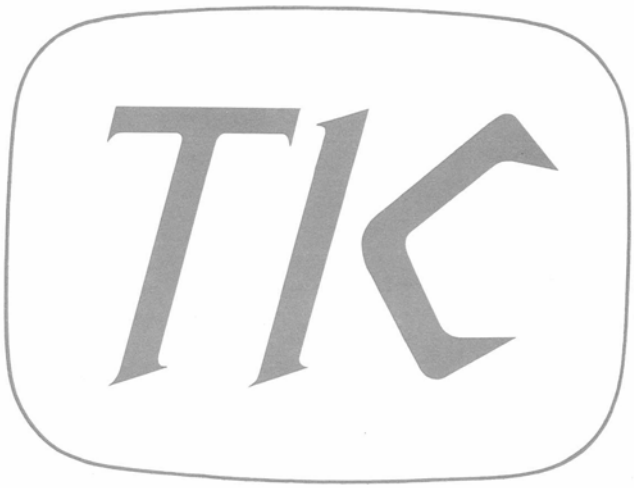
INSTRUCTION MANUAL

TYPE CES-116A CES-117A

ADF SIGNAL SIMULATORS



TEL-INSTRUMENT ELECTRONICS CORP

AVIATION DIVISION

728 GARDEN ST.

CARLSTADT N.J. 07072

U.S.A.

WARRANTY

The Tel-Instrument Electronics Corporation warrants each new product manufactured by it to be free from defective material and workmanship and agrees to remedy any such defect or to furnish a new part in exchange for any part of any unit of its manufacture which under normal installation, use and service discloses such defect, provided the unit is delivered by the owner to us intact for our examination with all transportation charges prepaid to our factory within one year from the date of sale to original purchaser and provided such examination discloses, in our judgment, that it is thus defective. This warranty does not include tubes or batteries.

This warranty does not extend to any of our products which have been subjected to misuse, neglect, accident, incorrect wiring not our own, improper installation, or to use in violation of instructions furnished by us, nor extend to units which have been repaired or altered outside of our factory, nor to cases where the serial number thereof has been removed, defaced or changed, nor to accessories used herewith not of our own manufacture.

Repair parts will be made available for a minimum period of five (5) years after the manufacture of this equipment has been discontinued.

This warranty is in lieu of all other warranties expressed or implied and no representative or person is authorized to assume for us any other liability in connection with the sale of our products.

ADDITIONAL INFORMATION with regard to the applications and maintenance of this equipment will be available from time to time. Users of our instruments are urged to discuss their problems with us and to suggest such modifications as might make them more adaptable to their special requirements.

THANK YOU

TIC
AVIONIC TEST EQUIPMENT FOR BENCH AND RAMP
Tel-Instrument ELECTRONICS CORP., 728 Garden St., Carlstadt, N.J. 07072
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CES-116A/CES-117A ADF SIGNAL SIMULATORS

SECTION I
SPECIFICATIONS

TIC CES-116A & CES-117A

ADF SIGNAL SIMULATORS

FEATURES:

Accurate Bearings at All Angles
No Screen Room Required
Calibrated Field Strengths
Fixed Sense Antenna Adapters (No Adjustments)
Time Proven Design
Adapters for All Makes of ADF's
Accepted by Receiver Manufacturers
Accepted by Air Frame Manufacturers

TECHNICAL DATA:

ROOM FACTOR: 5
(An input to the Simulator of 5000 microvolts will provide an internal field of 1000 microvolts/meter.

SENSE ANTENNA OUTPUT (FRONT PANEL) :
h_e = 1 meter, Z_o = 50 ohms

SENSE ANTENNA OUTPUT (TO RECEIVER) :
h_e = 0.1 - 1.0 meter. Attenuator and dummy antenna provided in Sense Antenna Matching Box designed for each receiver.

EQUALIZED E and H FIELDS:
For ADF antennas with built-in sense antennas.

BEARING CALIBRATION:
Every 1/2° over 360° range

IMPUT IMPEDANCE:
50 ohms

FREQUENCY RANGE:
100 kHz to 3 MHz

SIZE:
24" W x 24" H x 25" D (CES-116A)
48" W x 48" H x 12" D (CES-117A)

WEIGHT:
53 pounds Net (CES-116A)
97 pounds Net (CES-117A)

ACCESSORIES SUPPLIED:
1 - 4 ft BNC/BNC double shielded coax cable (RG55B/U) (Sig. Gen-CES)

1 - 4 ft BNC/BNC double shielded coax cable (RG55B/U) (CES-Sense Antenna Matching Box)

1 - Instruction Book

ACCESSORIES AVAILABLE:
Antenna Mounting Plates and Sense Antenna Matching Boxes for all makes of ADF's.

SECTION 2
DESCRIPTION

In order to check the bearing accuracy and loop sensitivity of an Avionics ADF receiver, it is necessary to have an RF field of known magnitude and direction. The classical method was to setup a radiating transmission line in a large shielded room (approximately 9' x 12' x 12'). Since the 1960's, the TIC CES series ADF Simulators have provided a compact alternative that can be used at the test bench.

By using a large internal circular drum (Fig. 1), it has been possible to provide a uniform field which does not change as the exciting antenna is rotated. In addition, field rotation is linearly related to antenna rotation, allowing a calibrated dial to be supplied for bearing accuracy checks.

Modern ADFs have the sense antenna built into the loop antenna housing. Since the loop antenna responds to Electromagnetic (or "H" waves), and the sense antenna responds to Electrostatic (or "E" waves), it is important that the E and H waves be balanced in magnitude.

For older receivers using a separate sense antenna, a "SENSE ANTENNA" jack on the simulator front panel provides a signal equivalent to that picked up by a sense antenna of 1 meter effective height. From this jack, a terminated 50 ohm cable goes to a sense antenna matching box, designed for the particular receiver under test.

The box contains a voltage divider to match the manufacturer's specified sense antenna effective height, as well as the proper matching network. For most boxes, a short, permanently attached output cable is provided with the proper connector to plug into the receiver. Others have a mounted connector, and use the receiver's standard sense antenna connecting cable. (Mounting plates and matching boxes are available from TIC for all old and new ADF receivers, or they may be easily made in the field.)

The CES-116A is 24" wide by 24" high by 25" deep, weighs 53 pounds, and has two handles on top for carrying. It is designed to be mounted either on top of the work bench, or hung underneath it. The normal loop antenna mounting plates for the CES-116A are 11-1/2" by 16-7/8", normally allowing for antennas up to 10-1/2" wide, with the electrical center of the loop itself no more than 8" from the furthest end. (In some cases it is possible for slightly larger antennas to be handled.)

All CES-116A's after Serial 2198 have been factory adjusted to provide equalized "E" and "H" fields. A free conversion kit is available from the factory for older units, including a sticker to be applied to the rear stating "This unit has Equalized E and H Fields".

Because it was designed to handle large (ARINC 712, etc.) ADF Loops, the CES-117A is too large (4' x 4' x 1') and heavy (97 pounds) to put on a bench. It has four non-swivelling casters to allow easy movement, as well as handles on both sides. The loop antenna mounting plates for the CES-117A are 17-1/4" by 43", allowing for antennas up to 16-1/4" wide with the electrical center of the loop itself no more than 21" from the furthest end.

Double RF Shielding (box within a box) construction has been employed in the CES-116A to allow operation even in proximity to powerful broadcast stations. (In general, the limitation will be found to be pickup in the shielded cables connection to the receiver.) In order to keep the size and weight of the CES-117A within reasonable bounds, it has been designed with single shielding, which is still adequate for its purpose.

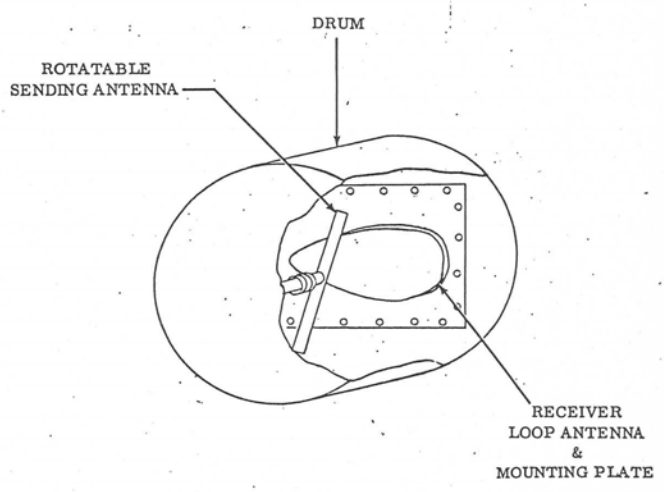


FIG. 1

SECTION 3
OPERATION

Antenna mounting plates for most small, non-rotating loops are 11-1/2" x 16-7/8", and are designed to be mounted either into the dishpan adapter normally supplied with the CES-116A, or onto a 17-1/4" x 43" CES-116A/117A adapter plate for use with the CES-117A. Antenna mounting plates for large non-rotating loops (such as ARINC 712 and Collins ANT-60B) are 17-1/4" x 43", and can only be used with the CES-117A. Antenna mounting plates for older mechanically rotating loops and some intermediate size loops, are 13-1/8" x 18-5/8", and are designed to be mounted into the CES-116A instead of the dishpan adapter.

The arrow on all antenna mounting plates point to the left as the operator faces the simulator cavity, and the loop should be mounted to the plate with its forward direction pointing in the same direction as the arrow, but on the opposite surface of the plate.

All 11-1/2" x 16-7/8" and 13-1/8" x 18-5/8" plates are fastened in place with 6 - 32 binder head screws. Install the center screw of each side first, as these are tight - tolerance holes. The remainder of the screws may be added to minimize pickup of external signals. After connecting the cable from the loop to the receiver, the rear door may be bolted onto the CES-116A if double shielding of the loop is desired. (Accuracy is not affected by the rear door presence or absence.)

The CES-117A uses snap-slide fasteners to mount the 17-1/4" x 43" plates. Make sure all the catches are in the "open" position (as far away from the opening as possible), and slip the top side of the plate on the top row of studs. Close two of the catches, and drop the plate onto the remaining studs. Close the rest of the catches, and connect the connecting cable from the loop to the receiver.

One of the two four foot coax cables supplied is to be connected from the RF Signal Generator to the Signal Generator jack on the front panel of the CES-116A or CES-117A. If the ADF loop under test does not have a built-in sense antenna, the other four foot coax cable is connected from the Sense Antenna jack on the front panel to the jack mounted on the Sense Antenna Matching Network supplied for the receiver to be tested. Most matching networks have a six-inch length of coax coming out of them, with the proper plug to fit the sense antenna jack of the receiver. A few networks are designed to use the receiver' s standard sense antenna cable for interconnection, and have an output jack.

Some signal generators radiate a very strong magnetic field at low RF frequencies, which will be picked up by the ADF loop if the signal generator and simulator are too close together. The resultant symptom, at low signal generator outputs, is an ADF bearing independent of simulator dial setting. Increased physical separation is the best cure.

Since the input impedance of the simulators is 50 ohms, it is necessary to know the output voltage of the signal generator into a 50 ohm load if sensitivity measurements are to be made. Most modern signal generator output meters are calibrated with a 50 ohm load connected so that no conversion factor is required, but some older generators are calibrated in EMF, or open circuit voltage. If they have a 50 ohm internal impedance, the voltage into a 50 ohm load is 1/2 of the indicated output voltage.

The drum and antenna dimension of the CES-116A and CES-117A are such as to introduce a room attenuation factor of 5; for example, a 5000 microvolt signal at the input jack will produce a field strength at the loop of 1000 microvolts/meter.

A sense antenna of 1/4 meter effective height, located in this field, will have an open-circuit pick-up of 250 microvolts. A loop antenna with a built-in sense antenna will pick up "E" and "H" signals equal to those picked up in a 1000 microvolt/meter field.

If loop antennas with built-in sense antennas are being tested, the Sense Antenna jack may be left disconnected, causing the input impedance of the simulator to be 54 ohms instead of 50 ohms, which should cause negligible errors.

If the receiver uses a separate sense antenna, the appropriate Sense Antenna Matching Network will provide the proper ratio of sense antenna voltage to loop field strength (further details will be found under "Theory of Operation").

With all connections made as described, and the signal generator and ADF receiver turned on and tuned to the same frequency, the ADF receiver should function. With the CES-116A dial set to "0", the ADF receiver will read either 0° (if it is connected for a top-mounted loop) or 180° (if it is connected for a bottom mounted loop). The CES-117A has a front panel switch for top-mount antenna or bottom-mount antenna wired receivers, so the receiver will always read "0" when the switch is properly set.

Clockwise rotation of the simulator dial will give either clockwise or counter clockwise rotation of the ADF dial, depending upon whether it is wired for a top - mounted sense antenna or a bottom - mounted sense antenna. Two sets of calibrations are provided on the simulator dial, so correct readings may be obtained in either case. Note that clockwise dial rotation on the CES-116A is equivalent to counter-clockwise rotation on the CES-117A, due to the change of dial rotation from in front of the ADF loop to in back of the ADF loop.

Readings may now be taken around the dial, checking dial readings against ADF receiver indications. The actual amount of quadrantal error contributed by the ADF antenna may be determined. (In general, this will be the maximum deviation between dial and indicator, and should maximise at 45°, 135°, 225°, and 315°. A sample curve is shown in Figure 2 .) Measurements may be taken in both directions, to detect any stickiness in the ADF indicator.

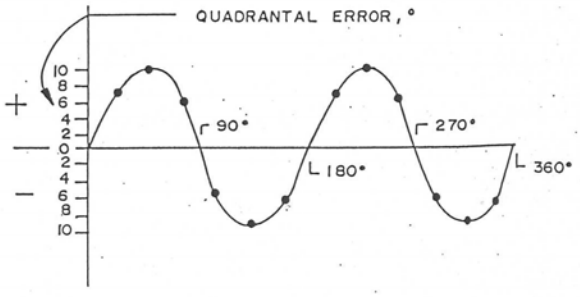


FIG. 2

Readings may be taken at various field strengths, remembering to take into account the room factor of 5.

SECTION 4
THEORY OF OPERATION

In order to test an ADF receiver, it is necessary to have an RF field of known magnitude and direction. The classical method as outlined in RTCA paper 158-61/DO-111, is to have a large shielded room (approx. 9' x 12' x 12-1/2'), with an unshielded transmission line running down the center of the room approximately 2 feet below the ceiling. The ADF loop is positioned directly under the center of this line, and approximately 3 feet below it. By a series of calculations the theoretical field strength at the loop may be expressed in terms of the signal generator voltage on the transmission line, the dimensions of the room, and the position of the transmission line and loop within the room. The end result is a room attenuation factor, or the number by which the transmission line voltage in micro-volts, is multiplied to get the field strength, at the loop, in microvolts/meter.

In an ADF installation, the sense antenna picks up a voltage proportional to the signal strength, and the effective height of the sense antenna. Note that it is only the vertical component of the sense antenna that picks up the signal, not the long horizontal run. (This is because broadcast and ADF stations radiate vertically polarized signals). The horizontal section of the antenna does not pick up any signal, but is used as "top-loading" capacitance, to provide greater signal strength into the antenna cable capacity.

An example may clarify the matter. Fig. 3a shows a typical installation:

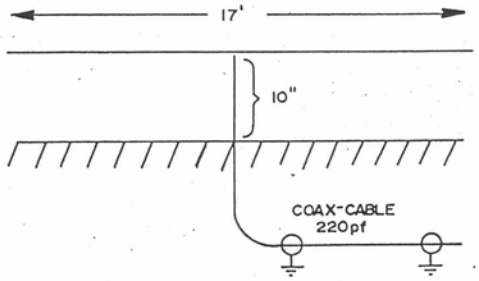


FIG. 3a

The 17' horizontal wire 10" away from the plane, will have a capacity to the metal plane body of 50 pF. If the plane is located within an RF field of 1000 μ/meter, the 10" (= 1/4 meter) vertical section will have a voltage of 250 μv induced in series with it. Electrically, we then have (Fig. 3b).

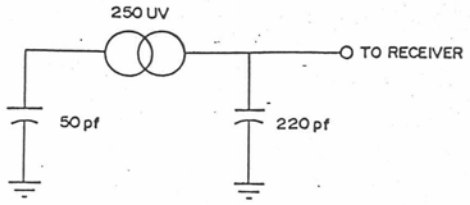


FIG. 3b

(Since an ungrounded RF generator is difficult to obtain on the service bench, we may redraw the diagram to the form shown in Fig. 3c, without affecting the results:)

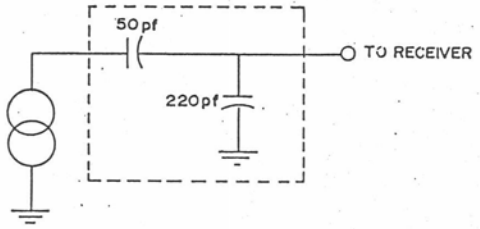


FIG. 3c

(The circuit inside the dotted lines will be recognized as the standard "dummy antenna" for many ADF receivers.)

It will be noted from Fig. 3b or 3c that a longer horizontal section on the antenna gives more signal into the receiver, not because there is more pick-up, but because there is less attenuation in the capacitive divider as the 50 pf capacity is increased.

The radiating circuit for the original CES-116A is basically as shown in Fig. 4a.

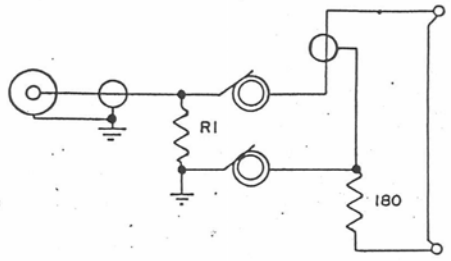


FIG. 4a

The 180Ω resistor sets the current in the radiating loop, and R1 is simply a shunt resistor (69.25Ω) to provide a 50Ω input impedance at J1. Knowing this, we may replace R1 with any equivalent network having the same impedance (see Fig. 4b). (The additional shunt resistor of 900Ω is used to allow a re-match of the input to adjust the impedance if the loop resistor is changed.) Our total circuit is now as shown in Fig. 4c.

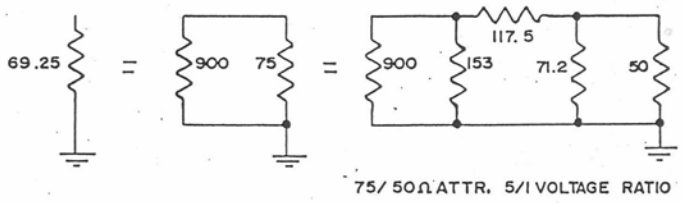


FIG. 4b

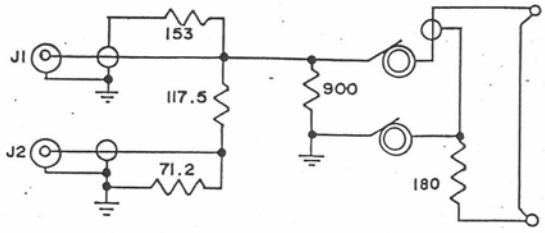


FIG. 4c

Since the room factor is 5, and the resistive pad has an attenuation factor of 5, the voltage at J2 is the same number as the field strength in the box. For example, with 5000 μv into J1, the field strength is 1000 μv/m, and the voltage at J2, into a 50Ω load, is 1000 μv, or the same voltage that would be picked up by an antenna of 1 meter effective height, in a field of 1000 μv/m. As the signal generator level is varied, the voltage at J2 (terminated) is always equal to that picked up by an antenna of 1 meter. Since this is so, J2 on the front panel of the CES-116A and CES-117A is marked "Sense Antenna - h_e = 1 meter".

We now see the procedure required to make a "Sense Antenna Matching Box" for any desired receiver. For example, particular receiver specifications may call for a 50 pf antenna, with an effective height of 0.25 meter, and a total antenna plus cable capacity of 270 pf. The proper network is shown in Fig. 4d.

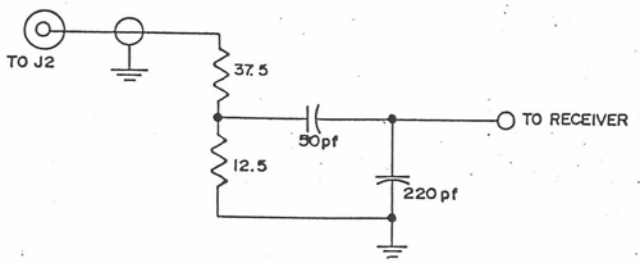


FIG. 4d

The 37.5Ω and 12.5Ω resistors in series properly terminate the 50Ω cable from J2 (which may be any desired length), and the voltage at the junction, which is 1/4 way "up" the termination, provides a signal equivalent to that picked up by an antenna of 1/4m effective height. The capacitors are picked as discussed earlier. Note that the 220 pf should include the capacitance of any cable from the matching box to the receiver jack. (Normally TIC boxes have a 6" length of coax, with the appropriate connector for the receiver under test.)

Measurements on older CES-116A have shown the E Field to be approximately 6 dB higher than would be expected with relation to the H field.

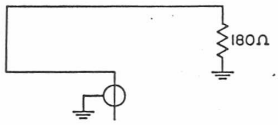


Fig. 4e

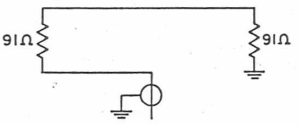


Fig. 4f

Figure 4e shows the sending antenna configuration on older CES-116As, while Figure 4f shows the configuration for equalized E and H fields. It will be noted that for a given input to the CES-116A the current in the loop is the same in both figures, so the room calibration factor is not affected. However, the voltage on the Figure 4f loop is 1/2, or 6 dB lower, than the voltage on the Figure 4e loop, thus providing equalized E and H fields.

The schematic (Fig. 4g) for the CES-117A is essentially the same, with provision for reversing the current in the radiating loop, to compensate for top or bottom mounted loops. Several resistor values are slightly different to utilize standard 1% value resistors, and the two resistors setting the "E" field value have been changed because of the mechanical differences. The room factor is still 5.

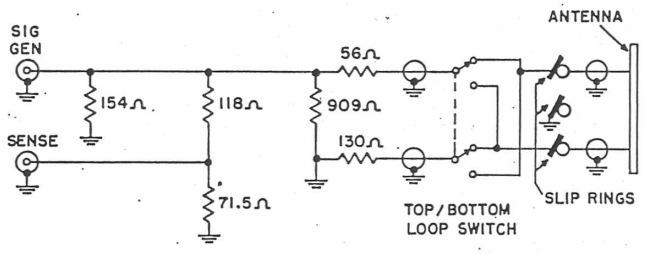


Fig. 4g

SECTION 5: MAINTENANCE

SECTION 5A - CES-116A

Since there is no power supply or active devices in the CES-116A, it will be found that very little maintenance will be required. The only troubles that might occasionally occur are erratic sensitivity readings of the receiver, caused by dirty brushes in the slip ring assembly, and consistent phase errors, if the dial has slipped on its shaft.

To gain access to the slip ring assembly, the front cover must be removed. To do this, remove all the screws around the outer edge of the front covers, set the phase dial to "0", and loosen the set screws in the knob. Without turning the phase shaft, remove the panel and dial assembly. Do not remove the fiducial. Take the cover off the slip ring assembly box, repair as required, and replace the box cover. Reassemble the front panel and dial to the main unit noting that the "0" screw on the knob is to rest on the flat of the shaft. Replace all the screws around the front cover, and recheck that the dial is not rubbing against the panel or fiducial.

Phasing of the CES-116A loop to the dial may be checked optically. Remove the rear door, and any antenna mounting plate that may be installed. Insert screws in the center hole of the left and right hand rows of tapped holes, and tightly stretch a piece of #20 wire between the screws. Rotate the antenna so that the side with the coax cable is towards your right as you face the rear of the unit, and optically line it up with the #20 wire just installed. The dial should read "0°", within ± 1° max.

If the reading is only slightly off, the fiducial screws on the front panel may be loosened, and the fiducial shifted slightly to minimize the error. Errors of several degrees or more indicate that either the knob has slipped on the shaft, the shaft has slipped in the slip ring assembly or the 5/16 - 18 bolt holding the antenna to the shaft has loosened.

Check for tightness of the 5/16 - 18 bolt first. If it had been loose, rephase the shaft, as described below. If the bolt was tight, set the antenna to 0° as described above, and loosen the two knob set-screws. Turn the dial to 0°, and tighten each set screw to contact, then loosen 1/8 turn. Hold the antenna, and try to turn the knob. If it can be turned equally in each direction, it indicates that one of the set screws is lined up with the shaft flat, as it should be. Tighten the screw on the flat, then tighten the other screw, and refine the zero setting accuracy with the fiducial, as described above.

If neither of these methods have helped, it will be necessary to re-phase the knob shaft to the slip ring assembly. To accomplish this, remove the knob and front cover, as previously described, and then remove the shaft from the slip ring assembly by loosening two Allen set-screws. Insert the flatted end of the shaft into the knob so that one of the knob set-screws bears on the flat, and tighten both knob set screws. Set the antenna to 0° as previously described, and put the other end of the shaft into the slip ring assembly. Place one of the CES-116A Antenna Mounting Plates on the

bench, parallel to the dial, and use it as a test square to set the dial with 0 and 180 in a vertical line, and 0 on top. Check that the antenna is still at 0°, and tighten the set screws in the slip ring assembly.

Loosen the knob set screws, remove the knob, and re-install the front panel and dial to the main unit, with the same knob set-screw on the shaft flat. Tighten both knob screws and replace all the screws around the front cover, making sure that the dial is not rubbing against the panel or fiducial. Again optically align the antenna at 0°, and loosen and shift the fiducial if the dial does not read "0". If there is not sufficient fiducial movement to read "0", it may be necessary to remove the cover and slightly reset the phasing between the shaft and slip ring assembly.

If it is desired to make electrical tests, they may be accomplished with a DVM and a 1.5V battery as follows. Place a 50 ohm termination on the Sense Antenna jack. and measure the input impedance at the Signal Generator jack - it should be 50 ohms ± 1-1/2 ohms. Connect the 1.5V battery to the Signal Generator jack. The voltage at the terminated Sense Antenna jack should be 1/5 of the battery voltage. The voltage at the antenna wire should be 1/2 of the battery voltage if the CES-116A has equalized E and H fields (so indicated by a sticker on the rear cover) and equal to the battery voltage if the unit does not have equalized E and H fields (units before serial 2198 that have not had the equalization kit installed).

SECTION 5B - CES-117A

Since there is no power supply or active devices in the CES-117A, it will be found that very little maintenance will be required. The only troubles that might occasionally occur are erratic sensitivity readings of the receiver, caused by dirty brushes in the slip ring assembly, and consistent phase errors, if the dial has slipped on its shaft.

Access to the slip ring assembly is thru the front cut-out. Remove one or more of the four sets of three screws holding the side covers on the central bearing assembly to reach the slip rings. Replace the side covers after maintenance,

Phasing of the CES-117A loop to the dial may be checked optically. Remove any antenna plate that may be installed, and tightly stretch a piece of #20 wire between the center snap-slide fastener studs on each side. Rotate the antenna so that the insulator stamped "LO" is to your left as you face the unit, and optically align it with the #20 wire just installed. The dial should read "0°", within ± 1/2° max.

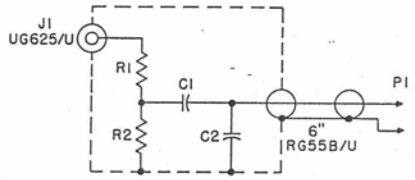
If the readings are off, first check that the knob screws are tight. The shaft has flats for the set screws, and they should be centered on the flats. To check, loosen the two knob set screws 1/8 turn, hold the antenna, and try to turn the knob. If it can be turned equally in each direction, it indicates that the set screws are lined up with the shaft flat, as they should be. Tighten the screws on the flats, and re-check the dial zero. A slight error may be compensated by loosening the fiducial screws and shifting the fiducial to one side or the other.

Larger errors must be corrected by removing the "L" shaped side plate covering the dial assembly, Top Loop/Bottom Loop switch, and coax connectors. The Allen screws in the gear in the rear may be loosened to allow rephasing of the dial to the antenna. Be sure the gear screws are tight before re-installing the cover. All the electrical components (coax connectors, switch, and all resistors) are also available for maintenance when the cover is removed.

If it is desired to make electrical tests, they may be accomplished with a DVM and a 1.5V battery as follows. Place a 50 ohm termination on the Sense Antenna jack, and measure the input impedance at the Signal Generator jack - it should be 50 ohms ± 1-1/2 ohms. Connect the 1.5V battery to the Signal Generator jack. The voltage at the terminated Sense Antenna jack should be 1/5 of the battery voltage. The voltage at the antenna wire should be 70% of the battery voltage for either position of the Top Loop/Bottom Loop switch.

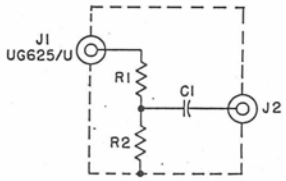
APPENDIX

CES-116A/CES-117A SENSE ADAPTERS



These Sense Adapters are designed to have P1 plug directly into the ADF.

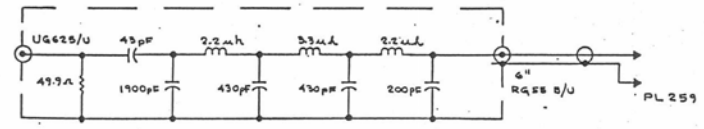
RECEIVER	R1	R2	C1	C2	P1
Bendix ARN21/BC433G/MN36C/ LP21A/LP21LM	39Ω	12Ω	47pF	0	Spade Lugs
Bendix DFA73	43Ω	6.8Ω	200pF	0	Spade Lugs
Collins 51Y3/179J5	39Ω	10Ω	51pF	200pF	Spade Lugs
Collins 51Y3/179J1	36Ω	12Ω	200pF	0	Spade Lugs
Bendix T12B/C/D	36Ω	15Ω	51pF	56pF	PL 259
Bendix MN62/DFA70	39Ω	10Ω	51pF	200pF	PL 259
Bendix ARN6	39Ω	12Ω	51pF	82pF	PL 259
EDO 556	39Ω	13Ω	51pF	82pF	PL 259
Lear ADF 12D3/12D4	33Ω	16Ω	51pF	56pF	PL 259
Genave Sigma 1500	39Ω	12Ω	51pF	200pF	RCA Plug
Dare DADF1	39Ω	13Ω	51pF	82 pF	BNC



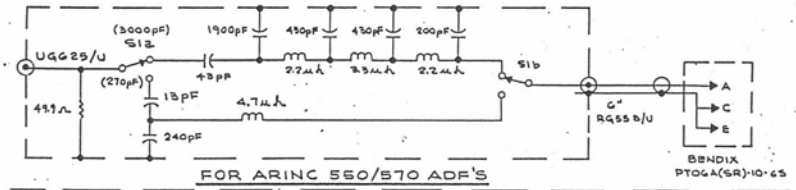
These Sense Adapters are designed to use the ADF manufacturers sense cable to connect J2 to the ADF.

	R1	R2	C1		J2
King KR-80/85/86	36Ω	12Ω	51pF	-	TED RPJ10B
ARC/All, Cessna/All	39Ω	13Ω	51pF	-	BNC - UG625U

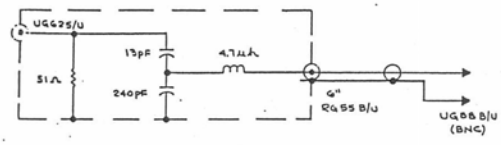
CES-116A/CES-117A SENSE ADAPTERS



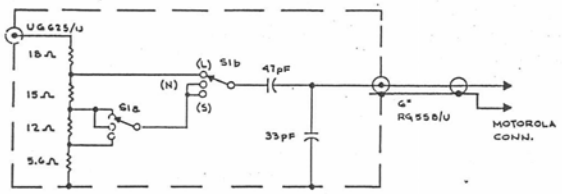
FOR ARINC 530 ADF'S



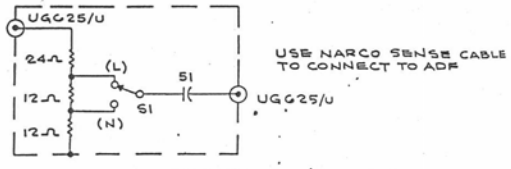
FOR ARINC 550/570 ADF'S



FOR KING KDF 800/805 ADF



FOR NARCO ADF 29/30/31/31A



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