Operating the AN/SRA-22 Antenna Tuner

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The radiating efficiency of a high-frequency transmitting antenna aboard ship is directly affected by its impedance characteristics, by its location, and by the impedance characteristic and tuning of the associated antenna coupler. This article explains the system impedance aspects of a standard 35-foot shipboard whip antenna in relation to the impedance characteristics of the AN/SRA-22 antenna tuning group. This unit is normally used with radio set AN/URC-32. An understanding of this antenna coupler's impedance matching characteristics will help operating personnel achieve maximum antenna system tuning efficiency. This information should also increase understanding of AN/SRA-22 capabilities when used with antennas other than the 35-foot whip.

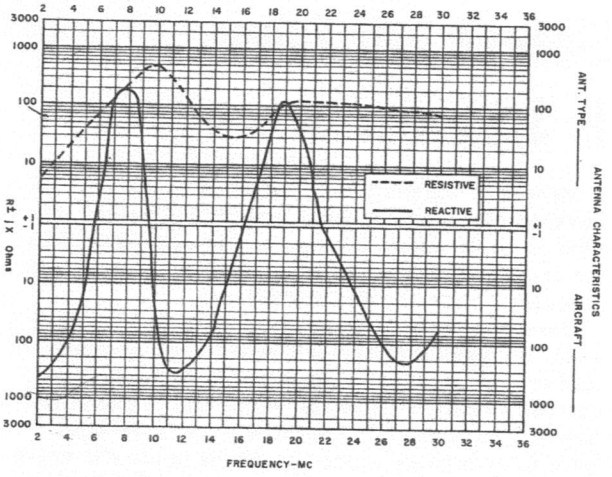


Figure 1. Impedance characteristics of isolated 35-foot whip antenna.

Figure 1 shows impedance characteristics measured on an isolated 35-foot whip antenna. This impedance can change materially when the antenna is installed in various locations on a ship. Two 35-foot whips on the same ship will not present the same impedance to the AN/SRA-22 coupler. To have an antenna tuner capable of compensating for the complex impedance of a 35-foot whip, a variable tapped coil is placed in series with the antenna being tuned. A variable capacitor is also placed either in series or shunt with the antenna.

The manual control of the variable coil and capacitor, SERIES or SHUNT position, must be a sequence operation. If the operator tries to adjust the variable coil and capacitor at the same time, the effect of the tuning capacity can be masked by the movement of the variable coil. Figure 2 is a simplified schematic diagram of the AN/SRA-22 which illustrates the functions of the variable coil tap and capacitor. The variable tap in the AN/SRA-22 is used to find the point on the coupler nearest 50 ohms. Adjusting this variable tap position is always the *last* operation in tuning.

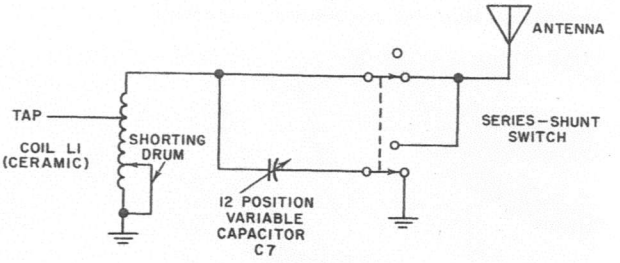


Figure 2. Simplified schematic of AN/SRA-22.

The tuning sequence for the AN/SRA-22 and any antenna, whether a 35-foot whip or other type antenna, always begins from the "home" position with the coil dial on 100, both coil and tap meters at zero, series-shunt switch on shunt, and the 12-position capacitor switch on position 1. This operation (figure 3) puts all variables near their minimum effective tuning position.

The transmitter must be set at tune power with an output of no more than 125 watts before tuning the AN/SRA-22 into an antenna of unknown characteristics. The power output of SSB transmitters such as the AN/URC-32 and AN/WRT-2 can be reduced to a few watts by varying the excitation. Until the tuning positions of the antenna coupler have been verified as efficient, no more power than necessary for tuning should be used.

Figure 3 shows the home position on the antenna control C-2698/SRA-22 and also the position of the

coil, tap, and capacitor in the CU-714/SRA-22. The coil on the ceramic drum is about two complete turns of ribbon. The rest of the coil is on the shorting storage drum. Each 20 divisions on the coil dial represents one additional turn of ribbon on the ceramic drum. Since the drum is connected in series with the antenna, the addition of coil ribbon on the ceramic drum has the same effect as adding coil inductance in series with the antenna or making the antenna longer electrically.

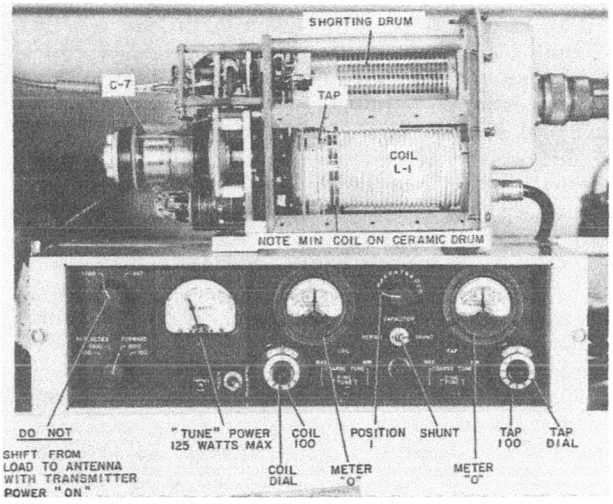


Figure 3. Home position at start of tuning procedure.

Heat

The RF current passing through the coil generates heat in the coil and coupler. The fewer the number of coil ribbon turns on the ceramic drum, the less heat will be generated. To keep heat down, the operator's instruction chart NavShips 93286.21(A) provides limits which should not be exceeded for coil settings when tuning to various frequency ranges: 500 for tuning frequencies 2-6 mc., 350 for 6-12 mc., 250 for 12-16 mc., and 200 for 16-30 mc.

For example, if the AN/SRA-22 is tuned into an antenna at 2.5 mc., the coil dial reading should be 500 or less. Approximately 500/20 or 25 turns of coil ribbon would be on the ceramic drum. The ribbon adds a considerable amount of inductance to the antenna, increases its electrical length, and reduces the efficiency of the coupler because of the inherent loss in any conductor. This loss cannot be avoided when using an antenna requiring a high coil setting such as a 35-foot whip antenna in the 2-6 mc. frequency range. Under no circumstances should the coil dial reading exceed 500 for frequencies 2-6 mc. This reading represents 25 turns of coil ribbon, which potentially is a source of a large amount of heat for the coupler to dissipate.

Tuning Procedure for 2-6 mc.

Figure 4 shows the initial position of the controls for tuning an antenna in the 2-6 mc. range. This operation also starts with the same number of turns on the ceramic drum. The COIL COARSE-FINE-TUNE switch is moved full left (figure 5) to bring the coil dial meter back to zero. This operation increases the amount of ribbon on the ceramic drum (figure 5).

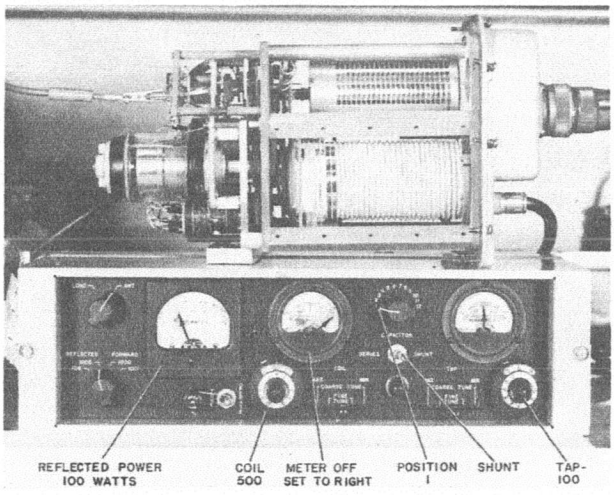


Figure 4. Initial position of controls for 2-6 mc. range.

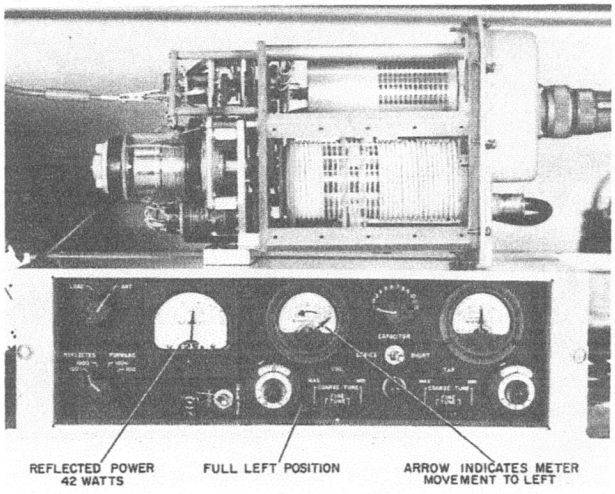


Figure 5. Coil coarse-fine tune switch moved to full left.

As the number of turns of the coil ribbon on the ceramic drum is increased (figure 6), reflected power is reduced. The reduction in reflected power continues (figure 7) until the reflection dip is obtained. This dip is obtained by varying the coil alone; since the coil meter is still to the right of zero, the coil setting must be less than 500.

Figure 8 shows the position of all indicators in full operate position for a frequency of 2.5 mc. after fine tuning to eliminate the reflected power. Forward power is 500 watts, coil reading is 459, capacitor is in shunt position 1, and tap indicator is on 93.

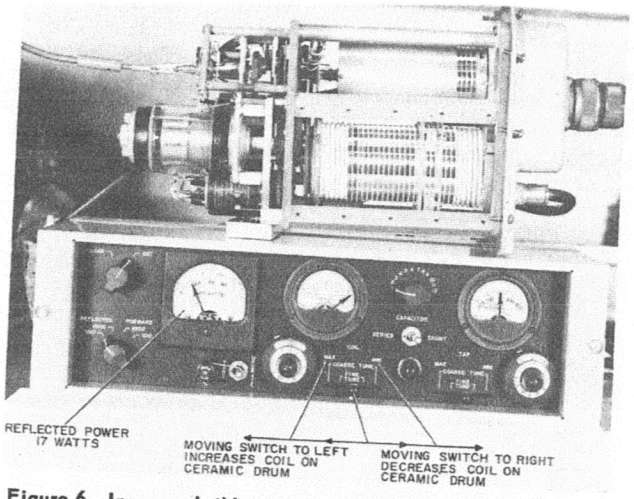


Figure 6. Increased ribbon on drum reduces reflected power.

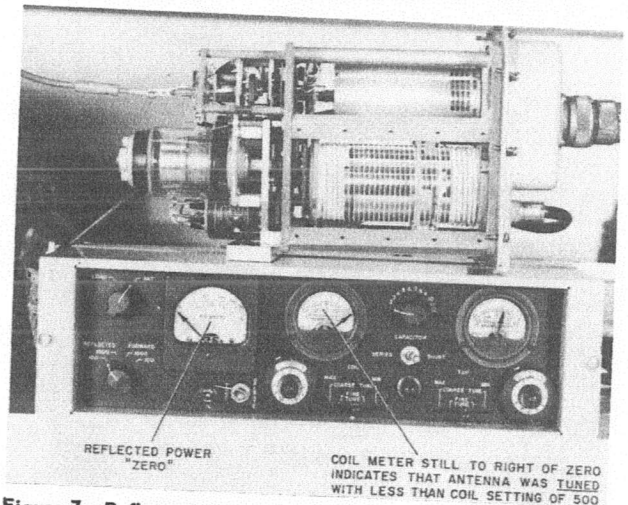
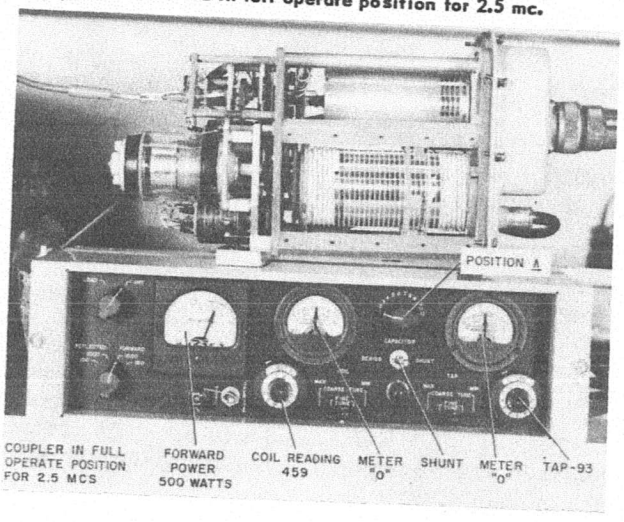


Figure 7. Reflected dip with coil setting at less than 500.

Figure 8. Indicators in full operate position for 2.5 mc.



Tuning Procedure for 6-12 mc.

When tuning the AN/SRA-22 in the 6-12 mc. range, the maximum coil reading is reduced to 350. In this range of frequencies, the coil limits are imposed for an additional reason. If more than 350/20 or 17.5 turns are used on the ceramic drum, any extra turns will cause the coil to go through parallel resonance. This condition makes the coil resemble a lossy capacitor by causing high circulating currents and very high voltages which will damage the coupler.

The maximum coil limits established for AN/SRA-22 tuning are intended to limit the amount of coil ribbon put on the ceramic drum. If a dip in reflected power cannot be obtained within these limits, the coil dial setting should be returned to 130, or slightly over 3 turns of ribbon with coil meter at zero. If a dip in reflected power cannot be obtained when using the coil alone, the antenna is already inductive, that is, the antenna is too long electrically at the tuning frequency, and series or shunt capacity must be used. This phase of tuning is started with minimum capacity; the SERIES-SHUNT switch is on SHUNT and the CAPACITOR switch is on position 1.

Position 1 on the CAPACITOR switch is the "home" position from which all tuning procedures start. Since position 1 does not tune the antenna, the capacitor switch must be turned to positions 2 up to 12, step by step. After each step, the red capacitor-tuning light should go out before the next step is made. Each step should be checked for a dip in reflected power. If no dip has occurred after position 12 shunt is reached, the SERIES-SHUNT switch should be changed to SERIES and the CAPACITOR switch should be operated in reverse, that is, 12 down to 1 in single steps. This step-by-step procedure enables the operator to find the lowest capacity needed to tune the antenna. The dip in reflected power indicates the lowest possible capacitor setting, closest to 1 in SHUNT or 12 in SERIES.

If excessive capacity is used, the operator will have to compensate for the excess by adding more inductance or coil ribbon to the ceramic drum. However, this procedure can result in high heat or voltage arcing with the coupler.

Tuning at 12-16 mc. and 16-30 mc.

Figure 9 shows the position of the various controls for tuning the coupler in the 12-16 mc. range. The coil dial is on 250; all other controls are in the home position. As the COIL COARSE-TUNE switch is moved to full left, the coil motor turns to add coil to the ceramic drum. Reflected power is still rather high. Figure 10 shows the coil meter zeroed but the reflected power is still too high, indicating that a dip in reflected power has not yet been achieved.

No dip can be obtained without exceeding the coil dial setting of 250 since the dial meter is zeroed with the dial indicator on 250. Continuing to operate the COIL COARSE-TUNE switch so that

the coil meter would go to the left of zero could cause additional turns to be put on the ceramic drum. The coil dial indicator would read more than 250 when the coil meter was finally zeroed. Therefore the meter should not be zeroed in the 12-16 mc. range. After the coil dial is set for the tuning ranges of 2-6 mc. at 500, for 6-12 mc. at 350, at 12-16 mc. at 250, and for 16-30 mc. at 200, and after the COIL COARSE-TUNE switch is energized to bring the coil meter back to zero, the coil meter should not go past zero if no dip is obtained.

When no dip in reflected power is obtained by staying within the coil dial limits, the following procedure should be used: Return to home position (figure 3). Set the coil dial at 130 and the coil meter at zero. Move the capacitor switch one step at a time starting from position 1. Wait each time until the red light on the antenna control panel is extinguished, indicating that the variable vacuum tuning capacitor has stopped at the position shown by the numbers on the switch. Note the action of the reflected power meter as the capacitor is switched one position at a time. When the reflected power dips, leave the capacitor switch in that position. If position 12 shunt is reached without a dip, shift the SERIES-SHUNT switch to SERIES and reverse the steps until a dip is obtained.

After a dip is noted, the COIL COARSE-TUNE switch should be used to obtain a further reduction in reflected power. The coil limits already stated should not be exceeded when tuning in the frequency bands of 12-16 and 16-30 mc. When the proper capacity is used, the coil settings will not exceed 200. After the reflected power is reduced by the COIL COARSE-TUNE switch, the TAP FINE-TUNE and COIL FINE-TUNE switch should be operated to obtain zero reflected power. All motors should be zeroed by operation of the COIL and TAP dial. These readings and the number and position of the CAPACITOR switch, SERIES or SHUNT, should be recorded for future reference.

Figure 11 shows the position of the controls for a frequency of 9 mc. tuned into a 35-foot simulated antenna (BuShips Plan RE66C2145B). Figure 12 illustrates the position of the controls for a frequency of 15 mc. tuned into the same 35-foot simulated antenna.

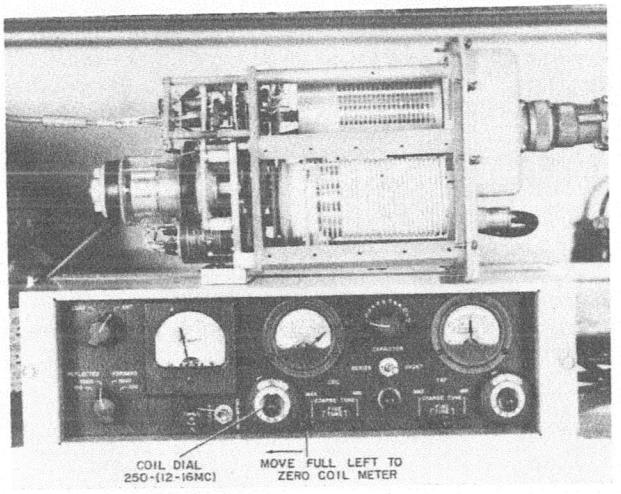
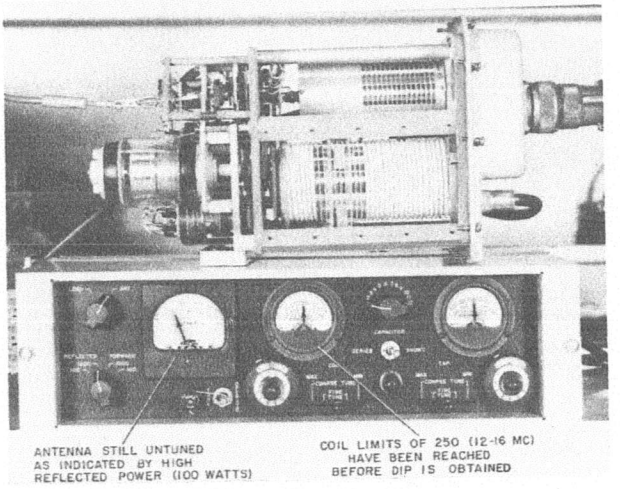


Figure 9. Position of controls for 12-16 mc. range.

Figure 10. Coil meter zeroed, but reflected power too high.



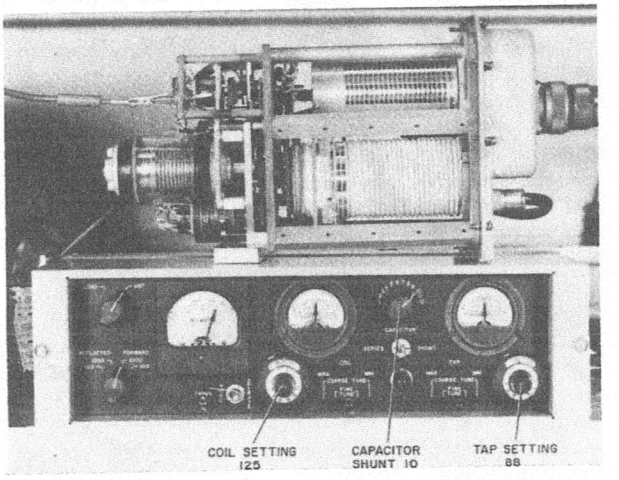


Figure 11. Position of controls for 9 mc. tuned into 35-foot simulated antenna.

The AN/SRA-22 can be tuned into a wide variety of antennas if used and operated as outlined. When tuning the AN/SRA-22 into a 35-foot whip at a frequency where the whip represents a quarter wave and the impedance of the antenna is resistive only, the dip in reflected power will be much broader than is normal elsewhere in the frequency band.

Importance of Minimum Tuning Power

Minimum transmitter power, not exceeding 125 watts, *must* be used in antenna tuning. The initial

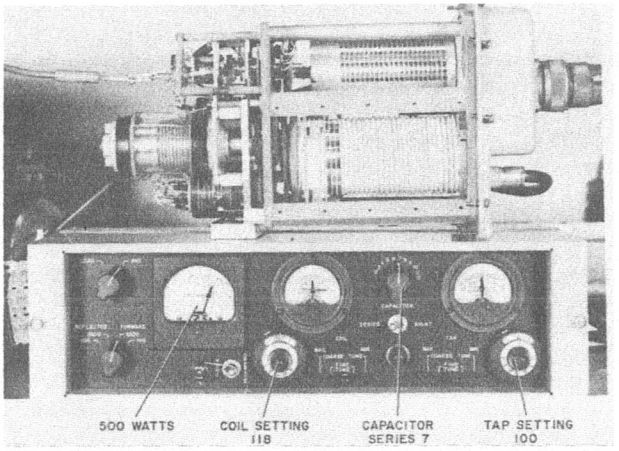


Figure 12. Position of controls for 15 mc. tuned into 35-foot simulated antenna.

home position of the coupler settings usually places the coupler in the detune position, resulting in high reflected power. At transmitter power levels of 125 watts, high reflected power will not damage the coupler. The reason for using minimum power on tune-up is that high reflected power reacts on the transmitter and causes the plate current of the transmitter tubes to exceed their current rating, resulting in probable damage to the power amplifier tubes or the high voltage supply fuses.

Operators who use the correct AN/SRA-22 tuning procedure should not have difficulty in tuning antennas of lengths other than 35 feet. The impedance of whip antennas as well as wire antennas changes radically depending on their location, length, and other physical characteristics. The roll of a ship and of aircraft on carriers near antennas can change the impedance. Antennas shorter than 35 feet used in the 2-6 mc. range are the most difficult type to use with any antenna coupler because of the high inductance, or coil, values required to tune the antenna. In this frequency range, the major problem is dissipating heat generated in the inductance (coil). Therefore, reduced power should be used to keep heat dissipation at a safe level. The AN/SRA-22 can dissipate 300 watts at 65° C. ambient.

Coupler Efficiency

Figure 13 is a curve of the efficiency of the AN/SRA-22 used with a 35-foot whip antenna. With a 25-foot whip, the coupler efficiency is only 50 percent at 2 mc. If the transmitter were operating at a power level of 500 watts, 250 watts would be dissipated within the coupler as heat.

With a 15-foot whip at 2 mc., the coupler efficiency is further reduced to 20 percent; 400 watts would have to be dissipated as heat if the transmitter were operated at 500 watts. Since 400 watts exceeds the heat dissipating capacity of the coupler, transmitter output would have to be reduced to 250 or 300 watts for safe operation.

Ships have used long wire antennas successfully with the AN/SRA-22. The USS *Northampton* is using the AN/SRA-22 and a 35-foot whip antenna on a voice-only circuit with a 2.5-kw power amplifier at frequencies of 4 to 30 mc. Antennas shorter than 35 feet should be tuned with care and the coil setting should never exceed 500 in the 2 to 6 mc. range. If short antennas must be used in an emergency on 2 to 6 mc., power must be reduced to keep down internal heat within the coupler.

Summary of Procedure

- Antenna impedance must be known before any antenna coupler can be operated intelligently. The shorter the antenna, the more severe are the operating conditions placed on the antenna coupler. If the antenna is shorter than 30 feet, transmitter power should be reduced to stay within safe coupler-operating limits.
- Minimum transmitter power should always be used in tuning the AN/SRA-22 (125 watts maximum).
- Tuning procedure should always be started from the "home" position:
  1. CAPACITOR SERIES-SHUNT switch on SHUNT.
  2. CAPACITOR switch on position 1.
  3. COIL and TAP dial on 100.
  4. COIL and TAP meters on zero.
  5. Red capacitor indicator light out.
- Coil indicator limits as provided in Operator's Instruction Chart (NavShips 93286.21(A)) should never by exceeded. Excessive coil causes heat and lowers efficiency.

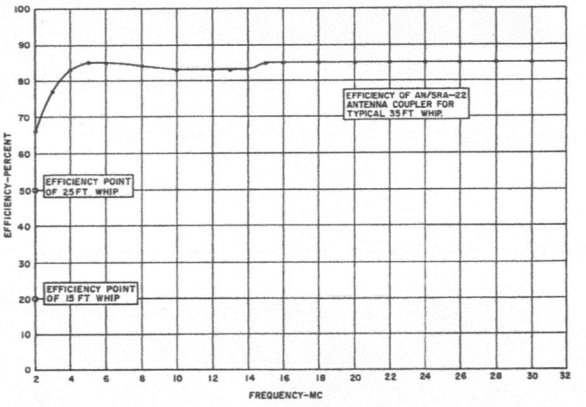


Figure 13. Efficiency curve of AN/SRA-22 with 35-foot whip antenna.

- Minimum coil needed to obtain a dip in reflected power should always be used.
- CAPACITOR switch should be operated in discrete single steps, use only minimum capacity settings.
- When tuning an antenna other than a 35-foot whip, extra care should be taken to tune the coupler at its most efficient point.
- Antennas shorter than 35 feet require special care. Antennas less than 25 feet long should not

be used unless an emergency requires their use. Reduced transmitter power should be used with antennas shorter than 35 feet on frequencies below 6 mc.; otherwise the coupler will burn out from excess internal heat.

- When transmitting FSK where the duty cycle is high or when the transmitter is to be operated for long continuous periods, the AN/SRA-22 should be tuned at the most efficient point for the frequency used. This precaution will greatly reduce the internal heat in the coupler.
- A good ground is essential at the coupler to prevent erratic tuning. Do not rely on unit mounting bolts for a good ground; *provide a grounding strap.*
- The bowl insulator should be clean and all outside connections should be watertight. Frequent inspections should be made.
- When a slightly reduced length of coil ribbon is used after emergency repairs, the COIL COARSE-TUNE switch should be operated cautiously and TAP or COIL should not be run to the stops. (Refer to *Electronics Information Bulletin 565.*) With reduced ribbon length, tuning should definitely start from the "home" position and the COIL COARSE-TUNE switch should be used to increase or decrease coil (figure 6).
- Since 35-foot whip antennas are normally used with the AN/SRA-22 and AN/URC-32, Fleet experience is that improved receiving capabilities can be obtained from the AN/URC-32 when used in the receive condition with a separate receiving antenna. This can be done by patching the AN/URC-32 receiver to the ship's receiving antenna patch panel as shown in NavShips 93285(A) TD-496, page 3, (AN/URC-32 manual).