ION CANNON -
ION GENERATOR KIT

Ramsey Electronics Model No. IG7

Have you ever wondered how those ion air cleaners work? Ever wonder why the air smells so fresh after a thunderstorm? This instructional manual takes you through several ion related experiments that you can play with to see for yourself how amazing ions are, their health benefits, and health risks. Also make a working air cleaner for the water closet when done!

- **ION power supply with adjustable control for a clean source of high voltage DC. Not a pulsed output like some so-called ION supplies.**
- **ION supply capable of delivering 7.5 kV with 400 uA max current output.**
- **Runs from 10V to 18VDC while drawing about 350 mA or less; run from a battery for portable use or in the car.**
- **Waterproof casing; no assembly of high-voltage portion necessary!**
- **Great for science fairs, high energy capacitor charging, and many experiments requiring "static" voltages.**
- **Perfect for exciting Van Degraff generator belts!**
- **Includes circuit board for making your own ion wind generator.**

RAMSEY TRANSMITTER KITS

- **FM100B Professional FM Stereo Transmitter**
- **FM25B Synthesized Stereo FM Transmitter**
- **MR6 Model Rocket Tracking Transmitter**
- **TV6 Television Transmitter**

RAMSEY RECEIVER KITS

- **FR1 FM Broadcast Receiver**
- **AR1 Aircraft Band Receiver**
- **SR2 Shortwave Receiver**
- **SC1 Shortwave Converter**

RAMSEY HOBBY KITS

- **SG7 Personal Speed Radar**
- **SS70A Speech Scrambler**
- **BS1 "Bullshooter" Digital Voice Storage Unit**
- **AVS10 Automatic Sequential Video Switcher**
- **WCT20 Cable Wizard Cable Tracer**
- **LABC1 Lead Acid Battery Charger**
- **ECG1 Electrocardiogram Heart Monitor**
- **LC1 Inductance-Capacitance Meter**

RAMSEY AMATEUR RADIO KITS

- **DDF1 Doppler Direction Finder**
- **HR Series HF All Mode Receivers**
- **QRP Series HF CW Transmitters**
- **CW7 CW Keyer**
- **CPO3 Code Practice Oscillator**
- **QRP Power Amplifiers**

RAMSEY MINI-KITS

Many other kits are available for hobby, school, Scouts and just plain FUN. New kits are always under development. Write or call for our free Ramsey catalog.

IG7 ION CANNON KIT MANUAL
Ramsey Electronics publication No. MIG7 Revision 1.1
First printing: December 2001 MRW

Ramsey Publication No. MIG7
Price $5.00

KIT ASSEMBLY
AND INSTRUCTION MANUAL FOR

IG7 ION CANNON - ION GENERATOR KIT

TABLE OF CONTENTS

RAMSEY ELECTRONICS, INC.
590 Fishers Station Drive
Victor, New York 14564
Phone (585) 924-4560
Fax (585) 924-4555

SOME SAFETY NOTES WITH THE IG7

Even though 7.5 kV sounds like a lot of voltage, and it is in relation to most other circuitry today, it is not necessarily lethal. What is dangerous about high voltage is the ability of a high voltage source to deliver current, whether it be a quick impulse of high current like a lightning strike, or a long term source like a high voltage power supply. It is generally accepted that you need at least 1 mA of current flowing through a person's body to kill them, though a person's health has a large role to play in this. If you are at all in question about your health or have heart problems, please follow the safety guide at the end of this chapter!

The IG7 has the capability to deliver about 400 uAmps (0.4 mA) of current. This is a bit less than the 1 mA previously mentioned, but still close enough to hurt a lot! Just ask one of our employees who pointed to the high voltage terminal and discovered what this project was the hard way! While the actual electrocution may not be what injures you, it can be the secondary reaction, such as falling out of your chair and injuring yourself in the fall. I have personally flown across a room when I was experimenting with a larger supply and had no recollection of how I put a dent in my parent's washing machine!

What I am trying to say here is that this is a relatively safe project, but there are certainly some precautions you must take to ensure an enjoyable experience, as well as a long life! Our fellow employee lived through it; so should you. Personally I have yet to be electrocuted by this little gem, and I don't care to be in the future. Any time I am around high voltage I make sure I am not tired, I don't take it for granted, and I am aware of the possible consequences.

Some basic rules around this kit:

- Always use only one hand. The easiest way to do this is to keep the other hand in your pocket. This reduces the chances of current flow across your heart. I would rather have a tingly leg than see wings sprout from my back on the way to cloud 9.

- Always unhook the power before working on anything. Don't trust the power switch, as many power supplies have enough capacitance to keep things running for quite a while after the power is turned off. Also wait a few seconds before reaching for the unit.

- Use a grounding wire to discharge any high voltage terminals before handling the device. By grounding I mean solder a wire to the black lead of the high voltage power supply, then touch the high voltage terminal connection with the other end of the wire. This will discharge any stored potential by shorting the output to ground. Many high voltage devices can maintain a charge for WEEKS after the power has been removed.

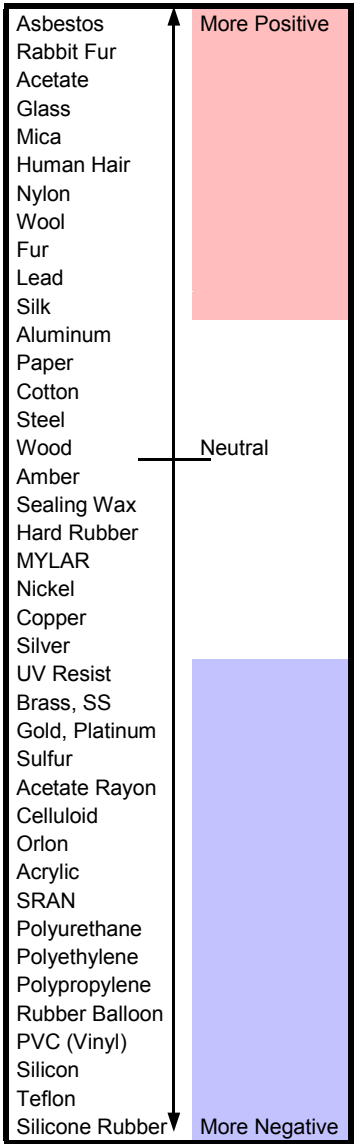
- NEVER EVER! charge capacitors unless you honestly know what you are doing! This increases the danger level astronomically! Even a small high voltage capacitor when charged can deliver more than enough current to kill or injure you!

- Keep a clean workbench. Having a clutter of wires around can confuse you as to which ones are actually grounded, and which ones you may use to try and discharge the high voltage terminal.

- Keep in mind that sensitive electronic equipment can be permanently harmed by the high voltage ions which this kit produces. Ions travel freely in the air and will accumulate on components at a distance. These ions have the potential to damage computers, calculators, portable phones, and other vulnerable electronics devices. If in question, keep these sensitive items in a different room or as far away as possible from this unit while you are experimenting with it.

ION THEORY

What are ions you may ask, are they protons or electrons? Actually they are neither one, at least not electrons by themselves. An ion is a charged molecule like that of a particle of smoke which either has one or more electrons removed, or one or more extra electrons added giving it the ability to carry a charge of electricity.



Triboelectric Series

Imagine rubbing a balloon on your head; we're making the assumption there's a little hair up there! The resulting static that accumulates on the balloon will have a negative charge as seen by looking at the Triboelectric series chart. This chart shows us how materials gain or loose electrons when brought in contact and then removed from one another. We can see that human hair is more positive than the rubber balloon, so the hair winds up loosing electrons while the rubber balloon gains them. The balloon now becomes a very large negative "ion" in the sense that it carries a net electrically negative charge.

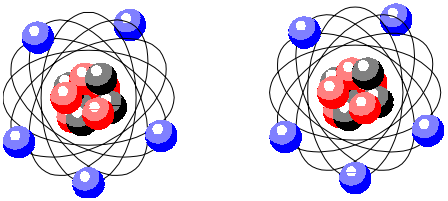
Now try and stick the balloon to the ceiling. When you bring the balloon closer and closer to the surface of the ceiling, its negative charge begins repelling electrons from the surface of the ceiling. The lack of electrons near the surface will give that area of the ceiling a net positive charge. Now when the balloon touches the ceiling, the attractive force between the balloon and the ceiling is enough to suspend the balloon! This inductive process allows you to use one charged object to induce a charge in another!

One thing you might expect with the prior experiment is that since the balloon and the ceiling are touching, the electrons would rapidly transfer and neutralize the charge. This isn't the case however. The electrons are prevented from doing so by the thin layer of air between the balloon and the ceiling. This experiment won't work as well in humid conditions because the air becomes more conductive with the additional water vapor. Increased humidity allows the electrons to migrate through the air and neutralize the charge even faster. This type of electron move-

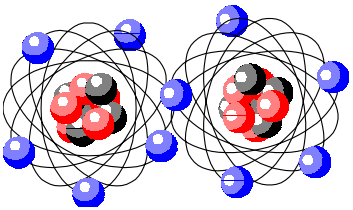
ment through the air is called ‘ionic flow’.

Instead of the electron from the balloon floating through the air all by itself, it is “grabbed” by a passing neutral air molecule. The air molecule acquires a negative charge which is the same as the balloon that has not yet lost all of it’s electrons. Since these charges are alike, they repel. Given that the air molecule is mobile, it moves away from the like charged balloon along with the extra electron. The positive charge on the ceiling close by causes the air molecule to become attracted to it. The closer the molecule gets to the ceiling, the more attractive force becomes on it. Suddenly the molecule bumps into the surface of the ceiling where there is a paint particle with a missing electron. The air molecule “hands off” the extra electron and continues on its random way with its now neutral charge and the paint particle on the ceiling as a result becomes neutrally charged as well.

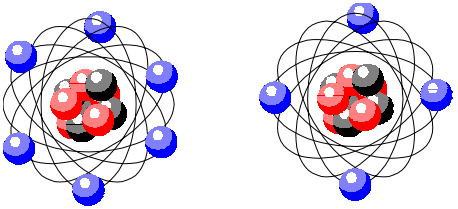
Below are a few simplistic diagrams showing how ions are created:



1. Two atoms in their neutral states.



2. The two atoms contact each other and one of the valence electrons is “captured” by the atom on the left.



3. The atom on the left now has a net charge of –1, and the one on the right has +1.

The previous diagrams show how ions are created by contacting two atoms together and thereby handing off an electron. If these atoms were mobile like in a gas or liquid, the different charges would attract each other very quickly and neutralize again. They wouldn't get very far at all unless the atoms had enough velocity to overcome the electrical attraction. If these atoms were rubber and hair, like in our balloon example, the motion of physical separation would draw these two particles apart and create two oppositely charges particles or ions.

The problem of getting ions into the air is that you have to have enough voltage gradient to initiate the electron exchange. A voltage gradient indicates lines of equal voltage potential the same way isobars indicate lines of equal air pressure on your weather-mans' weather map. A strong voltage gradient would have a lot of lines in a small area. This indicates a strong electrical field where ions will probably be able to flow. Similarly a strong air pressure gradient indicates there will be a lot of wind.

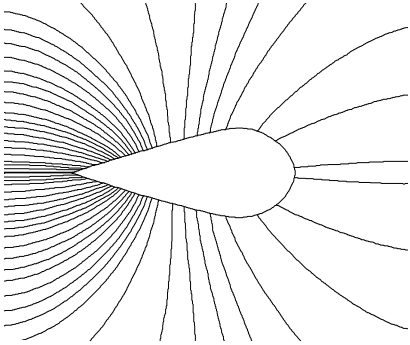
Some atoms and molecules are easier to ionize than others. This is dependant upon how strongly the atom or molecule is holding on to its electrons. If they are loosely bound, they will loose them easily and allow us to ionize the gas much easier. Some gasses make excellent insulators because they strongly hold onto their electrons. Others like Hydrogen and Helium have a loose grip on their electrons and make for poor insulators. Thus they are excellent sources of light when they are ionized, like in a laser.

To assist in allowing gasses to ionize, we can lower the pressure of the gas. Higher pressure gasses don't ionize as easily as low pressure gasses because the proximity of one gas molecule to another. If gas molecules are tightly packed together, the motion of the gas molecules keep knocking electrons back into place. Space the molecules out a bit more and there isn't enough motion to knock electrons back into place. They instead begin to roam around the gas and excite more molecules into ions.

Mixing of gasses together even has more impact on how easily ions are formed. For example Helium and Hydrogen mixed together in the right portions will ionize easier than either one by themselves. Mixing water vapor into your standard atmospheric gas mixture allows ions to flow very easily. Water vapor is very good at transporting charges due to the nature and geometry of the water molecule. We will leave further details up to the chemistry books!

In our case we need to get ions into the air at all times so we'll need to have plenty of voltage. The IG7 has plenty with its 7.5 kV output! In fact with normal dry air we only need about 3,000 Volts per millimeter to get the air to begin to ionize. Another factor to consider to get electrons in the air is the type of high voltage terminal to use. Due to repulsive forces we can change our terminal shape to better suit our purpose. To release ions, we want a sharp tip. To prevent them from being lost we will use a rounded tip. Why is this?

The diagram below shows a conductive tear-shaped object with a high voltage field around it. The lines are called equipotential lines and they indicate our voltage gradient potential as we mentioned before. A rounded tip will disperse the gradient over a larger area than that of a sharp tip. Notice below that the gradient on a rounded tip isn't very steep while the sharper tip is. In actuality, the sharper the tip the steeper the gradient is; also the distortion in the gradient lines makes it easier to "bleed" off ions into the air. The bleeding off of ions is called the corona effect.



Sharp Tip Gradient Rounded Tip Gradient

To estimate how concentrated and electrical field will be around a given shape and determine how good of an insulator or conductor to the air it is involves a little geometry. You can draw tangents to the curved surface at intervals of say 10 degrees of arc. Remember what a tangent to an arc is? It is a line that only intersects at one point on the arc and is at an exact right angle to a line drawn from the center of the arc to the tangent (also called the ray). A slow smooth arc, like the right hand side of the diagram, involves very few tangents at 10 degree intervals. A sharp point would need many. If you look at the previous diagram, you can see that the sharp points' angle looks to be around 315 degrees from the outside when we figure the metal is 45 degrees of angle or so. This would take 315 / 10 = 31.5 tangential lines to reproduce. The entire rest of the surface would only need the remaining 45 degrees or 45 / 10 or 4.5 tangents.

If you went in microscopically and looked at a well sharpened tip, it would not appear to be as sharp as you may think. Ideally you would like to have a perfectly sharp tip, but that is unlikely. When we make our ion wind generator, you will be able to see the effect of a very sharp tip vs. a dull one rather well.

Air Ions and their effects

Ions have always been touted as being one of the best methods of cleaning the air of dust and pollen as well as stimulating the cilia in your lungs to accelerate the removal of foreign debris. This tends to be a little more complicated than simply generating ions.

When air is ionized during the corona effect, you will see a sharp point of purple on the end of the metal tip. This indicates that air is either being stripped of electrons or electrons are being added to the air. The process emits some light as the electrons are moved about due to them jumping valences in the gas molecule. The problem is when air becomes highly ionized, it also can become quite reactive as well. This means that the Nitrogen in the air can combine with Oxygen to form Nitric Oxide (NO), and Oxygen to form Ozone (O_3). Both of these components are very reactive, and in large quantities can do a lot of harm to your lungs.

Usually in a device such as this, the quantity of Ozone generated is very low and Nitrous Oxide is almost undetectable. We will work to reduce the Ozone to a very low level to where it isn't a heath risk at all. Ozone counteracts any benefits that we may get from negative ions, so ideally we would like to get rid of the Ozone product altogether. Ozone does however have its benefits. It reacts with most odors in the air and will neutralize them as well as killing most airborne viruses and bacteria. This factor can be quite helpful in a bathroom, animal room, or near garbage cans.

To reduce the Ozone generated we will try and get a good balance between the amount of air we will ionize and the amount of ions we want to bleed off. We do this by sharpening the tips of our electrodes and adding enough electrode elements that it effectively reduces the supply voltage to the bare minimum to ionize the air. The steeper the voltage gradient is, the better the chances of creating Ozone from the fact that air will become heavily ionized within this gradient. We are going to reduce the steepness of the gradient by using a very sharp point and reducing the terminal voltage due to loading.

Another thing that amplifies how much Ozone is produced is the type of ion that we are creating. Positively ionized air creates Ozone at a much greater rate than negatively ionized air. This is part of the reason why our supply will be generating negative ions instead of positive ones. It is also rumored that it is negative ions which have most of the heath benefits.

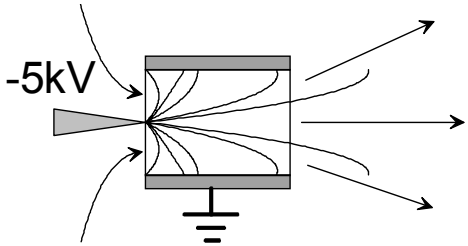
Keep in mind that ions in the air can transfer a great amount of voltage and current invisibly to all sorts of surfaces. Air movement from fans and open windows can move strongly charged air on its way to sensitive components. Imagine the surface of a chip inside of your nice new computer whose nonconductive surface acts like a capacitor to the conductive material inside. The charge from air ions sticking to it builds up over time to the point that it discharges to one of the leads and destroys the device!

As air ions move, they loose some of their energy. The amount of energy that is lost completely depends on how strong the originating terminal voltage was that generated it. For example a 100 kV terminal may be able to transfer some ions up to 10 feet away and still have a potential of 20 kV! 20 kV is a lot to a circuit that can only take a discharge voltage of 1 kV, a common specifi-

cation. In our case the terminal will be around 3 to 5 kV with the IG7. How do we reduce the potential energy of these charged ions to make it safer for electrical components? We use a simple device called an ion tube.

Ion Tubes

Ion tubes serve a few special functions and are luckily easy to construct. A tube consists of a grounded piece of conductive tubing with a sharp pin that is centered at one end to emit the high voltage ions we are looking for. The pin should not be positioned so close to the edge of the tube that you draw a spark however. The configuration generates a strong electrical gradient formed by the proximity of the needle tip to that of the grounded tube and



Dotted lines indicate Ion paths, arrows indicate air flow direction.

helps to draw off more ions at a much lower voltage potential than otherwise required with a dull tip. When the ions leave the needle tip and are repelled away from it, they are drawn to the edges of the pipe. In the process this accelerates some surrounding air as the ions bump into other molecules on their way to the pipe edge. As the air accelerates, it pushes the ions further down the tube and allows them to accelerate even more air in the further distance they travel. This action renders a decent amount of air motion that is mostly limited by frictional forces and the initial energy in the ions. Some ions that are released in the center of the tube manage to escape the tubing altogether and are released out into the open air. As the ions accelerate the air, they loose some of their potential energy to the form of kinetic energy (movement of the air particles). This helps to further reduce the high energy potential of the ions to a much lower level so that we don't have to worry as much about damaging sensitive electronics. Because of this, we can leave our ion tubes running in a room without many worries other than someone sticking his/her finger in it!

One point to note is If you make the tube longer, you can achieve a bit more air flow and release fewer ions with more likelihood of them being drawn to the grounded pipe edges. Conversely, making the tube shorter can release more ions that retain a much higher voltage potential into the surrounding air!

In this kit we will be building an array ion tubes with a variable distance between the needle points to the end of the tubes. This adjustability allows for various features while experimenting.

Believe it or not, there are always ions around you. They are created by numerous methods, most notably: radioactive decay, solar radiation, friction between dissimilar materials such as air and land, and materials like water changing state from water to ice and water to gas. Some of these methods combine to fuel lightning which we see during a storm. These provide plenty of ionic flow besides the actual lightning strikes.

A very good book on this subject is called Nature's Electricity written by Charles K. Adams and published by Tab Books.

Ions in your home

Natural occurrences aren't the only ion generators, many are generated by you and your actions! There is a large market for anti-static devices for protecting sensitive electronics as well as the dignity of people when their cloths cling together. That 'cling wrap' is pretty hand stuff too! With so many dissimilar materials around you, there is always an ability to create a static potential. Some of this static potential will dissipate in the air as ionic flow. Since static generation depends heavily on relative humidity, here is a little comparison chart to show you what kind of potentials may be found around your home and workplace.

Means of generation	10-25% RH	65-90% RH
Walking across carpet	35,000V	1,500V
Walking across vinyl	12,000V	250V
Worker at bench	6,000V	100V
Poly bag picked up from bench	20,000V	1,200V
Chair with urethane foam	18,000V	1,500V

Typical Voltage Levels

The chart shows you how much voltage is produced just through daily activities and how sensitive they are to humidity levels. It also brings to light how high voltages can be generated at your electronics workbench! Many modern components can't handle a discharge of more that 1,000V. Older components often can't handle more than 10 volts! Of course static potential doesn't indicate definite ion flow. When a potential like 35,000V is generated on your body (by you walking around a room), sharp points all over your body leak the ions into the air where they eventually get back to the carpet fibers you walked across and pull the high charge from originally. As the ions leak off of your body, the voltage becomes lower and lower until ion flow ceases.

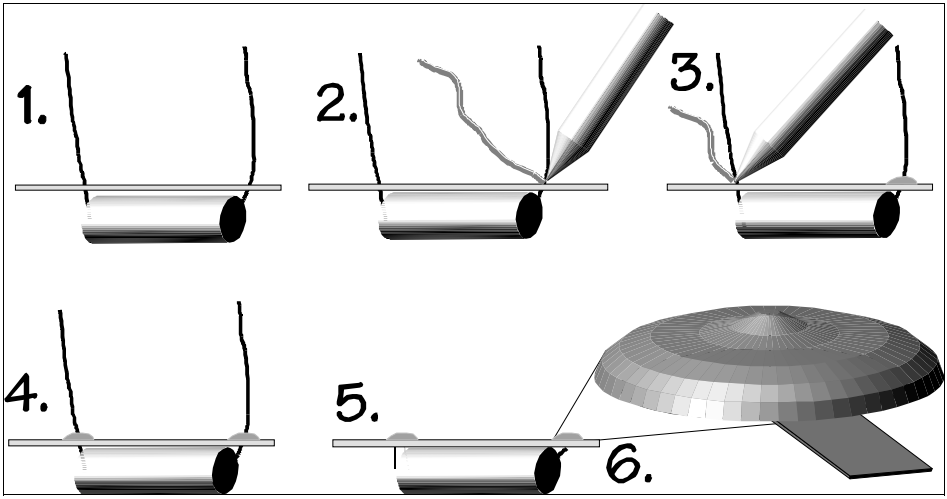
RAMSEY "LEARN-AS-YOU-BUILD" ASSEMBLY STRATEGY

Be sure to read through all of the steps, and check the boxes as you go to be sure you didn't miss any important steps. Although you may be in a hurry to see results, before you switch on the power check all wiring and components for proper orientation. Also check the board for any possible solder shorts, and/or cold solder joints. All of these mistakes could have detrimental effects on your kit - not to mention your ego!

Kit building tips

Use a good soldering technique - let your soldering iron tip gently heat the areas which you are soldering by heating both wires and pads simultaneously. Apply the solder on the iron and the pad when the pad is hot enough to melt the solder. The finished joint should look like a drop of water on paper, somewhat soaked in.

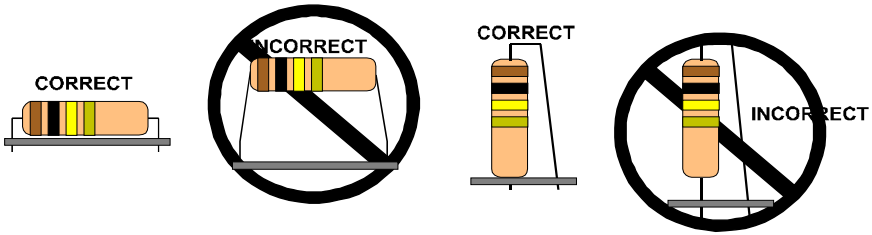
Mount all electrical parts on the top side of the board provided. The top side is clearly marked with the 'Silk Screen' reference designators. This is the side that has no circuit traces on it. When parts are installed, the part is placed flat to the board (unless otherwise instructed) and the leads are bent on the backside of the board to prevent the part from falling out before soldering (1). The part is then soldered securely to the board (2-4), and the remaining lead length is then clipped off (5). Notice how the solder joint looks on close up, clean and smooth with no holes or sharp points (6).



Since this is a High Voltage product, we sincerely hope you put this together in a professional manner. This project will not work as well as you wished if you just slap it together without following good assembly techniques and all the instructions. No matter how clear we may think our manual is, if you have any questions, give us a call at the factory instead of jumping to conclusions. We will be happy to help you with any problems.

This is a high voltage project so we want to mount the parts AS LOW AS POSSIBLE to the board. A 1/4" lead length on a resistor not mounted close to the board can act as a potential shorting point while experimenting. Be aware though that there are stand up components in your circuit. They don't need to be squished to the board. Just follow the specific instructions and check them off as you go.

For each part, our word "Install" always means these steps:



- ☐ 1. Pick the correct part value to start with.
- ☐ 2. Insert it into the correct PC board location, making sure the part is mounted flush to the PC board unless otherwise noted.
- ☐ 3. Orient it correctly, follow the PC board drawing and the written directions for all parts - especially when there's a right way and a wrong way to solder it in. (Diode bands, electrolytic capacitor polarity, transistor shapes, dotted or notched ends of IC's, and so forth.)
- ☐ 4. Solder all connections unless directed otherwise. Use enough heat and solder flow for clean, shiny, completed connections.

Keeping this in mind, lets begin by sorting out our components and cross-checking them against the parts list to make sure we have received everything.

NOTE TO NEWCOMERS: If you are a first time kit builder you may find this manual easier to understand than you may have expected. Each part in the kit is checked off as you go and a detailed description of each one is given while you install them. If you follow each step in the manual in order, and practice good soldering and kit building skills, the kit is next to fail-safe. If a problem does occur, the manual will lead you through step by step in the troubleshooting guide until you find the problem and are able to correct it.

RAMSEY IG7 PARTS LIST

Supplies

- ❑ 1...HVDC-1 7.5 kV Ion power supply
- ❑ 1...PC Board with 7 large holes
- ❑ 1...PC Board with 5 large holes
- ❑ 1...Base mounting PC board
- ❑ 4...L Brackets
- ❑ 7...#16 Nails, 1 1/4” long
- ❑ 4...Large rubber feet
- ❑ 1...small size LED (for HV indicator)
- ❑ 1...1K Ohm resistor (brown-black-red)
- ❑ 1...2.1 mm Power jack
- ❑ 7...1/2 Inch copper pipe couplers
- ❑ 2...#4 x 1/4” sheet metal screws
- ❑ 8...#4 x 3/16” machine screws
- ❑ 1...Neon light indicator
- ❑ 10” of #16 black stranded wire (for grounding)

ASSEMBLY

Assembly of you Ion Cannon is pretty simple. It does however require a pretty hot soldering iron and some patience. Most of this kit is mechanical in nature so think of it more like an erector set.

- ❑ 1. We will begin by assembling the most difficult item first in order to get it out of the way. This requires a bit of solder and a lot of patience to make it look good. Please don't rush this part. For this step you will need the seven couplers and the board with the seven holes in it. The goal is to solder all seven couplers so that they mount in place about 1/2 way through the circuit board.
  To make this job a bit easier, you may wish to make a temporary jig to hold the PC board up in place. Use something heat resistant and about half the height of the copper couplers in order to mount them at their mid-point in the holes. The setup should be secure enough that you can solder to it easily.

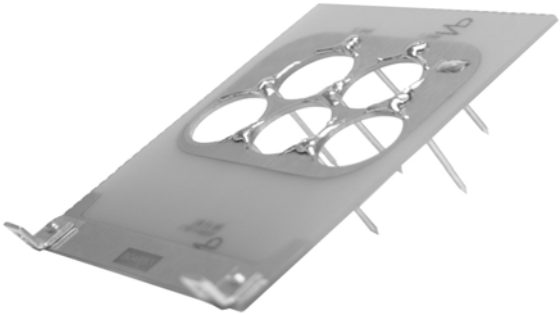
- ❑ 2. Solder the center coupler first. You do not need to solder all the way around the coupler unless you really want to. A full ring of solder is very difficult to do since once the pipe gets hot enough, all of you solder will run away on you. Soldering two opposite sides of each of the tubes in order to make sure they stayed in place is fine. When you are done soldering this coupler, blow on the pipe until it is cool! You don't want to handle it when it is hot enough to melt solder.

- ❑ 3. Using the same process, solder the remaining pipes in place. Try to keep them level with the first pipe and centered just like the first one. Once you get three pipes in a row installed, the rest will be easier to position.

Tack Solder Example of the Pipe Installation

- ❑ 4. Set aside the pipe and board assembly. We will now work on the nail (pin elements) assembly.
- ❑ 5. First thing first we are going to sharpen these nails. There are plenty of ways to sharpen nails but the easiest way is to use fine file to round and sharpen the points. Remember the sharper the better! It can take a while to get a good sharp point at the very tip so take your time. Note that nails are typically not extremely hardened steel so you wont get a tip that could cut an atom in two. It is however sharp enough for our purposes. How sharp is sharp enough? You can test the end by poking your finger and if it hurts… it's sharp… Duh! The other way is to look at the end with a magnifying lens so you can clearly see how well you have sharpened the tip. Probably the preferable way!
- ❑ 6. The next step is to mount the seven nails being used as our electrode elements. We want the nails to point straight out from the board as they will be positioned with the points inside the ion tubes. Insert the nails from the solder side of the PCB with the 5 large holes. It is labeled with Nail1 - Nail7 on the opposite side. You might want to scrape away a little more of the green resist layer from around the nail holes to make them easier to solder with the head flush to the copper side of the board.

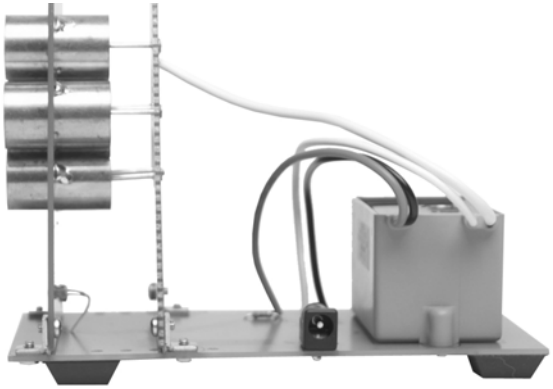
Solder Example of the Nail Installation



- ❑ 7. Solder all seven nails into place. This does take some decent heat as the nails have a zinc coating that makes it a bit difficult to solder to. Once they are hot enough though, the solder will flow.
- ❑ 8. Set the nail assembly aside for now and let's begin work on the main board assembly. We will start with the small components and go up from there.
- ❑ 9. Install R1, the 1K ohm resistor (brown-black-red). This resistor is used to limit current through the front panel LED. ensuring that is runs at the correct brightness. Hey, a little circuit theory always helps!

- ❑ 10. Install D1, the LED. Note that this is one of the exceptions to the rule, you want to leave the leads as long as possible! You want the LED to stand up at least 3/4" off of the board when you solder it in place. We will later bend over the leads so that the LED will poke its little head out of the front panel pipe assembly board. Remember, LEDs are diodes, they will only work if installed in the correct orientation! Notice that one lead is longer than the other and that there is a small flat edge on one side of the epoxy case. This indicates the Cathode. An indication of the flat side orientation on the silk screen helps you line up the LED on the PC board.
- ❑ 11. Install J1, the 2.1 mm power jack.
- ❑ 12. Time to mount the Ion Generator (PS1) high voltage supply. You will be mounting the Ion Generator on the top side of the board (the same side as the silk screen). Make sure to orient it so that the wires are pointing to the same side of the board that the power connector is on. Use the two #4 self tapping sheet metal screws to affix it to the PC board.
- ❑ 13. Let's begin wiring up the Ion Generator now. The silk screen on the board has been labeled to show the function of the individual wires.
- ❑ 14. Solder the black wire into the hole marked GND PWR. To do this, make sure the wire is stripped and tinned (if not done already) and placed through the hole then soldered on the bottom side of the board.
- ❑ 15. Solder the thin white wire to the hole marked GND HV. This is the high voltage return wire and it is the same thickness as the black wire.
- ❑ 16. Solder the red wire into the hole marked +12V. This is the power to the Ion Generator.
- ❑ 17. You should have the thicker high voltage wire left to attach at this point. We will solder this to the nail board later.
- ❑ 18. Using the four L brackets, the next step will be to mount the pipe board and the nail board to the main PC board.
- ❑ 19. Using four of the #4 x 3/16" screws, mount the L brackets to pipe board (front side) and the nail board (back side) in the bottom corners. Note the copper side of the two boards should be facing the Ion Generator module. These brackets will mate-up with the holes on the main board and allow you to experiment with the positioning of the nail elements.
- ❑ 20. Use four #4 x 3/16" screws to mount the L brackets to the main board. Use the two holes on the very end of the main board for one set (these are the mounts for the pipe board marked M3 and M4). Use the other two in the two holes marked M1 and M2. These are the standard board positions.

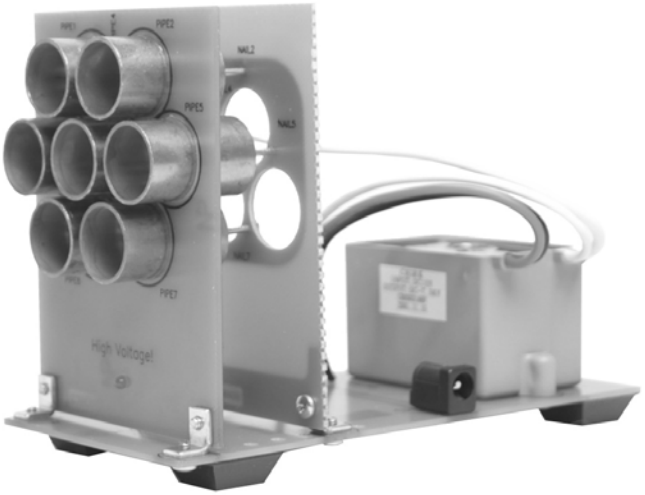
Attaching the Boards To the Main Board



- ❑ 21. Now solder the final larger white wire of the Ion Generator to the bare pad provided on the back side of the nail board in the upper right corner.
- ❑ 22. Check nail positions within the copper tubes and make sure they are approximately centered. They don't have to be right in the middle but if they are cocked at an angle, you may wish to heat up the solder and re-position the nail to center it properly.

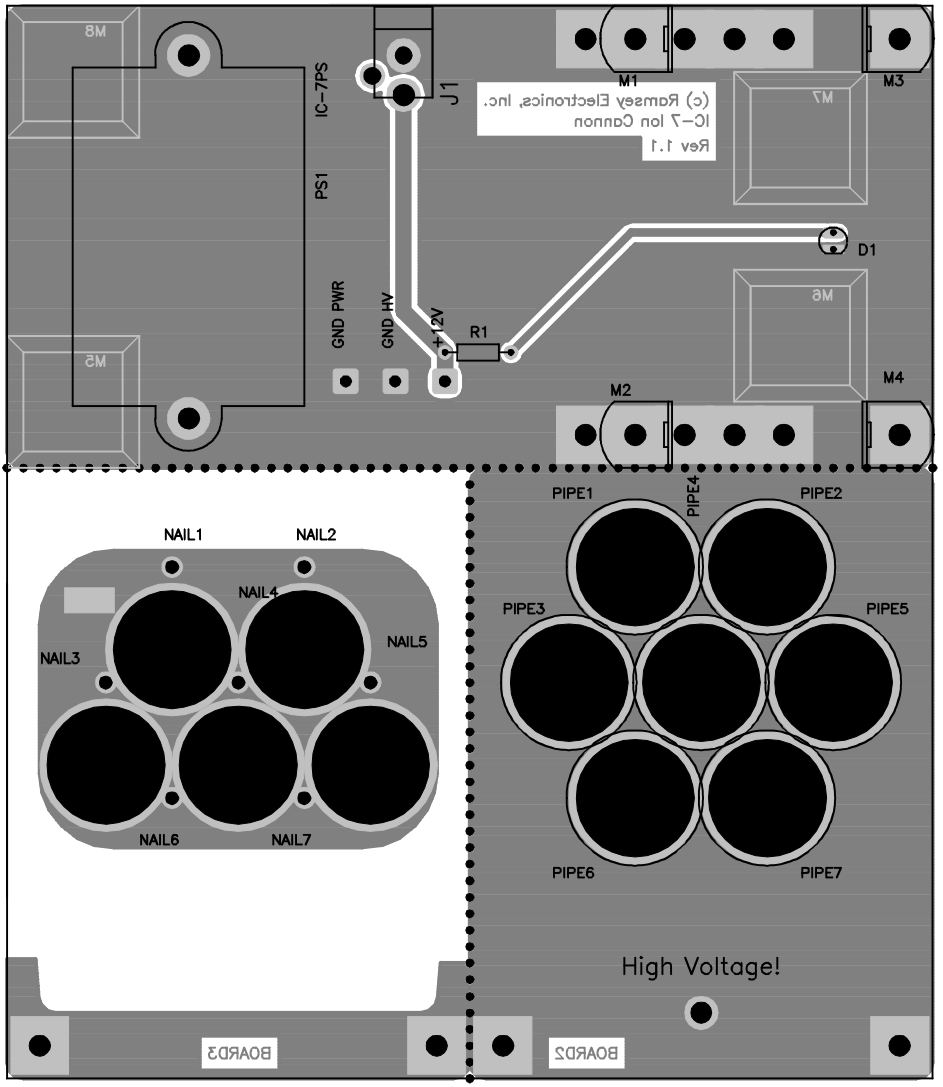
We're done with the assembly of your Ion Cannon! Now is probably a good time to re-read the safety precautions before you plug it in.

The Finished Product!



Parts Layout

MAIN BOARD



NAIL BOARD PIPE BOARD

EXPERIMENTS

On a personal note; back when I was in Junior High School, I really wished kits like this were available. I always loved tinkering with high voltage and seeing the strange phenomenon associated with high voltage and high power. Maybe this was a fixation with fire... or maybe something else (Froyd could better answer than I can). I used to have to dig around in old television sets looking for flyback transformers and high voltage diodes, praying that when I found one, it wasn't the reason why the TV was by the curb. I don't even want to mention how much I had to pay out of pocket for high voltage diodes and capacitors! Now I have gathered all of the pieces together in a reputable kit that actually has a warranty, imagine that! Life is so easy now.

I actually found this little gem of a high voltage power supply while working on another high voltage kit, the PG13. A nice company in Taiwan specializes in high voltage power supplies and they sent this item along for us to play with. Oh boy this is a neat little supply, much better than those $4.00 versions you see in some electronics surplus catalogs! Here is a quick message they sent me about the difference:

" There is other ion generator in the market similar to ours and the unit price is approx. USD3.- , it is AC110V, pulse type, the output power is less than 1/6 of ours, the output voltage will vary with discharge devices and the output voltage is un-adjustable also can not meet EMI regulation."*

(Pardon their English, you should see my Taiwanese! They're doing well!!)

Thus why ours is a bit more expensive. In fact when I was initially playing with the power supply I was quite impressed by how well is worked, the consistent corona it produced, and how easy it is to use. It was originally designed for car air filter use hence the reason why it runs on +12V. Because of this however, you can isolate the power supplies from one another and so some pretty interesting stuff. I will leave that up to you to play with.

Our first experiment of course is the kit we just put together, the Ion Cannon. The idea of the ion cannon is to be able to disperse ions into the air efficiently and with relatively low voltages (less than 10 kV). This little project shows many properties of ions that will help you understand how they work and show many neat scientific principles of ions, ion wind and more.

ION CANNON

Once the Ion Cannon has been assembled according to the previous directions. We'll need to find a suitable place to run the Ion Cannon project. Select a location that is not near sensitive electronics components and has easy access to power so that you don't have to reach across the running unit to turn off the power. You don't want to accidentally lean on it when you want to turn it off or you will be in for a big surprise!

Plug in your 12 VDC power supply power (unit draws about 350 mA) into the power jack (J1) on the Ion Cannon circuit board. Now turn on the power supply. You may possibly hear a slight hissing noise from the tubes and see a small purple "flame" on the end of each of the points inside the pipes. This is indicating that ion flow is occurring! Imagine, at this point there are complex chemical reactions taking place to create ozone and nitric oxide. Even more important is the constant release of ions into the air which can be felt with your hand as a fairly strong breeze coming from the tubes!

Hold your hand in front of the tubes and notice the air flow. It is pretty surprising how much air is being moved by the ions and how cool it feels. Why does it feel so cool? Well the ions certainly aren't chilling the air! It does have some relation to the air moving however. If you compared this ion-pushed air to the air of a fan that moved the same amount of air, this system would seem much cooler thanks to a common meteorological term called "Wind Chill Factor". Yes it is the same weather phenomenon that we New Yorkers (up here in Victor) have to deal with every time we step outside! "Wind Chill Factor" is designed to let us know how cold it feels to your skin versus how cold it actually is outside. It is related to a variety of factors such as wind speed, humidity, and how hairy you are! The hair factor isn't taken into account during TV forecasts very often however! Believe it or not, the hair and the rough surface of your skin is important in wind chill because they keeps a very thin layer of air close to your body that resists movement of the surrounding air. This makes an insulating layer that rides along with you at all times. In fact it takes a surprising amount of wind to break this layer, something in the order of 20 miles per hour or more!

Because our Ion Generator is producing ionically charged air, its attraction to your conductive skin barrels allow the breeze to pass through the insulating layer with very little effort. This causes a much greater 'wind chill effect' than what would otherwise occur at the same wind speed. The evaporating moisture from your skin only heightens this cooling effect as the ions transport the drier air to your skins surface. I personally feel this is why some days seem so bone-chillingly cold when there is hardly any wind and the thermometer doesn't seem to agree with how it cold it 'feels'. Days like this usually occur just before a strong snow storm. I think it has a lot to do with ionic flow in the atmosphere, not just the humidity levels!

Lets try some fun stuff now. Take the small neon light included with your kit and hold on to one of the leads. Point the other lead towards the tubes in the path of the discharged air. DO NOT STICK THE LEAD INTO THE TUBES! If you look closely, you should be able to see the neon light periodically flashing. This indicates that the air coming out of the pipes retains at least 60 volts of charge which is going through the bulb and in to you! You don't feel this because the current is very small. You may need to turn of the lights in the room to see the flashes.

Look at the additional holes on the front end of the main board. These will allow you to adjust the distance of the high voltage tips (the nails) from the end of the pipes (the ion tube array) giving you to the ability to adjust the quantity of air to ions ratio. The more air that is moved, the less energy the ions will have when they escape the ends of the tubes, if they can even escape at all. Can you guess which way the needles have to be moved to generate more air flow and fewer ions?

Using the 10 inch long piece of wire, solder it between one end of the neon bulb and a ground point on the bottom of the main board. The solder mask resist layer has been removed in the area of the screw mounts and provide a convenient contact point for this purpose. Safety-wise, soldering the wire firmly into place is best versus just wrapping the wire around one of the mounting screws (less likely hood it will fall off!).

Try using the neon bulb method like before but this time use a stop watch and try to count the number of flashes you can see in a minute. Position the sensing end of the neon bulbs' lead wire about 1/2" away from the end of the pipes and start counting. Record your results for further comparison.

Now move the nails closer to the ends of the tubes by moving the nail board forward. Repeat the same measurements again and record you count value. Work your way through all of the mounting positions recording your results as you go. Notice any pattern?

If the experiment went well, you should have seen that the closer the nails are positioned to the end of the pipes, the faster the neon bulb would blink. The neon bulb is actually giving you an indication of current, or the amount of free ions in the air. Here's how it works. The lead of the neon bulb that is pointing into the airflow attracts the released ions. The terminals inside the bulb act like a very small capacitor and allow a charge to build up inside the bulb. When the built up charge reaches about 60 volts, the neon gas ionizes and the bulb lights up. At this point, the current flow begins discharging the small 'capacitor' and causes the terminal voltage to drop below around 40 volts. At this voltage, ionization of the neon gas stops and the light goes out.

If the 'collected' ions have low a potential, the neon bulb will not be able to reach 60 volts break down voltage and it will never flash over. This does not

mean there are no ions present, just that their potential is too low.

The next experiment requires some objective observing. You will need to put your Ion Cannon in a place that normally contains a lot of bad smells like in the garage over the garbage can, or in the bathroom near the porcelain throne. Note the smell before and after you run the Ion Cannon. Can you guess what is going on?

Now that you have worked with the unit a bit, have you noticed a pretty strong “electronic” smell coming from the Ion Cannon tubes? Most of what you are smelling is Ozone. Ozone is a fairly reactive gas and in high quantities can trigger asthma attacks or aggravate other heath problems. Thankfully, the quantity coming out of our Ion Generator is pretty safe as long as you have a little air circulation. You wouldn’t want to stuff yourself in a cardboard box with the IG7 running and breath it in all day however. Not to be morbid, but you would probably suffocate long before Ozone got you.

The generated Ozone is a oxidizer (after all it is made up of oxygen molecules) much like that of Chlorine. Chlorine has long been used in homes and businesses as a cleaning agent because it is very good at disinfecting and deodorizing. Since most smells are organic in nature, they can be very reactive as well. A molecule of smelly gas that comes into contact with an oxidizer in the air can cause a reaction. The results of which is a mixture of gasses that will more likely be ‘non smelly’, like carbon dioxide and water. Some gasses like sulfur dioxide won’t be effected but most of the obnoxious ones will. That is what makes the little Ion Cannon so effective. Not only does it move air, but it also emits ozone to ‘scrub it’ at the same time.

In cases of particles like dust that are floating around in the air, they are usually neutral charged. As the Ion Cannon spits out negative ions, they are attracted to and cling to these floating particles. Once the particles are charged by the ions, they become attracted to neutral items like the walls and ceiling. Commercial ‘air purifiers’ often work in this manner by using a grounded filter element to collect the particles. Hey, that’s how those things work!

The Rubber Test

Here is a neat idea that the boss came up with back when I left this running in my office (he wanted to see just how reactive the Ozone was). This also shows how sensitive rubber is to Ozone and why natural rubber doesn’t last very long exposed to moving air.

Take a few regular brown rubber bands and wrap them tightly around a small box. Place the box in the air flow coming from the Ion Cannon and let it run for a day or two. Have you seen this effect before on a few old rubber bands that were left laying around?

Pinwheel (Corona Motor)

The Pinwheel experiment is the old standby experiment that demonstrates ionic flow as well as Newton's 3rd law of Motion: "For every action there is an equal and opposite reaction". When we expend ions off into the air with our Ion Cannon, we are not only pushing air out of the ends of the pipes, but we are also pushing the Ion Cannon in the opposite direction. Granted this force is pretty small in our case, but the pinwheel experiment helps to demonstrate the basic principle very well.

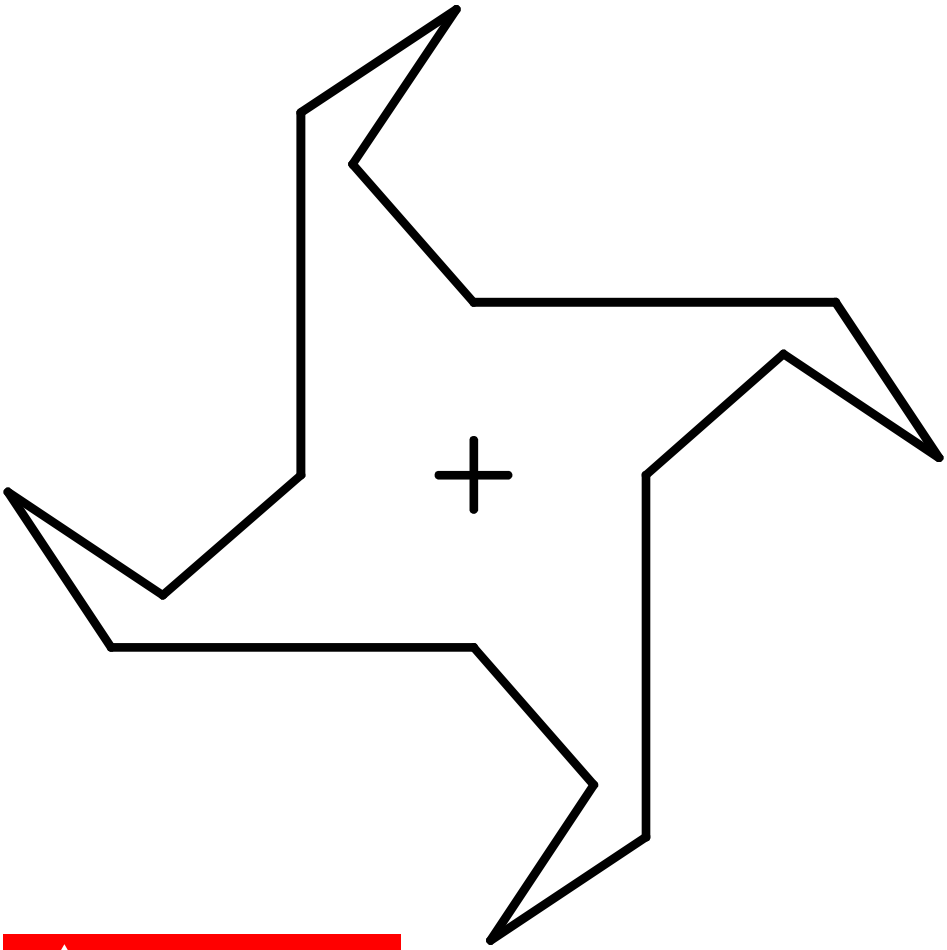
Copy the template (or cut it out) of the metal pinwheel and use it to cut a piece of tin to form. Using this "rotor" will demonstrate how the ions that are being released from the sharp tips also push back with equal force. The force exerted back on the tips will make the rotor spin in the opposite direction of the ion stream!.

- ❑ 1. Be sure to use leather gloves or even butchers' gloves to prevent slicing up your hand from the sharp metal edges when cutting our your rotor. Blood drops can through your rotor system off balance!
- ❑ 2. Cut the top and bottom off of a soda can, and slice it down one side.
- ❑ 3. Bend out and form the aluminum so that it is flat.
- ❑ 4. Cut out the pinwheel diagram from the manual so you can use it as a template to later cut the tin in a desired shape. Tape it on to the flat aluminum sheet.
- ❑ 5. Tap a nail on the center point light enough that it doesn't go through the metal. It should just leave a dimple that we can use to balance the rotor on a support nail. This will form our "frictionless" bearing!
- ❑ 6. Using sharp scissors to cut out the template. Make sure to use bold single slices with the scissors. Not a bunch of little slices that will leave many sharp points and make the rotor ineffective. You can always go back and trim off the sharp edges later.
- ❑ 7. Verify that the Ion Cannon is powered down and unplugged.
- ❑ 8. Unsolder the high voltage lead of your Ion Cannon from the nail board.
- ❑ 9. Using an insulated post like a hunk of plastic or small plastic soda bottle, hammer a nail through the lid so that it points out the top.
- ❑ 10. Secure the high voltage lead to the nail, make sure the nail base is stable.
- ❑ 11. Balance the rotor on top of the nail. Use small pieces of tape as weights to balance your rotor if needed so that it stays level by itself.

❑ 12. Power up the Ion Generator, and watch the motion of the rotor!

This demonstrates how ions can be used for propulsion! In fact NASA has employed this process on some space crafts to help them maneuver in outer space. Ion propulsion is used to slowly reposition the craft, and also assist in acceleration. There isn't much gas in space to ionize, but there is apparently enough for this to work!

Pinwheel Template



This page has been left blank so you may cut the pinwheel template out of the manual without losing any juicy information!!

TROUBLESHOOTING

PROBLEM: The LED doesn't light up.
SOLUTION: Not much that can go wrong in this circuit. Double check your solder connections again. It is quite possible you have a dead short someplace so you had better check it out without the power applied! This is most likely caused by the diode orientation. Check the Flat side against the silk screen.

PROBLEM: The LED lights, but no high voltage.
SOLUTION: There is probably an assembly problem. The main HV power supply included in this kit is very rugged, so it is very unlikely that it was accidentally damaged during assembly. You will definitely want to check your wiring that interfaces with the circuit board.

PROBLEM: The unit ran fine for weeks but now it seems to have lost its poop!
SOLUTION: You may need to clean the nail points and the inner lining of the ion tubes. Dust and other deposits can build up after a while and reduce the ion generating capability of the system.

CONCLUSION

We sincerely hope that you enjoy the use of this Ramsey product. As always, we have tried to compose our manual in the easiest, most user-friendly format that is possible. As our customers, we value your opinions, comments, and additions that you would like to see in future publications. Please submit comments or ideas to:

Ramsey Electronics Inc.
Attn. Hobby Kit Department
590 Fishers Station Drive
Victor, NY 14564

Please feel free to visit our Website at www.ramseyelectronics.com and offer your observations to other kit enthusiasts as well.

And once again, thanks from the folks at Ramsey!

The Ramsey Kit Warranty

Please read carefully BEFORE calling or writing in about your kit. Most problems can be solved without contacting the factory.

Notice that this is not a "fine print" warranty. We want you to understand your rights and ours too! All Ramsey kits will work if assembled properly. The very fact that your kit includes this new manual is your assurance that a team of knowledgeable people have field-tested several "copies" of this kit straight from the Ramsey Inventory. If you need help, please read through your manual carefully. All information required to properly build and test your kit is contained within the pages!

1. DEFECTIVE PARTS: It's always easy to blame a part for a problem in your kit, Before you conclude that a part may be bad, thoroughly check your work. Today's semiconductors and passive components have reached incredibly high reliability levels, and it's sad to say that our human construction skills have not! But on rare occasions a sour component can slip through. All our kit parts carry the Ramsey Electronics Warranty that they are free from defects for a full ninety (90) days from the date of purchase. Defective parts will be replaced promptly at our expense. If you suspect any part to be defective, please mail it to our factory for testing and replacement. Please send only the defective part(s), not the entire kit. The part(s) MUST be returned to us in suitable condition for testing. Please be aware that testing can usually determine if the part was truly defective or damaged by assembly or usage. Don't be afraid of telling us that you 'blew-it', we're all human and in most cases, replacement parts are very reasonably priced.

2. MISSING PARTS: Before assuming a part value is incorrect, check the parts listing carefully to see if it is a critical value such as a specific coil or IC, or whether a RANGE of values is suitable (such as "100 to 500 uF"). Often times, common sense will solve a mysterious missing part problem. If you're missing five 10K ohm resistors and received five extra 1K resistors, you can pretty much be assured that the '1K ohm' resistors are actually the 'missing' 10 K parts ("Hum-m-m, I guess the 'red' band really does look orange!") Ramsey Electronics project kits are packed with pride in the USA. If you believe we packed an incorrect part or omitted a part clearly indicated in your assembly manual as supplied with the basic kit by Ramsey, please write or call us with information on the part you need and proof of kit purchase.

3. FACTORY REPAIR OF ASSEMBLED KITS:

To qualify for Ramsey Electronics factory repair, kits MUST:

1. NOT be assembled with acid core solder or flux.

2. NOT be modified in any manner.

3. BE returned in fully-assembled form, not partially assembled.

4. BE accompanied by the proper repair fee. No repair will be undertaken until we have received the MINIMUM repair fee (1/2 hour labor) of $25.00, or authorization to charge it to your credit card account.

5. INCLUDE a description of the problem and legible return address. DO NOT send a separate letter; include all correspondence with the unit. Please do not include your own hardware such as non-Ramsey cabinets, knobs, cables, external battery packs and the like. Ramsey Electronics, Inc., reserves the right to refuse repair on ANY item in which we find excessive problems or damage due to construction methods. To assist customers in such situations, Ramsey Electronics, Inc., reserves the right to solve their needs on a case-by-case basis.

The repair is $50.00 per hour, regardless of the cost of the kit. Please understand that our technicians are not volunteers and that set-up, testing, diagnosis, repair and repacking and paperwork can take nearly an hour of paid employee time on even a simple kit. Of course, if we find that a part was defective in manufacture, there will be no charge to repair your kit (But please realize that our technicians know the difference between a defective part and parts burned out or damaged through improper use or assembly).

4. REFUNDS: You are given ten (10) days to examine our products. If you are not satisfied, you may return your unassembled kit with all the parts and instructions and proof of purchase to the factory for a full refund. The return package should be packed securely. Insurance is recommended. Please do not cause needless delays, read all information carefully.

IG7 ION CANNON KIT
Quick Reference Page Guide

REQUIRED TOOLS

- Soldering Iron Ramsey WLC100
- Thin Rosin Core Solder Ramsey RTS12
- Needle Nose Pliers Ramsey MPP4 or RTS05
- Small Diagonal Cutters Ramsey RTS04

<OR> Technician's Tool Kit TK405

ADDITIONAL SUGGESTED ITEMS

- Holder for PC Board/Parts Ramsey HH3
- Desoldering Braid Ramsey RTS08
- Digital Multimeter Ramsey M133

Price: $5.00
Ramsey Publication No. MIG7
Assembly and Instruction manual for:
RAMSEY MODEL NO. IG7

TOTAL SOLDER POINTS
22

ESTIMATED ASSEMBLY TIME
Beginner ..... 1 hrs
Intermediate ..... 0.5 hrs
Advanced..... 0.5 hrs

RAMSEY ELECTRONICS, INC.
590 Fishers Station Drive
Victor, New York 14564
Phone (585) 924-4560
Fax (585) 924-4555
www.ramseykits.com