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The Low Voltage Auto Boat Marine Radio Space-Charge Forgotten Vacuum Tube Set

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As a solution to the tube type auto [radio's](#) persistent vibrator replacement and [high voltage](#) generation problems, leading tube manufacturers at the time - most notably RCA, Sylvania and others - developed [vacuum tubes](#) that could work off the 12V of an [automobile battery](#) without the need of any higher voltages. Around the end of the vacuum-tube era a set of about **thirty tubes were designed and made available especially for low - 12 to 16V - B+ anode voltage use** for the auto, boat and other vehicular radio designers.

Figure 1. 12DZ6 Low Voltage Space Charge Tube These forgotten, but most useful are the; [12AD6](#), [12AE6](#), 12AE6A, 12AE7, [12AF6](#), 12AJ6, 12AL8, [12BL6](#), 12CN5, 12CX6, 12DE8, 12DK7, 12DL8, [12DS7](#), 12DS7A, [12DU7](#), [12DZ6](#), 12EA6, 12EC8, [12EG6](#), [12EK6](#), 12EL6, 12EM6, 12F8, [12FK6](#), [12FM6](#), 12FR8, 12FX8, 12FX8A, 12GA6, 12J8, 12K5, 12U7. Three of these tubes have an improved "A" version, but they are counted as a single type in the total count.

The tubes in the above series all rely on an old "forgotten" technology, the space-charge grid that was invented by Schottky around 1919. The space charge grid is an extra grid that is placed below the usual first or control grid. As the space charge grid is always connected to a positive voltage, usually to the anode potential, and since it is the closest to the tube's emitter, it greatly accelerates electron flow that translates to useable, higher anode current.

Using only a twelve-volt anode supply on a regular vacuum tube's plate, it would be next to impossible to produce useable plate current. Since the output power is the product of the available signal voltage and the current, with low plate voltage a large plate current required. But a large plate current is impossible in a space charge controlled tube.

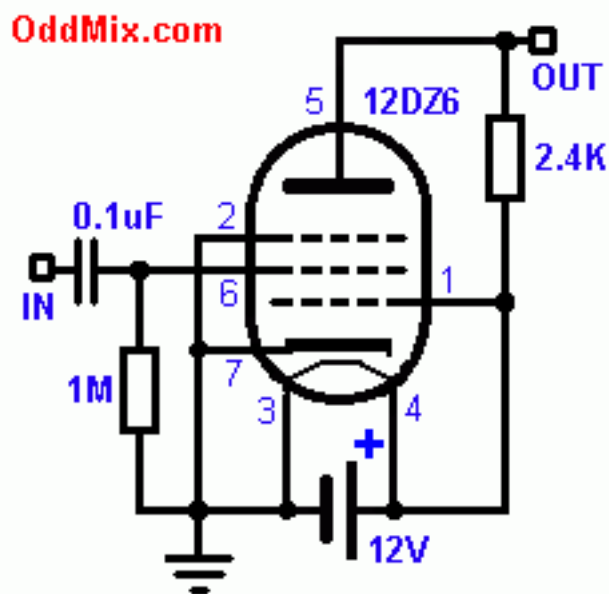


Figure 2. Audio Preamplifier with 12DZ6 Low Voltage Space Charge Tube

Space charge is a cloud of electrons - it forms a voltage gradient - enveloping the tube's hot cathode

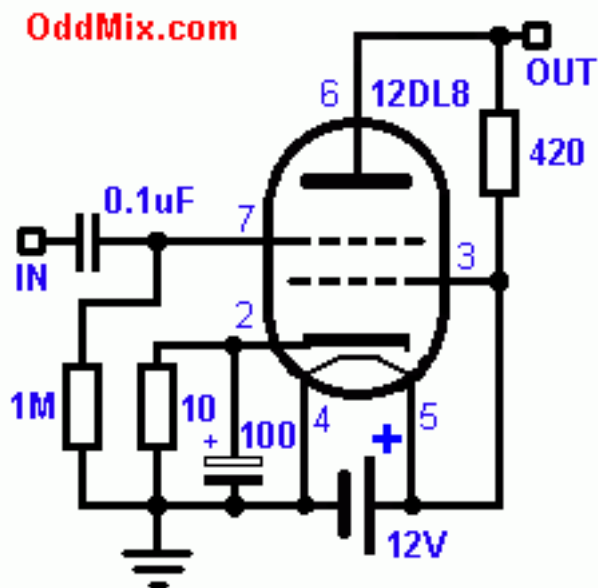


Figure 3. Audio Output Amplifier with Low Voltage 12DL8 Space Charge Tube

emitter, thus limiting electron flow. A grid located in the space-charge region, or very near it, connected to a positive potential would counteract the space charge build up and allow a larger plate current to flow. The control grid in space charge tubes are above the space-charge grid (nearer to the anode) and it controls the plate current in the usual way. In Schottky's time, the space charge built up was a problem with tubes.

Since space charge tubes were the last dying act of the vacuum tube industry, and their intended field was rather narrow, it need a fair amount of luck or a bit of money to obtain surviving members of the space charge series. If one is lucky and finds a few such tubes, than **building a guitar amplifier is eminently possible using just the 12-volt filament voltage** with the better sounding vacuum tubes.

Two single tube amplifiers depicted to provide examples about typical use of these tubes. A preamplifier stage built with the 12EK6 low voltage space charged tube is on **Figure 1**, and an output amplifier built with the 12DL8 low voltage space charged tube is shown on **Figure 2**. When combining the two stages the increased amplification will be a product of the two. IF the amplifiers use a battery, nothing else is needed. With a 12.6 VAC transformer, the heater may use AC, for the anode voltage a rectifier with filtering is needed.

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