

PULSE JET INTERNAL COMBUSTION ENGINE

BY

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ABSTRACT

This article describes using the pulse jet to create circular motion. Such an engine would be highly efficient, simple and cheap to build, light weight, and could use a wide variety of liquid fuels. Such a pulse jet engine would be a very efficient substitute for the piston engine.

The pulse jet is a highly efficient method of converting a burning fuel/air mixture into a force. The distinction between a pulse jet and a normal jet is that the pulse jet intermittently burns its fuel while the normal jet burns its fuel continuously. The intermittent burning of the pulse jet's fuel is caused by its basic design. The basic pulse jet is a tube with a valve at one end, that allows air to enter the tube and intermittently opens and closes. Fuel is entered into the tube and is ignited. The result is an intermittent pulse of hot gas out of the end of the tube. This causes an intermittent force in the opposite direction.

This force can be turned sideways by turning the end of the tube at right-angles.

The pulse jet can provide an ideal form of an internal combustion engine. The internal combustion engine described in this article attaches three of these tubes onto a rotating disk, with their ends turned sideways. A fuel/air mixture is entered into these tubes in turn from a fixed central cylindrical device, and then ignited. The hot gas jet forces the disk to turn. This generates power. If high pressure air is entered into this device, this pulse jet internal combustion engine can be highly fuel efficient.

The mechanical set-up of this device is described in detail in this article. It consists of the rotating disk rotating around the central fixed device from which the air and fuel enters the pulse jets. This central fixed device is attached to a central fixed axis.

The pulse jet internal combustion engine has a high power/weight ratio and is cheap to build. It is a very cheap and efficient substitute for the piston engine.

DISCLAIMER

While the author has conducted experiments on simple pulse jets (with near fatal consequences to himself!), he has not progressed to build a rotating pulse jet device described in this article. The engineering requirements were beyond the author's resources.

The author is therefore throwing this experiment open to other experimenters with better resources. The author has made no attempt to patent this device or idea, nor does he make any prior claim. The author acknowledges that by releasing this information, this knowledge from the patent application point of view is no longer novel, and the author has ceased in any attempt to make any financial gain from this idea. Any other user or experimenter is free to make any use of this idea without any recourse to myself.

INTRODUCTION

The pulse jet in concept and in practice has been around for nearly a century. Yet in all that time it has been used for only a single purpose, as a one directional jet. No attempt has been made to utilise the pulse jet as an internal combustion engine. In other words, no attempt has been made to utilize the pulse jet to provide rotary power.

This article will demonstrate that rotary power can be derived very simply using the pulse jet concept, and furthermore that the pulse jet internal combustion engine, if properly designed, can be very efficient. It is also very light and simple. Thus, a pulse jet engine can be used to power both ground vehicles and aircraft. It can be used also to provide stationary power for power generation.

The pulse jet engine can be relatively more fuel efficient than a piston engine or a jet engine, if, like both of those engines, steps are taken to compress the air before fuel is injected and ignited. See the web site.

www.pulse.jets.com/phpbb3/viewtopic.php?t=931

It is time to get away from the use of pistons. Pistons have been around since they were used to pump water in the 14th century. Since then pistons have been adapted to steam engines, and then internal combustion engines. Despite improvements evolving over time, the piston engine is intrinsically inefficient, requiring a compression stroke and then an exhaust stroke, even for two stroke engines.

Petroleum companies in particular have a strong interest in rapidly developing a pulse jet internal combustion engine as a replacement for the less efficient piston internal combustion engine. Why? In one word – competition. Soon there will be massive competition from electric cars. At a certain point, there will be a sudden catastrophic collapse of the oil industry. For the oil industry to continue to survive it must offer a more efficient replacement for the piston engine. The pulse jet internal combustion engine is a possible replacement. More efficient, cheaper, lighter. And it continues to use petroleum fuel. The oil industry will be able to continue to trade on its advantage of its existing infrastructure of fuel supply. The demise of the oil industry will be at the worst much slower, and quite possibly it could continue in competition with electric cars. With the piston engine, no matter how sophisticated, the chance of the continued existence of the oil industry is much lower.

WHAT IS A PULSE JET?

The basic concept of a pulse jet is very simple. The device is designed to fire intermittent pulses of very hot air out of one end of a conduit or tube, providing a pulse or intermittent force in the opposite direction. This device is conceptually different from a jet engine that provides a *continuous* thrust in one direction.

The basic design of a pulse jet is illustrated in **Figure 1**.

These figures were not professionally executed, but they are clear. There are two reasons that these designs were not professionally made. First, lack of knowledge and personal ability of the author to utilise computer aided design. Secondly, as the author was not going to personally gain from this idea there was less motivation to improve their appearance! Nevertheless these designs are clear and complete.

As shown in **Figure 1**, this device consists of an open-ended tube or conduit, that is open at one end and closed at the other end by valve or hinged lid that

opens inward. This hinged lid is prevented from opening outward by a segment affixed to the tube.

There are many possible designs for such a valve or lid, and indeed there have been made many improvements to the design of the pulse jet, but pulse jets all follow the same basic design – air is entered through a valve in one end of the tube, a fuel is sprayed into the tube, the fuel air/mixture is ignited, an explosion occurs inside the tube, the back pressure causes the valve to close, and the hot gas is ejected from the other end of the tube causing a reactive force in the opposite direction. The ejected air then causes a partial vacuum. The valve opens letting more air into the device. Fuel is sprayed into the air coming into the tube, it is exploded, and the cycle repeats at a regular rate.

Figure 1 shows a very simple design. Aside from the tube and air inlet valve, there is a fuel inlet that brings liquid fuel into the tube. This is usually attached to some sort of fuel spray. This fuel spray can be continuous, or the injection of the fuel can be intermittent, timed with the explosions in the pulse jet.

The second addition is a spark plug to detonate the fuel air mixture. This spark plug is placed at the end of the tube, near the fuel inlet and the air inlet valve. Certain pulse jets have been designed to operate using detonation by the residual hot air using 'blow back' or 'resonance', but such design sophistication is not necessary for constructing an effective pulse jet. It must be stressed that the device described in this article is the basic effective working design, and many improvements can and have been made. Some of these improvements are described in the web sites [/aardvark.co.nz/pjet/](http://aardvark.co.nz/pjet/) and www.pulse-jets.com. However, all these articles describe improvements in uni-directional jets of various types, and do not describe the workings of a rotating internal combustion engine.

In a pulse jet the hot gas is accelerated to a high speed. The acceleration of the hot gas causes a recoil, according to Newton's Third Law – for every action there is an equal and opposite reaction. This causes an equal and opposite reaction in the conduit, forcing it back in the direction opposite to the direction of travel of the hot gas. It must be understood that this reaction takes place inside the body of the conduit, where the explosion occurs, and not at its end.

Now if the pulse jet is securely held down, the energy of the gas is not transmitted to make the conduit travel backwards, but is entirely converted to

the forward movement of the hot gas. This effect is well known to rocket engineers. When a rocket engine is held down on a test bed for testing, the hot gases travel much faster relative to the rocket than when the rocket is moving forward – when part of the energy of the hot gases are converted to energy for the forward movement of the rocket.

This is an important consideration for the design of a pulse jet internal combustion engine, as will be seen.

HISTORY OF PULSE JETS

It is generally known that the first major use of pulse jets was with the V1 in WWII. These were very successful, flying faster than any propeller driven aircraft, and several thousand were dropped on London. They were simple to build and operate, and worked very well. The V1 was accelerated off a ramp to operating speed. The valve at the front end, opened by air pressure, lets air into the combustion chamber. The fuel-air mixture was initially ignited by a spark plug, and the back pressure of the hot gases closed the air inlet valves. The hot air was ejected out the back of the engine, forcing the V1 forward. A vacuum occurs in the pulse jet. The valve then opens and more air is drawn into the pulse jet. This fuel air/mixture is ignited by remnants of the previous hot gases, and exploded. The V1 accelerates forward. A vacuum occurs again in the chamber. The valve opens. More air is drawn into the chamber and mixed with fuel. An explosion occurs again driving the V1 forward. This cycle continues until the V1 reached a pre-set distance, and then it crash-dived into its target. The sound of the V1 was said to resemble a motor-bike.

Wikipedia tells us that the basic invention of the pulse jet dates back to 1906. The first working pulse jet was patented by Russian engineer V.V Karavodin, who completed a working model in 1907. The French inventor Georges Marconnet patented his valveless pulse jet in 1908, and the Spanish inventor, Ramon Casanova patented his pulse jet in 1917. All this demonstrates that the basic device is very simple and many people near simultaneously invented the pulse jet.

Robert Goddard of the US built a pulse jet engine in 1931. His design was “borrowed” by various German engineers in the 1930’s. The necessary research was then supported by the German government. The Argus company and Paul Schmidt developed the pulse jet engine up to and through the war, culminating in the V1.

It is not intended to provide a detailed historical account of this development. However, it is interesting to note that, as with the jet engine, if there had not been delays caused by cancellations and slow-downs in these projects, Germany would have had both the V1 and an operating jet engine two years earlier. Nazi ideology did not put a high value on technical development in a whole range of areas until it was too late.

PRACTICAL ADVICE

Warning. I end this introduction with a reference to a practical note and a dire warning. These basic pulse jets generate a great deal of heat. When I mentioned “tube”, the experimenter must not be tempted to use a standard water pipe! These will explode with devastating results as the tubes heat up and lose their strength. Red hot shards will fly everywhere. The conduit needs to be cast in in very strong steel-nickel compound or similar. I also recommend X-raying the castings for flaws. Most “high-tensile steel” tubes also lose strength when heated to red hot, and can be equally dangerous. Also, I strongly recommend the pulse jet experiment be surrounded by steel plates and two layers of sandbags. Red hot shards can penetrate the steel plates, and the effect is horrendous.

Some experimenters coat these conduits with ceramics obtained from NASA. At the very least I say take every safety precaution possible.

Raising the air input pressure can have the perverse effect of reducing the heat of the conduit. This is probably because the hot gases are ejected faster. Also there is a greater volume of air to heat.

Since the aim is to construct a pulse jet internal combustion engine and not a rocket, I suggest that you construct a **small** device. The pulse jet theoretically should work regardless of the size, and a small device is more manageable and a lot safer. The experimenter will be amazed at the amount of thrust delivered by even a small device. The device should be firmly attached to the ground.

The frequency of the cycles or explosions is an issue. They depend on the physical size of the pulse jet, and if un-regulated, in smaller pulse jets the cycles can be as frequent as 250 cycles a minute or faster. This frequency is not possible with an air input valve. Valveless pulse jets are possible. But, as will be

seen later, for the purpose of an internal combustion engine the frequency of the pulses is constrained by the rotation of the engine. This will be described later in this article.

The questions of dimensions of the device cannot be specified precisely, as the size of the device depends on the goal of power output together with engineering choices and trade-offs. A wide number of choices can be made. However, what will become clear is that a very high power/weight ratio is easily attainable, and if an air compressor is used, very high fuel efficiency can also be achieved. What I suggest is, that when it comes to designing a basic pulse jet engine described in **Figure 1**, the diameter of the conduit should not exceed 40 mm in diameter. When it comes to designing a pulse jet engine for use in vehicles, the diameter of the engine as a whole should be contained well inside the dimension of the vehicle, together with an explosion shield and space for exhaust, and the individual pulse jet conduits should not exceed 25 mm in diameter. Safety first should be the motto for these experiments.

A single layer of pulse jets should provide more than enough power for any road vehicle. Several layers can provide a high power output for aircraft.

ADDING THE CURVE TO THE END OF THE PULSE JET CONDUIT

The basic requirement for a pulse jet internal combustion engine is to create a sideways force, as different from the pulse jet in **Figure 1**, where the reactive force is in the rearward direction. In order to create a sideways force it is necessary to eject the hot gas sideways. This is shown in **Figure 2**. The gas from the explosion is ejected straight up the conduit until the end. It is then forced to turn sideways, as the conduit is turned sideways, and the gas is ejected at right angles to its previous direction of travel.

What happens to the force created by the velocity of the gas? If the conduit is held down, the entire energy of the gas is converted to forward motion of the gas. When this gas is forced sideways all this energy, or most of it, is converted to a sideways force in the opposite direction to the direction of the ejected hot gas. This sideways force is the basis for the pulse jet internal combustion engine.

In practical terms, I advise that it is not wise welding a curved piece on the end of the conduit. Welds were not strong enough, and rapidly weaken under the heat.

Bending even a strong high tensile tube will not work well. The curved end will heat up to red hot, and weaken. I suggest that what will work best is a relatively thick casting of high strength steel. The extra weight is not an issue, as the propulsion from the hot gas is extremely powerful. As an elaboration, air cooling fins can be added to the end of casting and may work well in moving air.

THE ROTATING DEVICE

Given that a conduit with a curve at the end, it can be used to cause a sideways motion. The aim now is to cause a rotating motion.

To do this three of these conduits are attached to a strong disk. Each conduit is one third of the distance around the circumference. This is shown in **Figure 3**.

Each of these conduits also have circular curved ends as shown.

As discussed later in this article the two components of the metal disk and the conduits could be cast, as top and bottom, at the same time, and attached facing each other.

Hot gases are ejected out of the curved ends of these three conduits, causing the disk to rotate.

HOLDING THE ROTATING DEVICE

The disk has to be held steady with respect to the surrounding environment while it rotates. The methodology to do this will be described later in this article after the other components have been described.

METHODOLOGY FOR INTRODUCING AIR AND FUEL INTO THE ROTATING CONDUITS, AND IGNITING THE FUEL/AIR MIX

As shown in **Figure 3**, there are three pulse jet conduits are held onto or in a disk, each conduit being one third the way round the circumference.

Each of those conduits lightly touch a central fixed device that does not rotate, but is held in place against the outside environment. This so-called “fixed

device". It is circular, with solid walls. Each of the conduits has a curved end that closely matches the curve of the fixed device. See **Figure 4**. However, there is an opening in the wall of the fixed device to let air into each conduit in turn. This opening is the same size of the end of the conduit. This hole in the fixed device wall can be of any size relative to its circumference, but its maximum size can be only one third of the size of the circumference. This is because the fuel/air mixture can only be exploded when the conduit has rotated to the closed position. If the open section of the fixed device takes up half the circumference, if its motion takes it a fraction further, the hot gases will detonate the fuel/air mixture entering the device.

On the other hand, more than three conduits can be used. But if more than three are used, the power/weight ratio of the engine will begin to decline.

The contact between the moving conduits and the central fixed device needs to be lubricated. I suggest that the wall of the central fixed device could be coated with graphite. Alternatively, the metal of the central fixed device could be imbued with graphite and/or molybdenum. As the central fixed device wears it should then release more lubricant.

The contact between the moving conduits and the central fixed device need not be tight. However this gap should be tight enough to prevent premature ignition of the fuel/air mix, by leakage of the hot gas into the subsequent fuel/air mix.

Air enters through the bottom or top of the hollow fixed device, and then enters a conduit through a cut-out section or hole in the fixed device's wall.

Now, the conduits rotate past this hole in turn, until their ends face the wall of the fixed device. Then the air entry into that conduit is closed off. Thus, each conduit in turn gets a pulse of air.

Near the end of the open section of the fixed device is placed a fuel spray. Fuel is sprayed into the air continuously or sporadically. The air then becomes a fuel/air mix.

A spark plug is placed further along the wall of the fixed device, inset into the wall so that it does not catch the rotating conduit. The spark plug is placed in the position where the conduit has moved over it after leaving the open section, and the end is totally closed.

At this point the fuel/air mix is ignited. The hot air rushes to the end of the conduit, and forces the device to rotate. This happens to all the conduits in turn. The device continuously rotates until the fuel is cut off.

To summarise this section, a circular valve is placed at the centre of the rotating device to intermittently allow an air/ fuel mixture into each conduit in turn. This air/fuel mixture is ignited by a spark plug causing the mixture to explode. This hot gas travels fast to the end of the conduit and ejected sideways, causing the device to rotate.

SIDE VIEW OF FIXED DEVICE SHOWING OPEN SECTION

Figure 5 shows the side view of the fixed component. It is very simple. It is just a steel cylinder with a roof, and with a section cut in one side equal in size to the end of a pulse jet conduit.

To one side of the cut-out section is placed the fuel spray. This is positioned to spray fuel into the conduit just before it closes.

The fixed component may also have an air funnel attached to its base, so that air is drawn into the open bottom of the fixed component. The top of the fixed component is closed to not allow air out the other end.

Figure 6 shows the other side of the fixed component. It is a smooth circular wall, except for a spark plug inset part way along it. The position of the spark plug is set to ignite the fuel air mixture when the conduit has moved to completely close access to the air and fuel inflow.

GEOMETRY OF THE DEVICE WITH MAXIMUM POSSIBLE SIZE OF OPEN SECTION

As previously stated, the maximum possible size of the open section in the fixed component is one third of the circumference. In this circumstance, the conduits can meet up and join. This is shown in **Figure 7**. While this is a stable design, there are trade-offs. The central fixed component will necessarily have a relatively small diameter compared to the length of the conduits, and this would restrict the air inflow. There is an optimum opening size/length ratio that can only be found by experiment. This will in turn set the size of the fixed

component. As will be seen in a following section, an optimum design size is possible.

CASTING DESIGN

As has been said, it is advisable to cast the pulse jet conduits from a strong steel composite, from the point of view of safety and efficiency. Safety requirements can be built into the design and specification. Another benefit of using casts is that the metal can be specified. This is a considerable advantage. Tubes from elsewhere, no matter how high tensile, are not designed for this sort of work, unless they have been specified and built for it.

Many casting designs are possible. **Figure 8** shows a very simple one. The casting comes in two parts, a top and bottom. The casting consists of a top and bottom of three pulse jet conduits set into an intervening reinforcing disk. The top and bottom of the pulse jet conduits are semi-circular. This design has the twin advantages of maximising strength and minimising the use of materials.

While a constant diameter for the conduit can be very efficient as it minimises drag, pulse jet designers have improved efficiency by varying the diameter of the conduit along its length; even adding adjusters at the end. Whether or not such modifications are cost effective is up to the designer, but early models certainly do not need these improvements. The device will work very well without them.

CASTING WITH ATTACHMENTS BETWEEN THE CONDUITS

As mentioned previously, if the conduits are attached together, the structure is far stronger. This can be done by making a single casting, with the inside openings of the conduits attached together in part circular attachments, and attached to a reinforcing disk, as in **Figure 9**. This structure is extremely strong.

An advantage with not making the walls of the conduits meet at the centre, as in **Figure 7**, is that the relative size of the conduit openings can be set to maximise air intake and maximise pulse jet efficiency, the size of the openings dependent on the relative diameter of the fixed component.

ROTATING DEVICE

The disk holding the three pulse jet conduits has to rotate. Yet it has to be held tightly in respect to the surrounding environment, and vibration minimised.

A possible solution to this problem is shown in **Figure 10**. The essential feature of this design is a stationary hollow tube passing through the device from top to bottom, securely held so that it does not move compared to the surrounding environment. Attached to this tube are two rotating sleeves. These could be held in place by lubricated pressure bearings.

Between these two rotating sleeves is placed the so-called fixed component. The stationary tube passes through this fixed component from top to bottom, and the fixed component is securely attached to the stationary tube so that the fixed component cannot move.

The pulse jet conduits are attached to a reinforcing disk, each conduit separated by one third of the circumference of the framework. This disk is set between the rotating sleeves, and the disk is attached to the rotating sleeves so that the framework can rotate.

The three pulse jet conduits are set in the disk so that their ends just touch the fixed device and can rotate around it. The mouths of the conduits are designed and set so that they just cover the cut-out section of the fixed component one at a time as the framework rotates.

Finally, the fuel pipe and the electricity supply for the spark plug enter the fixed component, avoiding the rotating components by travelling up the centre of the stationary hollow tube, and exiting through a hole in the side of the hollow tube.

Thus, the pulse jets can freely rotate around the stationary tube, which is the axis of the device. As fuel and electricity can be introduced into the pulse jets via the hollow tube, and air is entered into either the top or bottom of the fixed device, a fuel/air mixture can enter the pulse jet conduits. This fuel/air mixture is then ignited by the spark plug. The whole device rotates, and if properly designed, can be very stable.

A power take-off can be attached to one or both of the rotating sleeves. This device can be very suitable for operating an electricity generator.

INCREASING THE PRESSURE OF THE AIR INTAKE

It is strongly advisable to increase the air intake pressure. It is generally acknowledged by people working on pulse jets that efficiency is improved several hundred per cent by doubling or quadrupling air intake pressure compared to atmospheric pressure.

I am not going into possible designs for increasing pressure, but it can be seen that the design in **Figure 10** is ideally suited to the installation of a turbocharger. Electric power for this turbocharger can travel up the hollow stationary tube, or alternatively there can be a geared connection to a rotating sleeve.

CONCLUSION

It is amazing that a pulse jet internal combustion engine has not been developed to date, and work on improving internal combustion engines for the past 100 years have been confined to improving piston engines. A pulse jet internal combustion engine is potentially vastly more efficient than a piston engine with a far greater power/weight ratio. A pulse jet engine can also use a vastly wider range of fuels, either simultaneously or in succession.

It took about 30 years to develop the piston engine from the concept invented by Daimler, to the Ford V8 engine in the 1920's. Since then improvements have been marginal.

As the pulse jet concept is vastly simpler than a piston engine, useful designs can be created very quickly, and rapidly brought into production. Manufacturing cost, compared to the very complicated and expensive piston engine, can be reduced rapidly when the pulse jet internal combustion engine is brought into mass production.

Some say electric vehicles will overtake internal combustion engines. But currently there are major limits on the physics of storage batteries. Additionally, there are many countries in the world that do not have access to convenient sources of electricity. There is plenty of petroleum fuel world-wide.

In my opinion, internal combustion engines are here to stay for a long time. But the world needs a more efficient and cheaper internal combustion engines. The pulse jet internal combustion engine is the answer to the power supply needs of the world.

Figure 1

Basic Pulse jet

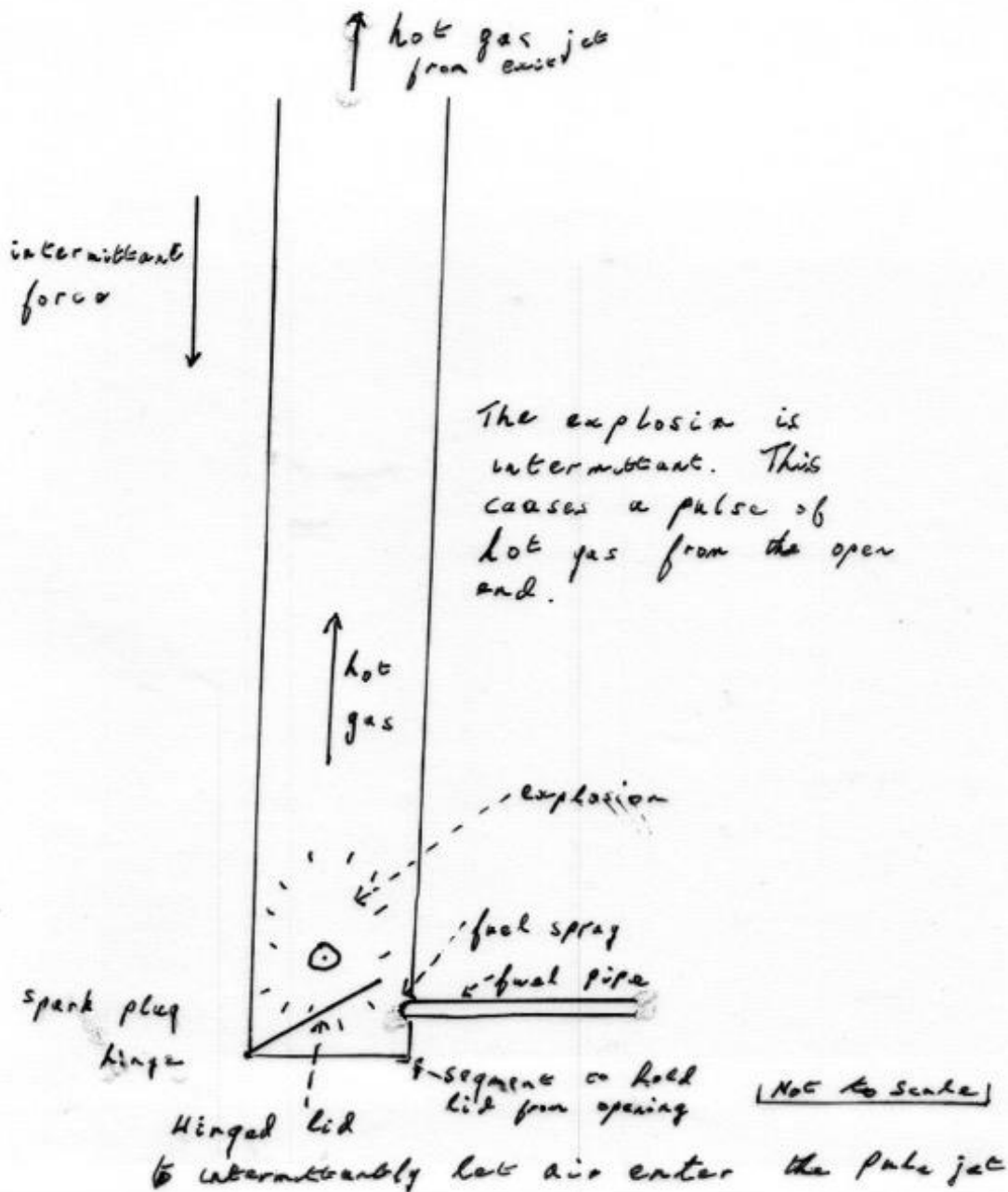
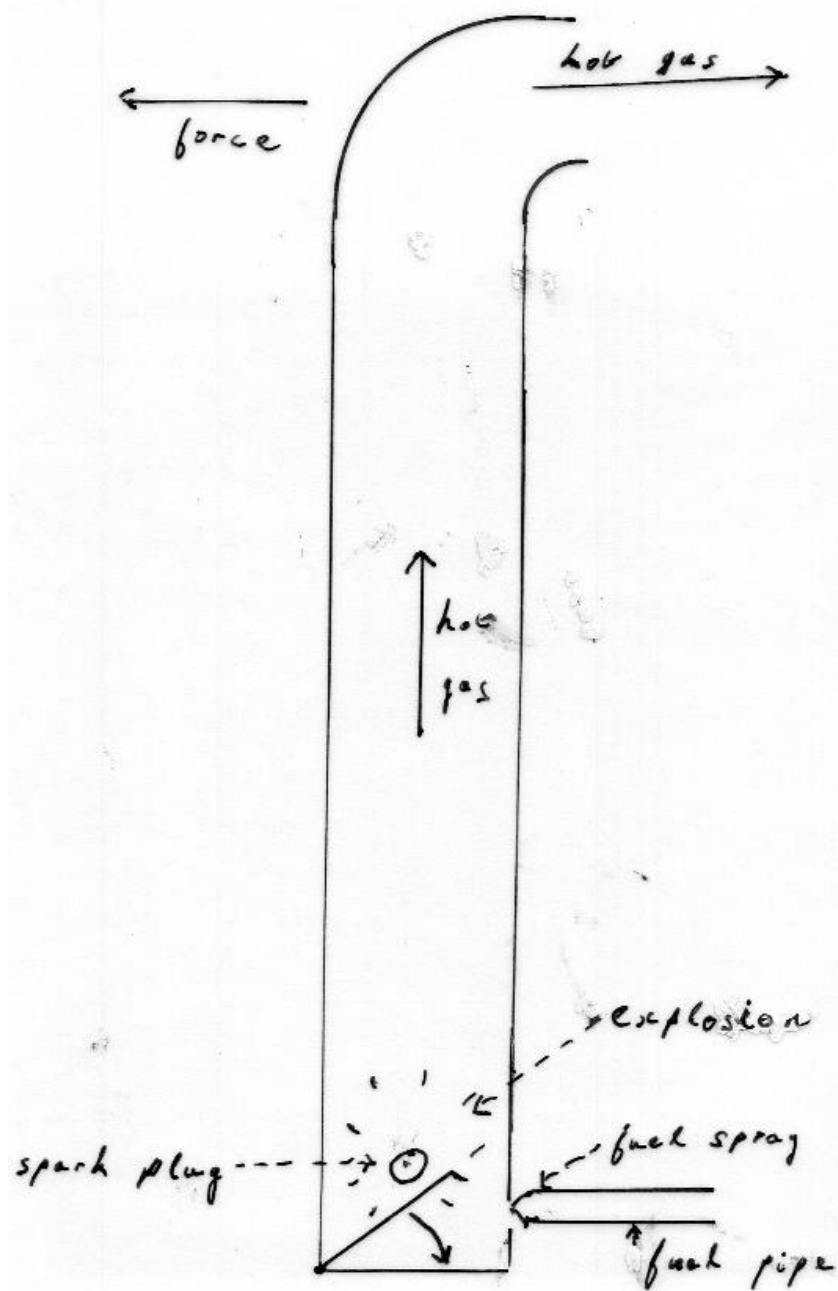
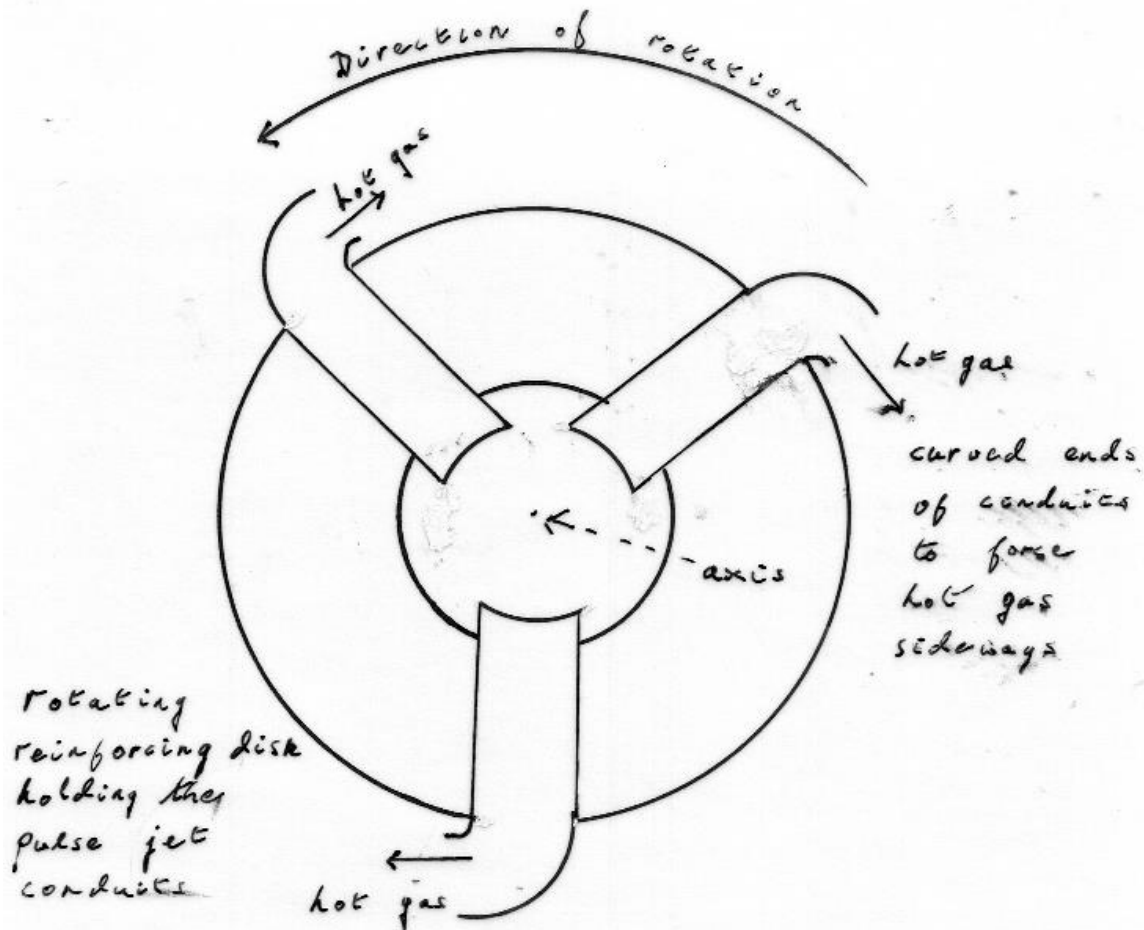


Figure 2 Curved pulse jet conduit



Not to Scale

Figure 3 Three rotating pulse jet conduits causing the device to rotate around an axis



(Not to scale)

Figure 4 Air is mixed with a spray of fuel, and the mixture is then detonated by a spark plug where the end of the rotating pulse jet conduit is closed by the wall of the fixed device

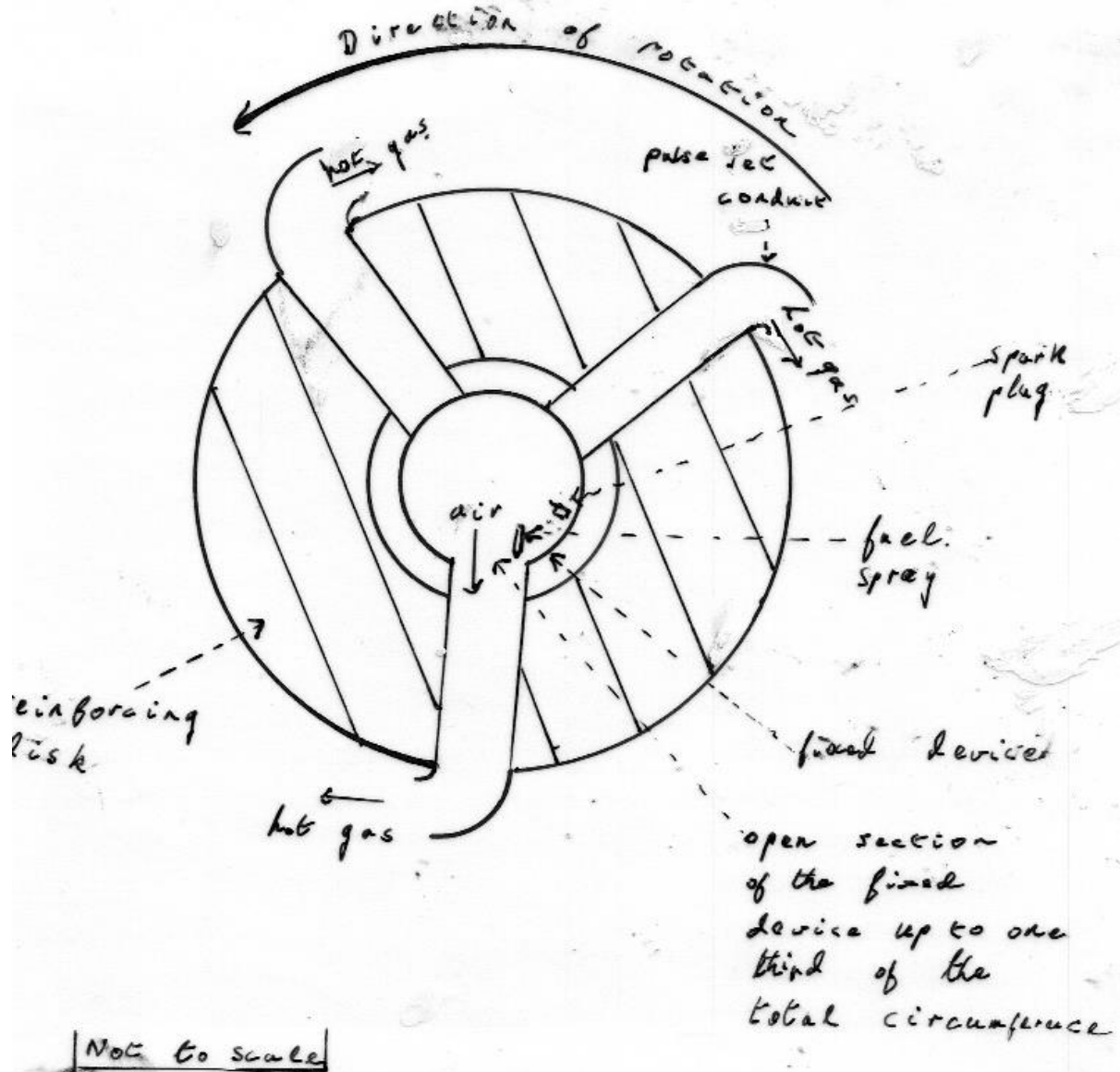
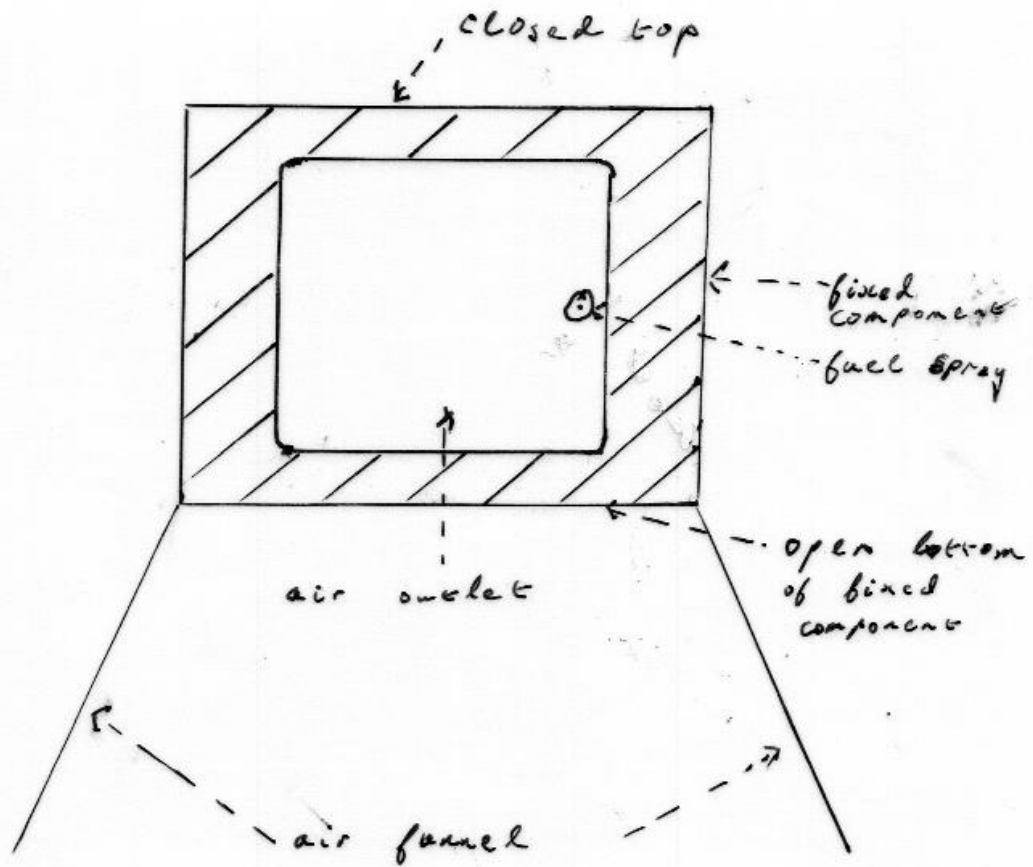
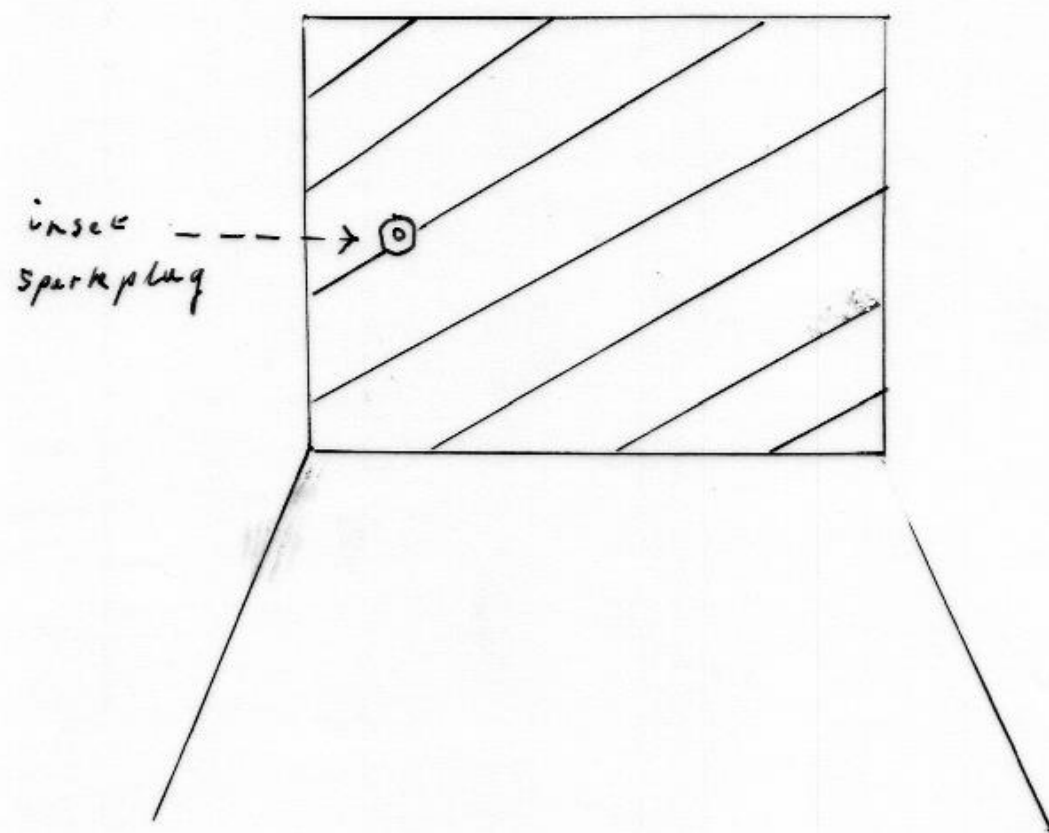


Figure 5 Side view of forced component



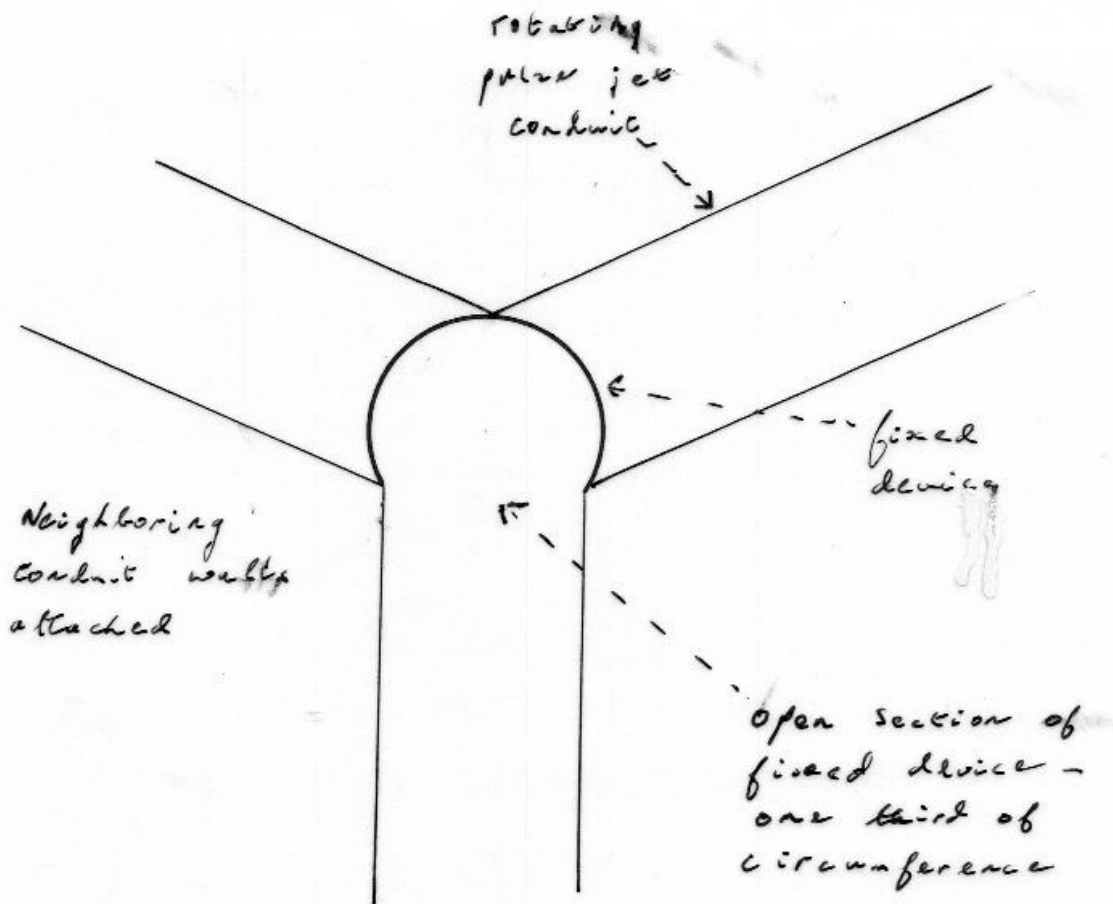
Not to scale

Figure 6 Opposite side view of fixed component



(Not to scale)

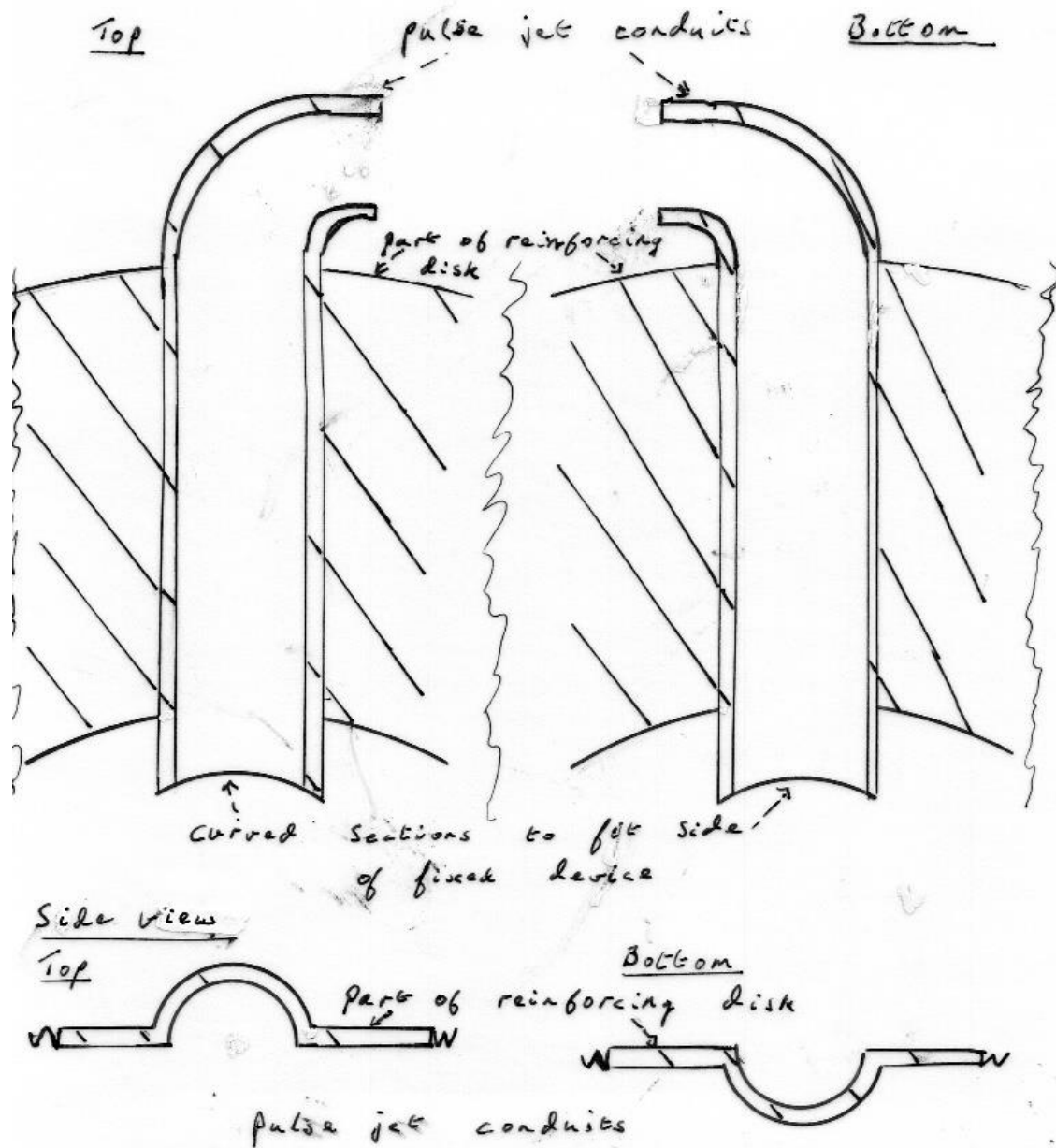
Figure 7 Geometry of device when maximum possible size of open section of fixed device is used - one third of the circumference of the fixed device



Note that when the diameters of the rotating conduits equal the width of the open section, the walls of the rotating conduits come into contact with the wall of the neighboring conduit, and can be physically attached.

Figure 8

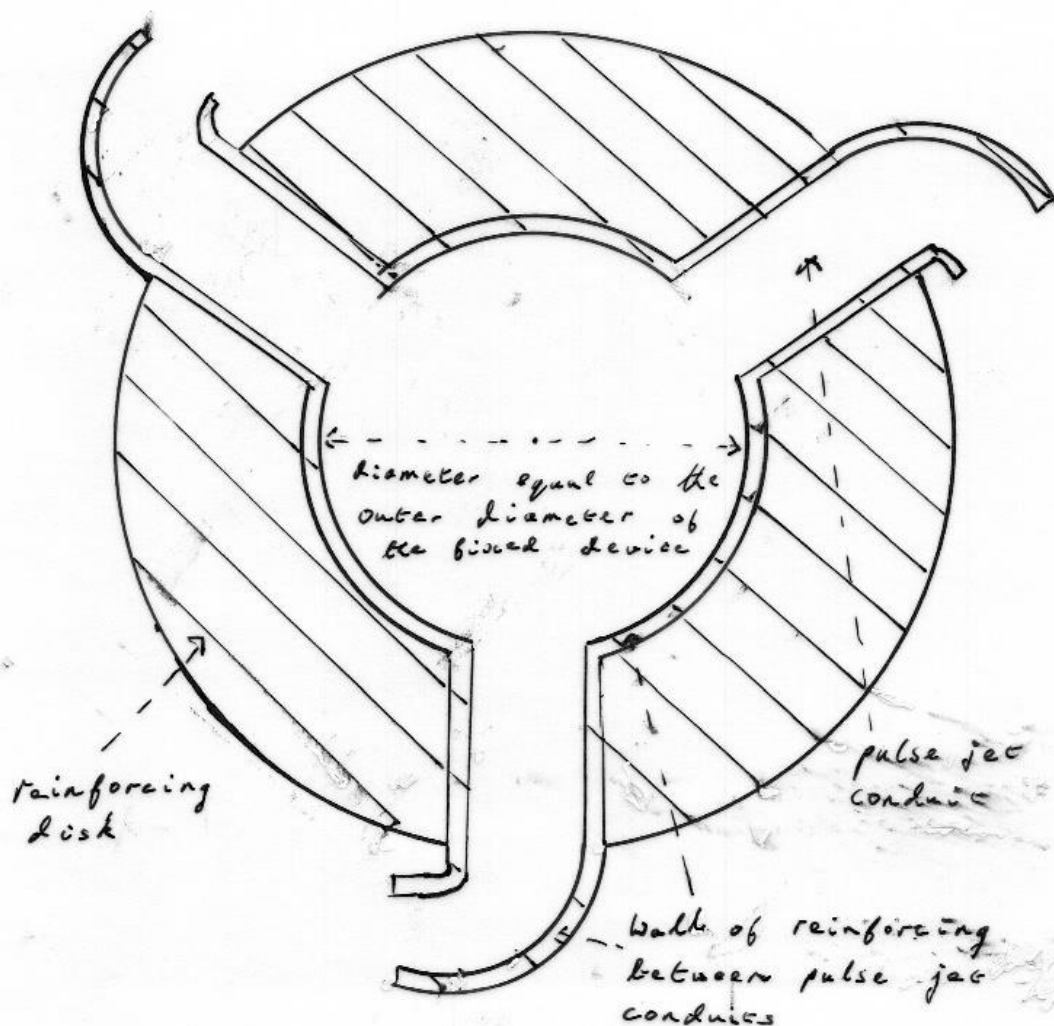
Castings of pulse jet conduit
set in reinforcing disk
(one third part of casting)



Not to scale

Figure 9 Diagram of casting from above showing attachments between the pulse jet conduits and the reinforcing disk

This casting is identical top and bottom, except that the pulse jet curved openings face in opposite directions



Not to scale

