Comparison Between
Vacuum Tube and Solid-State Switching Power Supplies
Size, Weight, Energy Efficiency, Reliability, Cost etc.

Size and Weight:

Imagine the following description:

1) There is a very large Water Tank.
2) There is a Bucket with capacity of 20 liters.
3) There is a small Cup with capacity of 100 milliliters, or 0.1 liter.
4) There are two containers with capacity of 60 liters each and have half full of water at the beginning. Each container has a faucet that flows out 20 liters of water a minute. Let us call the containers as Container A and Container B.
5) Both containers need to be refilled constantly after the faucets are turned on.
6) The Bucket is used to refill the Container A while the Cup is used to refill the Container B.
7) You can maintain Container A's faucet flow rate by filling it with the Bucket once a minute. However, the water level in Container A will vary from 1/3 to 2/3 of the container height.
8) Likewise, you can maintain Container B's faucet flow rate by filling it with the Cup--which only has 1/200 the capacity of the Bucket--200 times a minute. The water level in Container B will also vary but to a much lesser degree than that of Container A. Also, to maintain the same faucet flow rate, Container B does not have to be as big as Container A. In fact, it can be as small as 0.3 liter.

Conclusion of the above description:
Even though the Small Cup has a much lower capacity than the Bucket, the Small Cup can do the same task as the Bucket as long as it fills the container frequently enough.

What does it have to do with Power Supplies?

1) The Electricity Source is like the large Water Tank.
2) The Bucket is like the transformer used in the vacuum tube power supply.
3) The Small Cup is like the transformer used in the solid-state switching power supply.
4) The Containers are like the capacitors used to filter the ripple voltage at the High Voltage Outputs.
5) Both capacitors need to supply energy to the electron beam guns.
6) The transformer used in vacuum tube power supply is used to transfer energy to the output capacitor.
7) The transformer used in solid-state switching power supply is used to transfer energy to the output capacitor.
8) The frequencies used in the power supplies are analogous to the number of refills per mintue required to refill the Containers. The size of the output capacitors corresponds to the size of the containers.

Information you may like to know:

1) The typical weight of a power transformer used in a vacuum tube power supply is 100 - 350 pounds while a typical power transformer used in a solid-state switching power supply is 7 - 21 pounds, depending on the power rating of the power supply. The weight ratio is similar to the size ratio.
2) The physical size of a typical vacuum tube is about 5 ~ 20 times larger than that of a solid-state transistor.

3) The frequency for a vacuum tube power supply is the power line frequency, which is 60 Hz in the U.S. and 50Hz in Europe. The frequency used in Niles Electronics' solid state power supply is 25,000 Hz, or 25 KHz.
4) The size of the Output Capacitor used in the vacuum tube power supply is about 20 times larger than that of a solid-state power supply.
5) The lower ripple voltage the power has, the steadier electron beam you can get when it hits a target pocket.

Energy Efficiency:

In order to understand Energy Efficiency, we need to learn a little bit of the circuitry theory first:

Vacuum Tube Power Supply:

1) Uses the power transformer to boost the line voltage from 208 Volts (400 Volts in Europe) to about 12,500 Volts for a 10 KV power supply.
2) Rectifies the boosted voltage, 12,500 Volts in this example, from alternate current (AC) to direct current (DC). The resulting DC voltage usually is above 13,000 Volts. Let us call this “Total Supply Voltage”.
3) Uses a type of design known as *series regulation*. In this design, the vaccum tube is placed in series with the load and is used to regulate the output voltage (i.e. Total Supply Voltage = Voltage drop across the Tube + Voltage drop across the Load). As a result, the same amount of current flowing through the load also flows through the vacuum tube.
4) Uses the vacuum tube as an energy waste basket and turns the wasted energy into heat. The formula is: Energy Efficiency = Load Voltage / Total Supply Voltage. If Total Supply Voltage remains the same, lowering Load Voltage results in lower Energy Efficiency. The typical Energy Efficiency of a vacuum tube power supply is about 70%.

Niles Electronics’ Solid-State Switching Power Supply:

1) Rectifies the AC line voltage into DC voltage directly.
2) Chops the DC voltage to a new higher frequency of 25 KHz. This voltage has rectangular shape called “Pulses” and can vary its “Pulse Width”.
3) Uses a 25 KHz transformer to boost up the voltage.
4) Rectifies the pulsed AC High Voltage into DC High Voltage. The High DC Voltage charges the Output Capacitor.
5) Loses energy only during “Switching” and “On” states. The overall energy loss is relatively low compared to that of the vacuum tube.
6) Has a typical Energy Efficiency of about 90% which does not decrease with lower output voltage.

Reliability:

Theoretically, either type of power supply can be very reliable if well-designed. In 1989, Niles Electronics was the first in the world to introduce a solid-state switching power supply for electron beam gun. Originally sold under private labels, our products have always been renowned for their quality and dominated the world market in the 1990's.

Cost:

Vaccum tube power supplies have simpler designs and less expensive components. Consequently they command lower sale prices. In comparison, our strict manufacturing quality control and elegant designs have given our solid-state switching power supplies excellent reliability and the most advanced features. You will find our products well worth the premium.