DESIGN ANALYSIS

Reduced to basics a whistle is nothing more than a resonant chamber which produces a tone when excited by the steam flowing over a turbulence producing orifice. It would be nice if that were all there were to it – but it's not. There is also the sound of the steam which can be heard as a faint hiss as the whistle is blown. Also, like any other "musical" instrument a whistle has its own peculiar attack and decay characteristics. That is, it takes a short time for the sound to build up to a maximum and the vibrations persist for some short time after the exciting force (steam) is removed. Finally, there is a slight lowering of pitch as the vibrating medium in the cavity changes from air to a denser air/water combination.

For ease of analysis the whistle may be divided into three essentially independent sections; an oscillator, noise source and gating amplifier.

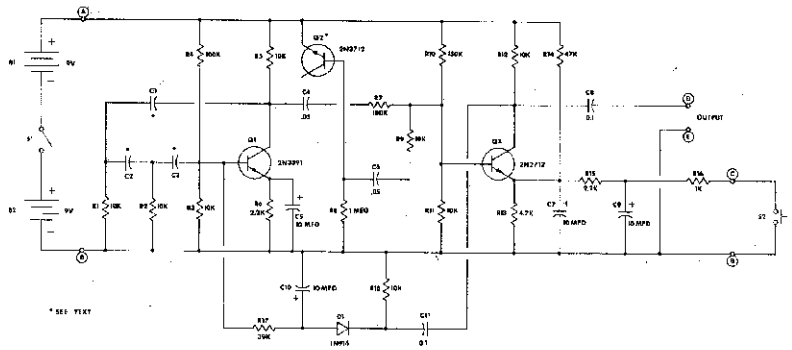
The oscillator is a standard phase shift design with Q1 in a common emitter configuration for gain and 180° of the required 360° phase shift. The remaining 180° of phase shift is provided by the frequency determining components C1, C2, C3, R1, R2 and R3.

Noise is provided by Q2, an inexpensive silicon NPN transistor which has it's base-emitter junction biased above the junction's breakdown potential. The shot noise of the resulting avalanche breakdown mechanism appears across R8 and is used to simulate the sound of steam.

The outputs of the oscillator and the noise source are mixed by resistors R7 and R9 respectively and applied to the input of the common emitter gain stage of Q3. When pushbutton S2 is open Q3 cannot pass audio because its emitter is held at a slightly higher voltage than its base by the voltage divider R14 and R13. When S2 is closed the voltage at Q3's emitter begins to drop as C9 discharges through R16.

As Q3's emitter voltage drops its base-emitter junction becomes more and more forward biased and thereby increases the gain of Q3. When S2 is opened a reverse action occurs as C9 charges through R15. These two time constants are chosen to simulate the attack and decay characteristics of a real steam whistle.

Part of the output signal is tapped off of Q3's collector and rectified and filtered by D1 and C10. The resulting DC voltage is applied to Q1's base where it gradually lowers the pitch of the oscillator slightly as the wistle is blown.



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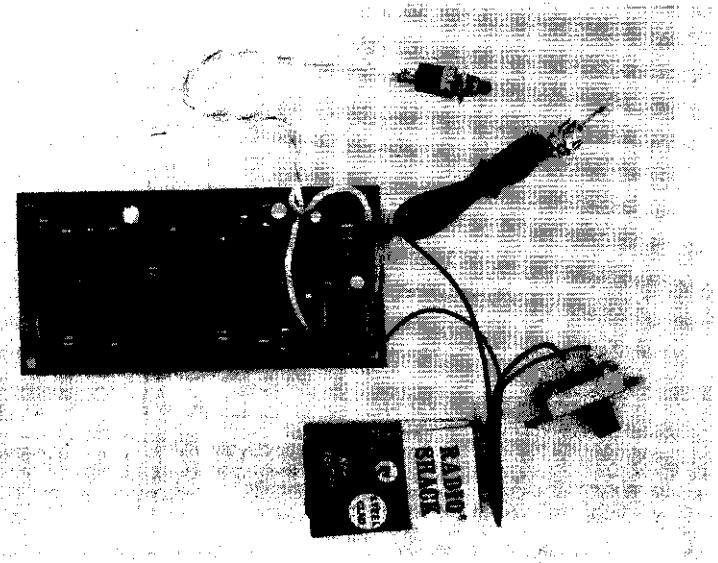
STEAM WHISTLE

Assembly Instructions



If model railroading is one of your hobbies you probably have at least one problem in common with every other railroad buff in the world – finding a steam whistle sound for your layout. If you're not inclined to invest the dough necessary to install boiler and pipes for a real whistle this design for an electronic substitute may be for you. You couldn't get any closer to the sound of a real locomotive even if you bought ol' 99 and rolled her into your living room.

SOLDERING

Use care when mounting all components. Use only rosin core solder (acid core solder is never used in electronics work). A proper solder joint has just enough solder to cover the round soldering pad and about 1/16 inch of the lead passing through it. There are two improper connections to beware of: Using too little solder will sometimes result in a connection which appears to be soldered but actually there is a layer of flux insulating the component lead from the solder pad. This situation can be cured by re-heating the joint and applying more solder. If too much solder is used on a joint there is the danger that a conducting bridge of excess solder will flow between adjacent circuit board conductors forming a short circuit. Unintentional bridges can be cleaned off by holding the board up-side down and flowing the excess solder off onto a clean, hot soldering iron.

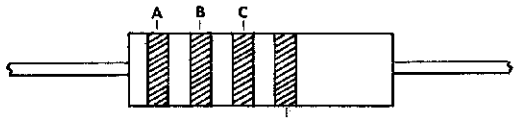
Select a soldering iron with a small tip and a power rating not more than 35 watts. Soldering Guns are completely unacceptable for assembling transistorized equipment because the large magnetic field they generate can damage solid state components.

CIRCUIT BOARD ASSEMBLY

Mount each part, cinching it in place by bending its leads out slightly (about 45 degrees) on the conductor side of the board. As each lead is soldered clip it off flush with the solder joint.

Begin assembly by mounting and soldering in place all resistors following the parts placement diagram (fig. 1). Resistor color coding is as follows:

DESIGNATION	VALUE	CODE A-B-C
R1, R2, R3, R5, R9, R11, R12, R18	10K	brown-black-orange
R4, R7	100K	brown-black-yellow
R6, R15	2.2K	red-red-red
R8	1 meg	brown-black-green
R10	150K	brown-green-yellow
R13	4.7K	yellow-violet-red
R14	47K	yellow-violet-orange
R16	1K	brown-black-red
R17	39K	orange-white-orange



When all resistors have been soldered in place proceed to the ceramic disc capacitors. The values of C1, C2 and C3 determine the pitch of the whistle (see Operation & Design Analysis sections). Mount and solder ceramic disc capacitors as per fig. 1 as listed below:

DESIGNATION	VALUE
C1, C2, C3	.005 mfd. or .05 (see text)
C4, C6	.05 mfd.
C8, C11	0.1 mfd.

None of the components to this point have been polarized; that is they may be mounted with either of their leads in either of the circuit board holes. When mounting an electrolytic capacitor note that one of its leads is marked with a plus sign and the other minus. The positive lead must go through the hole in the circuit board marked with the plus sign.

Mount and solder the electrolytic capacitors as per fig. 1 as listed below paying particular attention to polarity.

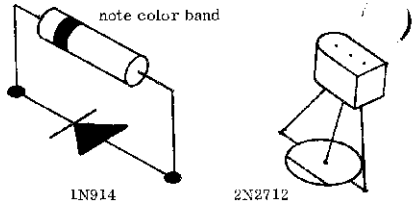
DESIGNATION	VALUE
C5, C7, C9, C10	10 mfd. at 10 volt

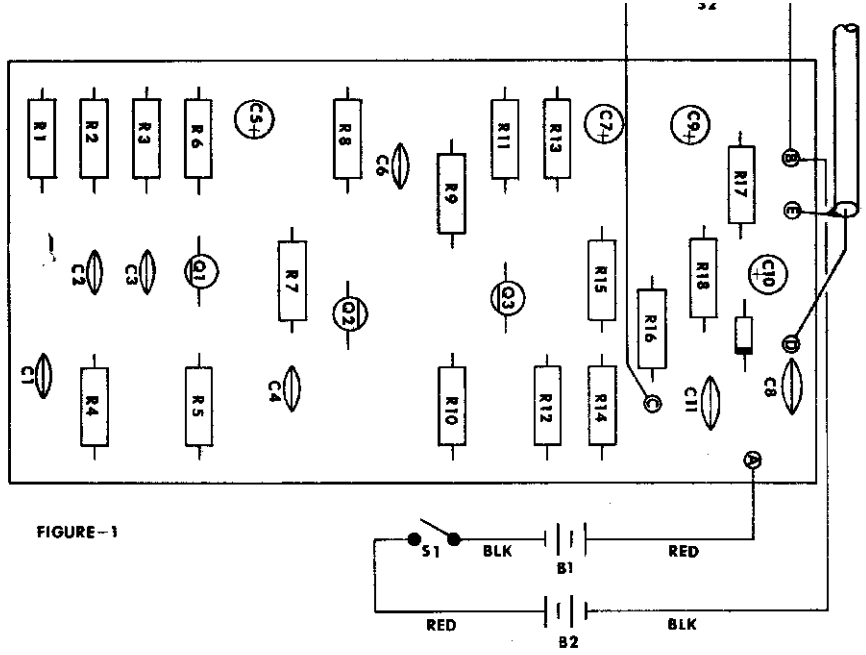
In a similar manner the transistors Q1, Q2, Q3 and diode D1 are polarized and their leads must be correctly oriented for them to operate properly. The schematic representation of the diode is related to the physical appearance of the device in the drawing below. Transistors are properly placed when the flats on their cases are as shown in the parts placement diagram. Transistors and diodes are heat sensitive and must be protected from temperature damage. While soldering them in place grip the lead being soldered with a pair of needle nose pliers between the body of the component and the point being soldered.

Note that one of the 2N2712's has been pre-tested and selected for its noise characteristics. The middle lead (collector) of this device has been clipped short and this unit is intended for use as Q2.

DESIGNATION	TYPE NO.
D1	1N914
Q1	2N3391
Q2	2N2712 (selected for noise)
Q3	2N2712

If the transistors you receive with this kit are as shown to the right install as illustrated.





FIGURE–1

This completes assembly of the circuit board.

There are a minimum number of connections between the circuit board and external parts. Use two pieces of the #22 stranded wire provided to connect the pushbutton S2 to the circuit board points "B" and "C". Note that the circuit board point "B" is shared between one of the pushbutton leads and the negative battery lead. Do not solder this connection until both the lead from the pushbutton and the black lead from one of the two battery clips provided is in place. Insert the red lead from the remaining battery connector in circuit board point "A" and solder this connection. The remaining red and black leads from the battery connectors is used as a switch leg and soldered to the lugs of power switch S1. Complete the assembly by soldering the shield of the co-ax provided to circuit board point "E" and the center conductor to point "D". Install a plug compatible with the input of the amplifier to be used.

OPERATION

There are no adjustments which must be made to the whistle to make it operate but there are a couple of component values you may want to trim out for what you consider to be the best sound.

As has been mentioned, the values of C1, C2 and C3 determine the pitch of the whistle. Using .005's for all three of these capacitors produces a high pitched screech similar to European trains while the use of .05's gives the roar of American Freights. The three capacitors need not be of equal value in order to sustain oscillation and pitches between these two extremes can be produced by changing the values of one or more of these capacitors.

The amount of "steam" may be varied by altering the value of R7. For more noise the value of this resistor may be decreased and for less hiss it's value increased.

Operation of the whistle is simply a matter of snapping two fresh 9 volt batteries into the battery connectors and plugging the output lead into the input of a suitable amplifier. Hi-fi, musical instrument or even battery powered amplifiers may be used but bear in mind that the quality of the sound is to a certain degree dependent on the quality of the amplifier used.