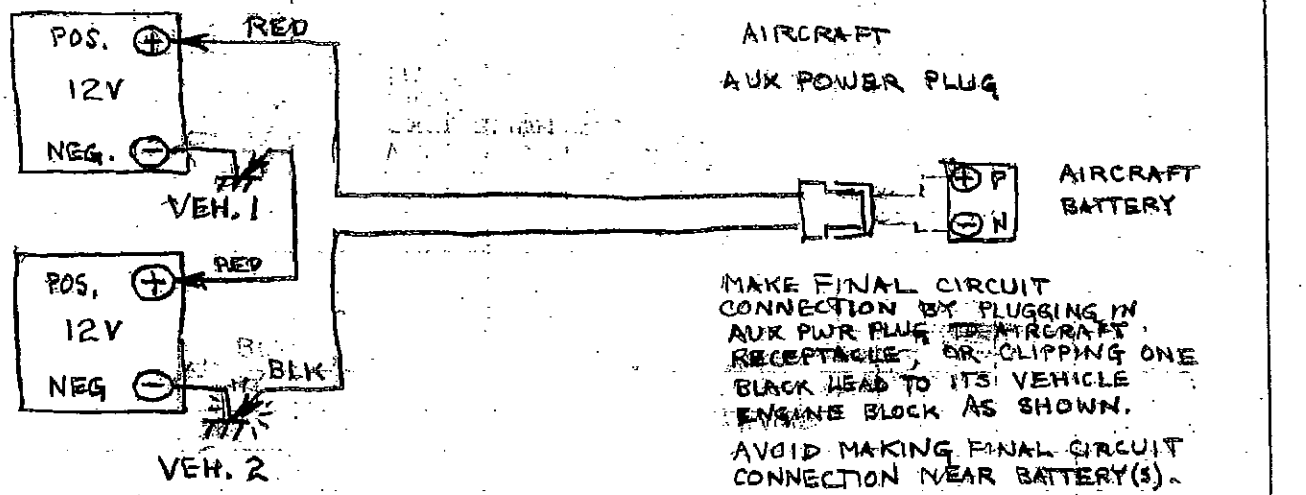
BATTERY CONNECTION DIAGRAMS



24-V BATTERY CART — FOR STARTING
— OR — — FOR PROLONGED GROUND OPERATION OF AVIONICS.

24-V BATTERY CHARGER — FOR CHARGING AIRCRAFT BATTERY

→ ALWAYS WEAR EYE PROTECTION ←
→ ALWAYS SHUT AVIONICS OFF WHEN MAKING/BREAKING CONNECTIONS ←
→ FOLLOW POH INSTRUCTIONS ←



TWO 12-VOLT AUTOMOBILES OR AUTOMOBILE BATTERIES — FOR STARTING
— FOR PROLONGED GROUND OPERATION OF AVIONICS

NOTE: GROUND OF VEHICLE 1 MUST NOT BE CONNECTED TO GROUND OF VEHICLE 2 IN CIRCUIT SHOWN ABOVE

JUMPING OR TRYING TO CHARGE A DEAD AIRCRAFT BATTERY WITH AUTOMOBILE ALTERNATORS RUNNING MAY NOT BE A GOOD THING TO DO. CHARGING CURRENT MUST BE LIMITED TO A SAFE VALUE FOR THE AIRCRAFT BATTERY

BEST TO MAKE FINAL CIRCUIT CONNECTION AWAY FROM BATTERIES, TO VEH. GND AS SHOWN, OR BY JOINING CLIPS AT FAR END OF 2-CONDUCTOR BATTERY CABLE USED AS (SINGLE) SERIES CONDUCTOR BETWEEN BATTERIES, OR BY PLUGGING AUX. PWR. PLUG INTO A/C RECEPTACLE.