Converting Pneumatic Pressure to Rotational Power.

As in all pneumatic compression or expansion situations, the effect of pneumatic pressure change on pneumatic temperature change,and visa versa, must be given due consideration. The reader may have noted that Chapter Three was concluded without such consideration being applied in reference to the final value of pressure increase , Pi. This was not an oversight but rather the result of a decision rendered some considerable time prior to this work based on numerous analyses and extensive laboratory testing , that the posture would actually be conservative if it concluded that the value of Pi was unaffected by the temperature change versus pressure change hypothesis. The reasoning in support of that decision was accumulated in somewhat the following manner.

Early on,in concept development, this consideration was comprehensively addressed. Many attempts were undertaken to apply the available equations for both isothermal and adiabatic compression-expansion. Perhaps the reader may not be familiar with these terms and a definition may be in order at this point . Adiabatic expansion or compression takes place when air is expanded or compressed entirely without transmission of heat to or from it. Isothermal expansion or compression takes place when the gas is expanded or compressed with an addition or transmission of sufficient heat to maintain a constant temperature. However the pertinent conditons involved a blending of both types and for this and other reasons,computing the effects proved to be very impractical. For this reason also , a long series of laboratory tests , involving hands-on experience with pertinent hardware resulted in a much more practical and accurate comprehension of the true effects of pressure change on temperature change in the inertial-pneumatic compression process. The net conclusion was that in an operational inertial-pneumatic compression system, such as the proposed prototype, for every one degree F. change in pneumatic temperature there will have been a 29 psig change in pneumatic pressure.

Perhaps the reader has never really understood why it is that a change in pneumatic pressure invariably produces an appropriate change in pneumatic temperature. In the simplest terms ,it is produced by a change in the btu's of heat per standard air cubic inch of pressure containment space. For example , if a pressure containment vessel has an internal containment standard air volume of 2700 cubic inches and is showing zero psig on its pressure gage, it will be considered as being empty at one atmosphere absolute pressure. It has been in this status long enough so that its interior temperature is identical to room temperature and each cubic inch of its interior contains x btu's of heat. The total heat within the vessel is 2700 x btu's .

Now, 24,300 cubic inches of one atmosphere room air is compressed into the vessel and its internal pressure is increased from one atmosphere to ten atmospheres and the air within the vessel is saturated with 27,000 x btu's of heat. Naturally the internal air temperature will rise.

The same principle applies in reverse. The same vessel has been filled to an internal pressure of ten atmospheres and has set idle long enough that internal pneumatic temperature has become identical to room temperature and contains 2700 x btu's of heat. Now it is suddenly emptied down to an internal pressure of one atmosphere and the internal air contains only 270 x btu's of heat. Naturally the internal air temperature will be significantly lower.

Referring back to the results of the tenth and final of the inertial-pneumatic compression analysis effects in Chapter Three, note that the 2000 psig pressure at Pneumatic Mass inner surface had been increased to 7295 psig pressure at the Mass outer surface, for an increase of 5295 psig, over all or maximum. However, the average pressure has become: $\frac{7295 + 2000}{2}$ or 4648 to the nearest psig. Thus, the average increase in pressure has been from an initial pressure of 2000 psig to a final pressure of 4648 psig for an increase of 2648 psig.

Now, if the established rule of thumb, regarding pressure change versus temperature change, is applied, the average change in temperature will become: $\frac{2648}{29}$ or 91°F. Since the initial temperature was specified at 52°F., the final average temperature will become 91 + 52 or 143°F. Referring to the graph in Figure 17 on page 102, note that the average change , in standard air density per degree F. change in standard air temperature,is .000000084 pound per cubic inch. Standard air density at 52°F. is .0000449 pound per cubic inch. Then standard air density at 143°F. will become (.0000449) - (91 x .000000084) or (.0000449 - .0000076) or .0000373 pound per cubic inch. Then the average density of the Pneumatic Mass, (if it was free to expand in the same manner that standard air freely expands and contracts), would become:

$\frac{4648 + 14.7}{14.7}$ x .0000373 or .0118312 pound per cubic inch.

Then the earth gravity weight W of the Pneumatic Mass would become: 146.868 x .0118312 or 1.738 pounds. Then the tenth effect value of Pi would become: $\frac{5295 \times 1.738}{2.084}$ or 4416 psig. The per cent decrease would become: $\frac{(5295 - 4416)}{5295}$ or .1660 or 16.60%

However , the very important fact is that the Pneumatic Mass within the Rotor Assembly is not free to expand or contract in the manner that the natural atmosphere's standard air enjoys. It is securely enclosed on all sides and this prohibits such free expansion. It is enclosed at its exterior surface by the inner surface of the Restraining Agent. It is enclosed at its end surfaces by the two End Closures. It is enclosed at its inner surface by approximately 230,169 G's of inertially-powered artificial gravity.

When a compressible fluid or gas, such as air, is totally contained within specific dimensional boundaries, and heat is added to it, the air would tend , naturally , to expand and reduce its pneumatic density. However, the total enclosure prohibits such expansion and therefor , the pneumatic density remains constant while the pneumatic pressure must increase, the reason being that pneumatic pressure is the measure of pneumatic molecular motion. When heat is added , molecular motion increases and the more rapid bombardment of molecules against container walls and one another increases expenditure of molecular kinetic energy which is evidenced by an increase in pneumatic pressure. When heat is subtracted , the reverse is true. Molecular motion decreases, molecular impacts decrease and the net result is a decrease in the rate of kinetic energy expenditure which is evidenced by a decrease in pneumatic pressure.

The inevitable conclusion must be drawn from this is that the increase in temperature, induced by inertial-pneumatic compression packing in additional btu's of heat, along with additonal pneumatic particles , into the constant inner containment space of the Rotor Assembly, will not decrease the value of pressure increase Pi but very probably will increase its value with pneumatic density remaining essentially constant. However, this work elects to assume a conservative posture and neglect the effects of temperature change versus pressure change on Pi value.

However, the question might arise that the temperature rise from inertial-pneumatic compression may eventually raise the temperature, of the Rotor Assembly environmental air, above the specified 52°F. The appropriate answer to that is, very unlikely because Thruster entrance pressure is immediately and continuously expanded back to environmental air pressure in the course of normal Thruster function. So whatever the Thruster entrance air temperature is, it is very likely to decrease back to environmental air temperature at Thruster exits. Also , it appears very likely that prototype system finalizing designers will provide accurate environmental air temperature control with a heat exchanger system incorporated into the particle replacement recycle transfer lines. Their primary objective in doing so will be to remove heat generated by the electric power Generator Assemblies and mechanical friction through out the system since the entire system is housed within the Environmental Control Vessel along with the Rotor Assembly environmental air.

In the opinion of this work, it was appropriate to clear the air of this important question regarding temperature change versus pressure change in the inertial-pneumatic compression function before initiating the fundamental business of Chapter Four, the conversion of pneumatic pressure to rotational power. Having thus done so, that fundamental subject matter can be approached in full confidence that a maximum operational value of <u>Pi</u> , which is both Pneumatic Mass pressure increase and operational pressure differential across Thrusters, is available to the analysis , the exploration and definition of this vital Thruster function in the Inertial-Pneumatic Electric Power System, which is at, or very close to, <u>5000</u> psig when <u>N</u> is specified at <u>120,000</u> RPM and Rotor Assembly environmental air pressure is specified at <u>2000</u> psig and at an operational controlled temperature of 52°F.

However, pneumatic pressure increase and pressure differential Pi remains nothing more than potential energy unless a method is provided to implement the second energy conversion, pneumatic pressure to rotational power. Ideally suited for this purpose is the rocket, which converts gaseous pressure to mass accelerating thrust in the desired direction. Many forms of the rocket principle are very familiar to most people, most of them operating on gaseous pressure developed by combustion of one kind or another. The Fourth of July pinwheel, the sky rocket, and other elements of the holiday fireworks, vividly demonstrate the rocket principle in action, energized by gaseous pressure developed by combustion, as dry chemical powders or granulated materials are ignited. The mighty thrust of the jet engines that lifts the huge passenger airliner

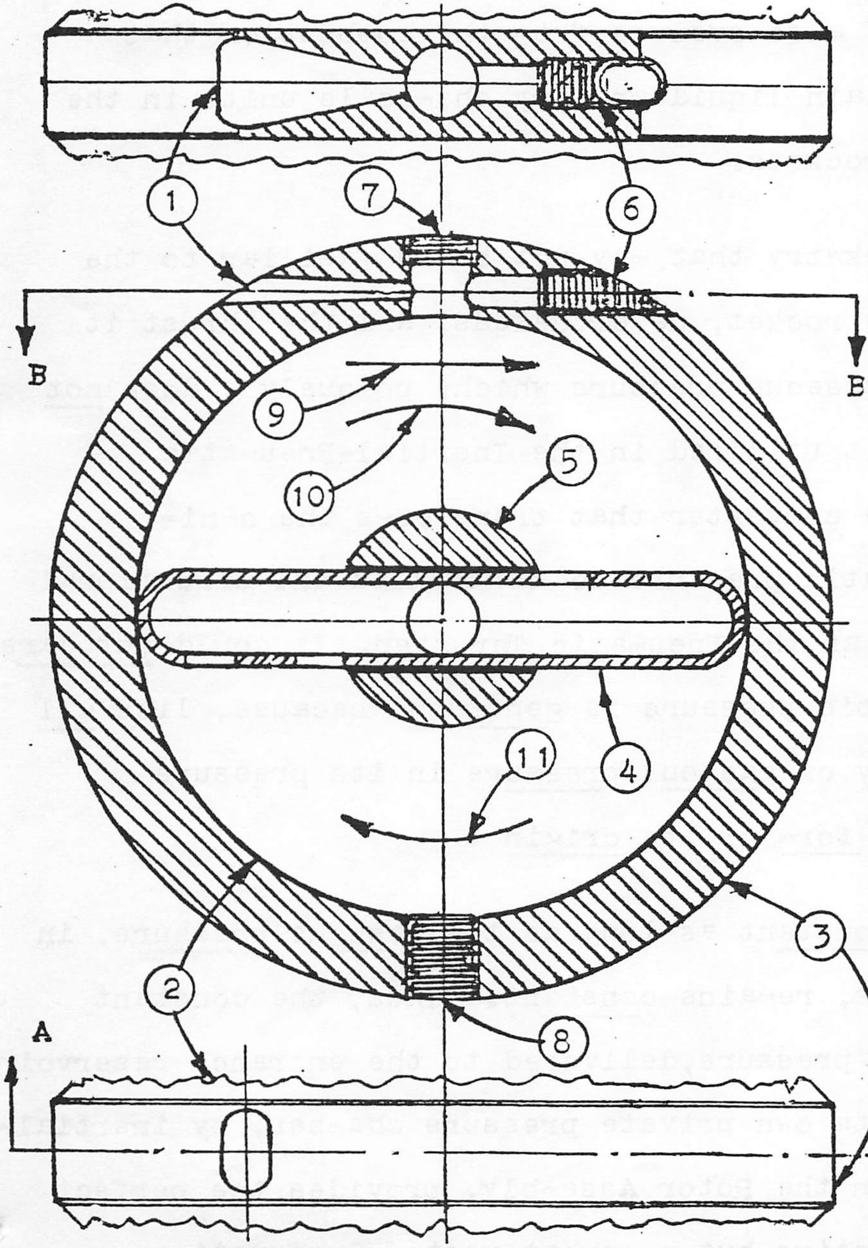


Figure 18

off the runway and into its cruise elevation is derived from gaseous pressure evolving from combustion , as elements of the engines efficiently combine jet fuel with compressed atmospheric air and ignite it continuously.

Perhaps the most familiar form of modern rocketry, however, are the mighty launch rockets that place the Shuttle Craft into orbit about the earth. The gaseous pressure that generates the millions of pounds of thrust required for lift-off also evolves from the combustion that occurs automatically as certain liquid and dry chemicals unite in the combustion chambers of the rockets.

There is another form of rocketry that may not be as familiar to the reader but it is a bona fide rocket, nevertheless, and the thrust it develops is energized by a gaseous pressure which, uniquely , does not evolve from combustion. It is utilized in the Inertial-Pneumatic Electric Power System as the converter that transforms the omni-directional energy of pneumatic pressure to controlled uni-directional thrust and it is identified as the Pneumatic Thruster. It could not care less how the gaseous pneumatic pressure is generated because, like all rockets, it functions solely on gaseous pressure in its pressure chamber , regardless of its form or its origin .

The thrust it develops is constant as long as the gaseous pressure, in this case pneumatic pressure, remains constant. Thus, the constant supply of gaseous pneumatic pressure,delivered to the entrance reservoir of the Thruster, which is its own private pressure chamber, by inertial-pneumatic compression within the Rotor Assembly, provides the perfect energizer for its very effective,but somewhat wasteful, function.

Like all rockets also, the Pneumatic Thruster delivers its thrust unaffected by the motion of the platform on which it is mounted, nor is it affected by the velocity of that motion. It continues to deliver its constant thrust whether its platform is stationary or moving at several thousands of feet per second , provided its energizing gaseous pressure is constant.

This is typical of rockets and explains their amazing effectiveness in the control of space vehicles where the achievement of high velocity motion in such vehicles is mandatory. Thus, the rocket propensity of the Pneumatic Thruster , such as that illustrated in Figure 18 on page 117 as item 1 , ideally qualifies it for the delivery of tangentially directed thrust , in support of rotation, against its mounting platform, the Rotor Assembly, whose productive efficiency and capacity varies as the square of its rotational velocity. It is assured a constant supply of gaseous pneumatic pressure by the constant availabilty of such pressure at its entrance, see above item 9 and below item 7 in Figure 18, provided by free inertial-pneumatic compression within the Rotor Assembly.

Figure 18 , by the way, illustrates a cross-sectional and partial exterior view , taken through the centerline of one of the two Thrusters of the Rotor Assembly of the proposed prototype system. It is approximately full scale ,and the top view is a section taken through the centerline of the Thruster as at B-B . The center view is a section through the centerline of the Thruster and the entire Rotor assembly as at **A-A**. The lower view is a partial exterior view looking down on the Rotor Assembly in an area centered on item 1 , the Thruster. The items in Figure 18 are identified as follows:

Item 1 is the Thruster, one of two in the prototype Rotor Assembly, Item 2 is the interior surface of the Restraining Agent, an essential part of inertial-pneumatic compression. Item 3 is the mounting ring for items 1 , 6 , 7 and 8 and the exterior surface of the Restraining Agent in this area of the Rotor Assembly. Item 4 is the Impellor, the part that assures that the Pneumatic Mass within the Rotor Assembly rotates in precise unison with all parts of the Rotor Assembly. The balloon arrow points to one of the two solid leading surfaces that perform this function. The interior of item 4 is also a pneumatic conduit for incoming replacement pneumatic particles and this function will be addressed comprehensively in Chapter Five of this work. Item 5 is the Shaft which is hollow and performs the dual function of axial suspender of the Rotor Assembly and pneumatic conduit for incoming replacement pneumatic particles. Item 6 is a threaded plug which is strictly for the convenience of Thruster fabrication. Its left end surface provides part of the total surfaces against which the Thruster exerts its product thrust. Item 7 is also a threaded plug which is strictly for the convenience of Thruster fabrication. Its bottom end surface forms the bottom surface of the Thruster entrance reservoir. Item 8 is a threaded plug which also serves as housing for an electronic pressure sensor and transmitter. This item,and its function, will be addressed comprehensively in Chapter Seven of this work. Item 9 is a construction arrow indicating that the propelling thrust product of the Thruster is delivered and applied tangentially in the direction of Rotor Assembly rotation in the rotational plane of the Thruster centerline. Items 10 and 11 are also construction arrows indicating the direction of Rotor Assembly rotation. The focus of this Chapter Four is, of course, on Item 1 , the Thruster but this legend of tabulated items provides the reader with some orientation to adjacent parts that serve as mounting platform and moving vehicle for the proposed prototype system's pneumatic rocket , the Thruster.

The Thruster and free Inertial-Pneumatic Compression combine their functions in beautiful,and fully effective , mutual assistance. Inertial-pneumatic compression provides constant gaseous pressure to the Thruster and the Thruster provides constant control of Pneumatic Mass and Rotor Assembly rotational velocity and, more importantly, constant control of the critical time period (t) , without contributing one inch-ounce of its thrust energy directly to the pneumatic compression process that provides its vital supply of gaseous pressure.

Of necessity , the Thruster must borrow a significant constant stream of pneumatic particles from among the millions of particles comprising the Pneumatic Mass within the Rotor Assembly to effectively perform its designed function. Each particle borrowed from Mass outside surface must be immediately replaced at Mass inside surface so that the value of W in the compression equation remains constant. System design effectively provides for such particle replacement but at significant cost to Thruster rotor-propelling energy and power. This essential borrowing by the Thrusters from the Pneumatic Mass within the Rotor Assembly has its exacted cost in inertial-pneumatic compression efficiency as well but fully effective system design confines this to less than 5% loss.

Figure 19 on page 122 illustrates that the positioning of the Thruster, as shown by item 1 in Figure 18, so that its thrust is delivered tangentially and the rotational plane of its centerline is parallel to the rotational plane of the Rotor Assembly and the direction of its rotation through that plane is the same as that of the Rotor

Assembly, was the thoroughly considered selection of the finalizing designers. They realized that, if the Rotor Assembly and the Pneumatic Mass that it houses and governs were rotated by any given means at a sufficiently high rate, a significantly high level of inertial-pneumatic compression would develop which would in turn produce a significantly high level of thrust by the Thrusters. That thrust would be constant as long as the energizing pneumatic pressure was constant regardless of the direction in which the thrust was delivered. Referring again to Figure 19 below, item 1 indicates the direction of Rotor Assembly rotation, which is away from the viewer looking down on the Assembly, or clockwise looking at the right end of the Rotor Assembly, and it rotates about the axial centerline 6 .

If the Thruster was positioned so as to deliver its thrust as indicated

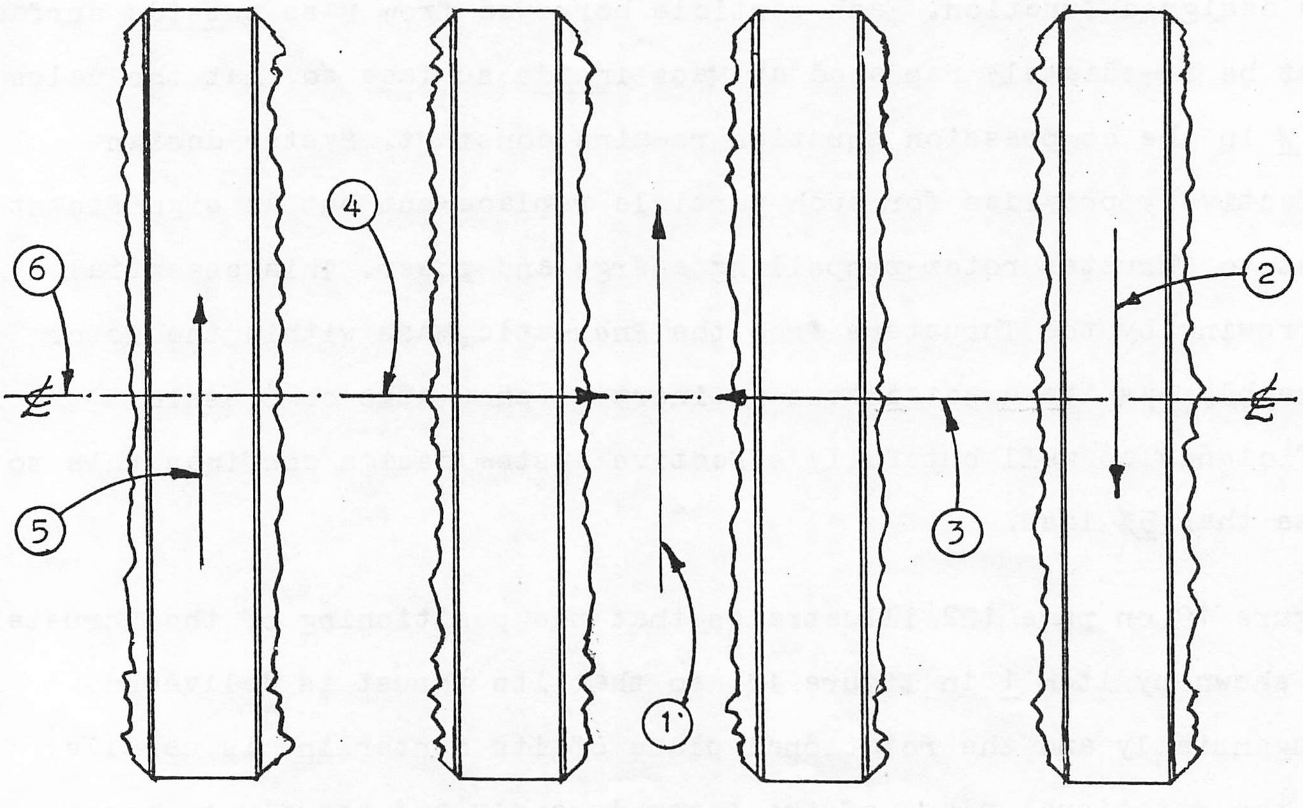


Figure 19

by the directional arrow 2 , in Figure 19, thrust would be delivered tangentially and in a rotational plane parallel to that of the Rotor Assembly but in precisely 180° opposition to Rotor rotation and therefor would oppose it with 100% of its thrust.

If the Thruster was positioned so as to deliver its thrust as indicated by the directional arrow 3 , in Figure 19, it would do so at 90° to the Rotor plane of rotation and would neither assist or oppose the Rotor's rotation but rather would deliver 100% of its thrust axially toward the left end of the Rotor Assembly and add that much thrust load to its suspension bearings.

If the Thruster was positioned so as to deliver its thrust as indicated by directional arrow 4 ,of Figure 19, it would do so at 90° to the Rotor plane of rotation and would neither assist nor oppose Rotor rotation but rather would deliver 100% of its thrust axially toward the right end of the Rotor Assembly and add that much thrust load to its suspension bearings.

However, if the Thruster was positioned so as to deliver its thrust as indicated by directional arrow 5 , Figure 19, it would be in the one and only position, identical to the position of item 1 in Figure 18, in which it can deliver 100% of its thrust in support of Rotor Assembly rotation.

Figure 20 on page 124 illustrates the true cross-sectional configuration of the Pneumatic Mass within the Rotor Assembly compared to what a simplified solid section with neat and clean inside and outside diameters of the Mass,as shown in Figure 16 on page 98, would be. This simplification liberty with Mass configuration was taken for the convenience of system functions analyses with no loss of accuracy.

Careful examination of Figure 20 will reassure the reader that the air displaced by the intrusion of the Impellor, as indicated by balloons 3 , 4 , 5 and 6 , is less in volume than that of the air inside the Impellor and inside the inner surface of the Mass at its inside diameter. There is a much smaller volume of air outside the outer surface of the Mass constantly retained by the two Thrusters, as indicated by balloons 7 , 8 , and 9 . Consequently, the net result and bottom line is that when the simplified Mass configuration of Figure 16 is utilized as the base for Mass volume and weight in functions analyses, solution results are probably slightly conservative.

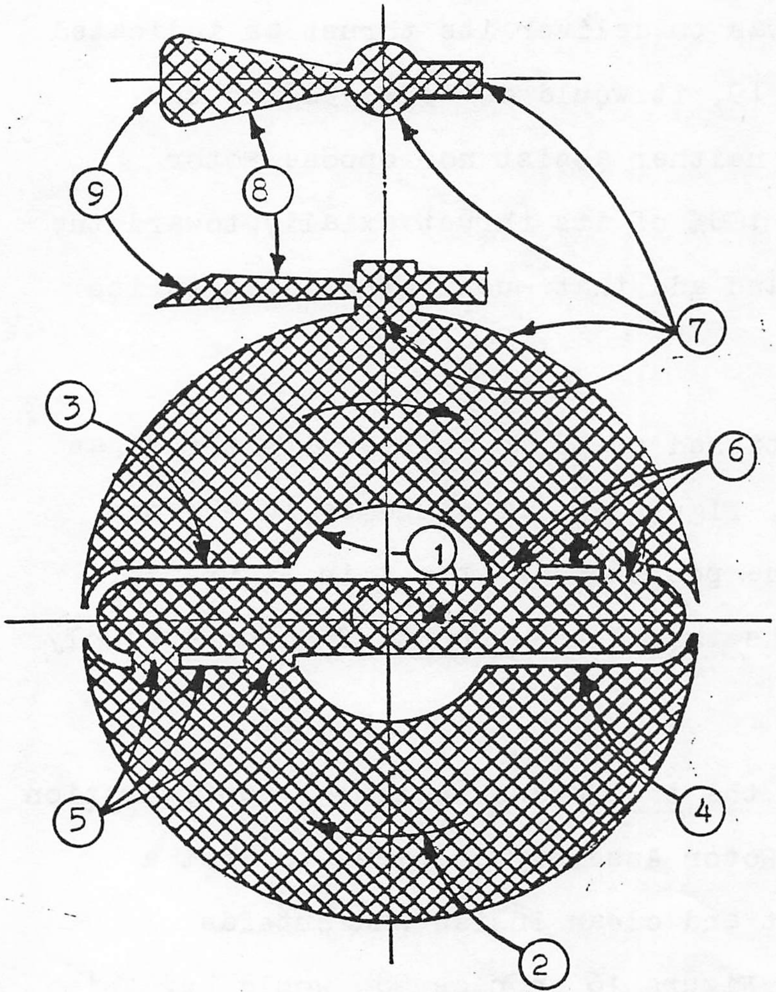


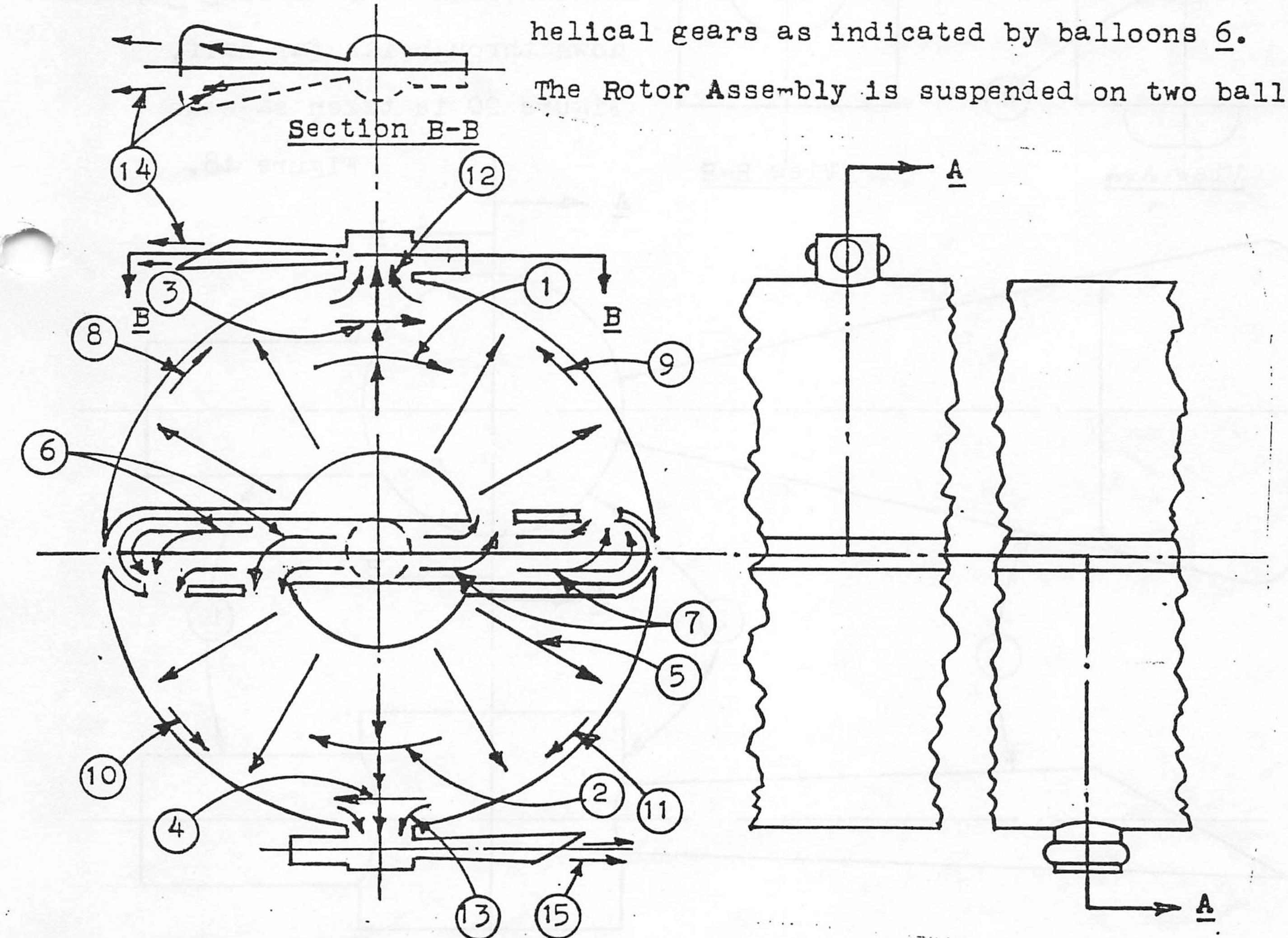
Figure 20

However, this Chapter Four of this work is focusing on the energy conversion function of the two Thrusters of the proposed prototype system and for this reason the true configuration of Figure 20 is the better reference.

Pneumatic pressure at the Shaft bores and the inner surface of the Pneumatic Mass, as indicated by balloon 1, is always identical with that of the Rotor Assembly environmental pressure.

Before proceeding further with this explanation , perhaps it would be well to aquaint the reader with the exterior configuration of the Rotor Assembly for the proposed prototype system as illustrated by Figure 25 on page 129.

One of the two Thrusters is fabricated into the far side of its mounting ring as indicated by balloon 1. The other Thruster is fabricated into its mounting ring on the near side, as indicated by balloon 2. These two mounting rings are integral parts of the Restraining Agent, indicated by balloon 3. The Pneumatic Mass is retained at its end surfaces by the two End Closures, indicated by balloons 7. The Rotor Assembly transfers its Generator drive power through two opposite hand helical gears as indicated by balloons 6. The Rotor Assembly is suspended on two ball bearings, as indicated by balloons 5. The hollow Shaft, indicated by balloons 4, performs the

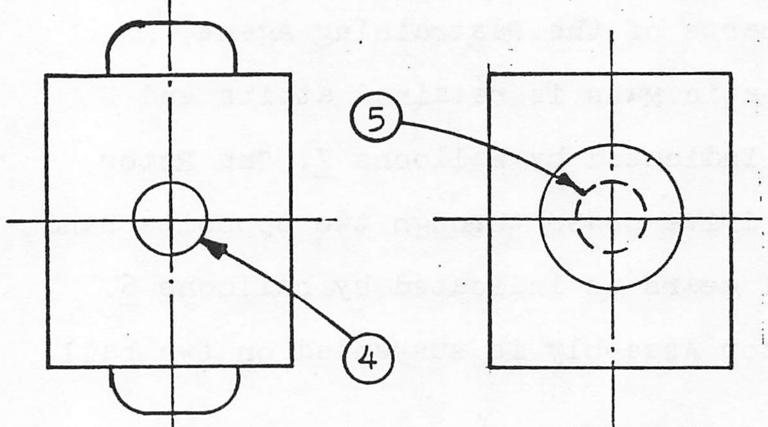


Section A-A

Figure 21

dual functions of axial center and suspender of the Rotor Assembly and pneumatic conduit for incoming replacement particles for the Pneumatic Mass within the Rotor Assembly.

Figure 18 is based on a section through the near ring 2 looking toward the upper end of Figure 25. Figure 19 could be an exterior side or top view of either ring 1 or ring 2. Section A-A of Figure 21 is taken down through ring 2 to the center, thence up to ring 1, then down through its far half. Figure 20 is taken same as Figure 18.



View A-A View B-B

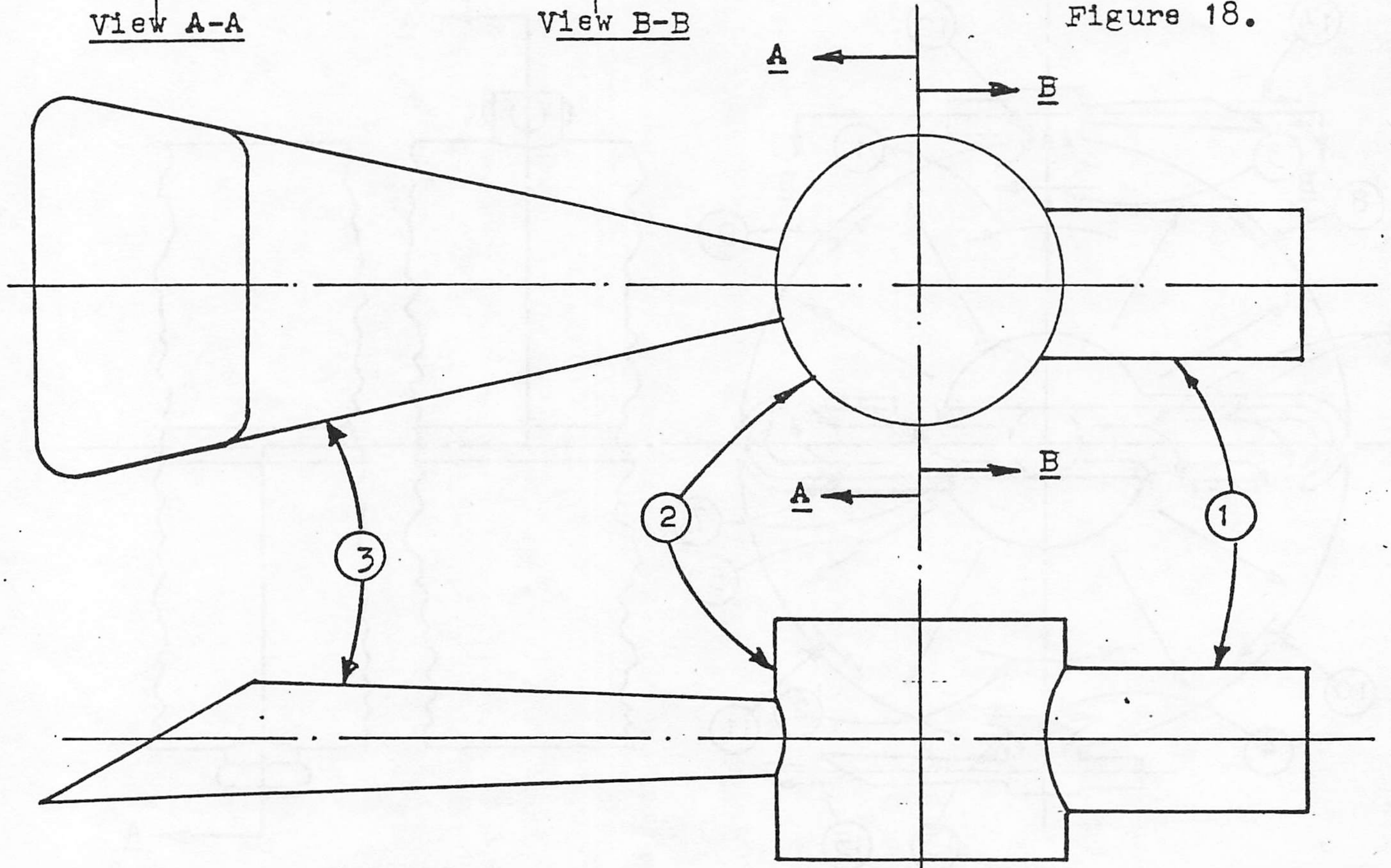


Figure 22

Referring again to Figure 20, the direction of rotation is clockwise, as indicated by balloon 2. The solid lead surfaces of the Impellor perform their functions, of assuring that the Pneumatic Mass and all parts of the Rotor Assembly rotate in precise unison, against the two Mass surfaces indicated by balloons 3 and 4. The trailing walls of the Impellor perform their functions, as replacement particles conduit, by permitting particles to filter through numerous holes through those walls into the Mass main body, as indicated by balloons 5 and 6. The pneumatic pressure at the Mass outside surface, entrance reservoir, Thruster entrance and Thruster primary thrust surface and thrust pressure stabilizing chamber, indicated by balloon 7, is always Rotor Assembly environmental pressure plus pressure increase Pi, produced by inertial-pneumatic compression. The average pressure at the Thruster funnel internal surfaces, as indicated by balloon 8, is always funnel entrance pressure plus Rotor environmental pressure divided by two. The pressure at the exit area of the Thruster discharge funnel, indicated by

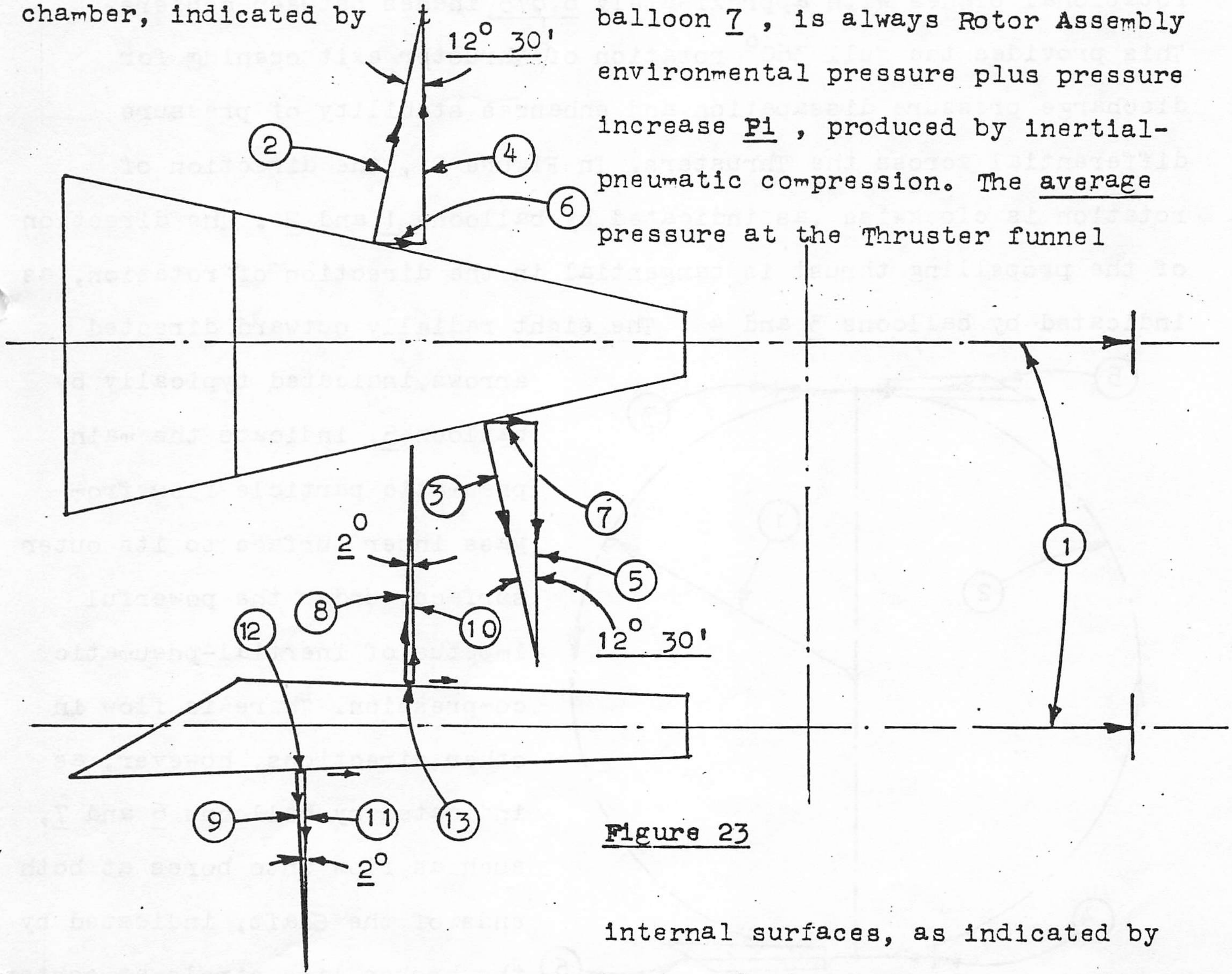


Figure 23

balloon 9 , is always identical with the Rotor Assembly environmental pressure.

Figure 21 on page 125 illustrates the general pattern of the flow of replacement pneumatic particles into and through the Pneumatic Mass and into and through the two Thrusters of the proposed prototype system's Rotor Assembly. To enhance Thruster discharge pressure expansion and dissipation, the two Thrusters are placed in two seperate and parallel rotational planes with approximately 6.875 inches between centers. This provides the full 360° rotation of Thruster exit opening for discharge pressure dissapation and enhances stability of pressure differential across the Thrusters. In Figure 21, the direction of rotation is clockwise ,as indicated by balloons 1 and 2 . The direction of the propelling thrust is tangential in the direction of rotation, as indicated by balloons 3 and 4 . The eight radially outward directed arrows,indicated typically by balloon 5, indicate the main pneumatic particle flow from Mass inner surface to its outer surface, under the powerful impetus of inertial-pneumatic compression. There is flow in other directions, however, as indicated by balloons 6 and 7, such as flow into bores at both ends of the Shaft, indicated by the broken line circle at center into and through the interior of the Impellor and Pneumatic Transfer Conduit, through the holes in the

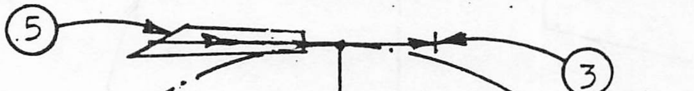


Figure 24

trailing walls and into the main body of the Pneumatic Mass. There is flow also at or near the Mass outer surface, as indicated by balloons 8, 9 ,10 and 11 , toward Thruster reservoirs. There is flow also into the Thruster reservoirs, indicated by balloons 12 and 13 , from the main body of the Pneumatic Mass. Then , of course, there is the flow through the Thruster funnel entrance , into and through the funnel, as indicated by balloon 14 , as the air expands and discharges into the lower pressure of the Rotor Assembly environmental air. This, of course , is where pneumatic flow through the fluid transfer system is initiated, as the Thrusters borrow particles from the Pneumatic Mass essential to their natural function.

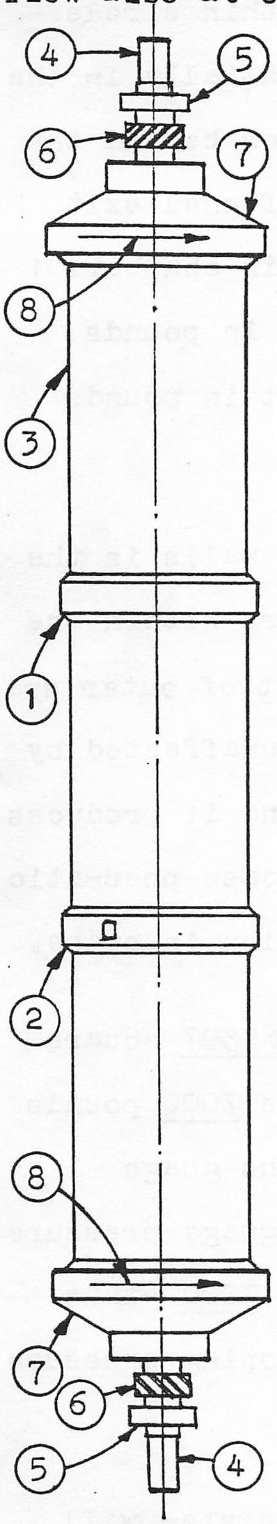


Figure 25

A much enlarged illustration of the interior configuration of each of the two Thrusters in the proposed Rotor Assembly , shown in exterior view by Figure 25, is illustrated by Figure 22 on page 126. The primary and central direct thrust surface and thrust pressure stabilizer, is indicated by balloon 1 . This chamber is a tangential extension of the reservoir , indicated by balloon 2 , for gaseous pressure. The extreme right wall is the plane of primary thrust and the view B-B looks directly into the chamber. The broken circle , indicated by balloon 5 , outlines the area of effective primary thrust development. The gaseous pressure on this side of the reservoir has a solid wall within the broken line circle to thrust tangentially in the direction of rotation.

Directly opposite , on the other side of reservoir 2 , is the open funnel entrance, indicated by balloon 4 in view **A-A** . Within circle 4 there is no wall for the gaseous pressure to thrust tangentially in the direction opposite rotation. The only obstacle to expansion beyond the funnel entrance 4 is the Rotor environmental pressure at funnel exit which is at a much lower level than the gaseous pressure in chambers 1 and 2. The areas of 4 and 5 are identical and the thrust in pounds developed at 5 is equal to the gaseous pressure against it in pounds per square inch times that area in square inches.

This unbalanced pressure against the pressure containment walls is the fundamental principle of all rocketry. This function occurs within the inner walls of all rockets totally independent of the rest of outer space or the bodies of matter in it. That is why it is totally unaffected by any motion that may develop from the thrust it produces and it produces constant thrust as long as the gaseous pressure, in this case pneumatic pressure, is constant , regardless of its motion or position in space.

Area 5 in the proposed prototype system Thrusters, is .0069397 square inch. If the gaseous guage pressure in chambers 1 and 2 is 7000 pounds per square inch , psig, and the Rotor environmental gaseous guage pressure is 2000 psig , then the differential in gaseous guage pressure, or pressure differential across each Thruster, is equal to 7000 minus 2000 or 5000 psig. This is the net effective thrust developing pressure against area 5 of Figure 22.

Then each of the two Thrusters of the proposed prototype system will deliver a primary constant and tangentially directed thrust in the direction of rotation equal to 5000 times .0069397 or 34.699 pounds. The two Thrusters combined will deliver a primary thrust of 69.397 lbs.

The reason for chamber 1 in Figure 22 is to remove area 5 as far as feasible from funnel entrance 4 to assure that pneumatic flow into entrance 4 will not reduce the gaseous pressure against thrust area 5.

The reasons for the configuration of discharge funnel 3 are twofold. First, to assure the complete expansion of the gaseous pressure in 1 and 2 to Rotor environmental gaseous pressure as the flow of pneumatic particles passes from funnel entrance 4 to its exit and thereby stabilizing the pressure differential across Thrusters with full dissipation of it within the discharge funnel. Second, to provide supplementary thrust surfaces capable of effectively utilizing components of the expanding internal gaseous pressure against them.

These component pressure forces, tangentially in the direction of rotation, are supplemental to the primary pressure force against area 5 in chamber 1 and together they comprise the total thrust generated in each Thruster. This is made possible by the funnel configuration. The component forces have the sloping walls of the funnel to push against tangentially in the direction of rotation but there is no wall at funnel exit for them to push against tangentially opposite the direction of rotation.

Figure 23 on page 127 illustrates how these component forces develop. It should be noted, in passing, that the bell shaped funnels of Shuttle Craft launch rockets serve much the same purpose as the funnel of Figure 23. The arrow 1 in Figure 23 represents the primary thrust force against area 5 of Figure 22. Because of having to adapt funnel design to the boundaries of the Rotor Assembly configuration, funnel configuration is neither that of a truncated cone or a truncated pyramid but a combination of both with its round hole entrance, which is a concession to facilitation of fabrication, and its flat sides joining at square corners except for slight rounding on short radius.

However, to facilitate definition and analyses with no significant effect on accuracy, Figure 23 considers that the inner surfaces of the discharge funnel form a truncated pyramid with the right small entrance end truncated perpendicular to the centerline forming a .0069397 square inch square opening. The upper and lower sides of the pyramid expand equally outward at 2° on either side of the centerline. The near and far sides of the pyramid expand equally outward at 12° 30' from the centerline. At a centerline length of .8125 inch from entrance to exit, the large exit end of the pyramid is truncated at 30° to the centerline. This is a concession to funnel interface to the round exterior circumference, on a 4.500 inches diameter, of the ring segment of the Restraining Agent that mounts each of the two Thrusters. See balloons 1 and 2 in Figure 25 on page 129.

Thus, the total pressure force against top and bottom inner surfaces of the funnel is applied at 2° to the Thruster centerline and the total pressure force against the sides of the funnel is applied at 12° 30' to the centerline. In each case the total pressure force can be resolved into two component forces. The first of these is a funnel bursting force applied away from and at 90° to the Thruster centerline which would be equal to the total pressure force times the cosine of 2° for the top and bottom and equal to the total pressure force times the cosine of 12° 30' for the two sides. This component would be of interest only for the design of funnel wall strength.

The second component force is a thrust producing force applied tangentially in the direction of rotation and it is equal to the total pressure force times the sine of 2° for the top and bottom areas. Thus, in the force resolution triangles of Figure 23 on page 127 , sides 2 and 3 represent the total pressure forces against the two side areas while sides 6 and 7 represent the tangential thrust force components for the two sides and sides 4 and 5 represent the funnel bursting force components for the two sides.

Sides 8 and 9 represent the total pressure forces against the top and bottom areas , sides 10 and 11 represent the funnel bursting force components for the top and bottom areas and sides 12 and 13 represent the tangential thrust force components for the top and bottom areas of the funnel.

The projected areas of the funnel top and bottom inner surfaces are considered to be true trapzoids and their respective areas are computed on that basis while the projected areas of the two sides are considered to be true trapziums and their identical areas are computed on that basis. The projected area of the funnel top proved to be .172 square inch. The projected area of the funnel bottom proved to be .291 square inch and the identical areas of each of the two sides proved to be .094 square inch.

Appropriate consideration of Thruster discharge funnel configuration and function correctly concludes that if funnel entrance pressure proves to be 7000 psig and funnel exit pressure is specified at 2000 psig , then the average funnel internal pressure is equal to 7000 plus 2000 divided by two or 4500 psig. The average pressure differential across the Thruster discharge funnel then becomes equal to 4500 minus 2000 or 2500 psig.

Thus, referring again to the force resolution triangles of Figure 23 on page 127, side 2 becomes 2500 times .094 or 235 pounds total pressure force against each of the two sides since side 3 is identical. Side 8 becomes 2500 times .172 or 430 pounds total pressure force against the top inner surface. Side 9 becomes 2500 times .291 or 728 pounds total pressure force against the bottom inner surface.

Then side 6 becomes 235 times the sine of 12° 30' or .21644 for a tangential thrust force of 51 pounds , to the nearest pound, for each of the two sides since side 7 is identical. Side 12 becomes 728 times the sine of 2° or .0349 for a tangential thrust force for the bottom inner surface of 25 pounds, to the nearest pound. Side 13 becomes 430 times the sine of 2° or .0349 for a tangential thrust force of 15 pounds, to the nearest pound.

Then the total of all the tangential thrust forces applied to funnel inner surfaces becomes 51 plus 51 plus 25 plus 15 or 142 pounds of thrust in support of and in the direction of rotation for each of the two Thrusters of the proposed Rotor Assembly as illustrated in Figure 25 on page 129. The total for both Thrusters becomes 284 pounds. The two Thrusters combined will deliver 69 pounds of primary thrust in addition to this funnel secondary thrust, as noted on page 130. Therefor the grand total thrust force delivered by both Thrusters becomes 284 plus 69 or 353 pounds, tangentially in the direction of rotation at a rotational velocity of 1799 feet per second, when the operational value of N is 120,000 RPM, the operational value of Pi is 5000 psig and the Rotor Assembly environmental pressure is 2000 psig.

This translates into an energy conversion of an unlimited supply of pneumatic pressure power at 5000 psig to 1155 horsepower or 861 kilowatts of rotational Rotor propelling power delivered on a 1.718 inch radius by the two Thrusters of the proposed Rotor Assembly of Figure 25 on page 129 as their maximum productive capacity under these specified conditions. Stated in the authenic equation applied in subsequent analyses in other Chapters of this work:

$$Pt = \frac{T \times Vt \times .746}{550} \quad \text{in which:}$$

Pt = the thrust power produced by the two Thrusters in kilowatts.

T = the total thrust in pounds delivered by the two Thrusters.

Vt = the tangential velocity of the Thruster centerlines in feet per second.

550 = a constant expressing the number of foot-pounds per second in one horsepower.

.746 = a constant applied to convert horsepower to kilowatts

In Figure 25 on page 129 balloons 1 and 2 indicate that the two Thrusters deliver their Pt in two seperate rotational planes but axially they are located 180° from one another on opposite sides of the axial centerline as illustrated by Figure 24 on page 128. The radius of their centerlines rotation 1 is 1.718 inches and the circumference 2 is 10.795 inches. Their primary thrusts are delivered tangentially as at 3 and 4 and their secondary as at 5 and 6, when the rotation is clockwise as indicated by the arrows on circumference 2.

While the reader may be truly impressed with this 1155 horsepower or 861 kilowatt probable maximum value of Pt for the Rotor Assembly of Figure 25 on page 129, a reminder is in order at this point that the Thrusters borrow heavily in pneumatic particles from the Pneumatic Mass for this massive production and their replacement is costly in Pt. Chapter Five addresses this cost and others versus pneumatic flow.