OPERATIONS AND MAINTENANCE MANUAL

FOR THE

RST-442C 2-CHANNEL
RST-445 4-CHANNEL

INTERCOM SYSTEMS

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A PRODUCT OF:
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A. INTRODUCTION

The model RST-442C, 2 channel or RST-445 4 channel intercommunications system is a build-it yourself piece of avionics equipment designed to give many hours of reliable use. The 442C and 445 intercoms may be carried from aircraft to aircraft as portable units.

The 442C intercom is easy to assemble; all components are mounted to one small printed circuit board or the chassis of the intercom. It is a fully complete voice-activated system which allows pilot-passenger or student-instructor conversation to take place with a minimum of interference from engine noise, wind noise and other outside distractions. The 445 intercom simply adds a remote chassis with connectors for the #3 and #4 passenger headsets. All electronics are still contained in the main chassis.

The intercoms may also be plugged into the aircraft radio circuitry so that the aircraft radio(s) may be used for both receive and transmit simultaneous with intercommunications. Depending on the desires of the instructor or pilot, the intercom may be used for pilot OR copilot/student or pilot AND copilot transmission on the aircraft radio(s). This feature allows either or both the pilot and copilot to serve as the communicator. Some uses of this feature would be copilot handling radio duties during cross-country flights, student radio operation with instructor override, and student monitoring an instructor's transmissions. Both pilot, copilot, and all passengers can hear both sides of all transmissions.

Several convenience features have been designed into the kit - any standard civilian aircraft carbon or transistorized boom-mike headset may be used with the intercom, power supplies from 11 to 32 volts DC (14 OR 28 volt systems) with no changes to the intercom, up to 50 hours operation on a single 9 volt transistor battery for no-electrical system or truly portable operation, tape recorder inputs and outputs for music or instructional playback as well as "cockpit voice recorder" recordings. The "tape" input circuit is deactivated if there is a signal present on the radio or any headset microphone.

In addition, The RST-442C has an adjustable master volume control and a front-panel squelch control to eliminate annoying background noise.

Specifications:

1. Size: 10 x 5.5 x 4 cm (4 x 2.1 x 1.5 in).
2. Weight: 442C 170g (6 oz) 445 280g (10 oz).
3. Power: 8 to 32 volts DC 8 10 mA (squelched) ® 25 ma (full output).
4. Microphone input: Carbon or transistorized CIVILIAN (*) aircraft microphones.
5. Radio and tape input: High level inputs from speaker or headphone circuits.
6. Phones output: 8 volts P-P across standard 150 ohm headsets (40 mW).
7. Tape Recorder Output: 8 volts P-P, 100 K ohms output impedance.
8. Operating temperature: -30 to +60 degrees C.
9. Operating altitude: -.15 to 6 km (-500 to 20,000 ft).

(*) NOTE: Military headsets will not work with this unit, nor can the circuit be modified to make them work. RST does not recommend the use of military headsets with any of their equipment, nor do we have any data on circuits to convert them for civilian use.

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B. LIMITED WARRANTY

Limited warranty means that RST limits the warranty to full and complete repair or replacement of components as described below. We are proud of our record of providing reliable, inexpensive avionics that WORK.

Our attorney, a SMEL-CFII ex-fighter pilot who builds and uses our products in his own single-engine Cherokee has tried to make our warranty as plain and easy to read as he could. Here it is:

1. For 30 days after initial shipment, you may return the completely unassembled kit for a full refund, less freight.

2. For 365 days (one year) after initial shipment, RST will repair or replace, free of charge, any components in this kit that fail due to defects in materials or workmanship. You may obtain parts or service by writing or telephoning the Product Service Group at the address below. We will pay premium routing shipping charges to get those parts to you anywhere in the world. We understand the value of your aircraft time.

3. For an additional 365 days (the 2nd year) RST will replace any defective parts returned to the RST factory postpaid.

4. For as long as the equipment remains airworthy, the original owner and any subsequent owner shall have the use of the Lifetime Lab Consulting Facilities of RST at no charge for advice on installation and applications. (Sorry, no collect calls).

5. The RST warranty does NOT cover, and we are not responsible for, damages caused by using acid-core or solder other than as supplied by RST, modifications except as described in the "Applications" section of this manual, errors in assembly, fire or misuse of the kit. Our warranty does not cover reimbursement for your time on assembly or repair. We do not warrant any rechargeable battery except as warranted to us by the battery manufacturer.

6. This warranty covers only the RST product, and is not extended to any other product, equipment, component or vehicle to which it may be attached, interconnected or used in conjunction with. WE ARE NOT RESPONSIBLE FOR INCIDENTAL, IMPLIED OR CONSEQUENTIAL DAMAGES. Some states do not allow the exclusion or limitation of incidental or consequential damages, or the duration of an implied warranty, so the above limitation or exclusion may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

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C. CONSTRUCTION AND ASSEMBLY TECHNIQUES

1. Common Practices

There are certain techniques which the avionics industry uses in construction because they are efficient, reliable and proven. These techniques all come under the general heading of "common practice". These techniques will help you to achieve "professional" results of which you may be duly proud.

a. Tools

There are certain tools which are mandatory for constructing this kit, and others which are highly recommended.

Mandatory:

1. Long Nose Pliers (2")
2. Diagonal Sidecutters (Wirecutters)
3. Small Slot Screwdriver
4. Medium Screwdriver
5. Gas Pliers or Slipjoint Pliers
6. Pencil Soldering Iron with 40-50 watt tip (60 watt MAXIMUM)
7. Wire stripper
8. Crescent Wrench (1/2" or larger)
9. Hobby Knife (X-Acto Knife or sharp Penknife)

Highly Recommended:

1. Small Socket Set (1/4" to 1/2") or Spintite Set
2. Automatic Wire Strippers
3. Grounded (3-wire) Pencil Soldering Iron (RST-302 with RST-303 stand)
4. Set of Jeweler's Screwdrivers

Remember, the quality of the work you turn out will be in direct proportion to the quality of the care used in construction. If you need a certain tool to do a job, beg, borrow, steal or buy it — the reward will be a job well done.

b. Hardware

Wherever machine screws and hex nuts are used, use a lockwasher on the NUT side of the chassis. Where a wire is connected to the chassis at this screw, use a locking solder lug.

Some manufacturers use a substance called Loc-Tite on the screws to hold them in place. We do not feel this is necessary. However, if it makes you feel better, you can use a SMALL drop of Loc-Tite (or even clear fingernail polish) to secure the bolt to the nut.

Self-tapping screws are used where it is impractical or impossible to use a machine screw and nut. Again, a lockwasher will be used to secure the screw. Do NOT over-tighten a self-tapping screw, or it will strip the material it is being threaded into. Perhaps the best advice is this: Tighten the screw until you think it needs just another SMALL amount of tightening and DON'T TAKE IT.

c. Soldering

Soldering is an art unto itself. In electronics, a good solder job will have more effect than any other factor in construction. While a discussion of soldering techniques is beyond the scope of this manual, we might review the basic rules of good soldering:

1. The joint must be mechanically strong. Solder makes a very poor glue.
2. Greasy tools and solder joints mix like oil and water. Use alcohol to clean suspected oily joints or tools BEFORE soldering.
3. Movement during cooling makes a cold joint. Solder will fall off a cold joint in chunks under vibration — like on an instrument panel. Good joints are shiny and bright — cold joints usually appear dull and grayish.
4. Avoid using too much solder — solder blobs have a way of shorting out adjacent connections.
5. A hot, clean iron solders swiftly and cleanly. Irons too small or filthy cause the joint to get hot too slowly, melting insulation and oxidizing metal. 40 to 50 watt irons and 100 to 150 watt guns are just about right.

d. Cabling

Cabling refers to the bundling together of wires with lacing cord or nylon cable ties. This technique provides great strength and vibration resistance to the wires in a cable, not to mention giving a clean appearance to the finished product. We will make extensive use of cabling in RST products, primarily for reliability and secondarily for neatness.

e. Modifications

RST reserves the right to decline repair or calibration of gear which has been modified in ways other than those specified in the "applications" section of our manuals (or in appropriate RST "update data" or "service bulletins"). Units with customized connectors will be accepted only if provided with adaptors which allow mating with standard RST connectors. If you have occasion to call or write the factory, always mention any specific changes you have made and be sure to include the serial # of the item in question.

f. Further Help

The RST folks are ready to help. However, you may wish to help yourself by reading some background material. Our suggestions are:

Practical Electronics - "The ARRL Radio Amateur's Handbook" (American Radio Relay League)

Theoretical Electronics - "Integrated Electronics" (Millman and Halkias)

Aviation Electronics - "Every Pilot's Guide To Aviation Electronics" (John Ferrera) Available from RST as the RST-801. (see RST Catalog)

2. Assembly Techniques
a. P.C. Boards. By far the greatest difficulty in assembling a kit correctly is using the proper technique when assembling printed circuit boards. An analysis of poor or improper operation on units returned for repair reveal the following faults to be most common:

1. Component lead is not soldered to foil. Assembler missed applying solder or heat to an individual lead. This error may be eliminated by either soldering each part as it is put in, or installing a number of parts, soldering all the leads, then checking when clipping off the excess wire to be sure each lead has been soldered.
2. Solder bridge left between P.C. board traces. Usually happens late at night when sleepy and also when using large irons or soldering gun for assembly of densely packaged boards. Solution: drink lots of coffee and use a 40 watt pencil iron with a conical or chisel tip.
3. Intermittent or Spurious Oscillations. Caused by leaving air space between component and board in high-gain or RF circuitry. Sometimes caused by "improving" circuit design by adding sockets to high gain IC's. Solution: before soldering parts to foil, press part as far down as it will go onto board. Use sockets if you must at your own risk.
4. We also have a technician who swears at: assemblers who bend component leads at right angles to the foil before soldering, thus insuring that the component AND the P.C. foil come off in one piece, assemblers who refuse to cable-tie wire bundles as per instructions and get maximum use of our high-gain amplifiers by turning them into uncontrolled feedback oscillators, assemblers who substitute their only-slightly-different-"MIL-SPEC"-parts to "improve" our circuit performance and wind up with unforecast problems. For the most part, however, he gets to smile a lot at the well-constructed kits returned to us for calibration.
5. Every now and again we get a board back with a part in upside down or backwards. The following parts have a polarity or a special way they MUST be installed: Integrated circuits (notch on one end of IC must correspond with notch silkscreened on PC Board), Transistors (have either a "flat" side if plastic or a keyway "tab" if metal), Diodes (banded end is cathode), most tapped coils (color dot is "hot" or RF side), in addition to those parts which mechanically can only be installed one way. Resistors, most capacitors other than electrolytics, crystals, incandescent bulbs, ferrite chokes and beads are all non-polar and can be installed in either direction. However, if these non-polar parts are all installed with the values reading in one direction, not only does it add a touch of class to the assembly, but also makes servicing and trouble-shooting much easier.

6. Perhaps the most difficult trouble to find is the wire that is soldered to a terminal, but through carelessness a long wire whisker is allowed to remain untrimmed. Murphy's Law demands that this whisker touch another circuit which will cause maximum damage. Solution: strip a minimum amount of insulation from wires, then twist the strands together before soldering.

3. Component Identification

You have been supplied with a sheet (p/n 89000) of instructions on the coding of the most common components. It is true that the great majority of the components supplied to you with this kit will fall neatly into one of the categories on this sheet. However, every now and again you will come across a component that is either marked with a special code or with numbers that don't fit the general description on the sheet of coding instructions. This section will help you determine the values of these strangely coded parts.

a. Capacitors

Capacitors have the highest chance of being mis-read. When you remember that the range of capacitance of common capacitors goes from 1 picofarad (= one farad times ten to the negative twelfth power) to 10,000 microfarads (= one hundredth of a farad), you realize the ratio of large to small is ten billion to 1, and the coding for this wide range is rather diverse.
1. Disc ceramic capacitors are, for the most part, marked with their value as shown on the coding sheet, in either picofarads (pF) or microfarads (uF). 1000 pF is the common dividing line between pF and uF, so if the value stamped on the disk is less than 1000, the value is in picofarads, and if less than 1, the value is in microfarads. Since the dividing line is at 1000 pF, some manufacturers call a 1000 pF capacitor "1000" and others call it a ".001". Please note that these capacitors are identical (1000 pF = .001 uF).
Every now and again a manufacturer will use the European/metric marking on the disk. While this is not the most common system, it is not at all unusual, and you should be alert for its use. Basically, the marking is a 3-digit number, most commonly followed by an alphabetic letter. The three-digit number is read just like a resistor (first number, second number, number of zeroes to add), and the alpha letter is the tolerance. Thus, a capacitor marked "124K" is a 12 0000 pF (120,000 pF) 10% tolerance capacitor. Note that 120,000 pF = .12 uF, and this capacitor would have been called out as a .12 uF in the instructions. It might be helpful for you to prove to yourself that "102" = 1000 pF = .001 uF, that "103" = .01 uF and that "104" = .1 uF, and so on.
2. It is also true that "plastic" capacitors (i.e. those that use nylon, polypropylene, polycarbonate, etc. as a dielectric) also more often than not use the metric identifier. However, most plastic capacitors use a marking like 2A103JT (for example), and it is up to you to pick the 103J out of this part number and correctly identify the .01 uF 5% value. (OK, OK, for you overachievers the 2A refers to the dielectric material and method of construction and the T refers to the package style.)
Some plastic capacitors, notably polystyrene, come marked not only in picofarads and microfarads, but also in nanofarads (as if we didn't have enough trouble). One nanofarad equals 1000 picofarads (which, you might remember, equals .001 microfarads). Thus, a capacitor marked 3.3N H would be called out as a 3300 pF 2% capacitor (or a .0033 uF 2% capacitor).

b. Semiconductors

Transistors, diodes, integrated circuits, all the various forms of semiconductor have a fairly easy (if you are "in the know") part numbering system.

1. Transistors are by far the easiest components to identify. Most transistors conform to the industry standard "2N" numbering system — the only problem being that there are over 8000 different devices registered with the 2N designation. It is also true that several 2N numbers will do similar tasks in the circuit (in fact, for an RST part number 31050, there are well over 2000 separate 2N numbers that will perform adequately in our circuits!). You may find, for example, that either 2N4400 or 2N5172 may be supplied for our part number 31050, and you may find either number in your parts bag.

2. Diodes, due to their small size, are the most difficult components in the kit to identify. There is one inviolate rule regarding diodes and that is there will always be a black band at one end, the CATHODE end, of the diode. Also, most diodes are registered as "IN" devices; once again, there are several thousand such registered diodes.

Some glass diodes come with several colored bands, just like resistors. Holding the black cathode band to the left, the colors are read from left to right and are the diode IN numbers. Thus, a diode marked black-orange-yellow would be read as (black-cathode stripe), 1N34 (and, you will note, is RST p/n 30100).

Very small glass diodes generally have the IN designation broken up into two or three lines, plus the manufacturer's logo. The diodes are small enough that a. You need a magnifying glass to read the letters and b. The diode, being cylindrical, makes it hard to know where to start reading the numbers. For instance, our most common diode (p/n 30022), under a magnifying glass, reveals the following digits on separate lines F, IN, 41, 48. This is deciphered as a diode made by Fairchild, 1N4148. Note that if you had started reading in another place on the cylinder you would have come up with 48, F IN, 41, and this would have made the decoding job quite difficult.

As if that wasn't bad enough, some diodes have an "A" or "B" suffix, notably zener diodes. Now, given that it is late in the evening, you are using a cracked magnifying glass, the printing on the glass (while no great shakes to begin with) has blurred ever so slightly in transit, you are excused for misreading a 1N9613 into a 1N9618. Be aware.

3. Integrated circuits are by far the hardest semiconductor to properly identify; there is no industry standard "IN, 2N, 3N" designation, but (it seems) "every manufacturer for himself".

For example, by far and away the most popular IC is the old reliable 741, the first mass-produced, cheap, easy-to-use op-amp. 741, right? Not to Fairchild. To them, it is a U5B7741312-7225F, and their part is so marked.

We have been fairly careful to use manufacturers who have easy-to-read part numbers, but you should be aware of some of the following variances.

The first two characters of a part number are generally an indication of who made the part. LM = National Semiconductor, CA = RCA, uA = Fairchild, MC = Motorola, NE = Signetics and so on. The next 3 to 5 characters are the actual part number, then a few characters representing the package style. Elsewhere on the package may be a 4-digit number representing year and week of manufacture, and a country where the IC "dice" was actually packaged. For example, in our parts bin #32005 was a part marked "LM3900N; 8136; MALAYSIA", a National Semiconductor 3900 in plastic 14-pin DIP package, manufactured the 36th week of 1981, and packaged in Malaysia. It is also true that the "4000" series of CMOS digital IC's have a hiccup in the numbering system of a small group of manufacturers (Motorola being high on the list); they put the numeral "1" in front of the 4000-series number. Thus, an "MC14020CBP" is in reality a Motorola 4020 in a plastic package.

c. Connectors

Connectors are not very often installed incorrectly, but when they are, it wreaks havoc with the unit-to-unit compatibility of the kit. In a word, it comes down to determining the SEX of the connector. Without reverting to sophomore hygiene class or crude jokes, a MALE connector component fits INSIDE a FEMALE connector component. Both PINS and SHELL will have a sex.

1. Coaxial connectors are invariably referred to by the sex of the pin. Thus, a MALE BNC connector is one that has the center pin a solid rod brought to a sharp point on the end, and a FEMALE BNC connector has the center pin a hollow cylinder with a slightly flared open end.
2. Power/signal connectors have two sexes, one for the shell (the insulating structure) and one for the pins.

   First, the pins. The male pin is a cylinder, either solid or hollow, with one end brought to a sharp point. The female pin is also a cylinder, always hollow, with one end open and usually very slightly flared as a guide for the male pin.

   Next, the shell. The male shell is called a plug, and fits inside the female shell, called a receptacle.

   Note that male and female pins will fit both plugs and receptacles, and it is here that most errors concerning connectors occur. Most folks seem to be able to put the correct sex of pins on the right wire, but then blow it by installing a receptacle instead of the correct plug, and vice-versa. (Refer to the picture sheet (p/n 89000).

NOTE - Section D (Assembly) is given as a separate part of this manual.

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E. TEST AND CALIBRATION

1. Test equipment required
   a. Headset - Boom mic (RST-412, Telex MRB 600, or equivalent)
   b. Power supply (11 to 32 volt DC or 9 volt alkaline transistor battery)
   c. Aircraft radio headphone output, tape recorder output, tape recorder input (optional - see section "G").

2. Operational Test Procedures

a. Plug the phones plug of the headset into the intercom pilot's phones jack J103. Similarly plug the mic plug of the headset into the pilot's mic jack J105. Place S102 in "ALL" position.
b. Apply power (power supply or battery) to the intercom through J101 (pin 6 is +, pin 8 is -) or connect a 9 volt alkaline battery to the battery snap connector. Current should be 5 to 15 mA.
c. Rotate the volume control to mid-rotation. If the squelch control is set fully counter-clockwise, background noise should be continually audible in the headset. If the control is adjusted to approximately a 3 o'clock position, the mic circuit will squelch automatically about 5 seconds after one stops talking. It will turn back on as soon as talking is resumed (use this setting for VOX). With the squelch control fully clockwise, it will still be possible to break squelch with most microphones. In some very noisy environments it may be desirable to substitute a lower value resistor for the 47K ohm resistor normally provided at R26 (try, for example, 39K ohm). This should prevent excessive background noise from breaking squelch. Power supply current may vary up to 20 mA with voice fluctuations.
d. Move the headset phones plug to the copilot position J104. Step c should reproduce identical results. Moving the mic plug to the copilot position J107 should also reproduce results identical to those obtained in step c.
e. (445 only) Move the headset plugs to the remote box jacks #3 (J108, J110), then #4 (J106, J109). The action of volume and squelch should be identical to the results obtained on the pilot's/copilot's jacks in steps c and d, above.
f. Connect an audio generator (test equipment, headphone output of a portable radio, tape recorder, etc.) to J101/P101 pin 2 (ground to the chassis or any ground pin on J101/P101 - 3, 4, 8 or 12). The audio should be present at all headphone jacks. Volume and squelch controls should have no effect on the audio signal. The audio from a low impedance generator (internal impedance 600 ohms or less) should be within 2 dB of half gain from point RC to any headphone output. Another way of saying this is that a headphone connected to point RC should be almost exactly twice as loud as the same headphone connected to any intercom headphone jack. Prove this by switching S102 to the "PILOT" position and listening to the rise in audio level in the pilot's headset. Only the audio connected to J101-2 should be audible. Return S102 to the "ALL" position.
g. Connect an audio generator (as above) to J101/P101 pin 9. Rotating the squelch control should cause this audio to cut in and out at any of the headphone jacks. Rotate the squelch control to the position at which the generator's audio first reoccurs. Reconnect the pilot's mic plug.
Speaking into the microphone should reproduce step 4, above, and should cause the audio from the generator to be muted as long as the microphone is being spoken into. (Optional — a second audio generator signal connected to J101/P101 pin 2 should also mute the audio connected to pin 9).

3. Troubleshooting Procedures

a. So your intercom is out to lunch, and you want it back on the job. This first section will consider the intercom only. AFTER we are sure that the intercom is working, we will cover problems with the interconnecting wiring, PTT switches, etc. If you don't have a reasonable quality multimeter and a signal source, such as a small transistor radio with an ear phone jack, send your unit in for repair. Now the question arises: what is it going to cost to have your unit repaired at the RST lab? Typically, it will be $15-$20 plus shipping. That is for repair only; if you wish construction to be completed by us or things added it will cost more. You don't have to address the unit to anyone, just send it to Radio Systems Technology, with a letter telling us the problem. The more detail that you can give, the quicker we can solve your problem. Please be sure to include information on the type of headsets and PTT switch you are using.

Trouble shooting procedures will be listed in three columns. First, Test Procedure, (where to measure or apply the signal), second, the normal results, and third, what to check if the results are abnormal. Unless otherwise specified, all signals or measurements are referenced to the intercom ground, so only the injection or measurement point is given. Start with the indication which best describes your problem.

b. NO OUTPUT/VERY WEAK OUTPUT

Setup: Battery connected, squelch fully counterclockwise (FCCW) unless otherwise noted (FCW = fully clockwise), volume control near FCW. Two headsets plugged in.

TEST PROCEDURE	NORMAL RESULTS	ABNORMAL RESULTS
1. Receiver Audio Input. Inject signal at P101-2. Connect an audio signal from the earphone output of a transistor radio to pin 2 of P101. Be sure to provide a common ground connection between the intercom and the radio.	Audio level with headsets plugged into intercom is half that obtained with headsets connected directly to signal source.	No output or output reduced by over 70%.
2. With squelch FCW inject signal at P101-9.	Signal level is just as loud with headsets plugged into intercom as with headsets connected directly to signal source.	No output or output reduced by more than 1/3.
3. With squelch FCCW speak into mic.	Voice level in headsets loud enough to be heard in aircraft environment.	No output or voice level too low to be usable in aircraft environment
4. Slowly adjust squelch CW until intercom squelches. Speak into mic to break squelch.	Voice level in headsets loud enough to be used in aircraft environment. A few seconds after you stop, the intercom audio squelches	Unable to break squelch while speaking into microphone using normal voice with mic placed within 1/2 inch of lips.

If all the above tests were abnormal continue at #5.
If procedure #1 was abnormal, go to NO OUTPUT WITH SIGNAL AT AIRCRAFT RADIO INPUT.
If procedure #2 was abnormal, go to NO OUTPUT WITH SIGNAL AT TAPE RECORDER INPUT.
If procedure #3 was abnormal, go to NO OUTPUT WITH SIGNAL AT MIC INPUT(S).
If procedure #4 was abnormal, go to SQUELCH CIRCUIT INOPERATIVE.
If procedures #2 and #4 were abnormal, go to SQUELCH CIRCUIT INOPERATIVE.
If procedures #2, #3 and #4 were abnormal, go to SQUELCH CIRCUIT INOPERATIVE.

TEST PROCEDURE	NORMAL RESULTS	ABNORMAL RESULTS
5. Measure voltage at U2 pin 6.	8.0 volts - 9.6 volts	If less than 8 volts check your battery, CR1, on/off switch and traces from point NO to U2 pin 6.
6. Measure voltage at U2 pin 4.	Less than 0.2 volt	If greater than 0.2 volt, check trace from U2 pin 4 to ground.
7. Measure voltage at U2 pin 7.	3.5 volts to 4.5 volts	If voltage not 3.5 volts to 4.5 volts, check C12.
8. Measure voltage at U2 pin 5.	3.5 volts to 4.5 volts	If voltage not 3.5 volts to 4.5 volts, measure (with power off) resistance from U2 pin 5 to ground (it should be above 10 ohms). If it is less than 10 ohms, check for solder bridges. If tests 5-7 are normal and there are no solder bridges, return U2 for replacement.
9. With headsets unplugged and power off, measure resistance from ground to J104 lug 1 and J103 lug 1.	1K ohms - open	If less than 2 ohms, note that J104's and J103's lugs are numbered 1, 3, 2 and that lug 2 (not lug 3) is connected to ground.
10. With power off, measure resistance from point HA on the PC board to J104 lug 1 and J103 lug 1.	Less than 1 ohm	If greater than 1 ohm, check wire connections.

c. NO OUTPUT WITH SIGNAL AT AIRCRAFT RADIO INPUT
(ALL OTHER INPUTS PRODUCE NORMAL OUTPUTS.)
Setup: Power on, 2 headsets plugged in, squelch FCCW, volume near FCW.

TEST PROCEDURE	NORMAL RESULTS	ABNORMAL RESULTS
1. Inject signal at point RC on board.	Output signal level equal to half source signal level, check green wire from point RC to P101-2.	If there is no output or output is reduced by more than 30%, continue at next step.
2. Turn power off and measure resistance from point RC to ground.	Measurement within 450 to 700 ohm range. Check R15 and C12 for proper value and installation and traces between.	If less than 2 ohms check for solder bridge to ground. If resistance is above 700 ohms, check R25.

d. NO OUTPUT WITH SIGNAL AT TAPE RECORDER INPUT
(SQUELCH FUNCTION NORMAL AND ALL OTHER INPUTS PRODUCE NORMAL OUTPUTS).
Setup: Power on, 2 headsets plugged in, squelch FCW, volume near FCW.

TEST PROCEDURE	NORMAL RESULTS	ABNORMAL RESULTS
1. Inject signal at point TR on board.	Output signal equal to the source signal level. Check orange wire from point TR to P101-9.	If no output, or output less than 30% of source signal level, continue with next step.
2. Measure voltage at Ul-7.	6-9 volts	If less than 6 volts go to section "f".
3. Measure voltage at base of Ql.	.4 - .7 volts	If less than .4 volts, check R31 and traces. If more than .7 volts, check connection to base of Ql.

4. Measure voltage at collector of Ql.	Less than .5 volts	If more than 1 volt, check Ql for proper installation and measure emitter voltage
5. Measure voltage at base of Q4.	Less than .5 volts. Check CI, R9, R16, C3, for bridges and proper installation.	If not less than .5 volts, recheck step 2.
6. Disconnect Q4's collector.	If disconnecting Q4's collector from the circuit results in an output signal, return Q4 for replacement.	Reinstall Q4's collector. Go to step 7.
7. Measure resistance from point TR to ground.	450 - 700 ohms	If resistance is not 450 - 700 ohms, check R35 for proper value and installation. Check for solder bridges.

e. NO OUTPUT WITH A SIGNAL AT MIC INPUT(S). (SQUELCH CIRCUIT OPERATIVE.)
Setup: Unit on, 2 headsets plugged in, volume FCW.

TEST PROCEDURE	NORMAL RESULTS	ABNORMAL RESULTS
1. Disconnect Q2's collector from circuit.	Still no output. (Replace Q2's collector.)	If output present, replace Q2's collector and go to section on SQUELCH CIRCUIT INOPERATIVE.
2. Inject low level signal (less than 0.5 volt peak-to-peak) at volume control - R101 lug 3.	Output signal level 6 to 8 times that of source.	If no output, check coax from R101 lug 2 to point DA for proper connections, no shorts between center conductor and shield.
3. Apply low level signal to point FA.	Output signal level 6 to 8 times that of source.	If no output, check coax from point FA to R101 lug 2 for proper connections, no shorts between center conductor and shield.

4. Measure voltage at Ul pin 1.	4 to 4.5 volts	If voltage NOT 4-4.5 volts, then measure voltage at Ul pin 3. If less than 4 volts check R17 for proper value and installation. If greater than 4.5 volts, check R18 for proper value and installation.
5. Inject a low level (less than 0.15 volt peak-to-peak) signal at the junction of C4 and R12.	Output signal level 8 to 12 times source.	Check C4, C5, R19, and Ul for proper values and installation.
6. Measure voltage at J105 lug 3 and J102 lug 3.	2 to 4 volts (with headsets plugged in). 7 to 9 volts (with headsets unplugged).	If less than 1.5 volts at J105 lug 3, check yellow-white wire to PM, R2 and Rl. If less than 1.5 volts at J102 lug 3, check violet-white wire to CM, R4 and R7.

f. SQUELCH CIRCUIT INOPERATIVE
Setup: power on, 2 headsets plugged in.

TEST PROCEDURE	NORMAL RESULTS	ABNORMAL RESULTS
1. Measure voltage at Ul pin 5.	1.5 to 2.5 volts with squelch CCW. 6 to 7 volts with squelch CW.	If voltage is abnormal, check squelch control R102, R33 and R26 for proper values and installation.
2. Measure voltage at junction of CR3, R23 and C7. Speak into mic.	3.6 to 4.2 volts. (Voltage increases when speaking into mic.)	If voltage is abnormal, check CR3, C7 and R23 for proper values and installation.

TEST PROCEDURE	NORMAL RESULTS	ABNORMAL RESULTS
3. Measure voltage at Ul pin 7.	6.5 volts to 8.5 volts (with squelch CW). 0 volts (with squelch CCW).	Check R24, C8, Ul pins 7, 6 and 5, for bad solder joints. If all solder joints are satisfactory, return Ul for replacement.
4. Measure voltage at base of Q2.	.4 to .6 volts (with squelch CW). Less than 0.4 volt (with squelch CCW).	Check CR4 & R22 for value and proper installation. Check Q2 for proper installation and solder bridges. If no solder bridges, return Q2 for replacement.

g. RADIO INPUT DOES NOT SQUELCH TAPE RECORDER INPUT.

Setup: power on, volume mid-rotation, squelch fully CW, NO headsets plugged in.

TEST PROCEDURE	NORMAL RESULTS	ABNORMAL RESULTS.
1. Inject a signal at P101 pin 1, another signal at P101 pin 9, and measure voltage at Q4's base.	.4 to .6 volts. If normal check Q4 for installation.	If less than 0.4 volt, check CR5 (note: glass diodes are very fragile and easily cracked), C16, & R32 for proper value and installation.

h. UNIT FUNCTIONS NORMALLY ON 9 VOLT BATTERY POWER, BUT NOT WITH 12 VOLT POWER INPUT.
Setup: Apply +12 volts at P101 pin 6 and ground at P101 pin 8, turn power on, plug in 2 headsets.

TEST PROCEDURE	NORMAL RESULTS	ABNORMAL RESULTS
1. Measure voltage at the junction of CR2 and R30.	9 volts to 11 volts	If less than 9 volts, check CR2, R29 and C15 for proper values and installation. If more than 11 volts, check CR2 for proper values and installation. Return CR2 for replacement if it was installed correctly.

TEST PROCEDURE	NORMAL RESULTS	ABNORMAL RESULTS
2. Measure voltage at Q3's base.	9 to 11 volts	If voltage is abnormal, check R30 for proper value and installation.
3. Measure voltage at Q3's collector.	Voltage should be within 1 volt of the voltage applied to P101-6.	If not within 1 volt of applied voltage at P101-6, check R28 for proper value and installation.
4. Measure voltage at Q3's emitter.	8.4 volts to 10.5 volts.	If less than 8.4 volts, check Q3 for proper value and installation. If these are OK, return Q3 for replacement.

i. INTERCONNECTING WIRING TEST

Check each wire of the interconnecting wiring for continuity with an ohmmeter. Terminals wired together should measure less than 2 ohms; terminals not wired together should measure infinite ohms (open circuit).

j. INTERFACE PROBLEMS

1. Intercom functions normally until connected to aircraft radio(s), then the audio from one (or more) headset becomes weak, distorted, or completely absent.

   The push-to-talk switch used with the intercom MUST break the high side of the microphone audio line when not depressed (Telex PT-200 switches are unsuitable; Telex PT-300 switches are excellent). We recommend wiring the cockpit exactly as shown in Drawing #442-4072 (Section I of this manual) with PT-300's, to alleviate this problem.

2. Cockpit experiences distortion during radio transmissions even though Tower receives aircraft "5-by-5".

   This may be caused by the sidetone of the radio and the audio of the intercom mixing out of phase. To verify this, disconnect the phones plug from the intercom to the aircraft radio while transmitting on the radio and note that distortion is eliminated. The way to solve this problem is to have your radio shop turn your radio's sidetone down.

3. When transmitting on the radio, intercom audio is distorted and continues to be distorted even when phones plug is disconnected from aircraft jack.

   This problem may occur when a very high level of RF from the transmitter is present within the aircraft. In this case, the aircraft's antenna system needs to be checked thoroughly and the excessive cabin RF removed.

4. Excessive alternator noise or ignition noise is present in the intercom audio.

   Alternator noise is very seldom a problem. Its presence may indicate that the voltage regulator in the intercom has failed. If the voltage regulator in the intercom is regulating at 9-10 volts, then the problem is likely with the aircraft regulator and the addition of a noise suppressor should be considered. NOTE: unshielded ignition wiring may cause noise, and the only solution is shielding the ignition system.

F. THEORY OF OPERATION [NOTE: data on the RST-445 is given in brackets]

In the following discussion please refer to PC051 schematic (Drawing #442-7000) and chassis schematic (Drawing #442-7800). Audio from the pilot's or copilot's [or #3, or #4] microphones is connected to point PM or CM [or TM or FM] on PC051 through the associated microphone jack on the chassis. All microphone audio signals are added together, and their sum appears at U1A pin 1, each signal being amplified by a factor of 12 (5 v P-P at pin 1 with normal voice signals being spoken into the headset microphone). After passing through R21 and C9, the microphone audio appears at the "hot" terminal of the volume control (point FA) attenuated by a factor of 5 (approximately 1 v P-P at FA with a normal mike audio input. This assumes Ul-B pin 7=0 volts d.c. See the section below concerning squelch action).

A fraction of the microphone audio available at FA is selected by the volume control and is routed to power amplifier U2 pin 3. This amplifier has a voltage gain of 20, so that about a .5 volt P-P signal at DA will drive amplifier U2 output (pin 5) to 9 volts P-P. Nominally, U2 pin 5 sits at 4.5 volts and is driven positive as far as the +9 volt supply rail and negative as far as ground for full output (9 v P-P). This audio power signal is then routed through d.c. blocking capacitor C14 to HB, HC [and HA] and thence to the pilot's headphones (via S102) and copilot's headphones, tape recorder [and #3 & #4 headphones] respectively.

The aircraft radio headphone signal is brought in through J101/P101 pin 2 and thence to point RC on PC051. This signal (10 volts P-P at RC for full output) is attenuated approximately 50 times by R15/R20, amplified 20 times by U2, and output to the intercom headphone jacks as described above.

An aircraft "entertainment radio" signal (monaural AM/FM, cassette deck, etc.) may be routed through DA to the intercom through P101/J101 pin 9 ("tape input") and thence to TR on PC051. This signal undergoes a -20, +20 gain processing and output as described above for the aircraft radio circuit.

The above descriptions do not take into account any squelch action. The following paragraphs describe both microphone squelch (voice-actuation) and "music" (tape input) muting.

Microphone squelch action occurs when Q2 is turned on by a positive voltage occurring at pin 7 of U1B. Without voice signals, the squelch control is normally adjusted for sufficient voltage at point AA (U1B pin 5) to exceed the normal, approximate 4-volt d.c. bias present at Ul pins 1 and 6. This keeps pin 7 above 1 volt in the squelched condition. When microphone audio is present at pin 1 of U1A, CR3 charges C7 to the level of the positive peaks, which in turn lowers the voltage at U1B pin 7 below the level required to keep Q2 from shunting signals present at the collector to ground. When Q2 is thus turned off, audio signals from the microphone can pass through the R34/C9 network to the volume control and thence to the headphone amplifier LI2.

The d.c. voltage level from U1B pin 7 will turn Q4 off through R31. Q4 turns on Ql which shunts the "music" (tape input) signal at TR to ground, effectively muting the entertainment.

In a similar manner, any radio audio present at RC will charge C16 through CR5 to a positive voltage, which turns Ql on through R32 to mute the "music" (tape input) when a communications radio signal is present.

Power for the intercom comes from either voltage regulator Q3 or gate diode CR1. A voltage from the aircraft supply (between 8 and 32 volts positive) is connected to BI on PC051 through J101/P101 pin 6. CR2 provides a 10 volt regulated reference, which appears at the emitter as a relatively high current 9.3 volt regulated supply. If the aircraft supply is not used, a 9-volt battery connected to B0 will provide an 8.3 volt supply at NI through CR1.

NOTE: Alkaline or ni-cad rechargeable batteries are recommended. The higher internal impedance of the inexpensive carbon-zinc battery may cause noise and/or oscillations at near fully clockwise settings of the volume control.

G. INSTALLATION

1. Intercom

a. If the intercom is being used in aircraft which do not have an electrical system, or if it is inconvenient to attach the intercom via the cigar lighter plug, or if emergency standby operation is desired, install a 9 volt transistor battery into the battery clip and attach the battery connector.

1. Alkaline batteries are recommended for long life. Up to 50 hours is expected. (See the note regarding use of zinc carbon batteries at the end of section F).

2. If the volume control switch is inadvertently left on, it will run the battery down. Turn the intercom off after use.

b. Plug aircraft headsets into the intercom.

2. Interconnecting Wiring See Drawing #442-4070 for details.

a. Connect the phone plug coming from J101 pins 2 and 3 to the aircraft radio headphone jack.

b. Connect the microphone "Y" plug to the aircraft microphone jack.

c. Connect the "pilot ICS" microphone plug from J101 into the pilot's PTT switch jack. Connect the PTT plug to either jack on the microphone "Y". (Also attach the pilot's PTT switch to the pilot's control yoke).

d. Similarly, connect the "copilot ICS" plug from J101 to the copilot's PTT switch and the PTT switch to the microphone "Y".

H. OPERATION

1. Intercom Only
   a. Apply power as installed in accordance with section "G", whether from the attached 9 volt battery, or a 14 or 28 volt electrical system through a cigarette lighter plug.
   b. Attach aircraft headsets and microphones to the pilot's and copilot's phones & mic jacks.
   c. Rotate the volume control to mid-rotation, place S102 in "ALL" position.
   d. Adjust the squelch control until the background noise just disappears. Note that there is a time lag between control adjustment and intercom response, so make small adjustments and allow the circuitry to settle between adjustments.
   e. Note that some pilots may hear their own voice as "raspy", yet the copilot hears the pilot fine, and the pilot hears the copilot loud and clear also. This is a quite normal situation arising from the physiological mechanics of the sense of hearing. Without going into a dissertation on the subject of human auditory response ("hearing"), suffice it to say that simultaneous acoustic and electrical feedback from a person's own voice will produce a distorted ("raspy") response in some people, and is to be considered normal.
2. Interconnecting Wiring
   a. These operations are in addition to section 1, above.
   b. Radio reception through the intercom is identical to reception prior to intercom installation, with the exception that intercom voice can be mixed with any radio signals. You may operate volume and squelch controls on the various radios just as you have in the past. If the pilot wishes to cut out intercom chatter while concentrating on a radio transmission, he may connect his headset directly to the radio's phones output by placing S102 in the "PILOT" position. NOTE: a slight increase in radio volume in this position is normal.
   c. There are no switches to throw to go from "intercom" to "transmit". To use the communications radio for transmit, the pilot or copilot pushes his own PTT switch. In the event both pilot and copilot simultaneously push their PTT buttons, both pilot and copilot voices will modulate the transmitter. This feature is desirable so that an instructor may intervene in a time-critical situation and override a potentially harmful student communication.
3. Tape Recorder Interface
   a. These operations are in addition to sections 1 and 2 above.
   b. Operate portable cassette recorder (not provided) in accordance with the manufacturer's instructions regarding recording and playback.
   c. To play tapes over the intercom system plug the 3.5 mm miniature phone plug attached to the coaxial cable into the earphone jack of a monaural (not stereo) tape recorder. Adjust the volume at the tape recorder for a comfortable listening level in the headsets. Note that whenever someone speaks into their headset microphone (or a COM radio signal is received via the radio interface) the tape recorder audio is automatically squelched for the duration of the conversation

. The tape input is designed for background music only and is deliberately silenced when it might interfere with the primary task of the intercom - cockpit communication. Also, when flying solo if you wish to use the intercom for background music, you may need to plug in the copilot's headset to avoid hum from occurring at high volume settings of the intercom.

d. To record cockpit conversations, plug the 3.5 mm miniature phone plug attached to the 2 conductor (non-coaxial) cable to the auxiliary ("aux") or "line" input of a portable tape recorder. Follow instructions provided with the recorder for making recordings. Note that the tape output provided by this intercom is of too high a level to plug directly into a tape recorder's microphone input without producing distortion.