



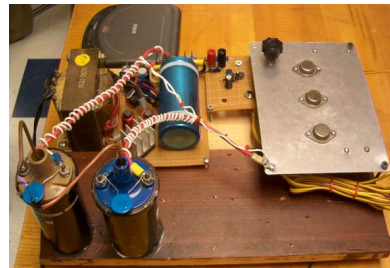
**Modulated Plasma Audio Transducer**  
**Circuit Simplification with Power Bipolar Junction Transistors**

**Inventor / Author:** Mark Barlow **For:** Dr. Munro **Date:** Jan 28, 2006

The following report will discuss the background and design of Modulated Plasma Audio Transducers also called Plasma Speakers. This paper will also point out some design improvements made by the author to yeild circuit simplicity and cost reduction.

Key points of the paper are as follows.

- Theory of Operation
- History of the Plasma Speaker
- Problems and Improvements
- Design Revisions and Schematics
- Parts Descriptions



## **Theory of Operation**

A plasma arc loudspeaker or plasma tweeter is a loudspeaker that creates sound by varying air pressure through a corona discharge or electric arc. As the ionized air in the electric arc thermaly expands and contracts (i.e. Heats and Cools) during the audio modulation, it vibrates the air in and around the arc creating sound.

A plasma arc loudspeaker is an improvement on the traditional diaphragm loudspeaker because the driver, electrical arc has very little mass, and low inertia, reducing distortion. A plasma arc loud speaker has a better frequency response far exceeding the material of speaker cones.

## History of the Plasma Speaker

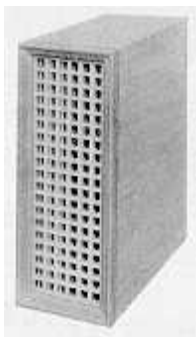
The invention of the plasma arc loudspeaker is an evolution of William Duddell's "singing arc" of 1900.

William Duddell was appointed to investigate carbon arc lamps (which created light by a spark between two carbon rods) solving efficiency and noise problems. During his experiments he found that by varying the voltage supplied to the lamps he could create controllable audible frequencies. Duddell used this knowledge to create the singing arc and demonstrated the novelty on several occasions. However Duddell never pursued marketing or a patent for the device.

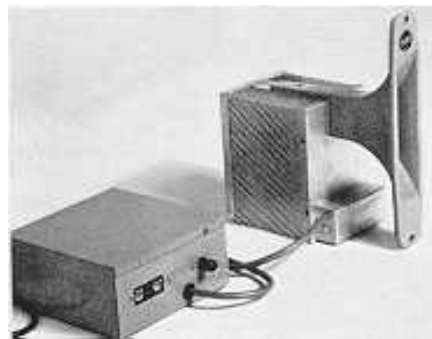
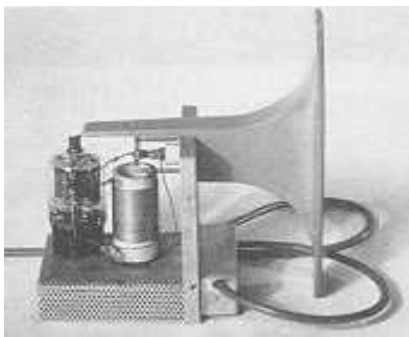


In 1956 Dukane marketed the "Ionovac" and was sold for \$147. Unfortunately, the element lasted only 200 to 300 hours.

DuKane revised the Ionovac, reducing the size and weight. Life of the quartz element was increased to 1200 hours, or about 2 years of use. The quartz element and electrode had to then be replaced. In 1961, the cost of a replacement element was \$6.25. The cost of the redesigned Ionovac was reduced to \$79 without the tweeter enclosure that is shown on the left Circa 1960.



In 1965, Fane Acoustics Ltd., Batley, Yorkshire came out with the Ionofane 601 loudspeaker. It is essentially a copy of the DuKane Ionovac. It comes in two parts: the power supply and the loudspeaker, with a connecting cable in between that allows remote placement of the power supply. The power supply comes in a metal box containing the power transformer, modulation transformer, solid-state high voltage supply, input level control and fuse. An RF carrier frequency of 27 MHz is used. This continues to eliminate the hissing sound of the corona. The Ionofane 601 sold for 29 pounds 8 shillings

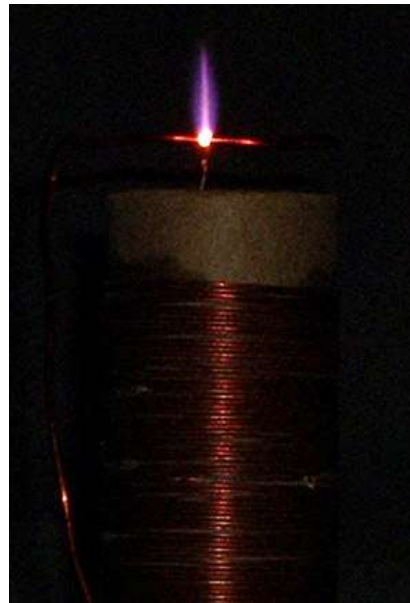
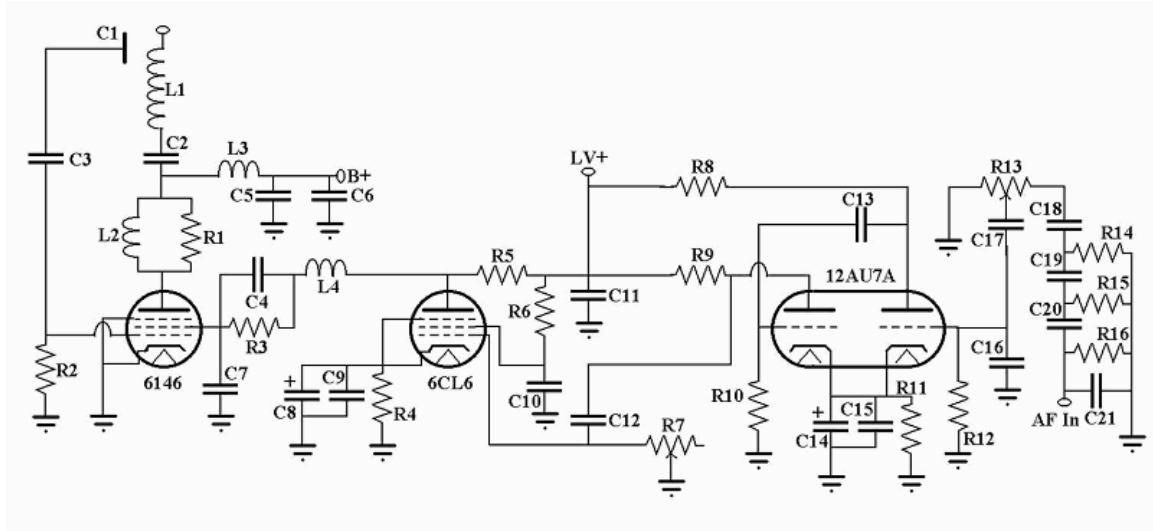


## **Problems and Improvements**

These Plasma Speakers require a larger amount of power than conventional speakers, and generate more heat. This is an inherent disadvantage to the plasma arc systems because of the requirements to produce electrical arcing. However, these devices offer a unique audio experience that is very desirable and would be marketable if cost and circuit complexity could be reduced. Some sources estimate up \$300 dollars in parts if you were to construct the device yourself. Many of the designs for plasma speakers call for the use of older and hard to find parts such a vacuum tubes or other high voltage components.

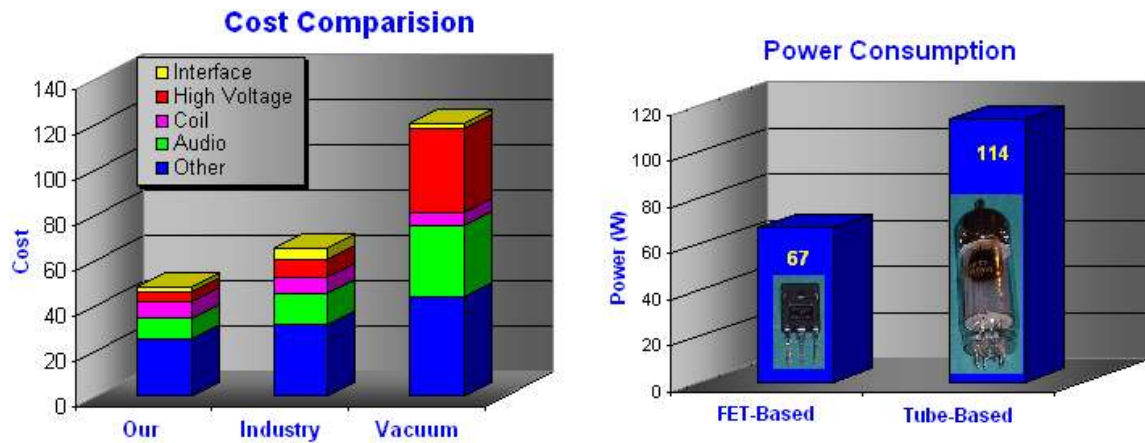
These rare and uncommon parts constitute the largest cost in spark speaker development.

Illustrated below is a schematic for a vacuum tube based Plasma Speaker, note the design complexity and usage of vacuum tubes.

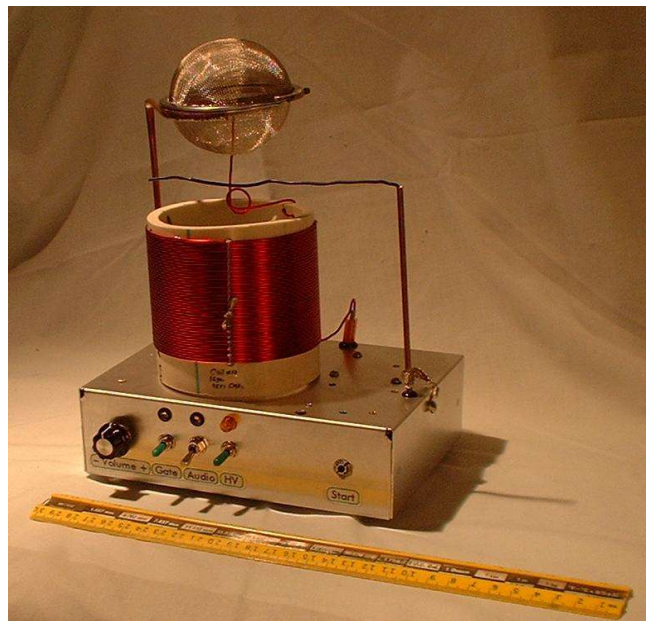


However some modern design techniques using solid state components may be implemented to greatly reduce the cost and power consumption of Plasma Speakers.

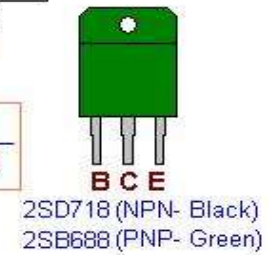
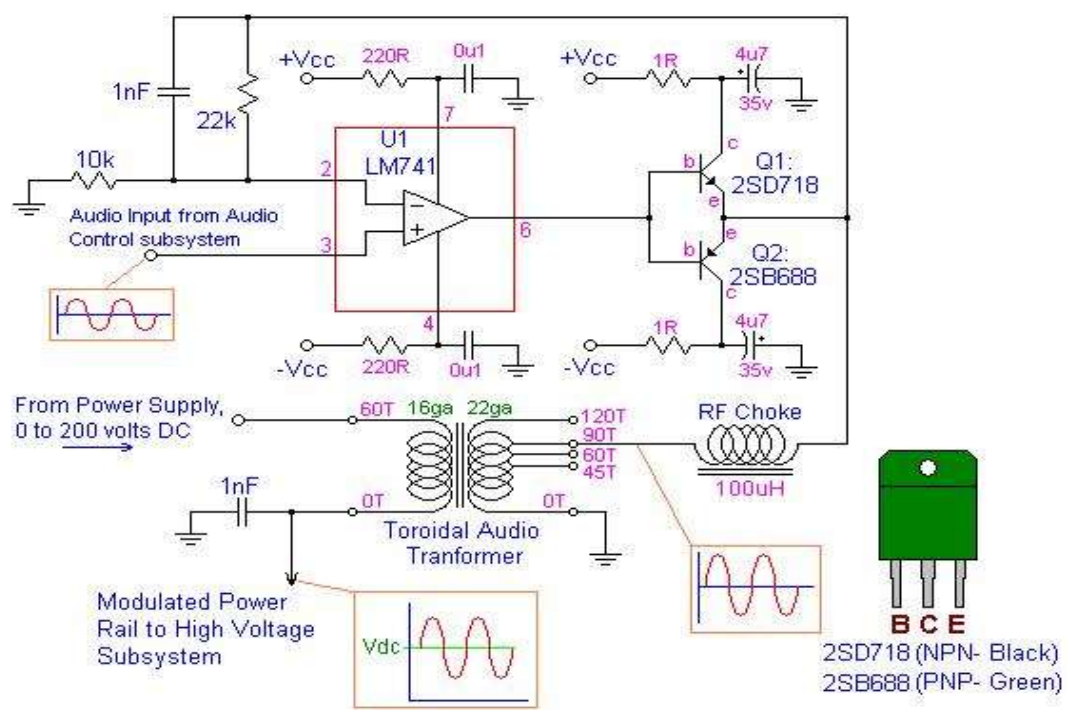
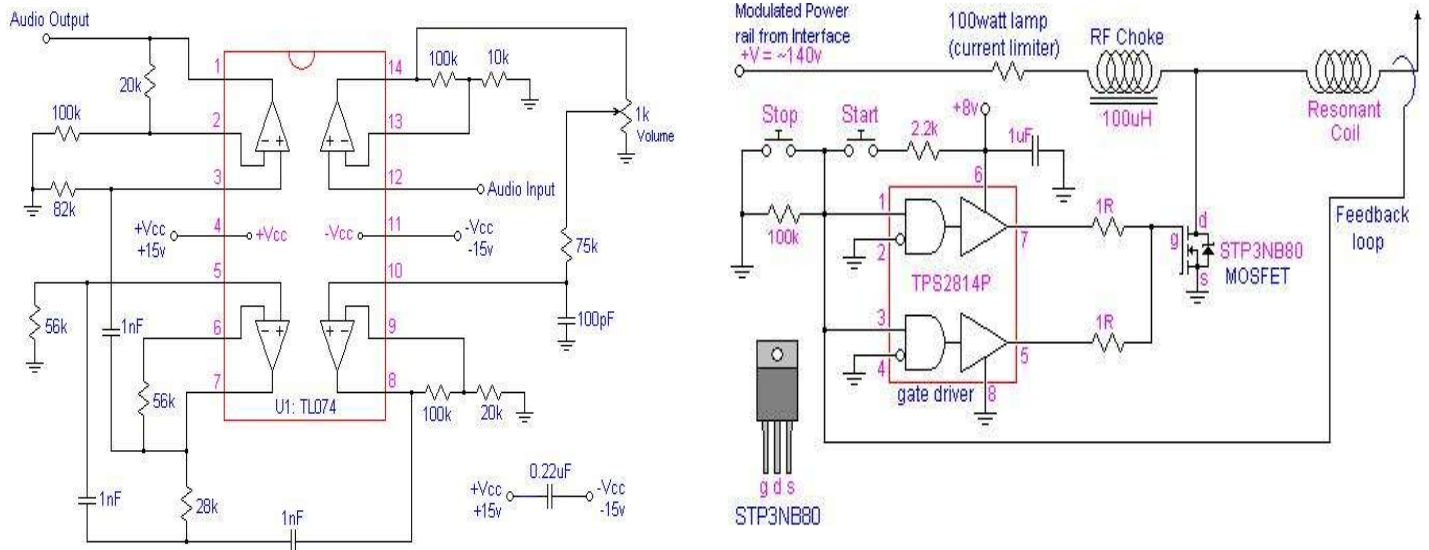
The following data was collected from a design project done at Villanova University by Rob Alejnikov, Mark Blattner, and Colin Joye. The material construction cost in dollars was about **\$65.44** for an industry built spark speaker to **\$120.53** for a vacuum tube spark speaker design.



Below is the finished product called the “Corona~Phone.” The group approximated 720 man hours of research and development was shared between the three students.

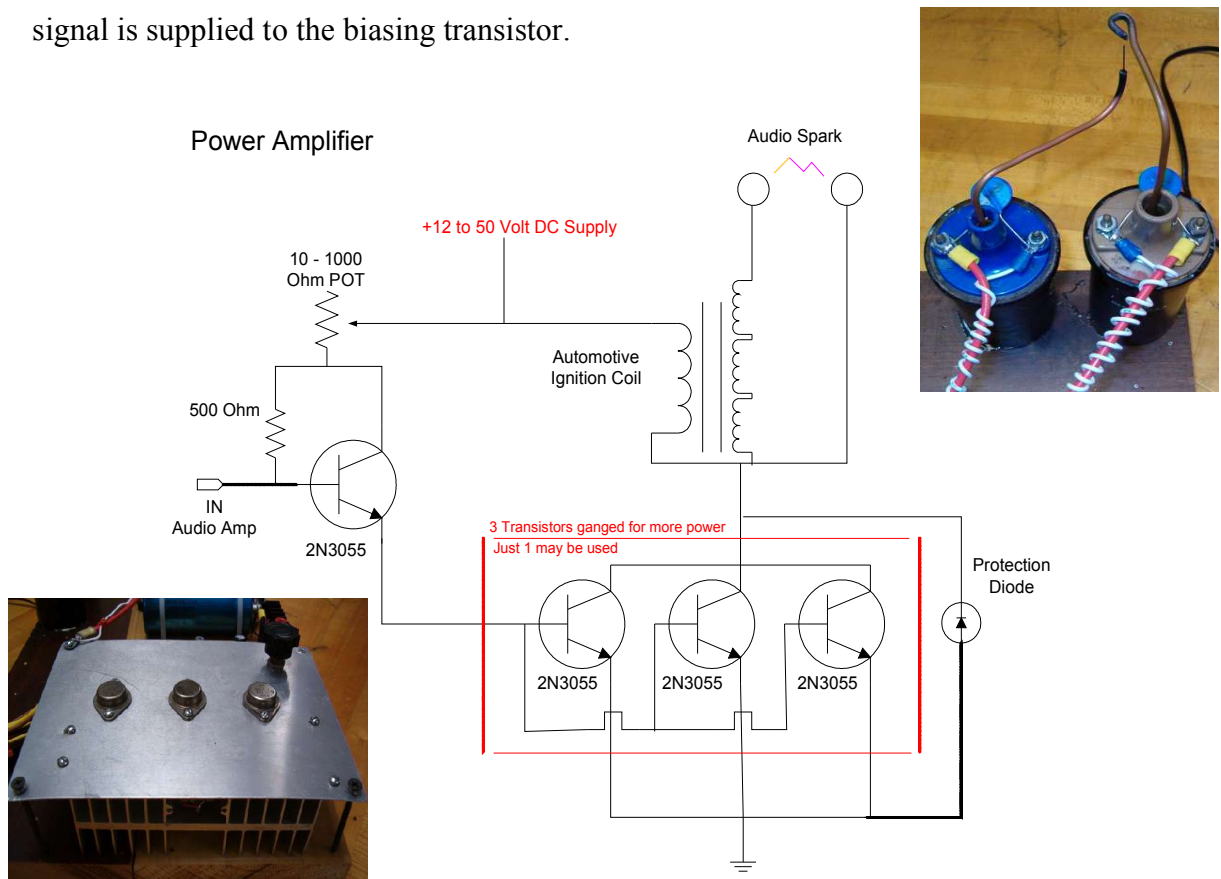


Below are the finalized schematics of the electronics system developed by the design team. This was the team's solid state solution to achieve the cost reduction and power efficiency that could not be provided with previous vacuum tube designs.



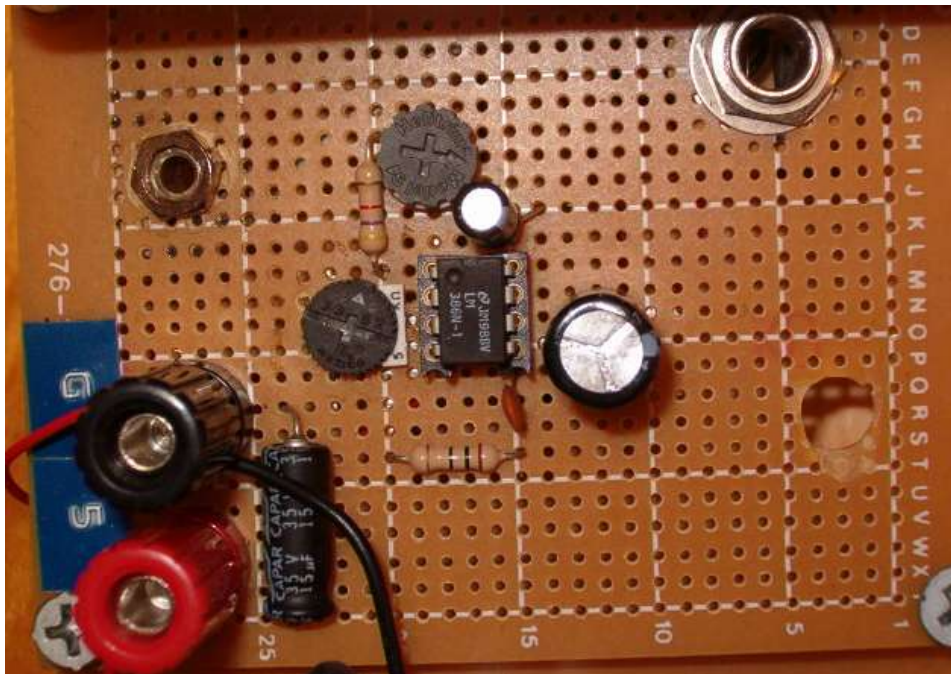
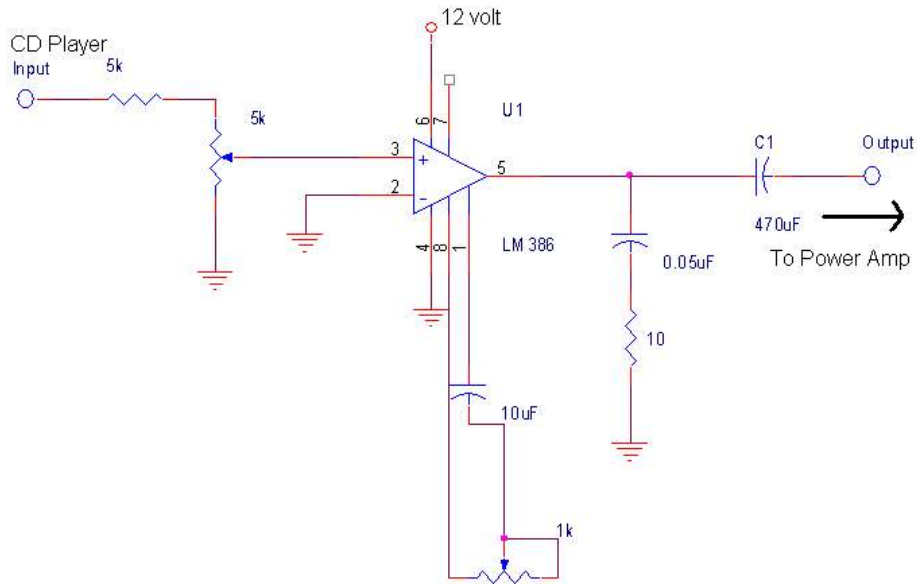
## Design Revisions and Schematics

The most significant design change was made in the Power Amplifier design by the selection of commonly available ignition coils and 2N3055 Power Transistors. These components are easy to find requiring a quick stop to your local AutoZone, junkyard, and Radio Shack. The first transistor is biased and drives the bases of the other transistors. The 10 – 1000 Ohm Pot controls the current through the biasing transistor and it in turn controls the base to emitter current to the ganged power transistors. This will lest a steady state current pass through the ignition coils. This current will be changed when an audio signal is supplied to the biasing transistor.



Upper right is an illustration the ignition coils used. The spark jumps between the two high voltage terminals of the coils in contrast to other designs. To the lower left the power transistors are pictured with the much needed heat sink for long term operation.

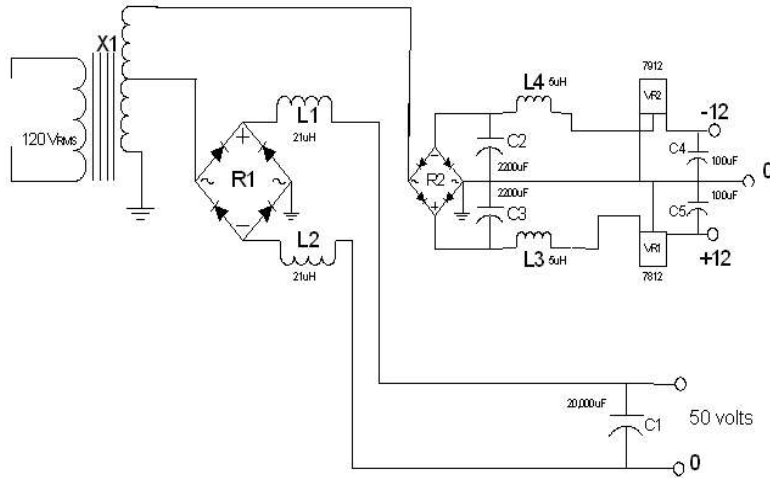
The audio preamplifier used to drive the biasing transistor in the Power Amplifier is based on the LM386 a Low Voltage Audio Power Amplifier. The circuit design for the amplifier and its peripherals was taken from the National Semiconductor's datasheet on the LM386. The circuit takes a standard audio input from a computer or CD player.



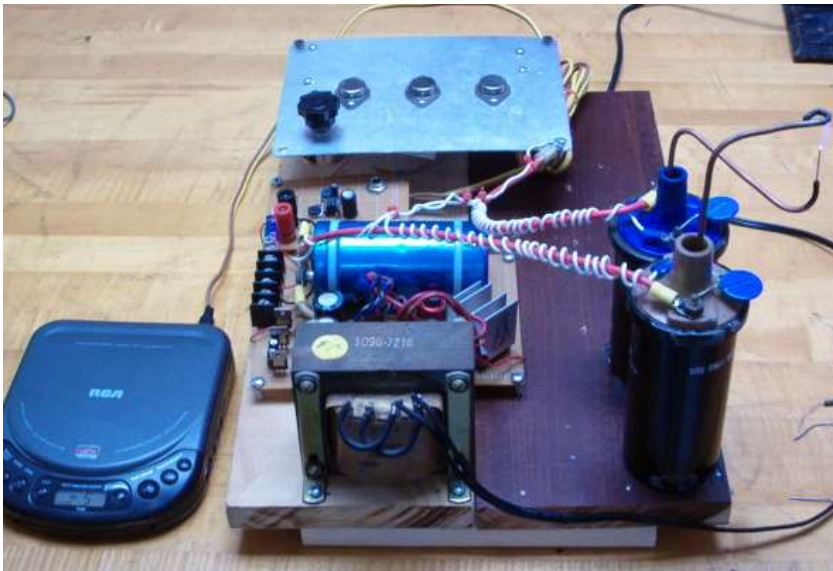
Above is an illustration of the LM386 circuit used in the Plasma Speaker



The final piece of the circuit is the ever critical power supply. The 50 volt supply drives the Power Amplifier / ignition coil circuitry. The +12 volts of the supply drives the LM386 circuitry and -12 volts is not used in this application.



Below is the complete Plasma Speaker assembly in operation. Note the use of two ignition coils allows a long hot spark of modulated plasma to be created between the high voltage terminals. This is not found in other Plasma Speaker designs shown in this paper which discharge from a single point into the surrounding air.



## References

- [1] Rob Alejnikov, Mark Blattner, Colin Joye “Solid-State, FET-Based IonTweeter”  
January 31, 2006, <http://www.ee.vill.edu/ion/>
- [2] Colin Joye “Welcome to the Plasma Tweeter Zone”  
January 31, 2006, <http://www.ece.villanova.edu/~cdanjo/plasma.html>
- [3] Roger Russell “Welcome to Roger Russell's Page about the Ionophone Loudspeaker. A History” January 31, 2006, <http://www.roger-russell.com/ionovac/ionovac.htm>
- [4] Author unknown “William Du Bois Duddell and the "Singing Arc"(1899)”  
January 31, 2006, [http://www.obsolete.com/120\\_years/machines/arc/](http://www.obsolete.com/120_years/machines/arc/)
- [5] Author unknown “Plasma Tweeter”  
January 31, 2006, [http://www.angelfire.com/electronic/cwillis /  
tweeter.html#plasmaintro](http://www.angelfire.com/electronic/cwillis/tweeter.html#plasmaintro)
- [6] Wikipedia “Plasma arc loudspeaker”  
January 31, 2006, [http://en.wikipedia.org/wiki/Plasma\\_arc\\_loudspeaker](http://en.wikipedia.org/wiki/Plasma_arc_loudspeaker)

## Datasheets of Critical Components Attached