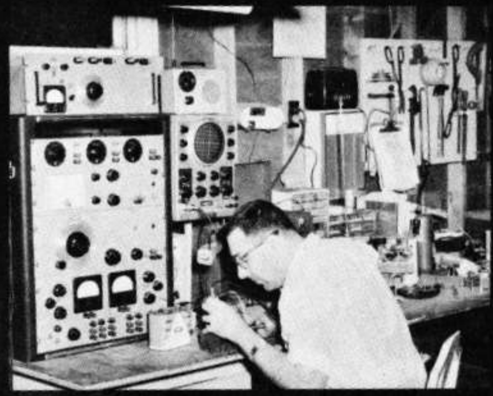
BENCH BITS



HANK GIUNTA
Technical Editor

● In response to the many requests we have received for construction notes and circuitry on RC test equipment, we are presenting several items this month which we feel you will be able to put to good use.

First, from Charles Fondecaro, Monterey Park, California, comes a very useful servo checker. It seems that Chuck "bends" his airplanes and equipment periodically and finally got tired of having to untangle the mess of spaghetti in order to check his servos for damage. The schematic for this unit is shown in Fig. 1. It is a standard servo hook-up—the only difference being that a SPDT switch is substituted for the reed bank.

When we tested this unit at RCM, we went a step further and included a reed switch in series with the switch shown. This is illustrated by the dotted line portion of the schematic. Although this feature is not necessary in order to obtain useful information from the servo checker, it does more closely simulate the actual operating conditions of the servo being used. For example, without the reed switch, a servo with open filter capacitors would still work okay on the checker, since it is D.C. which is applied instead of pulsating D.C. such as the servo gets from the reed bank in the receiver. You may not feel the extra expense is necessary, so pay your money and take your choice. Reed switches are available from Ace Radio Control, Higginsville, Missouri. We used a coil from a 110V A.C. relay and drove it directly off the power line. This gives a 120 cps switch rate, as the reed switch activates on both the positive and negative portions of the cps power. This is considerably less than the lowest frequency used on your reed bank, so if the servo works from this frequency input, you can rest assured that it will work from your reed bank.

One of the frequent causes of burned-out glow plugs is excess voltage from a lead-acid cell used as a starter battery. While these cells are available at very reasonable prices and are easily rechargable, thus lending themselves to use as ignition batteries, a device must be employed to drop the terminal voltage to some safe value. Normally, a resistor of about .2 of an Ohm would be sufficient, but with the many different types of glow plugs currently in use, varying loads are presented to the starting battery, and the current drawn from the battery may differ by as much as one ampere! These changing currents cause a changing voltage drop across the series resistor. If a silicon diode (10-20 ampere) is substituted for the series resistor, the voltage drop across it will be about .5 to .7 volts, which value remains fairly constant throughout a wide range of load current. This will drop the 2.2 volts to about 1.5 to 1.7 volts at the glow plug, which is just about right.

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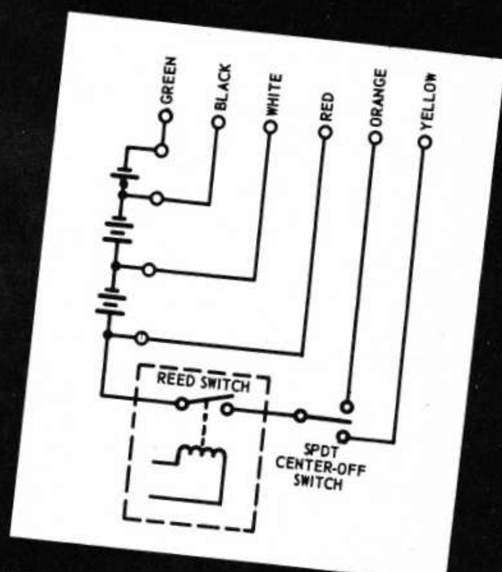

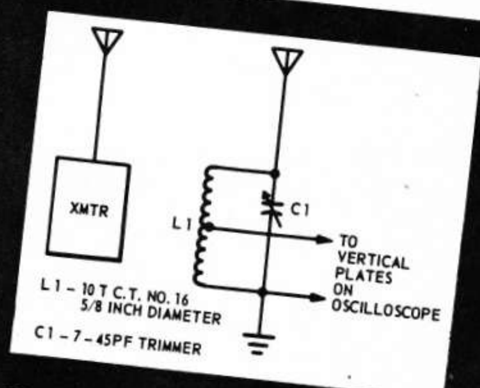

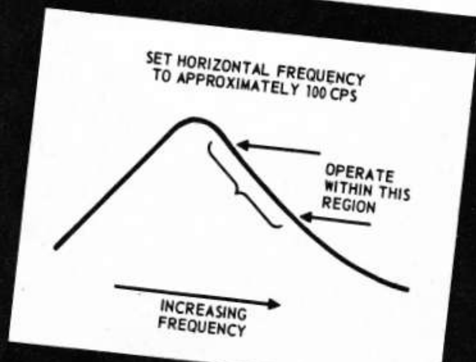

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Motorola has a line of silicon diodes which are very reasonably priced. A Motorola MR-24 is a 15 amp. 150 PRU unit, and is available for $1.20. Be sure to observe polarity when wiring in the diode—if you put it in backwards, Clyde, the glow plug ain't gonna glow!

During the past two years of RC equipment repair and service, it has been my personal experience that many cases of poor equipment performance and malfunction has been due to improperly tuned transmitters. It may be stated here that the only satisfactory way to tune an RC transmitter and to **know** that it is tuned properly involves the use of an oscilloscope. This is not to imply that it is impossible to tune a transmitter without a scope, as this is not the case. In general, those transmitters employing a vacuum tube as a modulator have sufficient audio power available to make tuning feasible with the simplest of equipment. The following applies mostly to those transmitters employing transistor modulators, which normally do not have much reserve power, and in some cases, barely enough. This does not mean that transistor modulators are unreliable, but only that some care must be taken to insure adequate modulation.

The point of maximum RF output is **not** necessarily the point of optimum tuning. The point of maximum modulation without exceeding 100% (in the downward direction) is the optimum tuning point. A tone receiver does not "see" the carrier as bearing any information of its own, but it responds to the modulation envelope. Why peak the RF at the expense of modulation? This practice leads to those frustrating days at the field when the range is short, yet the output is strong as indicated on the FSM. A kilowatt of RF carrier doesn't give you one microvolt of audio at the receiver, and without audio, you have no rudder either. The whole idea is to give the receiver the greatest possible audio signal on which to work.

Control grid modulation used on virtually all of the tube type transmitters is by nature one of the most difficult of ampltiude modulation systems to adjust properly. It is used because it requires relatively little audio power, and thereby reduces component numbers and battery drain. Since we are stuck with it you ask, how do we go about making the system work?

Since the audio power is fixed, the only adjustment we can make is in the RF drive to the amplifier. It can be seen that if the oscillator is lowered slightly, the audio power being constant, the net result is a higher percentage of modulation accompanied by slightly lowered RF output. In practice, this is precisely what is done. We must match the RF power from the oscillator to give us the modulation we need. Actually, modulation percentages of greater than 85% cannot normally be obtained with control grid modulation without some distortion and non-linearity of the modulation characteristic; however, some distortion is tolerable—insufficient range is not!

We assume that everyone is familiar with the restrictions imposed by Part 19 of the FCC regulations—therefore, the following tuning procedure is presented for information only. Equipment required is an oscilloscope, a field strength meter, and a **proper** tuning wand—no Allen wrenches, can openers, corkscrews, etc!

The purpose of the external tuned circuit (FSM) is to enable us to couple some of the RF energy being radiated from the antenna into our test circuit for observation. The standard practice of inserting a pickup link inside the transmitter tank coil or in the vicinity of the coil is fine for rigs with more power output, but doing the test in the manner prescribed does not alter the loading of the final amplifier in the transmitter.

Hook-up the equipment according to the sketch. Then, starting at the **low** frequency end of the oscillator coil adjustment, (for ferrite slug-tuned circuits, the slug is turned into the form for lower frequencies; capacitors are set to maximum capacity) turn the slug or capacitor until the oscillator starts. This will be indicated by a wide pattern on the oscilloscope screen. Make this adjustment quickly, because the tubes draw heavy plate current Further turning of the slug or capacit- when the oscillator is not operating. or in the same direction will cause the height of the pattern to decrease. This is the effect we want. Now, key the audio and adjust the tuning slug or capacitor until the troughs in the waveform barely touch each other. Over-modulation will result if you go any further. Key the audio on and off, and check the setting for stability. Also turn the transmitter on and off, and ascertain that it starts **every time.**

It will be noticed that the oscillator starts abruptly and then decreases in output more slowly as the circuit is tuned to higher frequency. Be **sure** that all adjustments are terminated on the high frequency side of the crystal oscillator curve, as instability will surely result if the tuning is done on the steeper low-frequency side. As a final precaution, make a **ground range check.**

In conjunction with the preceding discussion on the effects of transmitter tuning on modulation, the following notes cover the construction of a Field Strength Meter—a very useful piece of equipment, both at home and at the field—giving a relative indication of proper transmitter operation.

This particular circuit is far from being the ultimate in FSM's, but for our purposes it is more than adequate. Mine has been in use for five years and still perks right along. (Changed the batteries once!).

Starting at the antenna, the operation is as follows: some of the radiated power from the transmitter is picked up by the antenna and impressed on the tuned circuit fromed by L1 and C1. L1 and C1 are chosen to form a parallel resonant circuit at the transmitter frequency. Making C1 a variable capacitor allows the circuit to be tuned over a range sufficient to cover all the assigned RC frequencies. L1 is tapped to provide a closer match to the low impedance input of TR1. The diode D rectifies the RF carrier, and due to its connection, presents a negative DC voltage to the base of TR1. C2 is a filter for the rectified carrier. TR1

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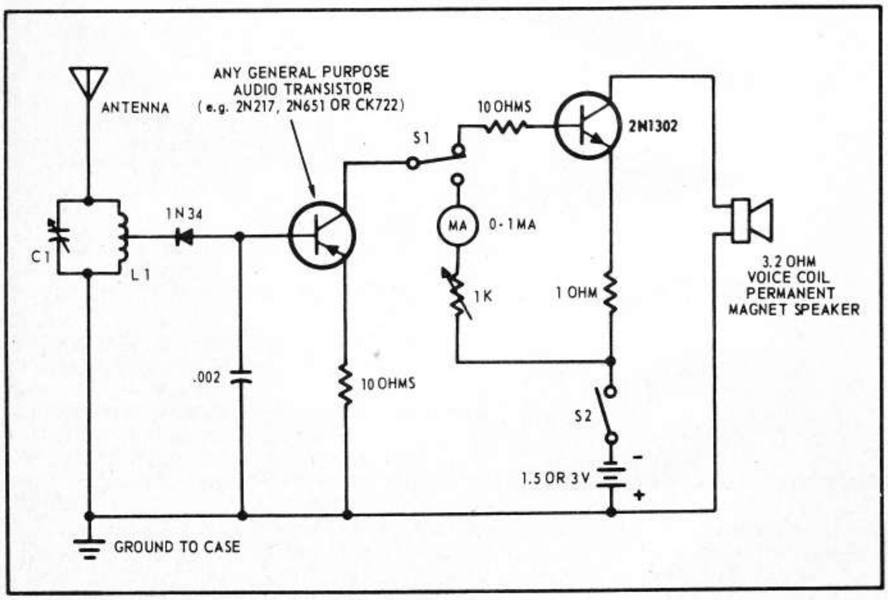

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is a PNP transistor, and a negative voltage on its base forms a forward bias, causing the transistor to conduct. The current flowing in the base circuit is amplified by the transistor, and the collector current is approximately equal to the base current times Beta, which may vary from 20 to 100 in inexpensive transistors. All this means is is that we can use a more rugged and less sensitive meter for M1. (Less expensive, too!). R2 is a variable resistor which is used to adjust the sensitivity of the FSM. R1 increases the input impedance to TR1 slightly and gives some measure of temperature stability. (Not very much, but apparently enough). The series combination of R1 and R2 affords some protection to the meter in the event that TR1 develops an emitter to collector short. (Depending on where R2 is set, the meter may still end up by being ruined, but it doesn't smoke quite as much!).

For those who do not need or want to listen to the audio output from their transmitter, the FSM is complete. By eliminating S1 and forgetting the remainder of the circuit, the unit can be constructed very compactly and may be easily carried to the field. This is a practical application because we all know the transmitter always works on the bench! Practical failures generally occur where such failures will cause the most possible damage—on takeoff, while in a steep dive, when inverted 50 feet of the deck, etc. **This** is when the transmitter usually fails, if it fails at all!

Getting back to the FSM, if S1 is switched to its other contact, the meter is disconnected from the circuit and TR2 and the speaker are subsequently connected. When the transmitter tone is keyed, you will be able to hear it from the speaker. TR2 is an NPN transistor which further amplifies the signal from TR1 and energizes the speaker. There is adequate volume obtainable, but don't expect high fidelity!

Total cost for the unit will range from a couple of dollars to about twelve dollars, depending on how well your junk box is stocked. S2 is not really necessary, especially if TR1 is a low-leakage unit.

Typical component values are:

- L1 = 10T #16⅝″ dia. (For 6 meters 5T) Both coils center tapped.
- C1 = 7-45 pf (for 6 meters, 3-12 pf)
- D = 1N34
- S1 = SPDT toggle, lever, or rotary switch
- C2 = .001 uf
- R1 = 22 ohms ½ or ¼ watt 10%
- R2 = 1K pot
- R3 = 10 ohms ½ watt 10%
- R4 = 3.3 ohms 1 watt (can be omitted)
- Speaker = any 4 or 8 ohm permanent magnet speaker from 3″ to 8″ (the larger speakers offer more volume)
- TR1 = any general purpose audio transistor (CK 722, 2N224, 2N-461, 2N217, 2N651). PNP's.
- TR2 = 2N1302, or almost any NPN transistor rated at 150 ma or greater collector current.
- Meter = 0-1 ma or 0-5 ma (a 0-10 ma may be used at reduced sensitivity)
- Antenna: 20″-30″ (the longer the better)

If you have more than one PNP transistor available, use the one which has the lowest leakage. This is indicated by the lowest meter reading with no RF signal coming in. My CK722 leakage is low enough so that there is no discernible meter indication with no RF.

Since the FSM does not indicate an absolute value of RF output, some hints on the use of the instrument are in order. To determine if the output of your transmitter has increased or decreased since the last reading, the FSM must always be placed the same distance away from the transmitter. Only then will the readings have any real value to you. For example, if the FSM gave a half-scale reading at a distance of 3 feet from the transmitter when the latter was properly tuned, using the FSM at a distance of 3 feet in subsequent tests will enable you to determine if the RF output is less, equal to, or greater than the original.

Normally, a field strength meter should be placed at least one or two wavelengths away from the RF source. In the 27mc band this amounts to about 37 feet. And at the 37 feet the meter looks like a gnat's eye, and even if you could see it well enough to read, it is doubtful that it would even twitch when the transmitter was turned on!

One other thing which may be of interest is that this meter is not a logarithmic device but is almost linear. Consequently, small improvements in transmitter tuning will cause the FSM to exaggerate the increase in RF power in terms of range. That is, a 100% increase in the FSM reading will not double the range of a particular transmitter-receiver combination. In order to double the range, the R Fpower at the transmitter must be 2 or 4 times the original power; to triple, the RF power must 3 or 9 times the original power. Don't expect fantastic increases in range if the FSM shows a little more output from your transmitter.

And don't forget to send in your schematics, gimmicks, and what-have-you for next month's Tech Topics!