HORSE TRADES

This page of the Bulletin is for use of amateurs who have RTTY EQUIPMENT FOR SALE OR TRADE and those looking for equipment to buy or trade. It is a free service and may be the means of getting someone on the air.

FOR SALE: O-5/FR Exciter.......W6EHZ
Wanted: Boehme Keying head for morse tape. With or without motor. McElroy if Boehme not available....W5AJG
For Sale: Polar relays, Sigma 7JOZ 16OT $2.00....W0HBD
Wanted: Tape equipment.......W3FU
Wanted: RTTYs all 1954, all 1953 and April and May 1955.......W0YKZ/5
For Sale: AN/FGC-1X new.......W7IWH
Wanted: Tape perf and distributor.......W9HHP
Trade: Model 12 for 26.......W7HPH
Wanted: Toroids for TU filters.......W5EYX
Wanted: Model 14 typing reperf with keyboard, or without. State price.......W8SDZ
For Sale: Keyboard only for model 28.......W4MWU
For Sale: Gates Filters—2125/2975.......W6DOU
For Sale: Model 26 printer, waiver required.......W6DOU
For Sale: Dual diversity TU, Heintz&Kaufman mfg..W6DOU

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NEWS OF AMATEUR RTTY

JULY, 1957
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Vol. 5, No. 7

Note

The READERS will note a different style in this issue. The material which makes up this issue is of such interest to all RTTY operators, that your Editor decided to print it "as is." Regardless of the type of Terminal Unit you are using, you will find information in this article which will apply to your own TU. About the author, Don Wiggins, W4EHU is well known on the various RTTY bands. He is a Professor at the University of Florida. He worked at Hughes Aircraft Company in Los Angeles, during the summers, hence has a very practical as well as theoretical approach to circuit problems.—Ed.

"SO SORRY DEPARTMENT"

(APRIL 1957 RTTY, Page 2)

The author omitted a 100K resistor in the generator tone article in the April issue of RTTY.

Please correct the circuit with a 100K resistor in place of the lead from the junction of the relay and keyboard contacts to the junction of the two 100K resistors at the grid of the gate control tube.

Also note that the crystal oscillator is not a Pierce oscillator. This was changed in the second revision.

The cascode multivibrator developed at NAA is a very reliable divider. The capacitor between the two cathodes determine the free running frequency in the absence of drive voltage and is chosen for a free running frequency just below the required frequency.

The initial frequency adjustment of the dividers is made by setting the drive for the appropriate divider ratio while observing the Lissajous figure on an oscilloscope which has the vertical and horizontal inputs connected to the divider input and output. Set the drive for a mid point of the lock-in range.

Temperature coefficients of the capacitors and resistors in the divider circuits may require re-adjustment of the voltage drive to the divider tubes for correct frequency lock-in during abnormal temperature conditions.

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VACUUM TUBE KEYER CIRCUITS

Don Wiggins, W4EHU

There has been quite a bit of discussion lately concerning vacuum tube keyer circuits. The importance of the keyer is evident when it is realized that any bias in the printer magnet keying pulses will reduce the range of the printer. This loss of range does not do any damage when signals are strong and little interference is present. However under weak signal conditions, the bias and distortion which are unavoidably present can combine with the loss in range to cause misprinting. Thus, it behooves us to have our keying circuit as "clean" as possible to reduce errors when signals are marginal.

To help us to understand the operation of a keyer circuit so that we can design a good circuit, it is advisable to analyze some of the possible configurations to determine the characteristics which influence their operation. Actually, an exact analysis is difficult because of the nonlinearities present. First, if we drive a vacuum tube from conduction into cut-off, it is obvious that we are not operating the tube over a linear range! If this were not enough, the inductance of our printer magnet is changing as the armature approaches the closed position. For example, measurements made on a Model 26 show an inductance of 1.23 henry open and 2.3 henry closed.

We can, however, perform an approximate analysis by making some simplifying assumptions. This will certainly yield some useful information. First, let's assume the tube characteristics are linear during the conduction period, and secondly, that the inductance of the printer coil is constant at 2 henry. The assumption of tube linearity (Fig. 1) allows mu and R_p to be handled as constants.

Analysis of Common Circuits

For a triode connected 6V6 or 6AQ5, the tube manual gives the following characteristics:

mu = 9 R_p = 2500 ohms Cut-off bias = -12 volts

First, take a look at the simplest circuit; the magnet coil is in the plate circuit and the cathode is grounded. (Fig. 2) The bias to allow the desired mark current to flow may be obtained from a fixed source, from a cathode resistor (heavily by-passed) or the plate voltage may be adjusted to allow zero-bias operation. In any of these methods, the d-c bias does not enter into the analysis. During conduction, we can represent this circuit by the equivalent circuit shown in Fig. 2. The applied grid signal will be a positive-going "step function" where the grid voltage suddenly increases from cut-off to a value, E_s in zero time. From this type of grid signal, the build-up current in the magnet coils may be calculated. By reversing this procedure and allowing the grid voltage to drop suddenly from E_s to cut-off value, the manner in which the current decays through the coils may be found. The analysis is a simple problem involving differential equations. I have worked these out for the various circuits which will be discussed in this article but to save space, ~~they will~~ the calculations will not be reproduced. Anyone who is interested

may drop me a line and I will send along a ditto copy. The result of the calculations for this circuit gives the following expression for the plate current:

$$i_p = \frac{\mu E_s}{R+r_p} - \frac{\mu E_s}{R+r_p} e^{-\left(\frac{R+r_p}{L}\right)t} \qquad ①$$

Plugging in values of the parameters for a 6V6 gives:

$$i_p = 40 - 40e^{-1350t} \text{ ma.}$$

This time function is plotted in Fig. 3. The time-constant (time required for the current to reach about 63% of its max. value) is 1/1350 seconds or 0.74 milliseconds. From equation 1 it is noted that this time constant is inversely proportional to the sum of the plate resistance and the coil resistance; that is, the higher the series resistance, the shorter the time-constant. This is the reason that relays are usually "over-voltaged" and a series resistance added to drop the closed circuit coil voltage to the proper value.

When the tube is suddenly cut off, the current will attempt to drop suddenly. However, the inductance will not allow this and the back emf (or inductive "kick") will raise the plate voltage to try to keep the current flowing. To limit this back emf to a safe value, it is necessary to shunt the magnet coil with a resistor. The value built into the Model 26 is 5000 ohms. Solving for the decay of current in the coil gives:

$$i_{coil} = 40 e^{-\frac{R'}{L}t} = 40 e^{-2500t} \text{ ma.} \qquad ②$$

The time constant is then 0.4 milliseconds. The effect of the shunt resistance during the operate time is neglible so was not included in the calculations previously discussed. To determine the maximum back emf:

$$e_{back} = L\frac{di}{dt} = (2)\frac{d\left(40e^{-2500t}\text{ ma.}\right)}{dt} = 0.08\overset{(-2500)}{\wedge}e^{-2500t} \text{ volts} \qquad ③$$

$$@\ t=0\ ,\quad e = 0.08(2500)(1) = 200 \text{ volts}$$

which is a safe value.

Since the time constants for the mark and space conditions are quite small compared to the 22 millisecond m-s pulses, this circuit will introduce neglible bias and therefore is adequate for a good keying circuit. The main disadvantage is that the printer coils are above ground and might give trouble in old machines where the insulation may have deteriorated.

In order to place the coils at ground potential, most terminal unit circuits have the magnet coils in the cathode circuit of the keyer tube as in Fig. 4. This changes the characteristics of the entire circuit since "degeneration" has been added. Just how this influences the operation should be clear from the following analysis. The basic difference here is that there is voltage feedback to the grid circuit. That is, the voltage across the coil is in series with the signal source as far as the grid-to-cathode voltage is concerned, and always subtracts from the signal voltage. If the signal voltage tries to rise, the increased plate current produces a larger drop across the coil. This voltage then subtracts from the signal voltage so that the final grid-to-cathode voltage change is less than the signal change. The source of the bias voltage has no influence on this feedback action, and only serves to set the static operating conditions of the tube.

To obtain a qualitative answer for the response of the coil current to a step function we return to a mathematical analysis. This gives:

$$i_{coil} = \frac{\mu}{\mu+1}\left(\frac{E_s}{R+\frac{r_p}{\mu+1}}\right)\left[1 - e^{-\left(\frac{R+\frac{r_p}{\mu+1}}{L}\right)t}\right] \qquad ④$$

Plugging in actual values:

$$i_{coil} = 2\times10^{-3}E_s\left[1-e^{-225t}\right]$$

The time constant is now 1/225 sec. or 4.45 millisecond. Note that the time constant is now inversely proportional to the coil resistance plus the plate resistance of the tube lowered by a factor of mu plus one. Thus our high series resistance has been reduced by a factor of ten. Also the "gain" of the stage which is ordinarily proportional to mu has been also reduced by a factor of ten!

Now when a negative going step is applied, trying to cut the tube off, the feedback tries to keep the current flowing and the math gives us:

$$i_{coil} = 2\times10^{-3} E_s e^{-225t} \qquad ⑤$$

We have omitted the shunt resistor that was used in the previous circuit, since the voltage across the coil will always follow the applied signal voltage so the back emf is no problem. While most TU circuits include this resistor, a check will reveal that it is not needed:

Check for $E_s = 20$: $E_{back} = L\frac{di}{dt} = (2)(2\times10^{-3})(20)(-225e^{-225t})$

for $t=0$ (max. value): $E_{back} = \underline{\underline{18 \text{ volts}}}$

Check for $E_s = 100$:

$E_{back} = 2(2\times10^{-3})(100)(225) = \underline{\underline{90 \text{ volts}}}$

and it is seen that the back emf will be slightly less than the driving pulse.

What will be the effect of the lengthened time constant on the printer magnet operation? Suppose we use a driving pulse just sufficient to cause the tube to conduct the proper coil current. This will be about 20 volts for the triode 6V6. The coil current will look like Fig.5. Since the armature requires a lower value to hold-in than to pull-in, the slow decay of the current will delay the release and lengthen the closed time. It is desirable to obtain a faster decay time to minimize this bias distortion. Inspection of the equation for the coil current reveals that the slope of the decay can be controlled by the value of E_s. Suppose we drive the grid to -100 volts instead of just to cut-off. Then the initial slope of the decaying current will start off toward a negative current value of

about -50 ma. Of course, the tube will cut off as current cannot flow in the negative direction.

This is an improvement in release time, but now the slow build-up of current is a problem. Again, this can be corrected by driving the grid instantaneously to, say, + 100 volts. Actually, the grid can never reach this value since clipping will occur. However, the current will change as if the grid were going that far! See Fig. 6.

Practical Circuits

A circuit which will have the characteristics just described is shown in Fig. 7. The triode connected 6V6 will draw about 35 ma. with about 100 volts on the plate and no extra bias is needed. The 12AX7 stage is designed to produce peak-to-peak pulses of about 150 volts. The preceding ~~stage~~ gain should be such that the noise with no signal is just below the triggering level. A negative going pulse at the grid of the 6V6 will drive the grid about 100 volts below cut-off. A positive pulse will then start trying to make the grid go positive with respect to the cathode. However, the back emf from the coil raises the cathode preventing the grid-to-cathode voltage from becoming excessive. As the back emf falls off the grid begins to conduct, clamping the signal at the normal bias level. Thus we have a fast build-up for a "mark" signal, clamping at the normal coil current, and a fast decay for a "space" signal.

Another circuit which has the same action is shown in Fig.8. The VR 150 raises the cathode to plus 150 volts so that the no-signal grid to cathode bias is near zero. With about 100 volts across the 6V6, 35 ma. will flow. When the 12AX7 is driven to saturation, the keyer grid will be at about plus 50 volts or -100 volts below the cathode. Similarly, when the 12AX7 is cut-off, the grid of the keyer tube will try to go to about plus 100 volts but of course will be clamped at the bias level.

These two circuits have been tried out in the breadboard stage and observation of the current waveforms bears out the theory and calculations. I have not had time to give them an extensive on-the-air test, as yet; but I hope that they may furnish a starting point for some who like to "tinker" with various circuits.

For those who prefer the plate-circuit coil connection (which is my own preference) Fig. 9 shows a simple scheme which will allow the coil to be grounded. A small filament transformer is fed from the filament winding of the main power supply and the 115 v. primary used for a separate supply for the keyer tube. The 4K ohm pot is adjusted for the required plate current at zero bias.

Experimental Results

In order to check on the various calculations made and to test the validity of some of the assumptions, I breadboarded a number of the circuits discussed. Some of the waveforms obtained may be of interest. A square wave generator with 50 volt peak-to-peak output at 25 cps was used as a signal source for all circuits shown. This was considered to be the lowest useful signal; however, better rise times and decay times were obtained by increasing this as previously discussed.

Figure 10 shows the magnet current waveform from the most common circuit. The "bumps" are caused by the change in inductance as the armature closes and opens and the breaks or discontinuities are due to the 5K shunt resistor and disappear when it is removed. Recently, it was suggested that a separate bias supply be used between grid and cathode. The results of this connection are shown in Fig. 11 and show no difference. This scheme does not help since the signal return is still to ground and degeneration is still present. Fig. 12 is the response of the separate keyer tube supply circuit described above. The rise time is faster than the other circuit, but the decay current is not shown due to the scope connection used. However, very little bias can be noted. NOTE: The time scale on all oscillographs is backward and should be read from right-to-left. This is the fault of the camera and is not a sign that I do things backward!

Note that in these circuits where a-c coupling is used, I have a coupling time constant of ½ second. The longest space (or negative pulse) received is a blank which is 132 milliseconds. Thus the grid will only recover about 20% in this time which is adequate to keep the keyer cut off.

I hope these few thoughts on this problem will be of some assistance, either in understanding of the circuits or perhaps in starting someone toward better solutions. I will be glad to hear from anyone who has any thoughts on this subject.

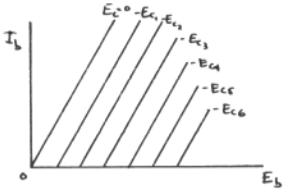
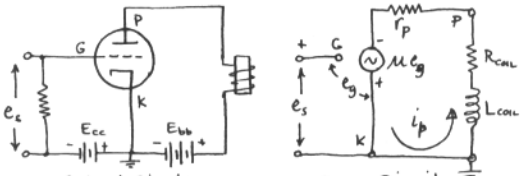


FIG. 1



Actual Circuit

Equiv. Circuit $e_g = e_s$

FIG. 2

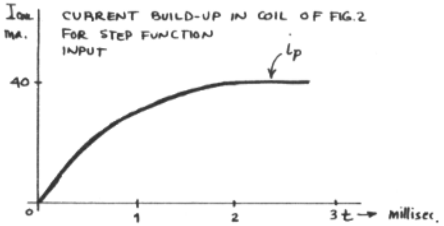
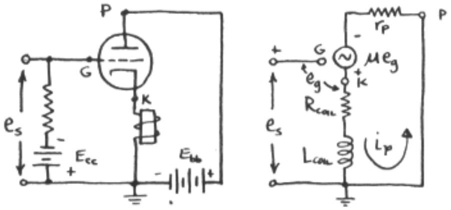


FIG. 3



$e_g = e_s - e_{coil}$

FIG. 4

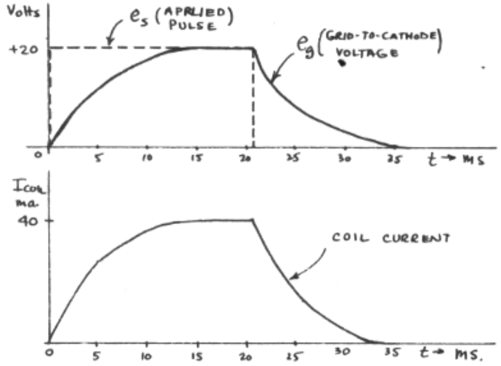


FIG. 5

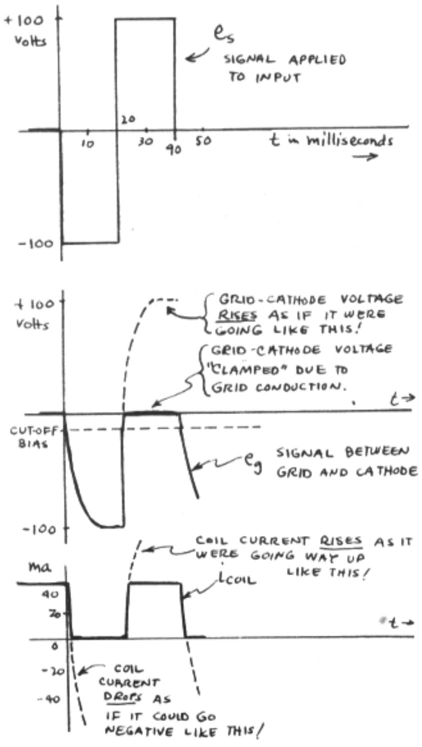


FIGURE 6

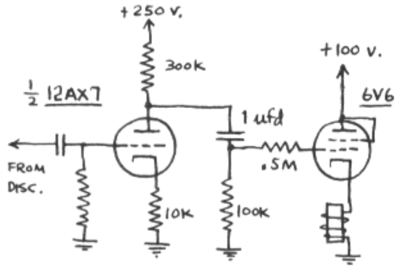


FIGURE 7

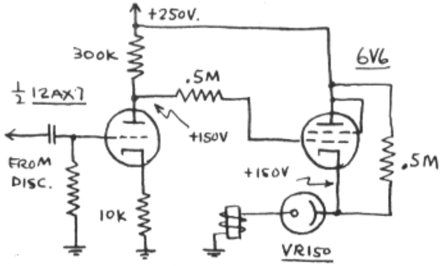


FIGURE 8