Design and Development of an Odorless Toilet

by

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Thesis submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Master of Science

in

Mechanical Engineering

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October 30, 1988

Blacksburg, Virginia

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(ABSTRACT)

The design and development of a novel system for removing odorous gases from toilets is presented. A review of the numerous existing patents for mechanical systems designed to deodorize commodes, none of which is fully satisfactory, shows that they all employ suction using one of two basic configurations: single point suction or perimetral suction, to remove the obnoxious fumes. The present design uses the single suction approach with two new features added: the use of an activated charcoal filter to deodorize the gases removed from the toilet, and the recirculation of part of the deodorized gases into the bowl to augment the suction and thereby expedite the cleansing of the air within the toilet. Since all essential functions are performed either within the seat or completely external to the toilet proper, the unit can be easily retrofitted to any commode by replacing the existing seat.

Acknowledgements

I would like to thank M.R. Young whose idea this project was and whose generous funding led to the development of the current system. I would also like to thank Dr. A. G. Szeless for the constant attention and wealth of ideas he gave to this project. His insight and expertise were instrumental. Thanks also go to Dr. F. J. Pierce and Dr. H. L. Moses for the assistance they lent as members of my committee. In addition I would like to thank the members of the Mechanical Engineering shop whose help was essential in the design of the prototype. And finally I thank my parents for their love and support.

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Chapter 1 Introduction

Gases with unpleasant odors emanating from toilets have long been meekly tolerated by occupants of bathrooms. Such devices as air fresheners, ceiling fans, and odorless commodes developed in the past have sought to eliminate these fumes. Due to the impracticality, expense, or ineffectiveness of earlier systems, there is currently no system accessible to the consumer which effectively deodorizes the bathroom. The focus of this research was to develop an odorless toilet capable of removing such odors before they contaminate the ambient air in the bathroom.

Not only would the unit have to be functional, in order to satisfy the project's sponsor, it would also have to be patentable and easy to retrofit to existing commodes. In order to keep the system retrofittable, it was decided to have all of the system's essential functions performed within the seat or completely external to the commode. Drilling into existing plumbing or walls was to be avoided if another alternative of equal merit was available.

Making the system functional involved the tasks of developing methods to:

1. efficiently remove the odorous gases from the commode,
2. effectively deodorize the gases.

Existing odorless toilet designs were studied in order to understand how past designers intended to resolve these two problems. Common to all existing patents, though rarely a part of the patent itself, is a suction mechanism used to remove the odorous gases from the commode. Various options were examined, including water head induced suction such as that found in the only currently marketed odorless commode: the Vent-Away by American Standard. Due mainly to constraints imposed by the fact that our system would have to be retrofittable, it was decided to use a motor and fan assembly to remove the obnoxious fumes from the bowl. Mounted externally, this blower would be connected to the suction inlet in the seat through a series of pipes. A number of locations for the suction inlet in the seat were examined. Since no one location proved to be any more effective than another, the back of the seat was chosen as the inlet of the suction for the system because this location was easily accessible and the connections to the blower were most out of the way. Various improvements to this basic suction configuration were then made to increase the efficiency of the suction. Many ways to deodorize the gases were considered, including venting them to existing sewer pipes or to the outside of the house. Again, the fact that the system would have to be easily retrofittable made the filtration of the gases the most desirable option. Tests were run to determine what type of filter was the best to effectively deodorize the obnoxious fumes. Finally an activated charcoal granule based filter was incorporated into the system.

In most respects this basic configuration is not new; what had previously been overlooked, however, was that introducing additional air into the bowl could direct the flow pattern in such a way that more efficient odor removal would result. Using a purely experimental approach, first ambient air was allowed to enter the bowl at certain strategic locations. The flow pattern in the bowl was examined but no significant improvement in the efficiency of the suction was noted until the air was introduced under pressure. Air under pressure emanating from a number of holes spread around the perimeter of the seat greatly reduced the amount of suction required. This in turn resulted in a smaller, quieter, and less expensive blower. It was then proposed that the exhaust from the suction blower be used as the source of the pressurized air. By placing the filter into the suction line, the gases would be deodorized before they entered the blower. Thus the reintroduced air,

being completely deodorized, could be used to create the most efficient flow pattern for odor removal in the bowl. After a prototype of the unit was installed in a bathroom it confirmed what the experimentation in the laboratory had indicated: the blower and seat combination efficiently remove the obnoxious gases and the charcoal granule based filter effectively neutralizes the odors.

The inclusion of the reintroduced air is the basic difference between this and other odorless toilets. It is believed that this departure from existing designs is sufficient to claim a patent for this system. Thus the system meets the three criteria originally set. The system is:

1. retrofittable to existing commodes,
2. able to efficiently remove and effectively neutralize the odorous gases and,
3. is patentable.

Chapter 2 Review of Literature

The concept of an odorless commode is not new. Numerous patents exist for such systems which operate on a variety of principles. But, as is evidenced by the fact that none of these units has been commercially successful, the previously developed systems are not fully satisfactory. This is because previous systems are impractical, expensive, difficult to use, and/or ineffective at removing the undesirable odors.

All odorless toilet systems which have been patented in the past involve the removal of the obnoxious fumes from the bowl with some sort of a suction device. Though it may be possible to introduce a chemical additive to deodorize the contents of the bowl, insufficient knowledge about the nature of the odor causing constituents, as well as the tedious and possibly hazardous nature of the chemicals involved, limits this approach. Such systems have, however, been applied to deodorize the holding tanks on ships, planes, and portable restrooms with limited success. A suction system for odor removal has various advantages: intuitively it is appealing to the user because the offensive odors are completely removed, they are also easy to care for requiring only occasional cleaning and thereby providing largely maintenance free service.

Though only representative designs are discussed here, a complete list of available patents can be found in Appendix: A. A review of these patents reveals that there are two distinct geometrical

configurations commonly used for the suction: suction taken from just one specific point in the bowl and suction from the entire perimeter of the bowl. As can be seen from Fig. 1, taken from D. L. Cox's invention of 1969 (patent No. 3,585,651), the single suction point configuration is rather simple. The major problem associated with systems which take suction from only one point is that the turbulent eddies which are set up in the bowl as a result of this suction are unmanageable and deleterious. That is, the effectiveness of the odor removal unit is impeded by the existence of certain dead zones in the bowl through which air is not circulated and, as a consequence, from which odor is not removed.

To remedy the problem and eliminate the dead zones, some of the inventors distribute the suction around the entire perimeter of the bowl. This second method is employed, for example, by J. E. Lindley (patent No. 4,556,999) and also by the only presumably odorless commode on the market: the Vent-Away (patent No. 3,188,658 and No. 3,386,459) by American Standard (Fig. 2). In the perimetral suction arrangement a number of openings exist along the perimeter of either the seat or the bowl portion of the commode and the suction is applied to each of the holes. The purpose of this configuration is to create flow patterns such that no pockets of contaminated air will remain in the bowl. This plurality of openings creates some difficulties: most notably the problem of non-uniform suction through each of the peripheral holes. Since the suction originates close to the rear of the bowl (in all of the previous designs found), the suction effect is greatest towards the rear and increasingly smaller towards the front of the bowl. This again creates undesirable turbulences, and it results in an ineffective system.

The suction in the Vent-Away toilet is created by a venturi device located inside the water tank of the commode. Upon activating the suction mechanism, a valve admits water from the tank filling line to the venturi, where it creates a slight vacuum. The vacuum chamber is connected to the commode's porcelain ducting by means of a plastic piping system. The suction created by the vacuum (amounting to 0.16 CFM of air flow) is connected to evenly spaced holes around the perimeter of the inside of the bowl. The obnoxious fumes, entrained into the porcelain ducting by

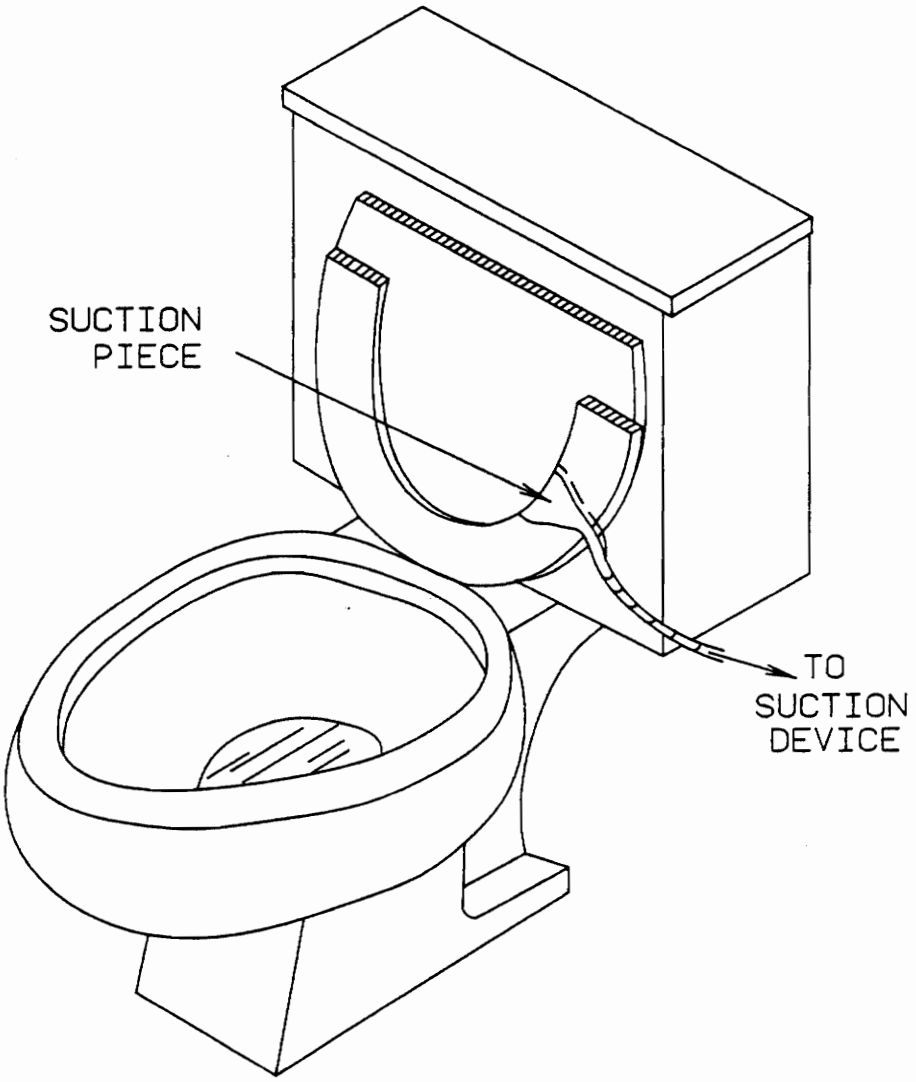


Figure 1. Typical single point suction system

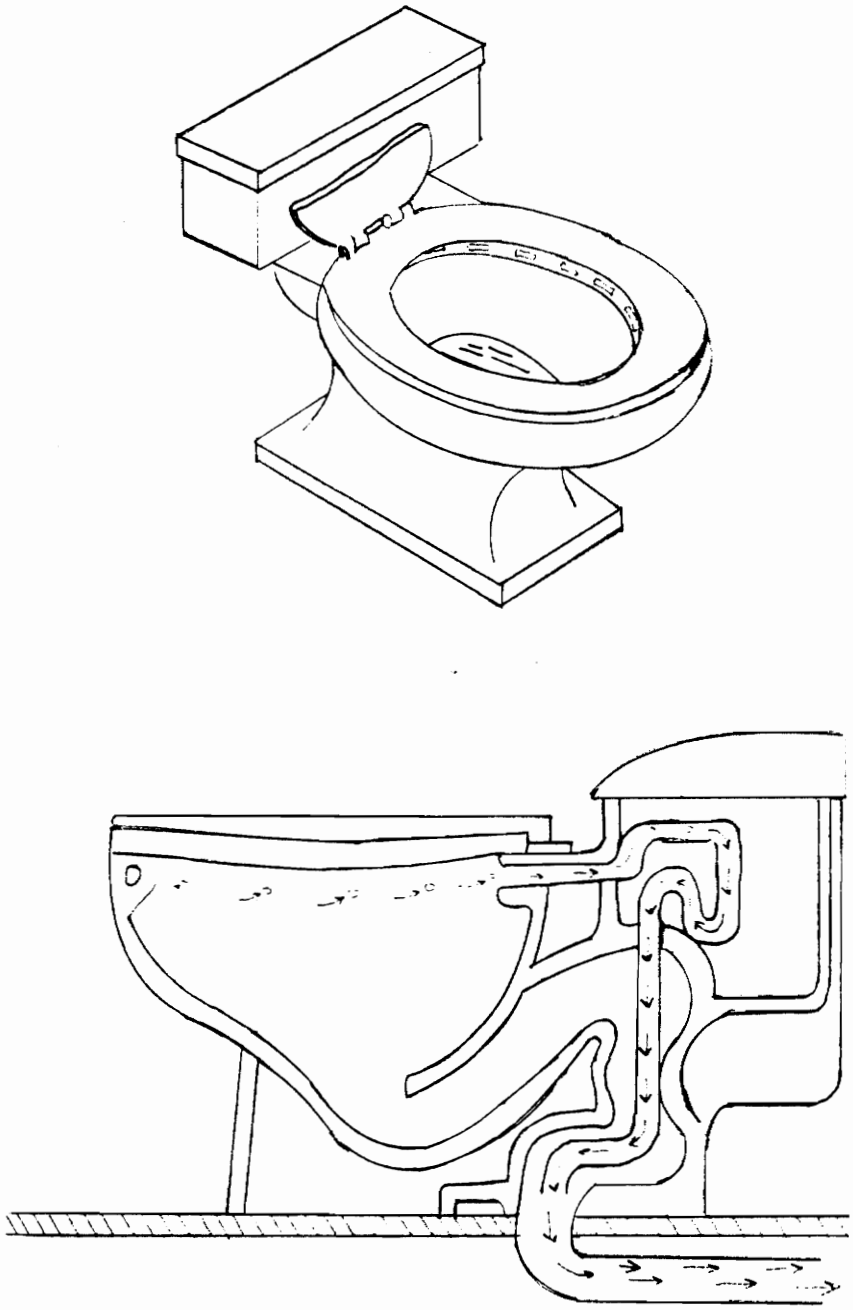


Figure 2. Schematic of Vent-Away's suction system

the venturi, are led through the unit's internal water seal and then forced into the same plumbing through which the toilet's regular contents enter the sewage system.

Once flushing is commenced water is introduced into the bowl of the Vent-Away not only through the large opening in the base of the bowl but also though the numerous peripheral holes used for venting during the deodorizing procedure. Water is continuously added to refill the bowl through these holes until the tank is full again. Because the same holes that are used for suction are now used to refill the bowl, the suction of the contaminated gases is terminated at the start of the flushing.

The venturi induced suction of the Vent-Away introduces some problems. The most significant of these is that the suction is inadequate: during our experimentation on a Vent-Away unit it was found that over two minutes were required to completely evacuate the bowl's contents. This slow pace can be attributed to the lack of sufficient suction from the venturi. It would be possible to increase the suction by increasing the water flow rate through the venturi. At present 0.60 GPM of water is used by the venturi. Recent research at Stevens Institute of Technology in N.J. [1] seeks to reduce the amount of water consumed during flushing to below 3 gal/flush. In light of this research, the amount used by the Vent-Away's venturi is significant. A second problem manifests itself during flushing. The peripheral holes have two functions: during venting they remove the odors, during flushing they introduce water into the bowl in conjunction with the large opening at the base of the bowl. Since water is flowing out of the peripherally distributed holes during flushing, odor removal is terminated with the commencement of flushing and refilling. In addition, any odors that are in the bowl at the time that flushing is initiated are released into the bathroom because the water level rises significantly before the draining process starts through the water trap. Flushing and odor removal cannot occur concurrently.

Due to the perimetral suction systems' inability to adequately remove odors, these suction systems are commercially no more successful than single point suction systems (with the exception of the

Vent-Away which has been commercialized but is by no means successful). This makes the simplicity of the single point suction commode more appealing.

Most of the patents on odor removing systems (single point as well as peripheral) do not identify a specific type of suction mechanism to be used by their system. In fact, many patents do not include the suction mechanism in their system at all; this selection is presumably left to the user or the manufacturer. Often squirrel-cage blowers or axial fans are suggested. The venturi idea found in the Vent-Away seems to be a unique approach.

As to what is to be done with the trapped contaminated air: various options exist. The simplest of these involves exhausting the contaminated air through the wall, ceiling, or floor of the house directly to the outside. This would create an unpleasant odor outside of the house and is certainly not applicable in large apartment houses or other tight quarters. An improvement on this rather crude idea has been suggested by D. L. Cox (patent No. 3,585,651). He suggests expelling the contaminated air into the existing venting duct of the sewer system, through which the trapped gases would eventually be released into the atmosphere. This would require tapping into the plumbing which is hidden inside the walls of the house. A tedious and expensive task. A variation on Cox's idea is to send the gases down the same plumbing tubes as the remainder of the commode's contents, or possibly other nearby plumbing such as that of a wash basin (see M. Ivancevic's idea: patent No. 3,916,459). All of these methods would necessitate a separate seal between the suction mechanism and the existing plumbing in order to keep sewer odors from entering the bathroom through an unsealed pipe. More exotic still is the idea of combusting the odorous gases after they are trapped. This has been proposed by W. Buchanan (patent No. 4,200,940). However, even he is not specific about how this combustion is to take place. He mentions "an incinerating device preferably incorporating tungsten grid wires," but this is just as vague as his claim that "some chemists believe ... a methane base (a volatile and combustible gas) ... gives the gas its objectionable odor." The final method proposed by some inventors for eliminating the contaminated air is to use a filter.

Chapter 3 Experimental Procedure

3.1 Overview

The following problems were faced during the design process:

1. development of the suction configuration,
2. visualization of the flow patterns inside the toilet bowl,
3. deodorization and disposal of the obnoxious gases,
4. design of an actuator for the system.

These problems had to be solved simultaneously, with the aim of designing an inexpensive, and if possible, patentable unit which can easily be retrofitted to most existing commodes.

3.2 Initial Test Apparatus

The system's initial design is shown in Fig. 3. It consisted of a toilet bowl with a number of openings in the seat of the bowl. A blower to create suction and remove the gases, and a filter to neutralize the odors were also part of the system. Suction was to be taken from the back of the

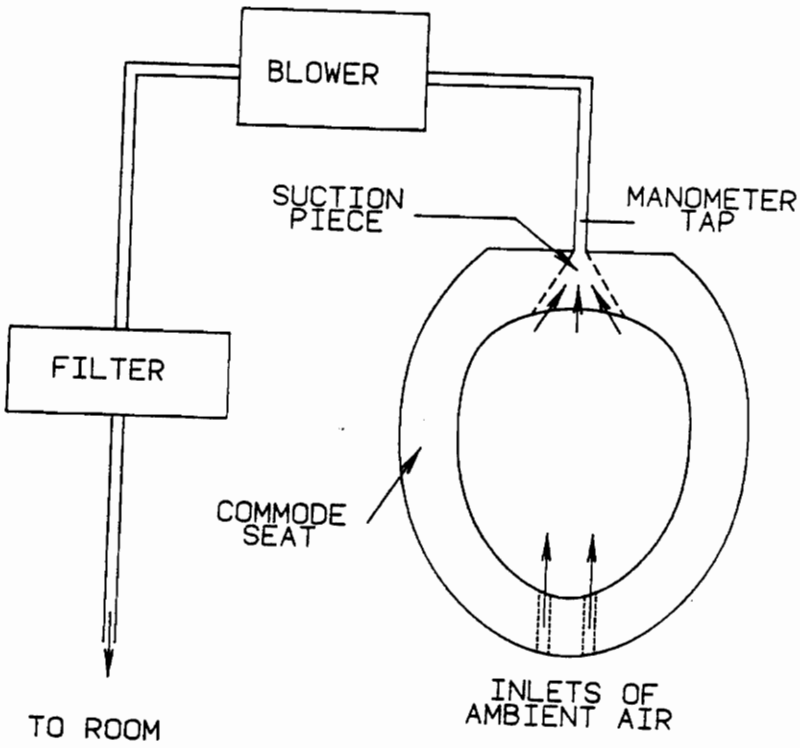


Figure 3. Initial System Configuration

bowl, at a single location. The odorous gases would be removed through a tube by means of the blower. The exhaust of the blower would be connected to a filter which would deodorize the gases. Although the recirculation of deodorized gases was not part of the initial system, it was considered shortly after experimentation began. In that concept most of the deodorized gases would be bled off, but some would be reintroduced in the front of the bowl, possibly through more than one opening. The basic idea, which seemed to have been overlooked by past designers, was that the reintroduced gases could be of some benefit by creating a sweeping flow pattern in the bowl making odor removal at the rear of the bowl more effective. In order not to limit ourselves by possibly insufficient flow rates of small blowers, a large shop vacuum cleaner, with over 300 CFM of capacity, was used to create the suction in this original system. The shop vacuum cleaner has an inlet hose of 1.5 inch diameter. A 3/4 inch diameter tygon tube was attached to this inlet and connected to the suction piece. This suction piece with a 3/4 inch round exit and a 0.5 by 2.5 inch rectangular inlet was mounted into the rear of the seat. A valve was placed between the suction piece and the vacuum cleaner to control the amount of suction in the bowl. A manometer was attached to a pressure tap at the exit of the suction piece in order to measure the suction.

3.3 Visualization of Flow Patterns

Since the gases whose ultimate removal is the object of this design are difficult to experiment with and are invisible at any rate, it became necessary to visualize movement of the the odorous gases in the bowl. After some experimentation with cigar smoke and dry ice, a water base fog, known by the trade name Theatre Fog, was chosen. A can of this water based liquid fog is attached to an electrically heated gun designed for the purpose of expelling the fog on the user's command. By pulling the trigger, liquid from the can is forced past a heater element which turns the liquid into a gray vapor. This vapor, once injected into the bowl, allows the experimenter to view existing flow patterns. It is not possible with this system to regulate the rate of smoke creation, only the duration of smoke production is controllable. The gun produces smoke at much higher rates than would

be needed to model normal odor production. It was therefore determined that a mechanism was to be developed so that the rate at which smoke is sent into the bowl of the commode could be regulated.

The mechanism used for controlling smoke induction into the bowl is shown in Fig. 4. A collapsible 5 gallon plastic water container was used as a smoke reservoir. The existing spout of the container was used as the exit from the reservoir. This spout contained a shut off valve so that the smoke could be kept from exiting the reservoir when this was not desired. The exit from the reservoir was attached to tubing that entered the bowl of the commode through its discharge plumbing, at the virtual waterline of the toilet. An additional opening was cut directly opposite the water spout into the side of the container. It was used as the inlet opening through which smoke was to enter the reservoir. A valve was attached to the inlet of the reservoir so as to be able to close the inlet after the container was filled with smoke. The smoke gun was used to fill the reservoir with smoke after which the valve at the inlet was closed and the discharge valve opened. Weights were then placed onto the collapsible reservoir. The steady collapsing of the reservoir expelled smoke at a constant rate through the tubing leading from the exit of the reservoir into the bowl of the commode. By varying the weight used on the reservoir, the rate at which smoke was sent into the commode could be regulated.

A systematic approach was now adopted to determine the proper amount of suction necessary to remove a given rate of induction of smoke from the bowl. Flow patterns inside the bowl were also studied. The bowl of the commode was covered in a leak-proof fashion. A cellophane wrapper was stretched across the seat and a half inch thick foam insulation was placed between the bowl and the seat. This was to model the leak proof ideal case. Leaks, representing increasing reality (and complexity) were to be added in stages later.

In a series of trials, pairs of rectangular inlets (of 0.5 square inches and/or 1.0 square inches) were inserted into the insulation between the bowl and the seat of the toilet. The location of these air inlets was varied from zero degrees (corresponding to the back end of the commode, near its water

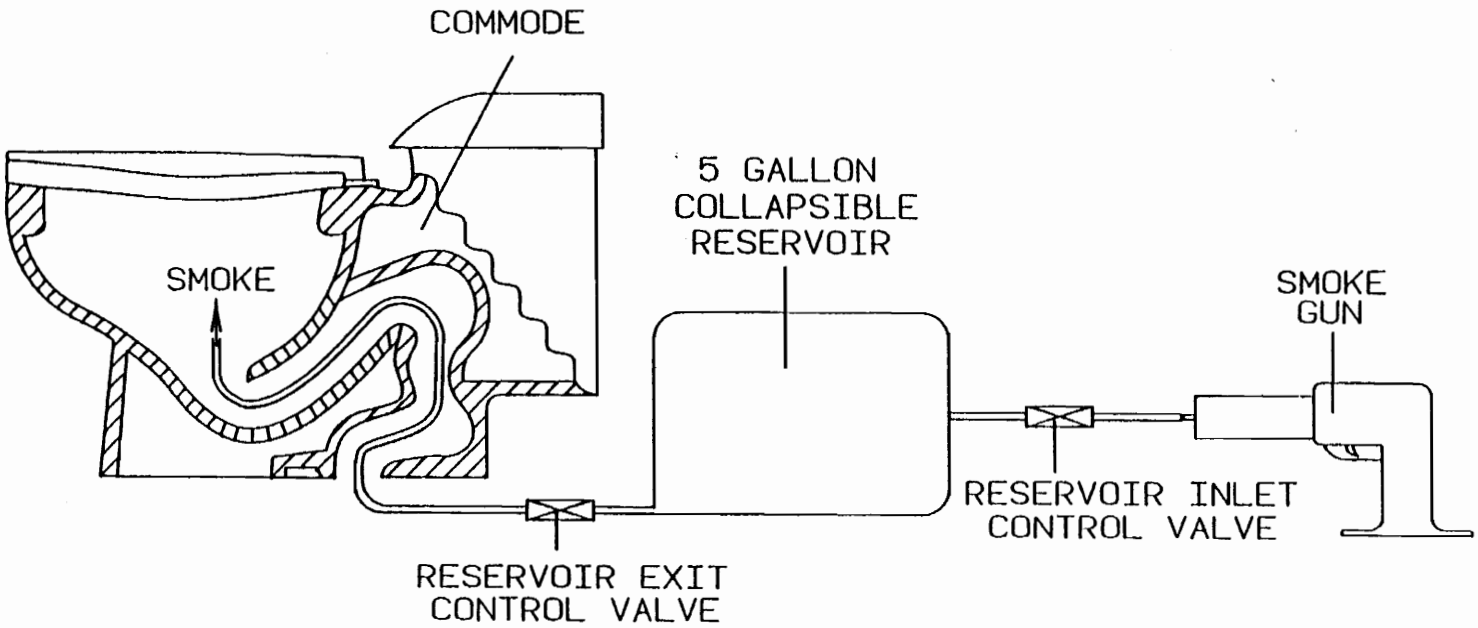


Figure 4. Reservoir configuration

tank), to 180 degrees (corresponding to the front of the commode). The inlets were always placed symmetrically on both sides of the toilet. In later trials, a triangular inlet was cut into the cellophane cover at the front, to represent a space through which air could enter the toilet when the unit was occupied. At first this pie shaped gap was omitted in favor of simplicity. After each series of trials, the size of this opening was enlarged until a 3 inch long by 2 inch wide triangular opening was attained. It was found that larger openings here actually allowed for more effective suction. Flow patterns such as those shown in Fig. 5 were noted.

The hypothesis tested by these trials was that air admitted into the commode between the bowl and the seat may create a sweeping flow pattern that would result in more efficient smoke/odor removal at the rear of the bowl. This did not prove to be the case. It was concluded that the turbulent eddies in the bowl, induced by the suction at its rear, could not be alleviated by strategically placed air inlets. The only configuration of air inlets which was of any value in attenuating existing turbulence was that of air inlets towards the rear (near the suction piece) of the bowl. These trials did, however, give the experimenter some insight into the proper amount of suction required to evacuate the bowl in a timely fashion.

It was hoped that the amount of smoke forced into the commode from the reservoir by the various weights could later be correlated to a specific amount of odor production. Each weight would have a corresponding level of odor production associated with it. A system could then be designed to function properly at slightly above the worst case. This, however, could never be attained since no criteria for comparison could be developed. It did become apparent through these trials that at most 0.5 inches of water of suction was required at the suction piece's exit (Fig. 3, pg. 11, shows the location of the manometer tap used for obtaining pressure drop readings). This suction corresponds to approximately 3 CFM air flow as measured with a rotameter.

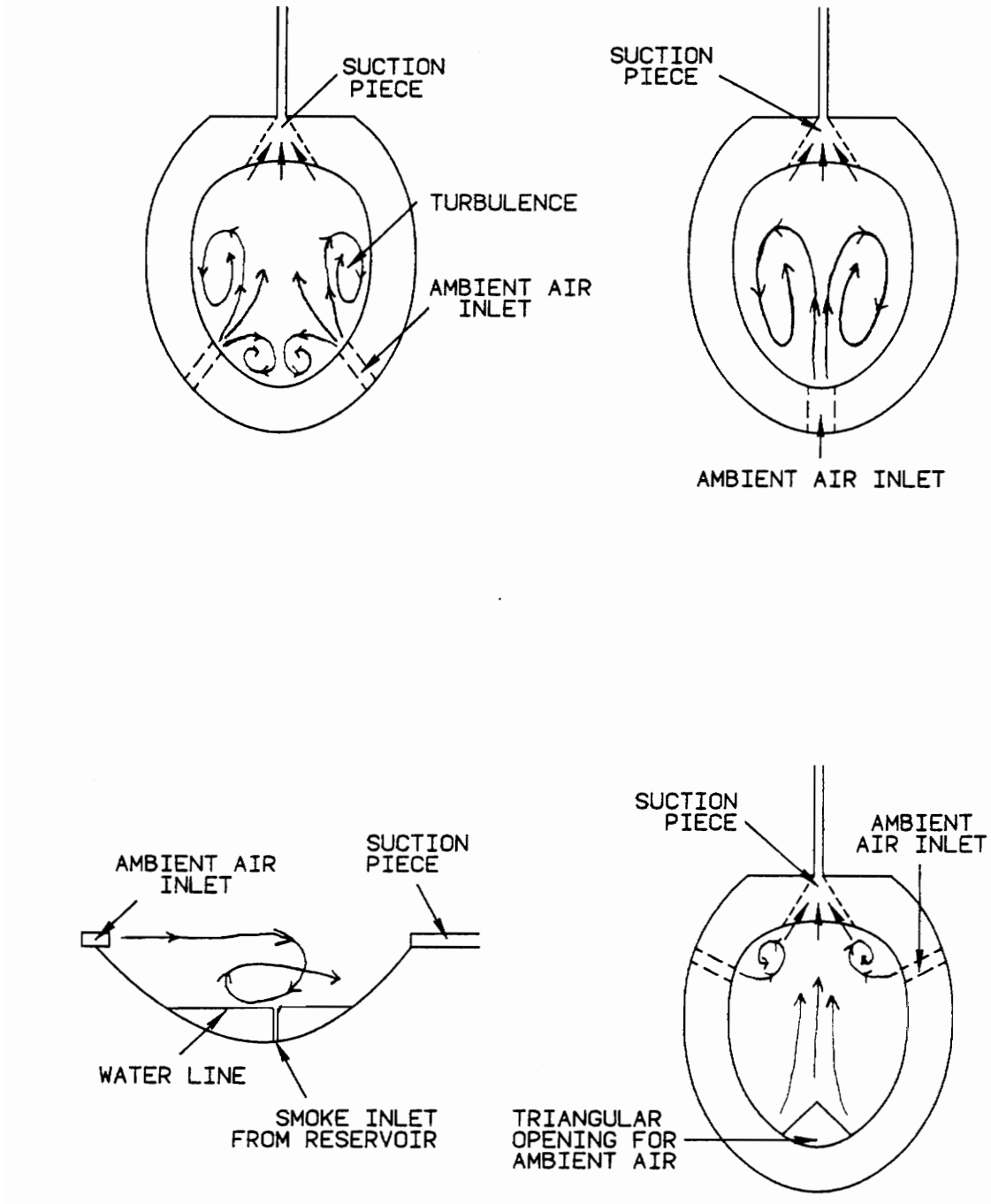


Figure 5. Some Typical Flow Patterns Without Recirculation

3.4 Recirculation

Although letting ambient air enter the bowl at various specific locations proved to be of little value, it was hoped that forcing air into the bowl under pressure might overcome some of the turbulence induced by the suction at the rear. The introduction of air under pressure is in conformity with the original idea to recirculate some of the deodorized air.

As Fig. 6 shows, originally only one location was proposed for the introduction of air under pressure: the front of the bowl. The exhaust from the vacuum cleaner was routed to a Y-shaped section, one exit of which was attached to tygon tubing leading into the bowl through the foam insulation between the seat and bowl. In order to introduce part of the deodorized air into the bowl. The other exit from the Y-section exhausted into the room. A valve in the Y-section divided the exhaust allowing the experimenter to control the fraction of air which was to enter the bowl, and the fraction intended to bypass the bowl. It was found that even the slightest amount of recirculated air caused large turbulent eddies in the bowl, turbulence which made smoke removal from the rear even more inefficient than without such reintroduced air. Varying the location at which the pressurized air was introduced did not decrease the turbulence in the bowl. It was thought that the turbulence added in this configuration could be due to the high rate of air flow entering the bowl at a single location.

It had become apparent that the shop vacuum used to this point in the experiment produced much higher flow rates than would be required. For this reason a single blower was sought that would produce suction rates close to the 3 CFM need as was determined earlier. No single blower could be found that produced the desired amount of suction and also allowed for a reasonable amount of the exhausted air to be recirculated. The pressure requirements of this system were too high for any blower found at this time. Therefore it was decided to use two separate blowers, one for suction and one for recirculation until one unit capable of performing both tasks could be located.

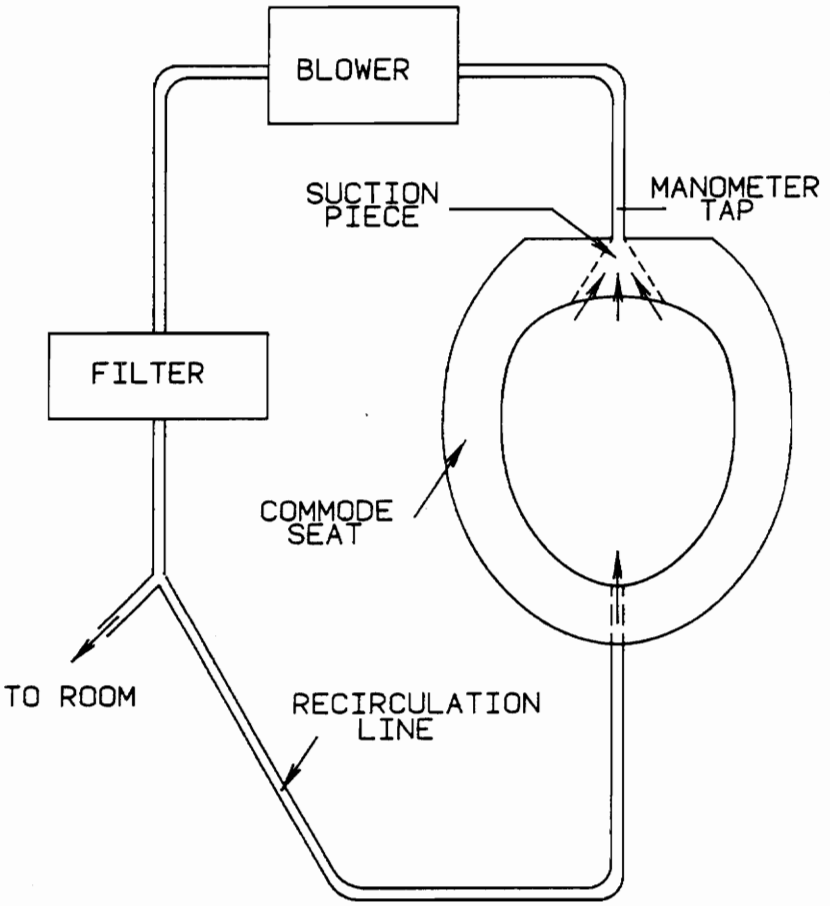


Figure 6. Original Recirculation Configuration

In order to overcome the turbulence experienced with just a single recirculation location, a system was developed which distributes the introduced air over a large area. Since two separate blowers could now be used to produce suction and recirculation, the air flow in both the suction and the recirculation lines could be changed independently of each other. With this system the effect of distributed, peripheral recirculation on suction requirements could be determined. It was hoped that the forced air introduced throughout the entire perimeter of the bowl could lower suction requirements by creating smoother flow patterns in the bowl.

Fig. 7 shows the experimental apparatus using two blowers. The exhaust from the recirculation blower (Herbach and Rademan Co. No. TM23K194) passed through a valve, a pressure tap, and a Y-sectioned piece which divided the flow downstream from the blower's exhaust. A valve internal to the Y-piece allowed for the regulation of air flow into each of the two arms of the recirculation line. This allowed the experimenter to equalize the flow in the two arms of the recirculation line. The pressure tap was connected to a manometer in order to attain an indication of the flow in the recirculation lines. Holes were drilled into the peripheral tygon tubing to allow the recirculated air to enter the bowl at specific locations.

The holes drilled into the tubing around the inside of the bowl created openings through which a part of the deodorized gases was forced back into the bowl. These holes were spaced 4 inches apart and were distributed around the entire perimeter of the bowl. A weight was placed on the reservoir which had been filled with smoke. The inlet to the reservoir was closed and the exhaust of the reservoir was opened. Thus smoke forced out of the reservoir by the weight entered the bowl. It was hoped that forcing air back into the bowl at strategic locations would improve flow patterns in the commode. This initial recirculation configuration did not prove effective. Additional turbulence was created in the bowl. The plume of smoke emanating from the tube in the base of the bowl was greatly disturbed by the newly introduced air. The amount of recirculation was reduced to a bare minimum in hope that some positive effect would be noted, none was. Since the steadiness of the plume was an integral part of the criterion by which effective suction was being judged, a new criterion had to be developed.

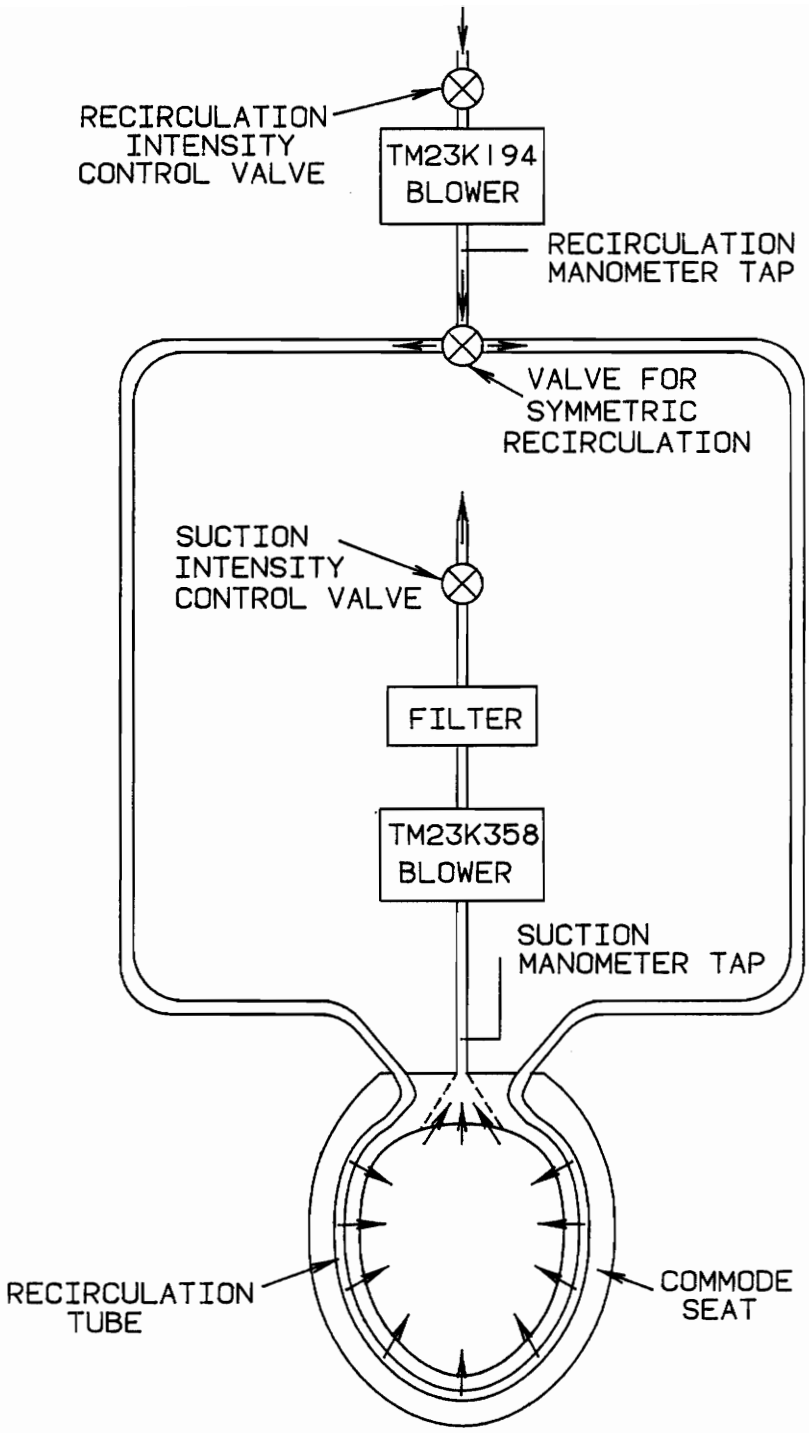


Figure 7. Experimental Peripheral Recirculation Configuration

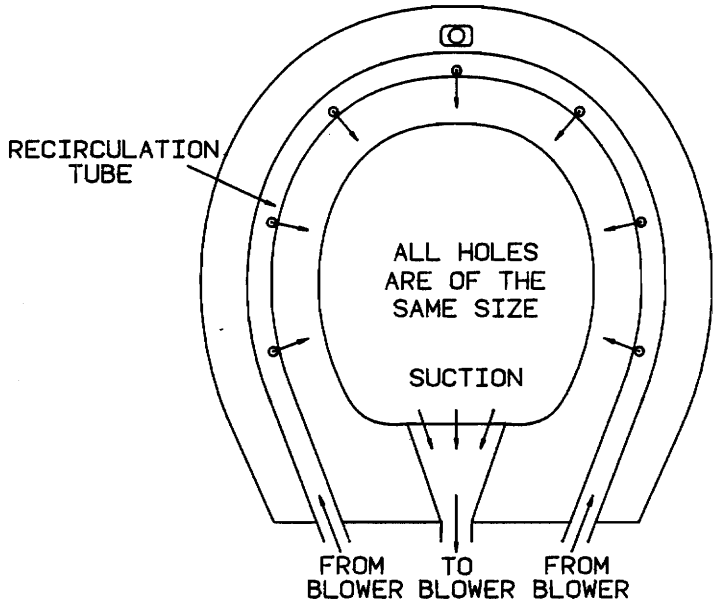
A new way of viewing the flow patterns in the bowl was developed in order to see what effect recirculation had on suction requirements. It was decided that the bowl would be filled with smoke completely, directly from the smoke gun. The thick smoke was kept in the bowl by the cellophane wrapped around the seat and the insulation filling the gap between the seat and the bowl. The amount of suction in the line, as measured by the pressure tap between the blower and the suction piece, was set at 0.2 inches of water. Previous experimentation had revealed that 0.5 inches of water were needed to evacuate the bowl with high smoke induction rates. However, corresponding to this lower suction was lower turbulence in the bowl. The degree to which suction was contributing to the turbulence versus the recirculation's contribution could be more easily determined because the effect of the recirculation on turbulence was magnified. This created more dramatic differences in the flow patterns of the various configurations.

It has been stated that the suction was operating at a vacuum of 0.2 inches of water. The separate recirculation blower's flow rate was controlled by another valve; its pressure was set to 0.1 inches of water for the early trials. Both arms of the recirculation line were calibrated to supply the same amount of air flow using a rotameter installed into the line (for the calibration only since its internal resistance cuts down on the flow rate). The spacing of the holes in the recirculation line was varied in order to find the configuration that produced the lowest amount of turbulence in the bowl. This turbulence was very sensitive to the location and spacing of the holes.

The first trial was run with seven holes spaced four inches apart and originating at 60 degrees from the suction piece as shown in Fig: 8a. This configuration was the first to show any attenuation in turbulence. By trial and error it was found that more holes were needed in order to distribute the recirculated air more evenly. Holes were drilled half way in between the existing recirculation openings so that each hole was now only two inches from the next. Still there was only slight room for optimism; the recirculation was however, no longer adding to the turbulence.

Before the final configuration for the recirculation line could be developed, the system had to be simplified somewhat. A pipe fitting for each of the two recirculation arms as well as for the suction,

A) ORIGINAL CONFIGURATION



B) FINAL CONFIGURATION

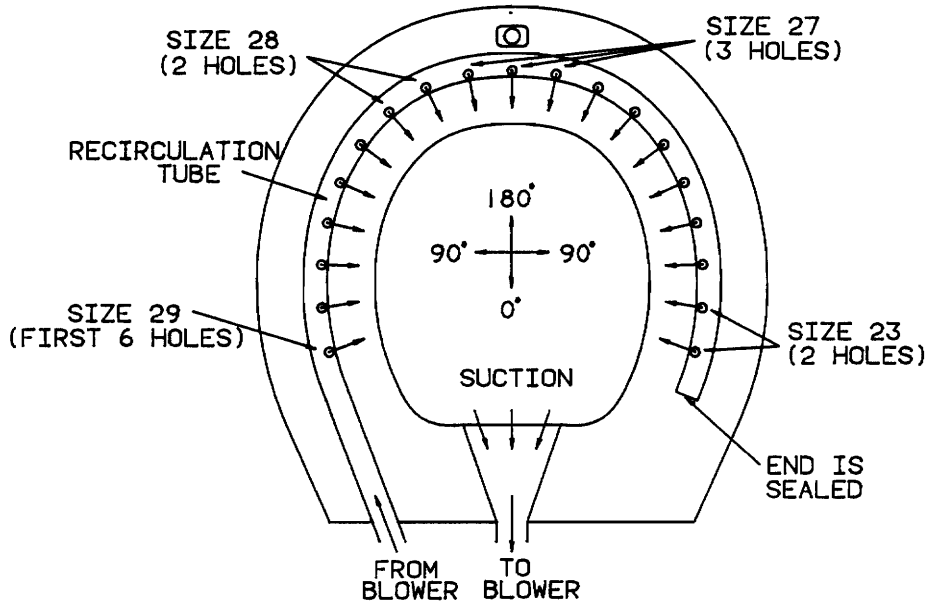


Figure 8. The Recirculation Line

would make for a crowded area at the back of the seat when the time came to install the fittings into the seat. Elimination of one of the two recirculation arms resulted in an organized and clean format. With the elimination of one of these leads, the recirculation became asymmetric with more air flowing out the holes which were closer to the blower. This asymmetry reintroduced excessive turbulence into the bowl. Two methods could be used to remedy this problem:

1. the holes could be unequally spaced,
2. the holes could be of unequal size.

It was difficult to obtain a satisfactory configuration for unequally spaced holes. Changing the location of only one hole by 1/2 inch completely changed the flow pattern in the bowl. Due to the first method's strong sensitivity to the location of the holes, the second method was tried. The total circumference of the bowl's inner edge is forty inches. As had been revealed in earlier attempts, holes placed within about 90 degrees of the suction piece were detrimental to the suction's effectiveness. After a number of trials a final recirculation configuration was determined. The final format has 19 holes spaced 1.5 inches apart (Fig. 8b). The size of these holes varies. The first six holes were made with a .1360 inch diameter (size 29) drill bit. The next two are .1405 inch in diameter (size 28). Each additional pair of holes has the next larger drill size up to .1540 inch diameter (size 23) for the last two holes. The odd hole in the center, like the two on either side of it is drilled with a .1440 inch diameter (size 27) bit. This configuration places holes within 13.5 inches on either side of the front of the bowl, or around 67% of the perimeter of the bowl (from 60 to 180 degrees on either side of the bowl). In addition it was found that angling the holes downward into the bowl reduced turbulence. When the recirculation is turned on the smoke collects in a small area towards the rear of the bowl just under the suction piece. From here it is easily removed.

3.5 Suction and Filtration

As was discussed in the literature review, there are many possible ways of disposing of the odorous gases from the bowl. The simplest one is to exhaust the untreated gases directly to the outside of the building. This would require making openings in the existing walls, floors, or ceilings of the bathroom. A slight variation on this option is to exhaust the fumes into the existing plumbing of the house, ultimately venting them to the outside. Such arrangements also require modification to the bathroom's walls as well as require a seal between the exhaust opening and the sewer line in order to keep gases from reentering the bathroom. Another option is to combust the fumes and thus destroy them. Still another option found in the literature is to pass the gases through a filter and thus deodorize the extracted air. This last option was most appealing to us.

Passing the contaminated air through a filter eliminates the need for a seal to be installed between the commode and the designated vent for the odors. The walls, ceiling and floors of the bathroom also remain undamaged. This greatly simplifies the installation of the unit permitting easy retrofitting to existing toilets. In addition, part of the filtered air can be reintroduced into the bowl making odor removal more efficient.

In attempting to determine the effect of the various filters on the suction, a separate blower (the suction blower) was used independently of any recirculation. This blower (Herbach and Rademan Co. No. TM23K358) was also obtained from the Herbach and Rademan (H + R) Corporation. It was hoped that a filter which introduced minimal resistance yet proved to be effective, could be found among those available commercially. Fig. 9 shows the apparatus used to test the filters. A valve to control the amount of airflow entering the blower was installed into the tubing at the blower's inlet. The filter was installed behind the blower, again after a length of tubing. Pressure taps were installed before the valve at the inlet and between the blower's exhaust and the aft mounted filter. Since the odors encountered by the unit will be organic in nature, an organic odor was needed to test the effectiveness of the filters. Diluted acetone was used as a source of this

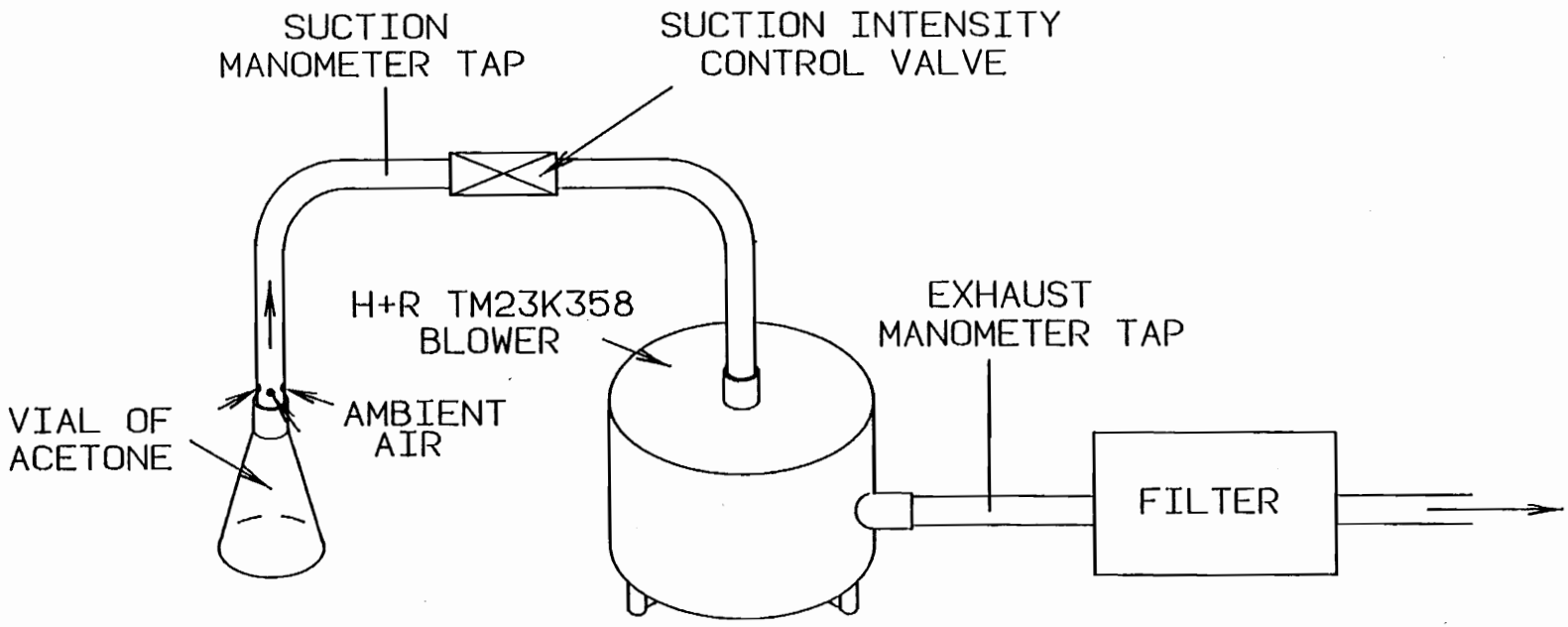


Figure 9. Filter Test Configuration

organic odor. The scent of the acetone was very strong when the exhaust line was unfiltered. When filters from various "air cleaning" machines (made of charcoal impregnated fibers) were installed, the acetone odor was reduced but not eliminated. Such filters either did not contain enough filter material or enough activated charcoal to attenuate the odors. Flow rates through the system with these types of filters remained relatively high due to their low internal resistance, but since odors were not removed completely these filters were unsatisfactory.

A number of filters from various gas mask manufacturers were tried next. These filters contain solid charcoal granules in a plastic housing layered between various screens and cloth filters inside the filter unit. The different filters restricted the air flow to varying degrees. The filter that had the least restriction to flow among those tested is manufactured by the North Safety Company as No. N-7500 and sold by W. W. Grainger Co. as No. 3A169. This filter also proved to be the most effective against the acetone produced odor, as well as against a second kind of organic odor used, that of spoiled chicken eggs. This is the filter which has been incorporated into the final design of the system.

The housing of the N-7500 filter had to be modified so that it could be installed more easily into the tubing system. As manufactured by the North Filter Company, only the inlet to the filter has pipe threads. To provide a threaded connection at the exit, the threaded inlet of a similar filter was epoxied to the non-threaded exit side of the N-7500. This resulted in a filter with two right hand threads that still makes removal of the filter (for replacement purposes), somewhat difficult. Ideally one of the threads should be a left hand thread. This would allow the user to simply turn the filter in one direction to engage and in the other direction to free both threads simultaneously.

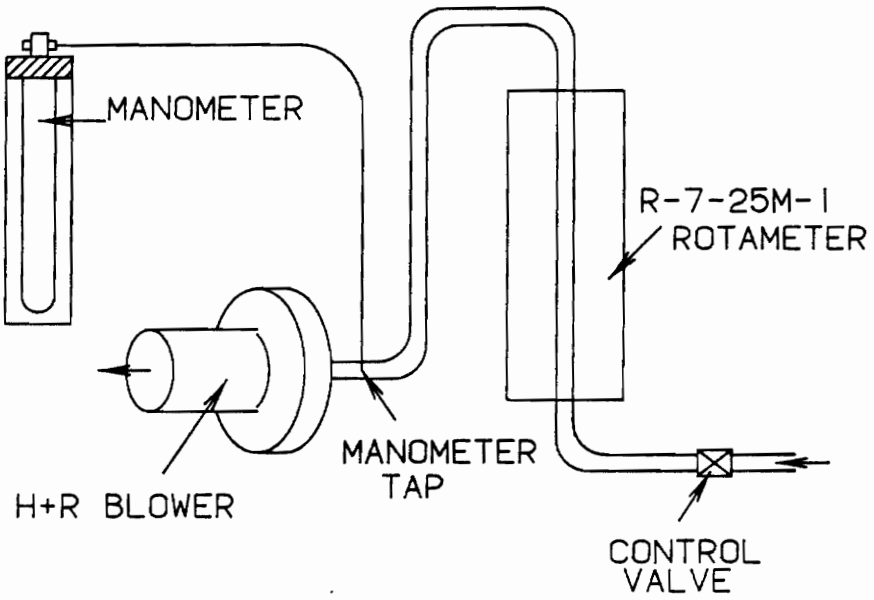
3.6 Prototype Blower

With the use of two separate blowers it was determined how much of the deodorized gases should be recirculated to reduce suction requirements. In addition, the use of separate blowers facilitated the selection of the most efficient filter. At this point in the development a single blower was sought that could fulfill both the suction and recirculation requirements simultaneously. These requirements were determined earlier as 0.5 inches of water suction at 3 CFM, and 0.1 inches of water head at 0.5 CFM for recirculation. In other words a unit had to be located with which the effectiveness of the entire system could be checked.

Such a blower was purchased on the surplus market from the Herbach and Rademan (H + R) Company in Philadelphia Pa. The unit (Herbach and Rademan No. TM24K586) has a 12 Volt AC/DC 20 amp motor. The blower was connected to the AC terminals of a large voltage regulator. A rotameter and a manometer were attached to the suction side of the unit as shown in Fig. 10a. A strobe light was used to determine the rotational speed of the motor (and fan) as a function of the input voltage. By varying the input voltage to the motor (with the voltage regulator) an indication of the overall performance of the H + R blower was obtained. In order to see where our system would fit in the overall performance of the blower with filter and suction piece in place, the rotameter was removed and the N-7500 filter placed into the system along with the suction piece. Fig. 10b shows this configuration. With the filter and the suction piece in place it was determined that only 6.5 Volts (and 14.0 amps) were required to deliver the necessary 0.5 inches of water static pressure at the manometer tap (ΔP_2) With this voltage input, the motor turned at 10,900 RPM and the blower unit had 10.9 inches of water pressure rise across it (ΔP_1).

Since this motor needed only 6.5 Volts to satisfactorily remove the odorous gases, a transformer was purchased which produced 6.5 Volts and allowed for the 14.0 amps required. The system was then assembled and tested in an existing toilet. One week of testing with regular use showed that the system worked as intended. Some problems still existed. The blower used was in short supply

A) MEASURING BLOWER PERFORMANCE



B) MEASURING SYSTEM PERFORMANCE

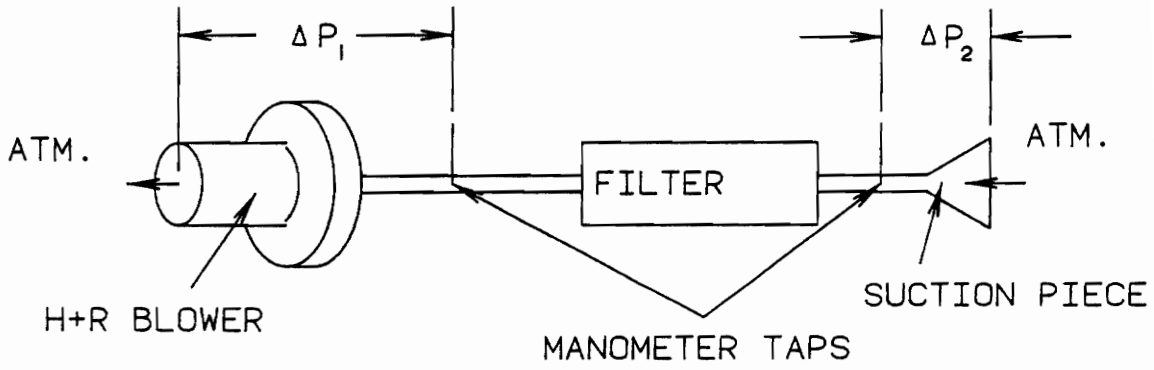


Figure 10. Blower Test Apparatus

and its manufacturer could not be determined. In addition the added cost of the transformer would be avoided if a 120 Volt motor/blower assembly could be found. For this reason a different blower was sought.

A blower manufactured by the Fuji Electric Corporation of America, model No. VFC 083P, also matched the previously mentioned suction and recirculation requirements simultaneously. In addition, this blower operates on 120 Volt household current. Fig. 11 shows the performance curves of this blower. It will be noted that this blower seems to produce more suction than is required by our system. However, Fig. 11top, showing the delivery side, represents measurements made with only the output port throttled. Likewise, Fig. 11bottom, showing the suction side, represents measurements made with only the suction port throttled. Since in our system both the suction and the delivery ports have restrictions placed on them, we can expect lower flow rates than those predicted by these graphs. It was later determined that this is in fact the case.

As previously mentioned, recirculating too much of the deodorized gases unacceptably increased the turbulence in the bowl. With the H+R blower (Herbach and Rademan No. TM24K586), a Y-sectioned by-pass was attached to the exhaust of the blower so that the proper amount of recirculation was attained. With the new Fuji blower, a by-pass of a different sort was installed. Eleven 0.1770 inch diameter (size 16 drill bit) holes were drilled into the piping connecting the exhaust of the blower to the recirculation tubing in the seat. A sleeve covers these holes. By sliding the sleeve in an axial direction, these holes are gradually uncovered increasing the amount of air that is by-passed. It was found that with half of the 11 holes opened, the time to evacuate the smoke from the bowl is minimized. Thus with the Fuji blower, the by-pass is not located directly after the exhaust of the blower, but rather in the piping connecting the blower's exhaust to the recirculation tubing in the seat.

In order to determine the system's flow rates with this blower, a number of different measurements were made using three different configurations as shown in Fig. 12. All pressure readings were taken with a manometer relative to atmospheric pressure. The configuration in Fig. 12a is a

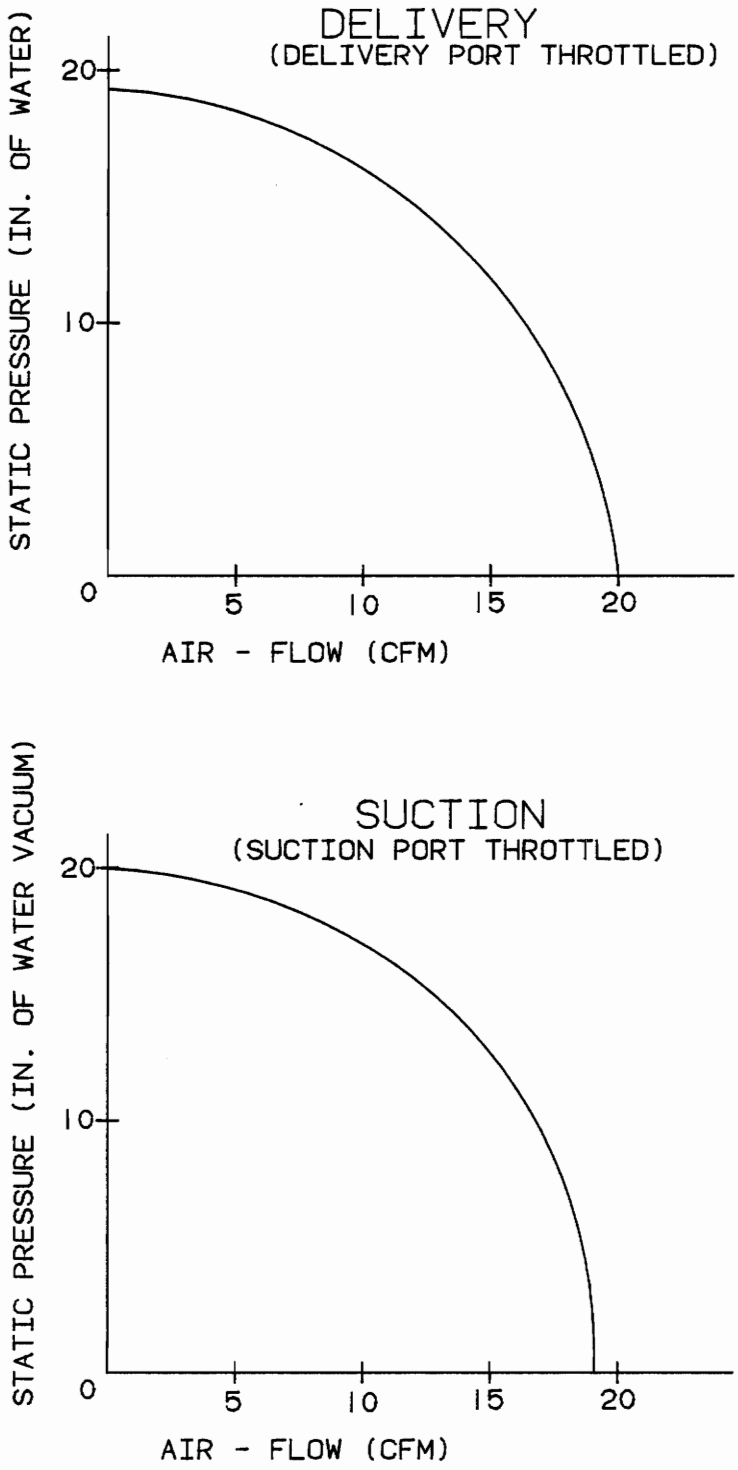


Figure 11. Fuji Co. VFC 083P Blower Performance Curves

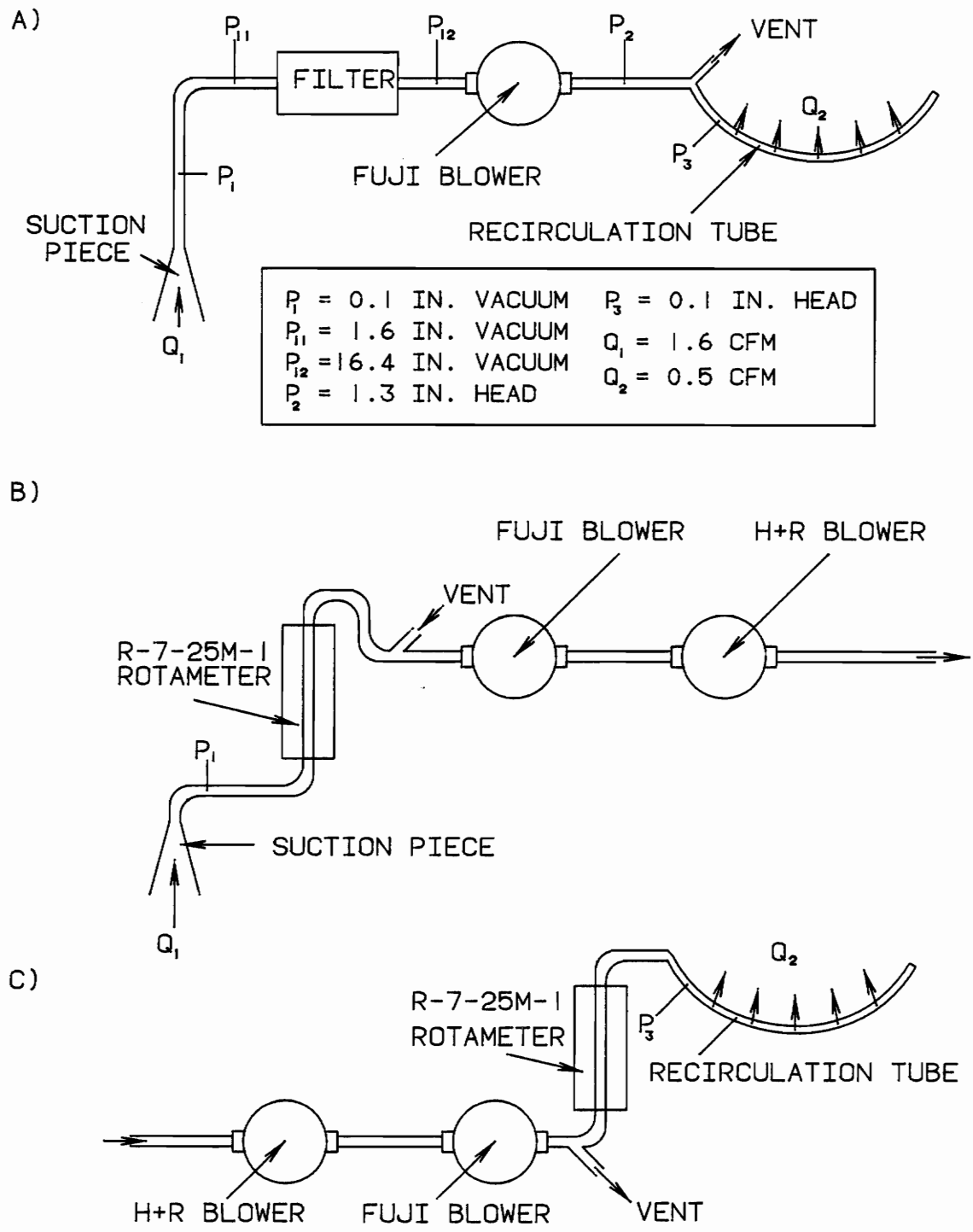


Figure 12. Configurations for Determining Flow Rates With the Fuji Blower

schematic of the final design. This configuration was used to obtain the pressures at various locations in the system. The pressure P_1 uniquely determines the flow rate Q_1 ; likewise, the pressure P_3 uniquely specifies the recirculation flow rate: Q_2. Here Q_1 is the suction flow rate, Q_2 is the recirculation flow rate. The difference between these two is the flow rate of the by-passed air.

The configuration shown in Fig. 12b was used to determine Q_1 . The addition of a flowmeter into the system increased the resistance of the system and thus changed the system's characteristics. By placing the H + R blower (Herbach and Rademan No. TM24K586) in series with the Fuji blower as shown in Fig. 12b, the flow in the system increased the flow rate beyond that of the actual system (Fig. 12a). The vent shown in Fig. 12b was slowly opened until the pressure P_1 in this configuration was equal to the 0.1 inches of water vacuum measured in the configuration of Fig. 12a. At this point the flowmeter registered the flow rates of both the "A" and "B" configurations at a value of 1.6 CFM. Thus the Fuji blower is delivering 1.6 CFM air flow in the suction line of the system. This is slightly less than originally anticipated; however, the system functions properly with this amount of suction.

A similar procedure was repeated in order to obtain the flow rate in the recirculation line. Fig. 12c shows this configuration. Again the H + R blower was placed in series with the Fuji blower to overcome the added resistance of the flowmeter. In the recirculation line, half of the eleven holes were opened to by-pass the proper amount of deodorized air. Another vent, installed before the flowmeter to regulate the air flow was gradually opened until the pressure P_3 in this configuration equaled the 0.1 inches of water found in the "A" configuration. At this point the flowmeter registered the recirculation line's flow rate, Q_2, in both the "C" and the "A" configurations. This flow rate was found to be 0.5 CFM. Thus 0.5 CFM of deodorized air is recirculated back into the bowl.

This procedure has determined that 1.6 CFM is sucked out of the bowl of the commode by the present system. The recirculation of 0.5 CFM (approximately 30%) back into the bowl makes the

suction more efficient. It will be noticed that the suction side has a pressure drop of 0.1 inches of water, the recirculation side has a pressure rise of 0.1 inches of water. This is purely coincidental. Due to the differing resistances of the suction and the recirculation lines, the similarity of these pressure readings is of no significance. In addition, the manometer used to obtain these measurements only measures to the nearest tenth of an inch so the two readings may not be as close as they first appear.

3.7 The Switching Circuit

It was desired that the blower would start up automatically as soon as the user occupies the toilet. To accomplish this an electric switch was mounted on the seat of the toilet. Both push-button mechanical switches and capacitance governed proximity switches were considered. The high cost of proximity switches as well as their questionable effectiveness for this application, favored the mechanical switch. Since the switch will be located close to the commode's occupant, the 120 Volt household current was considered potentially hazardous. For this reason a 12 Volt circuit was adopted. A small "door-bell" transformer has been included in the system to reduce the voltage for the switch to 12 Volts. A common "normally off" type switch is used. The corresponding switching circuit is shown in Fig. 13. The switch is initially in the off (open circuit) position, depressing the switch closes the circuit. This activates a relay which energizes the 6.5 Volt transformer and starts up the motor. When the pressure is removed, the switch reverts to the open circuit position, de-energizing the relay, thus cutting off the current to the motor.

The location of the switch in the seat was also of concern. The switch could have been installed such that it protruded out of the upper side of the seat. In this position actual physical contact between the occupant and the switch would have started the motor. This idea is somewhat crude. It was more desirable to incorporate the switch into the underside of the seat. The pressure exerted on the seat by the occupant's weight would then push the switch, shown in Fig. 14, against the

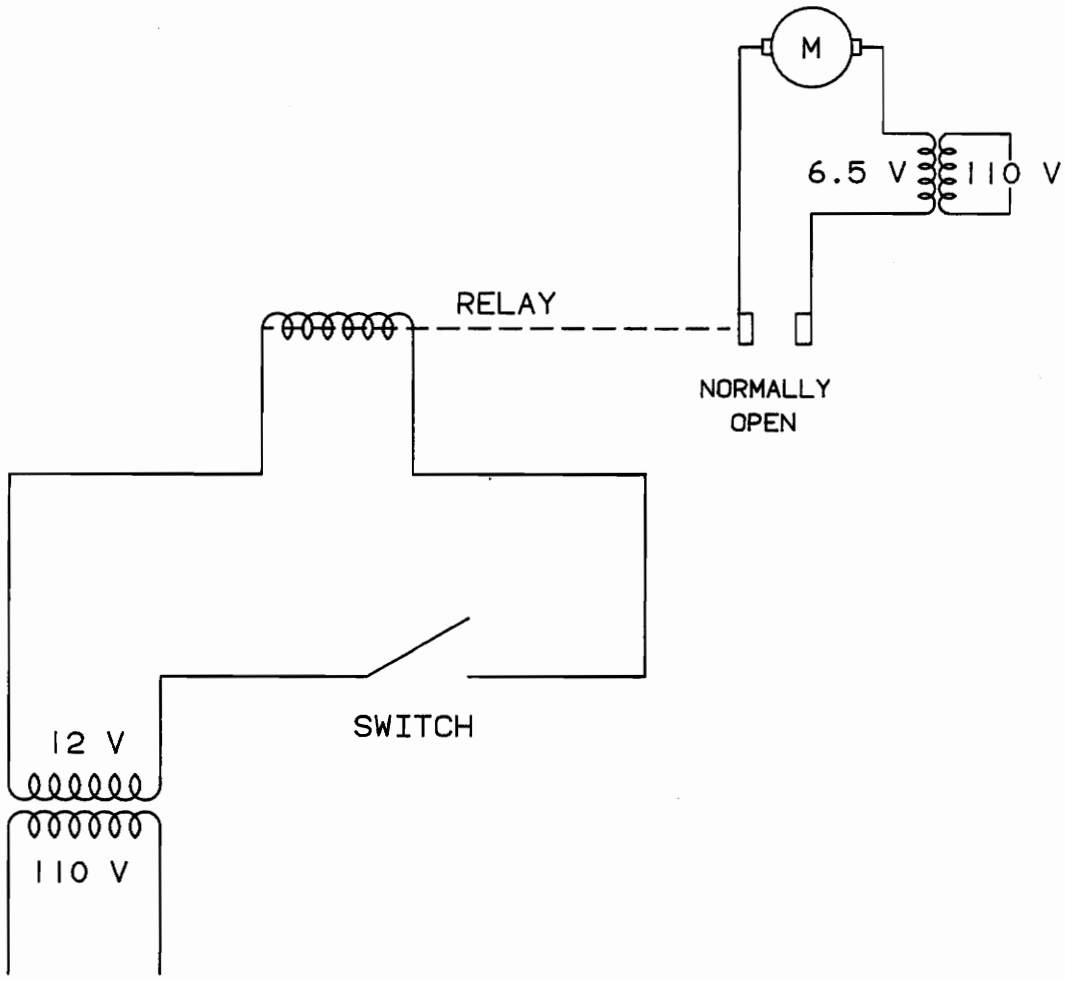


Figure 13. Actuating Circuit

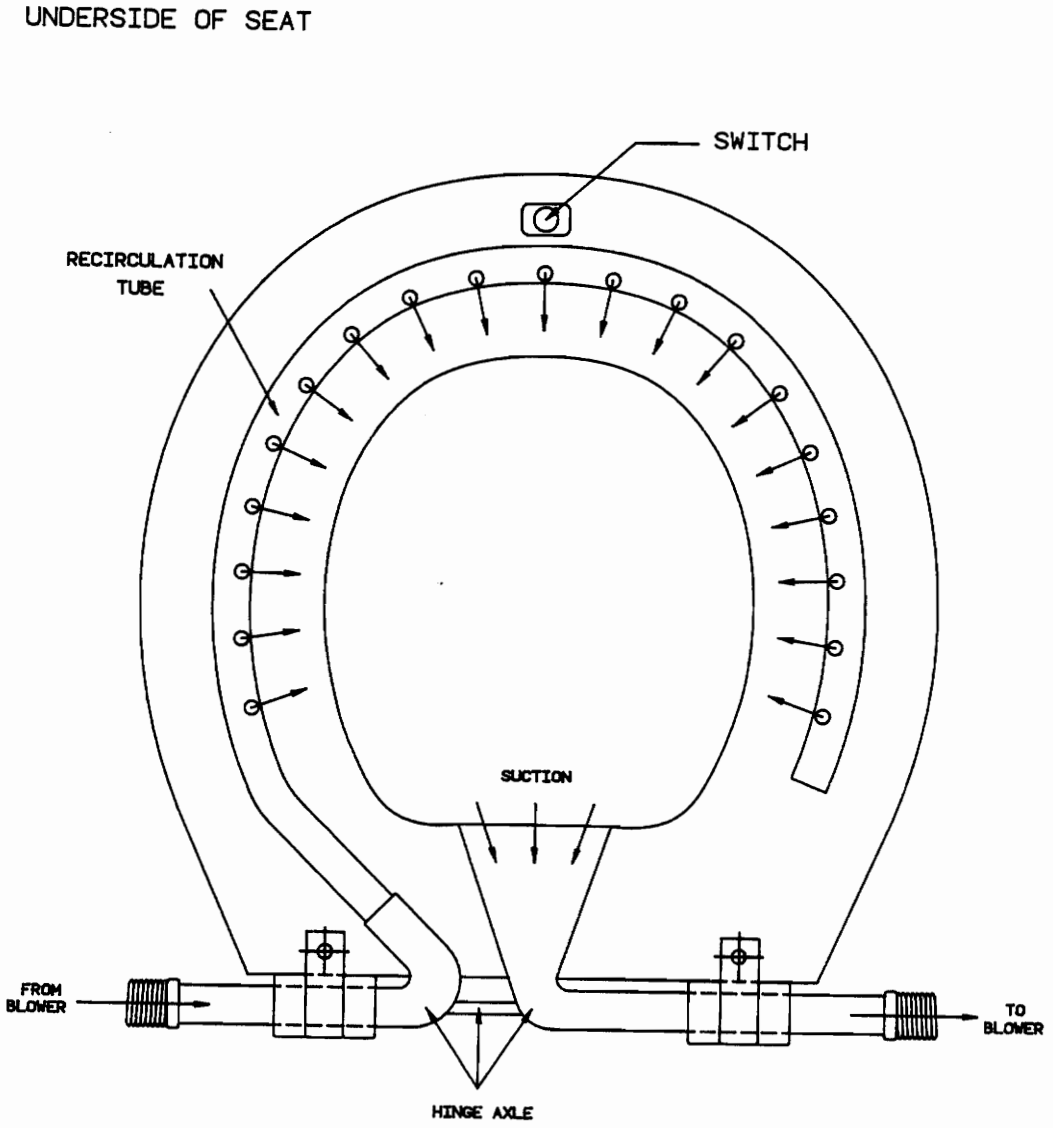


Figure 14. Switch Location

porcelain bowl of the toilet; this would start the system. Attention had to be paid to the space needed between the seat and the bowl such that the weight of the seat alone would not depress the switch. The somewhat flexible recirculation tubing acts like a spring, keeping the weight of the seat and lid from actuating the switch. Also, a location on the seat's underside had to be found that would allow for the necessary travel required to close the circuit when the occupant's weight depressed the switch. Since the front of the seat travels further than any other part of the seat due to the existence of a hinge at the rear of the seat, the switch was located at the front of the seat.

3.8 Other Design Considerations

Now that the system was complete some practical problems needed to be addressed:

1. the formation and location of a box to house the motor and other electrical components;
2. a redesigned hinge for the seat and lid of the commode to allow for rotating suction and recirculation connections.

In the prototype with the H + R blower, the box which houses the motor, its transformer, the relay and the "door-bell" transformer for the switch was originally made of wood. This was done because of the ease in manufacturing as well as the soundproofing that wood provides. A decibel sound meter using the "A" scale (which is weighted to incorporate the ear's sensitivity to midrange frequencies) registers 65 dB within a one foot hemisphere of the box. This is approximately 7 dB less than the noise generated by a standard ceiling fan located in the same room within a one foot hemisphere. The 65 dB is a significantly high sound level, further attenuation is very desirable. Mounting the box on the ground (at a distance of about 3 feet from the commode's occupant) reduces the sound level to 60 dB near the user. In addition, a box made of airtight, sound retardant plastic (such as certain fiberglass) would reduce sound emission further.

The positioning of the suction and recirculation connections at the rear of the seat introduced another problem. The hinge which allows for the independent movement of the seat and the lid, and fastens the seat and lid to the bowl, had to be redesigned. As Fig. 15 shows this could only be done by placing the axes of the seat, lid, suction and recirculation pieces on a common axis. A hinge consisting of two sets of three clamps was developed to accomplish this. The central clamp attaches the suction/recirculation line (hereafter referred to as the hinge axle) to the seat. The inward clamp attaches the seat (et. al.) to the porcelain bowl of the commode. The outward clamp attaches the lid to the toilet seat and thus ultimately to the rest of the commode. The inward and outward clamps are hinges, that is they rotate relative to the hinge axle; the central clamp and the seat, however, rotate with the axle.

Another complication is introduced with the use of the hinge axle. This axle must rotate with the seat when the seat is raised, however, the suction line as well as the recirculation line leading to the blower must remain stationary. It was initially thought that an o-ring type clutch would have to be included in the design which would isolate the rotation of the hinge axle from the piping connecting this axle to the blower. However, since the pressures encountered are so small, less than 1.0 inch of water, a pipe thread connection between the hinge axle and the connecting tubing would function as well. Thus a loosely tightened pipe fitting is attached to the end of the hinge axle allowing relative rotation between the axle and the piping.

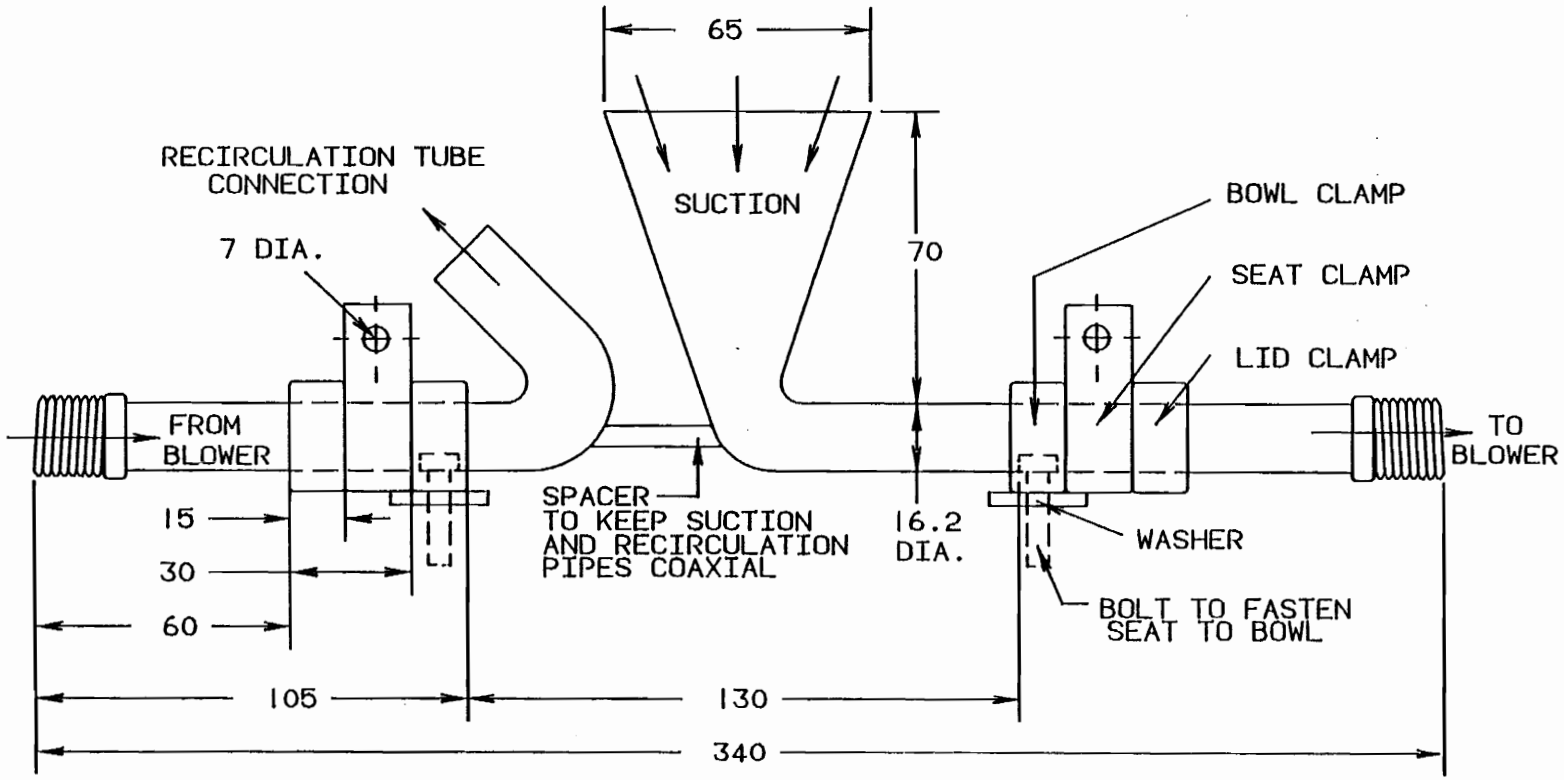


Figure 15. Hinge at Rear of Commode ALL DIMENSIONS ARE IN MILLIMETERS

Chapter 4 The Final Design

4.1 Overview

As a result of the previously discussed experimentation, a final design has been developed and a prototype built to eliminate all obnoxious fumes from the bowl without discomfort to the occupant. The unit is also easily adaptable to an existing commode. The commercial unit may differ in minor details from the prototype described here, however; the basic design is sound and accomplishes the ultimate purpose of this unit: the elimination of the odorous gases.

As shown in Fig. 16, the system is composed of three basic elements which are connected by plastic piping: the seat, the motor/blower unit, and the filter. It has been found that the introduction of air under pressure into the bowl alleviates much of the undesirable turbulence, resulting in more efficient suction at the bowl's rear. This idea has evolved into the recirculation of part of the deodorized gases from the blower's exhaust back into the bowl. Thus the seat is designed such that the suction's intake is at the seat's rear while the circumferential recirculation tube, distributing the reintroduced deodorized gases back into the bowl, is built into the underside of the seat. The blower which is in the center of the loop, is connected to the rear of the seat by way of poly-vinyl-chloride (PVC) pipes. The suction line starts at the suction piece in the seat from which

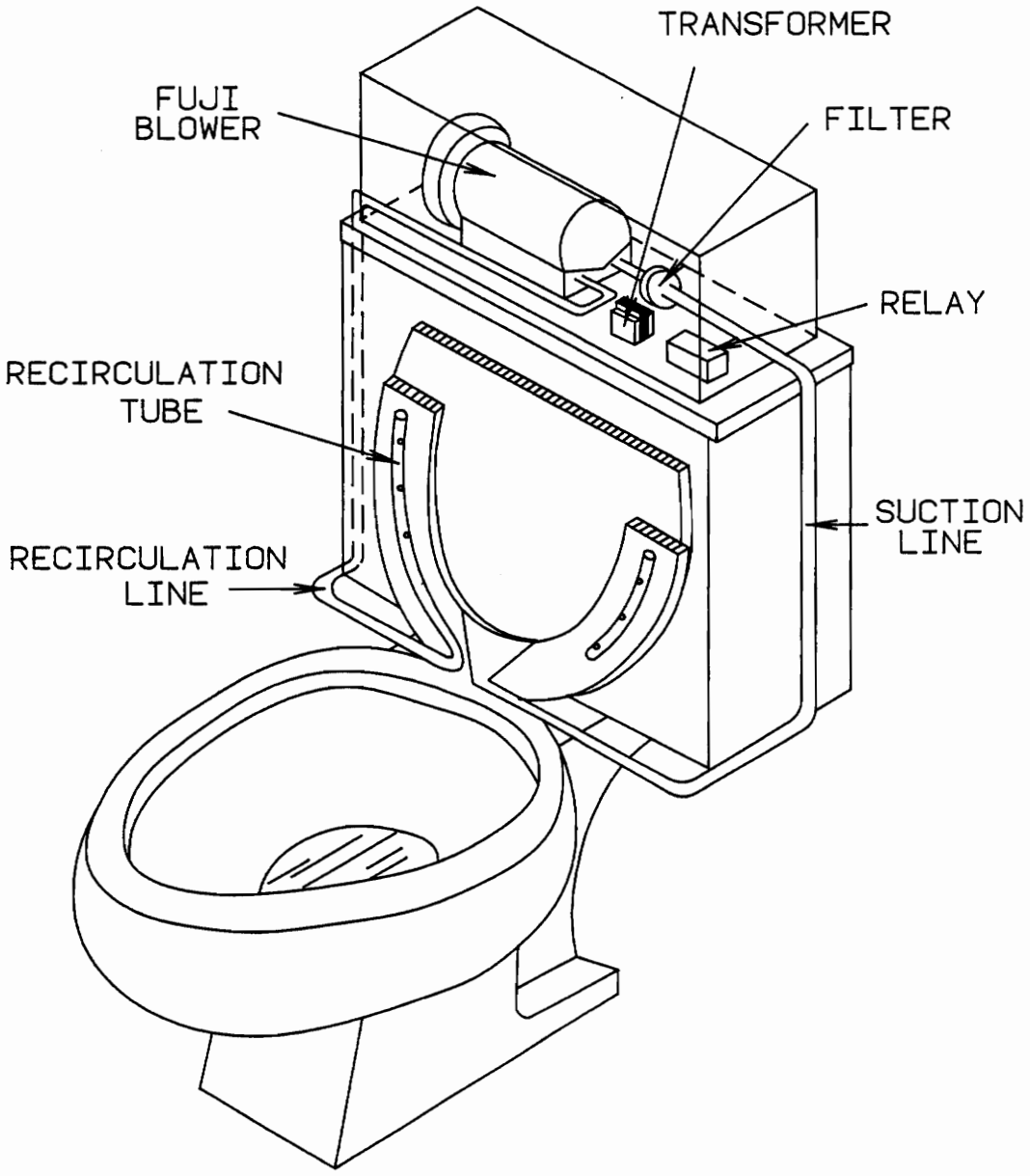


Figure 16. Final Design Of Odorless Toilet System

it goes to the filter and subsequently to the intake of the blower. This means that the gases entering the blower have already been deodorized by the filter. The blower's exhaust is connected to the recirculation tubing in the seat via the recirculation line. The by-pass holes are drilled into the recirculation line and partially covered by a moveable sleeve to create the proper amount of recirculation.

4.2 Seat Design

The design of the seat is shown in Fig. 17. It incorporates provisions for both suction and recirculation. A 0.5 inch by 2.5 inch rectangular to 3/4 inch round transition piece (the suction piece) which is a part of the hinge axle, is imbedded into the seat of the commode at its rear. Combining this suction intake with the recirculation of deodorized air, creates the flow pattern which removes the odorous gases most efficiently.

Recirculation is accomplished through circumferential 1/2 inch diameter tubing that is partially imbedded into the underside of the seat. The end of the tube is sealed, the recirculated air exits through a number of inward pointing holes drilled into this tube. Experimentation has shown that distributing the recirculated air around the perimeter of the bowl results in more efficient suction at the commode's rear. Furthermore, it has been found that having holes only along the front and sides of the seat, and angling them downward by 45 degrees into the bowl creates the most efficient flow patterns. Nineteen holes spaced 1.5 inches apart are drilled into this tubing. Thus, 27 inches of the 40 inch perimeter of the bowl is active in recirculation.

Since space at the rear of the seat is very crowded, recirculating air cannot be introduced symmetrically through both ends of the recirculation tube. Feeding air through only one end of the tube alleviates this problem but creates asymmetric recirculation because more air tends to flow out of the holes which are closer to the blower. To counteract this tendency, the diameters of the holes

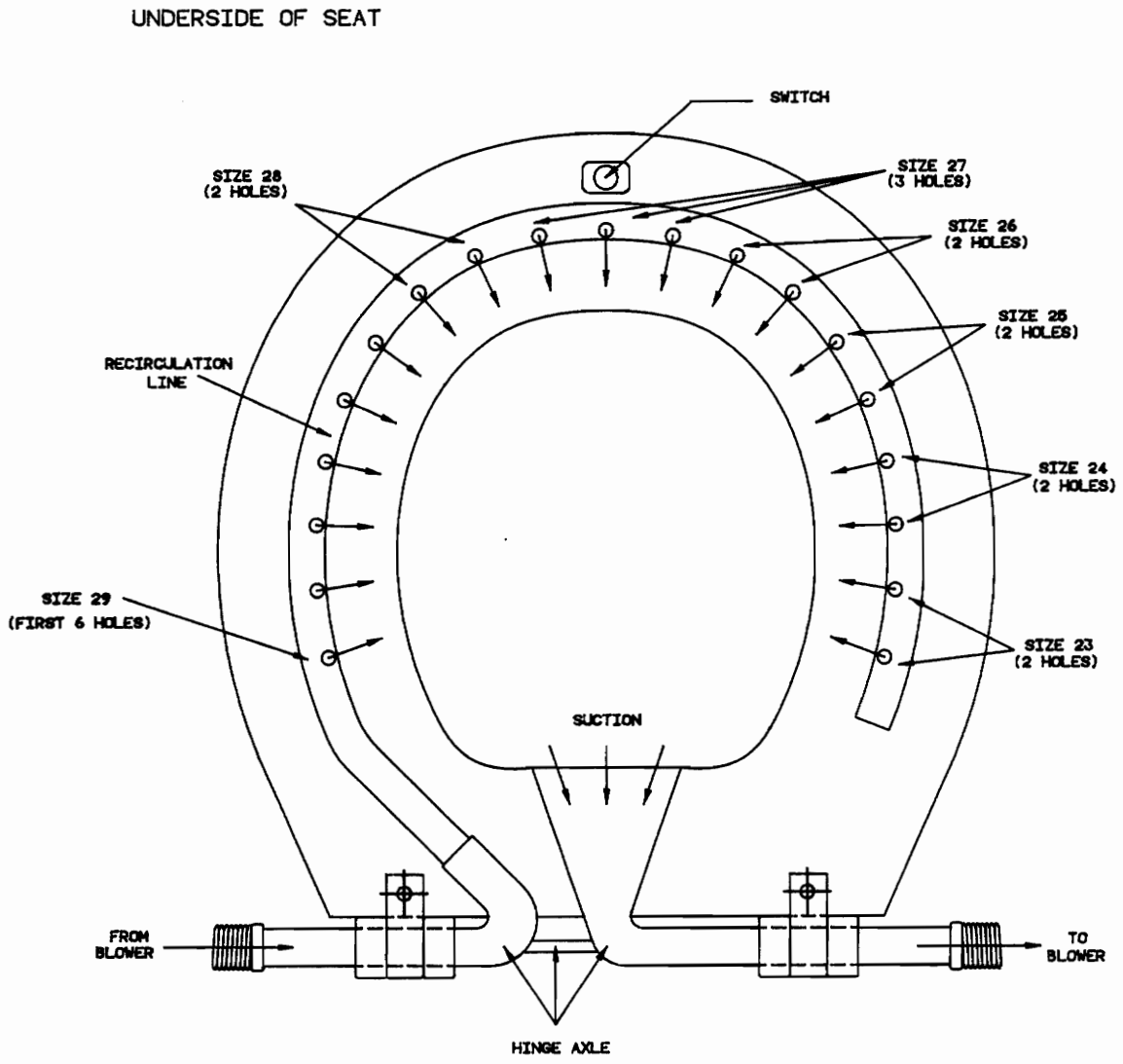


Figure 17. Seat Design

are increased with their distance from the blower. Each of the first six holes is drilled with a .1360 inch diameter (size 29) drill bit. From here the size of the holes increases as shown in Fig. 17 to .1540 inch diameter (size 23).

An integral part of the seat's design are the suction's as well as the recirculation line's connections to the piping leading to the blower. Both of these connections are rigidly attached to the seat and are combined into one unit, which also serves as the hinge axle of the seat and cover. Fig. 15 (page: 38) shows the hinge axle in detail. This piece, the hinge axle, is rigidly connected to the rear underside of the seat. The seat must be able to rotate between the down and upright positions. Therefore, the suction and recirculation connections of the hinge axle must also rotate with the seat.

Poly-vinyl-chloride piping connects the suction end of the hinge axle to the filter and ultimately to the blower's inlet. Likewise, PVC piping connects the blower's exhaust to the recirculation end of the axle. Since the PVC piping is stationary and the hinge rotates, two requirements are placed on the hinge axle:

1. The axis of rotation of the hinge axle must coincide with the axis of rotation of the seat. In addition, this axis of rotation must correspond to the centerline of the connecting PVC piping in order to keep the piping stationary;
2. the rotation of the hinge axle must not be impaired by the stationary PVC piping.

The hinge as shown in Fig. 15 (page: 38), fulfills the first of these requirements on the hinge axle. It consists of two sets of three separate clamps. A central clamp attaches the hinge axle rigidly to the seat. The inward clamp attaches the seat (et. al) to the porcelain part of the commode. The outward clamp attaches the lid of the toilet to the seat and thus ultimately to the rest of the commode. The inward and outward clamps constitute hinges; i.e. they rotate relative to the hinge axle, while the center clamp (and the seat) rotate together with the axle. These three clamps

together hinge the seat and lid and attach this assembly to the bowl. As in conventional toilets, two sets of hinges are used to keep the seat aligned with the bowl.

Fig. 18 shows the arrangement used to fulfill the second requirement on the hinge axle. By attaching a loosely tightened threaded coupling to each end of the hinge axle the rotation of this piece is not impaired by the PVC piping. Since the pressures encountered are low (less than 1 inch of water), no significant leakage will occur at these connections. Any leakage would be harmless anyway. If the suction side leaks, ambient air leaks into the suction line; a leak at the recirculation side would discharge deodorized air into the room.

4.3 The Switching Circuit

The electrical switch for activating the blower is also attached to the bottom of the seat (Fig. 14, page: 35). It is of a simple "normally off" mechanical type. The switch is located at the front of the underside of the seat. This corresponds to the greatest possible distance from the hinge at the back of the seat. The large arm afforded by this location allows for the greatest amount of travel in the switch's actuator. The somewhat flexible recirculation tubing acts like a spring, such that just the weight of the seat and lid will not activate the switch. The weight of the occupant is needed to close the switch, complete the circuit, and start the blower.

Fig. 19 shows the corresponding circuit diagram. Since the switch is in a location where accidental contact between it and the commode's occupant may occur, a 12 Volt system is used for the switching circuit. A "doorbell" transformer supplies the 12 Volt current for the switch. Depressing the switch closes the 12 Volt circuit which engages a relay. This relay completes the 110 Volt circuit which starts the blower.

The relay and the "doorbell" transformer as well as the blower are housed in a box, which is presently located on the tank of the commode. The advantage of placing the box on the top of the

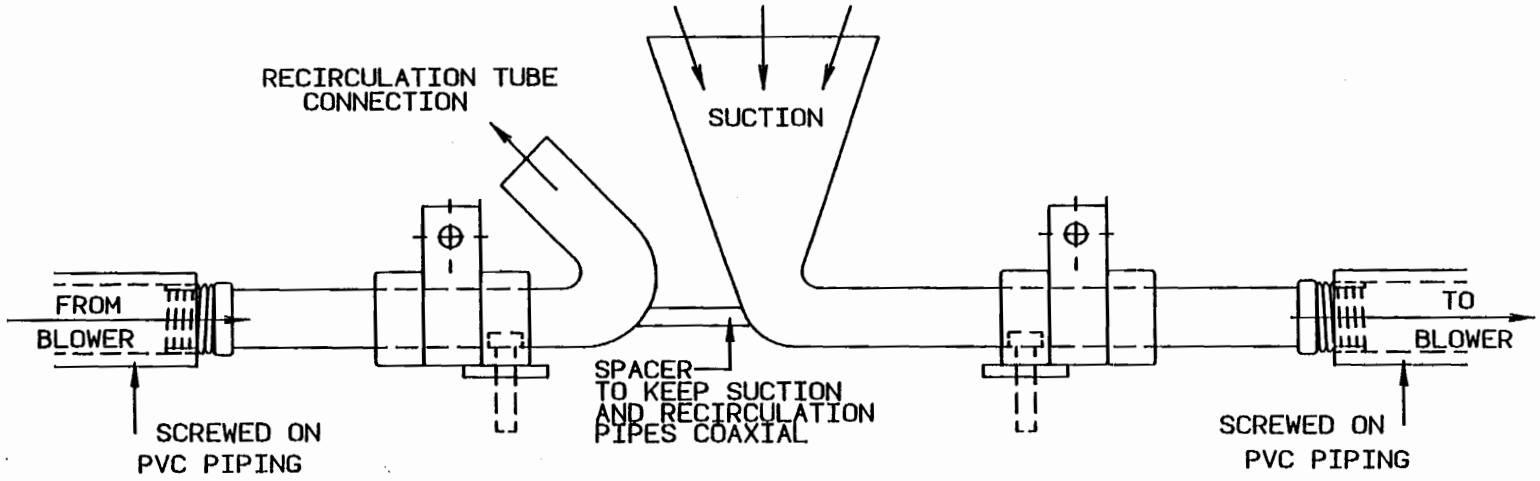


Figure 18. PVC Piping's Connections to the Suction/Recirculation Piece

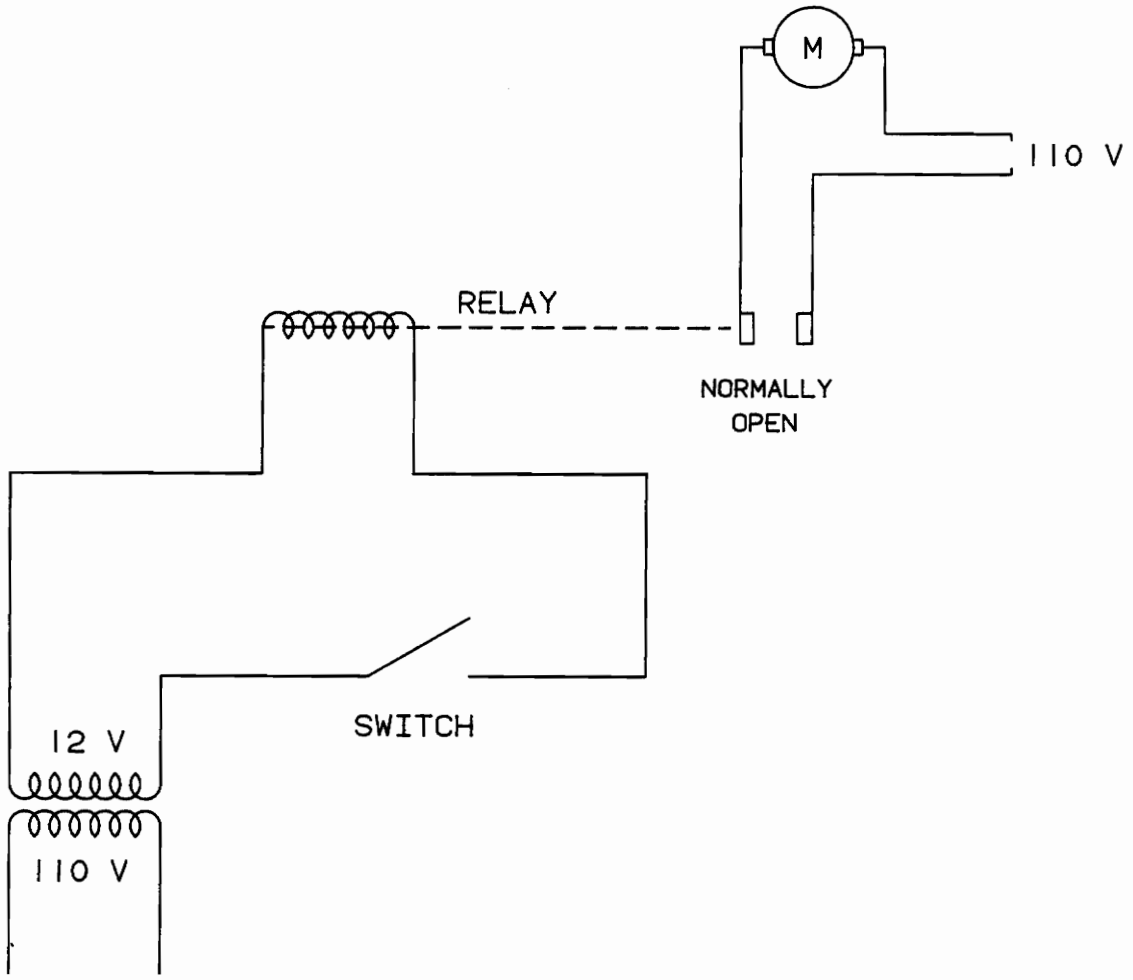


Figure 19. The Final Design's Switching Circuit

tank is that here the box does not get in the way of regular cleaning of the bathroom. It is, however, difficult to access the commode's tank with the box on top of it. By not cementing together (with PVC cement) the connections of the PVC piping to the blower's inlet and exhaust, the piping here is easily disconnected from the blower. At this point the box can be taken off of the tank.

4.4 The Blower

The motor/blower unit used in the final design is a Fuji Co. ring compressor: model VFC 083P. Fig. 20 shows the main dimensions of this blower in more detail. According to the manufacturer's literature [2], unlike most centrifugal type blowers, this unit does not simply hurl air radially out from a central point. The blower operates on a regenerative principle which allows it to produce the high discharge pressure and inlet vacuum desired. Air entering through an inlet port is accelerated by the impeller. This air, thrown against the impeller housing by centrifugal force, is reflected back off the housing to be struck again by the impeller blades. This process is repeated by the next blade compounding the energy and acceleration imparted to the incoming air. Fig. 21 shows this schematically. The motor runs on 110 Volt household current at 60Hz. According to reference [2] the blower is rated for 20 CFM at 0 inches water static pressure and 0 CFM at 20 inches water static pressure on the delivery (pressure) side (delivery measurement was made with only the output port throttled). On the suction side the rating is 20.1 CFM at 0 inches water static pressure and 0 CFM at 19 inches water static pressure (suction measurement was made with the only the input port throttled). In our system the unit produces 1.60 CFM at 0.1 inches water static pressure in the recirculation tube and 0.1 inches water vacuum on the suction side. As seen in Fig. 12 (page 31), the pressure rise across the blower associated with this flow rate is 17.7 inches of water, which is within the performance limits of the Fuji blower.

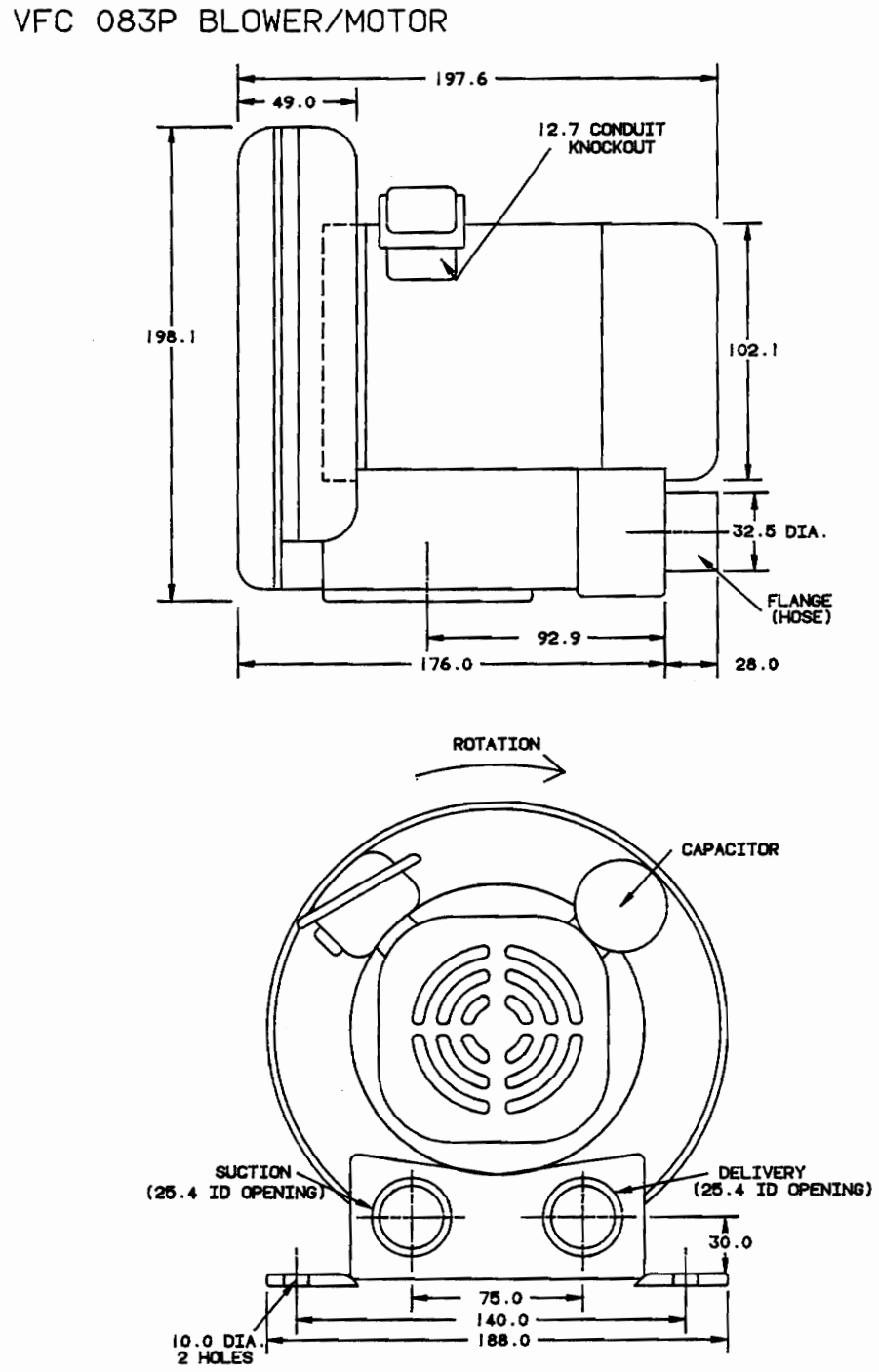


Figure 20. Fuji Co. Model VFC 083P Blower

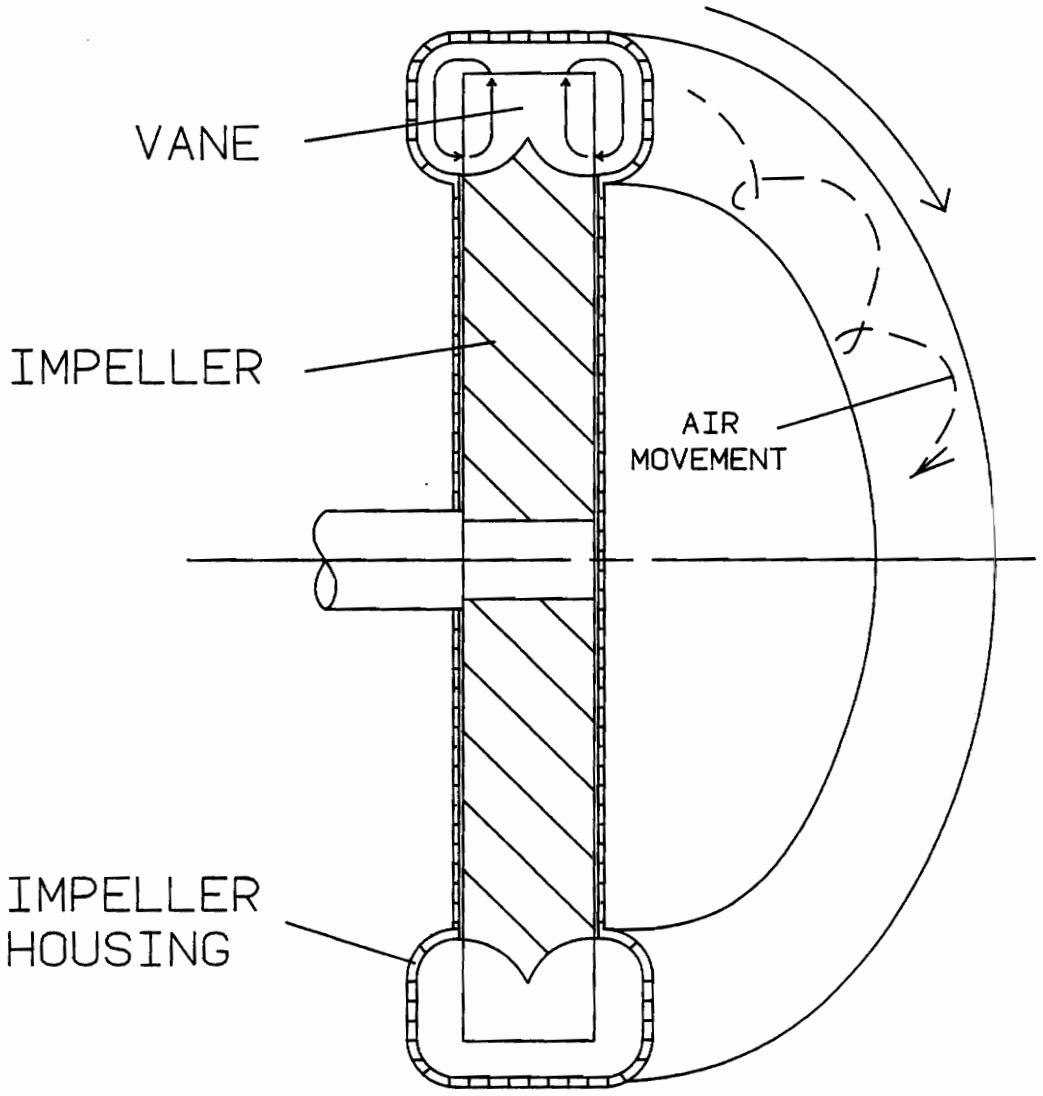


Figure 21. Sketch of Fuji Blower's Impeller Blades

4.5 The Suction and Recirculation Lines

Both the suction and the recirculation lines are made of common poly-vinyl-chloride piping. In order to offer the user some control over the amount of suction from the bowl, a sleeved section of piping is included in the suction line as shown in Fig. 22. By sliding the sleeve back a series of holes is gradually uncovered which causes air to be taken in from the ambient. Since the blower continues to take in essentially the same amount of air, the amount taken out of the bowl decreases as the bypass opening is increased.

The sleeve on the recirculation line is also shown in Fig. 22. As discussed earlier, too much recirculated air is detrimental to the efficiency of the suction. With too much recirculation, flow patterns are created in the bowl which hinder the removal of the gases. For this reason, a sleeved section of PVC piping has also been added to the recirculation line. Here 11 holes were drilled into a section of the recirculation line with a .1770 inch diameter (size 16 wire gage drill). The sleeve can be moved to adjust the amount of deodorized air that is not recirculated into the bowl. Half of 11 holes exposed seems to be the optimum setting for our test unit. At this setting enough air is recirculated to enhance efficient flow patterns without introducing more air into the bowl than is necessary.

4.6 The Filter

The filter's location relative to the blower is shown in Fig. 23. The filter currently being used is manufactured by the North Safety Company: No. N-7500. This is a conventional gas mask filter used to protect the bearer against organic gases and odors. It was chosen because of all the filters tested which successfully eliminated the odors, this filter had the lowest internal resistance. Lower static pressure requirements ultimately result in a less expensive blower unit.

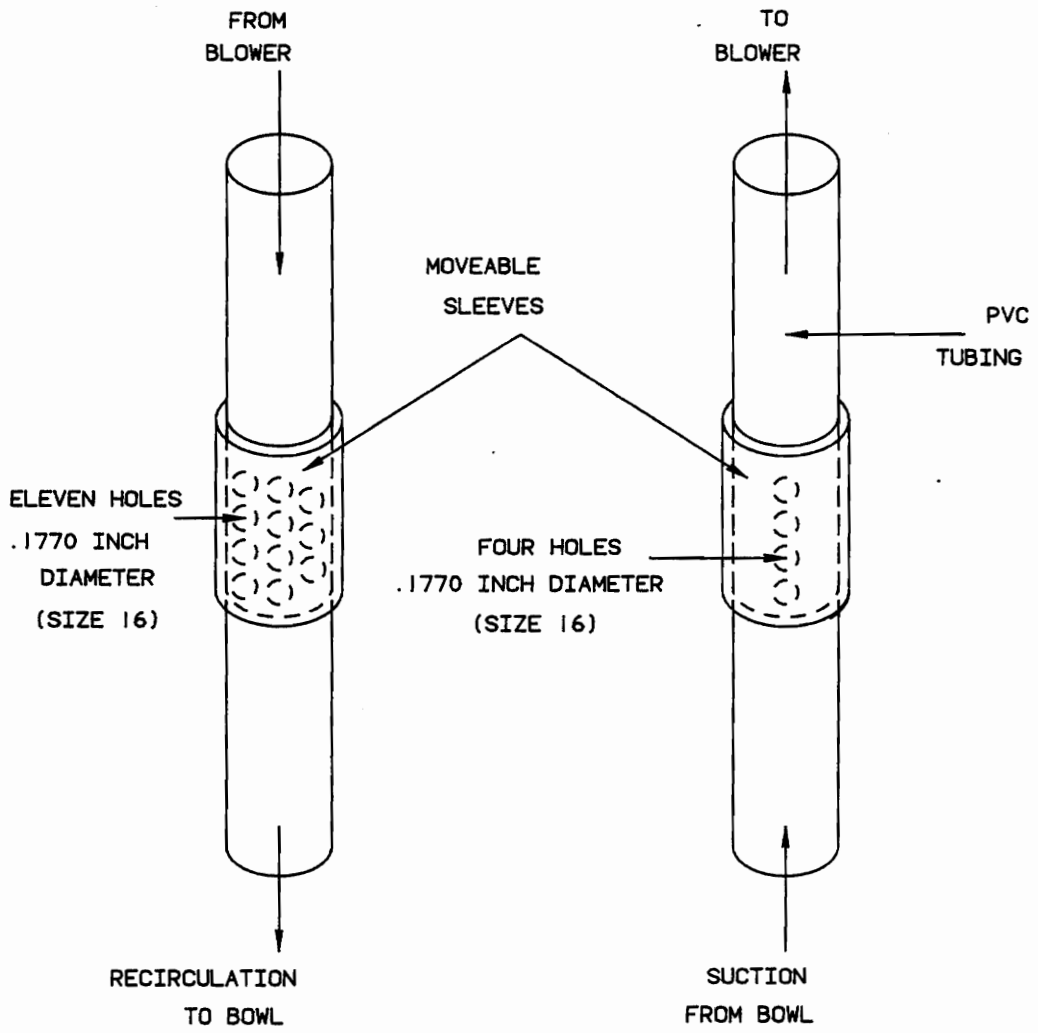


Figure 22. Sleeves on the Suction and Recirculation Lines

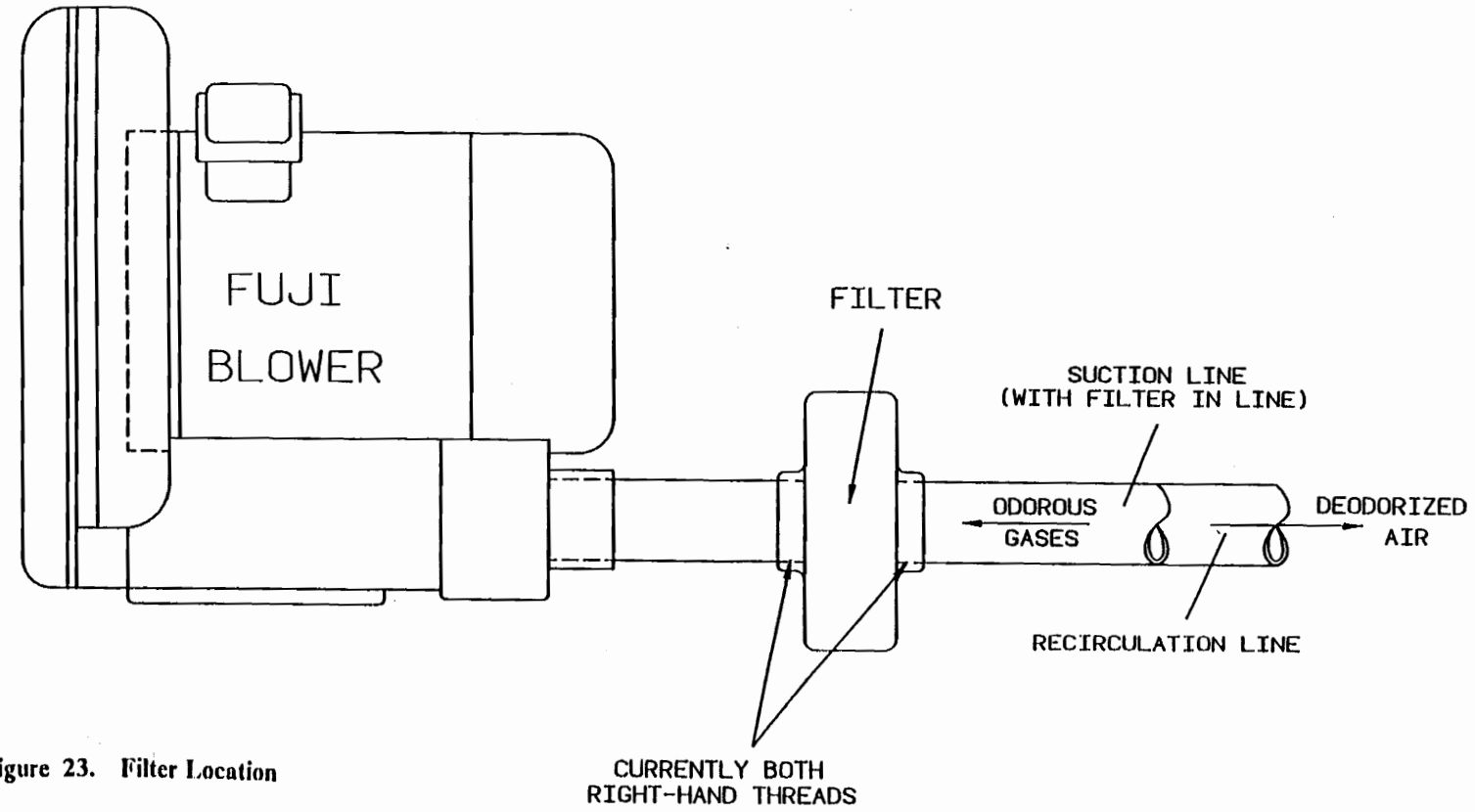


Figure 23. Filter Location

The filter's plastic shell is filled with charcoal granules that deodorize the gases. One side of the filter's housing has 3/4 inch pipe thread already in place. To the other side a similar section of plastic from another N-7500 filter was epoxied making the filter easy to install into the present system.

Chapter 5 Conclusions and Recommendations

5.1 Overview

Through a trial and error process, a system has been developed which removes and neutralizes odorous gases from a commode. The original assumption, that reintroducing a part of the deodorized gases back into the bowl would lead to more efficient suction at the bowl's rear, has been substantiated. Tests conducted in the laboratory with organic odors as well as actual use of the unit installed into an existing toilet, confirmed that odors are removed before they can contaminate the ambient air and be offensive to the commode's occupant. Since all essential functions are performed either within the seat or completely external to the toilet proper, the unit can easily be retrofitted to any commode by replacing the existing seat.

5.2 The Seat

The prototype configuration has been developed through trial and error. With the present system's 1.6 CFM suction and 0.5 CFM recirculation the time to evacuate the bowl is reduced to

approximately 25 seconds. More suction is not possible due to constraints imparted by the blower, less suction is not desirable as it would increase evacuation time (the volume in the bowl is approximately 0.5 cubic feet). More recirculation results in a resurgence of turbulence in the bowl, which causes gases to leak through the openings that exist between the seat and the bowl. Less recirculation increases the time to evacuate the bowl since gases which are located at the front of the bowl must be moved towards the suction piece at the rear of the bowl with little help from the incoming recirculated air. Thus, as originally anticipated, most of the deodorized gases by-pass the recirculation line; only approximately 30% of the filtered gases are reintroduced into the bowl.

5.2.1 Recommendations for the Seat's Design

It is recommended that a seat as thick as possible be used. With the implantation of the 1/2 inch thick suction piece into the seat, the strength of a thin seat would be severely reduced. The recirculation could possibly be improved, not only with the use of a tube which forms a better seal between the seat and the bowl, but also by further experimentation into the effects of angling the holes down into the bowl. At present these holes are angled into the bowl by 45 degrees, further investigation of the effect of various angles on the flow pattern may be useful.

It is also recommended that a slight alteration in the switching mechanism be made. The Vent-Away unit has been criticized by us for the interruption in the venting process which necessarily takes place when flushing commences. Our unit has a similar, though less extreme problem. The unit can be flushed without interrupting the odor removal process, so long as the occupant remains on the seat. Once weight is taken off the seat, however, odor removal ceases. Therefore, any odor still in the bowl when the occupant gets up is emitted into the bathroom. This is unpleasant to the bathroom's next occupant. It would be possible to incorporate a "delay-off" relay into the system in place of the existing relay of the actuating circuit. This could delay the

shut-off of the blower for a period of time, perhaps 10 seconds, after the occupant has left the commode. During these ten seconds the odors would continue to be trapped by the suction (though not as effectively as before since there is now much more area for the odors to escape through the top of the seat that is exposed if the lid is not closed).

Better yet, this problem could also be alleviated by repositioning the switch, currently located beneath the seat. At present, the weight of the commode's occupant depresses the switch and activates the blower, thus causing the interruption of the odor removal when the occupant leaves the seat. Instead, a toggle-switch could be mounted to the tank of the commode or perhaps to the blower's box and manually activated. Disengaging the switch would terminate the odor removal process. Though this would eliminate some of the automation of the present design, various advantages would result. The suction could be interrupted at any time, or if one so desired, not used at all. The relay, which adds 20 dollars to the price of the current design, could be eliminated because the switch could be directly placed into the 110 Volt supply line to the blower. The transformer, which adds 10 dollars to the price of the current design, would also be eliminated since there would be no need for a 12 Volt circuit; the occupant would be in no danger of coming in contact with the wires.

It is possible that the suction and recirculation lines will, through regular use, become partially clogged with solid material thus diminishing the effectiveness of the system. It may therefore be necessary to make the unit easier to clean. The suction piece could have a screen or filter of its own implanted into it. Such a screen, positioned inside the suction piece, could be clamped to the suction piece's inlet and thus be easily removed from the seat for replacement. Soiling from the inside of the hinge axle as well as from the recirculation tube could be washed out by passing water, perhaps from a garden hose, through the hinge axle's connections. Pipe thread to garden hose thread connections are available and could be used to connect the hinge axle to a garden hose. In order to clean the PVC tubing, to expose the hinge axle, and to replace the filter, one should be able to disconnect the PVC tubing easily at various strategic points. Since the pressures in the

system are low, it would be possible to connect the PVC piping without the use of PVC cement at these locations.

5.3 The Blower

In the early stages of this research, it was thought that 0.5 inches of water of suction at the exit from the suction piece would be needed to properly evacuate the odorous gases from the bowl. This early experimentation was performed with a large shop vacuum as the suction source. With the incorporation of the recirculation tube, suction requirements were reduced. The current blower produces only 0.1 inches of water of suction, corresponding to a flow rate of 1.6 CFM. The Herbach and Rademan blower (Herbach and Rademan No. TM24K586), on which actual odor removal tests were performed by installing the unit into an existing commode, also produces approximately the same amount of suction. Though no actual odor removal tests were performed with the Fuji blower, the fact that its flow rate is slightly higher than that of the Herbach and Rademan (H + R) blower, which successfully removed all odors, assures that the Fuji blower would be at least as effective as the H + R blower at deodorizing the bowl.

At present there are two different prototypes: one driven by the 110 Volt Fuji blower, the other by the 6.5 Volt H + R blower. The Fuji blower is recirculating 0.5 CFM (30% of its suction capacity) back into the bowl. This amount of recirculation was determined by trial and error to minimize the time to evacuate the bowl. The H + R blower required 0.7 CFM of recirculation to evacuate the bowl most efficiently. This is due to the differing recirculation tube configurations used in the two prototypes. The H + R blower had a recirculation line with 19 holes varying in pairs. The first two were .1200 inch diameter (size 31), the next two were .1285 inch diameter (size 30) and so on, the last two were .1540 inch diameter (size 23). The odd holes in the center, like the two on either side of it was .1440 inch diameter (size 27). This recirculation tube has since been discarded, however, all tests done on the H + R blower were performed with this recirculation tube.

The Fuji blower's recirculation tube has a similar configuration, except that the first 6 holes are all the same size. In addition, it was noted that the recirculation tube in the H+R blower's configuration was offset from center by 1/2 inch. The combination of these two differences resulted in the differing recirculation requirements of the two configurations. The optimum fraction of recirculation seems to be very sensitive to the configuration of the recirculation tube.

5.3.1 Recommendation for the Blower

The time to evacuate the bowl could be decreased by increasing the intensity of suction. However, a point will be reached where the suction and corresponding recirculation will be unpleasant for the commode's occupant. Experimentation on the system with large, commercial shop vacuums has revealed that 5 CFM of suction is easily noticeable. In addition, the increased cost of a larger blower is not warranted since no gain in the effectiveness of the system is observed by increasing the suction. Slightly less suction may be tolerated; however, difficulties will arise in finding a blower capable of fulfilling the static pressure and flow rate requirements simultaneously.

It is recommended that the box, which houses the blower, the relay, and the doorbell transformer, be made of a soundproofing fiberglass. Though the Fuji blower is not noisy, any attenuation in the noise would be beneficial. It is possible to further attenuate the noise of the unit by situating the box away from the commode's occupant, perhaps on the floor behind the commode. This, however, would complicate the regular maintenance of the bathroom, the box could well get in the way. In addition, not enough space may be available in existing bathrooms to accommodate the box behind the toilet, nor would it be possible to mount a manual switch (should this be desired) onto the box if it is located in such a difficult to reach position. Placing the box on top of the toilet's tank keeps it out of the way and makes it easy to mount and use a remote switch. In turn, it increases the noise of the unit for the commode's occupant, as well as increasing the difficulty in accessing the tank of the toilet. Since the blower is not noisy and the frequency at which the

commode's tank is accessed is very small, it is recommended that the box be placed on top of the toilet's tank. Since all connections are of PVC piping, which is easily formed to any configuration, this detail could be left up to the individual purchaser of the unit.

The present Fuji blower has inlet and outlet ports on the same side of the blower making it difficult to create a symmetrical unit with the suction line on one side of the commode and the recirculation line on the other. Since it is more aesthetically pleasing to have a symmetrical system, the recirculation line has been rerouted inside the blower's box to emerge from the opposite side of the suction line. A blower with its inlet and outlet on opposite side would avoid this troublesome rerouting.

5.4 The Filter

This system is one of the firsts to incorporate a charcoal filter into its design. Though no information is available to determine the life of the filter element, its moderate cost ($5.00) makes replacement relatively inexpensive. It has been found that activated charcoal granules eliminate the organic odors encountered. This research concentrated on finding a filter among the multitude of this basic design, with a relatively low restriction to air flow. This would enable the manufacturer to use a blower with lower static pressure requirements, and ultimately to reduce the cost of the system. Though various filter companies, including Norelco, American Optical, Geberit, and the North Safety Co. were contacted, there might exist a filter which is as effective at removing the odors of interest as the one used, but with an even lower internal resistance. Finding such a filter may allow the use of a less powerful blower.

5.4.1 Recommendations for the Filter

The current filter must be modified before it can be incorporated into a marketable system. Only one end of the filter unit has a pipe threaded opening, therefore attaching pipe to the other end of a stock filter is not possible. A threaded opening had to be mated to the end of the filter which was lacking this opening. Only conventional right handed threads were available. Making this opening with a left-handed pipe-thread would enable the user to quickly exchange the filter, because both connecting pipes could engage or disengage simultaneously, depending upon the direction in which the filter is rotated. This would simplify the replacement of the filter. It should also be noted that the filter's pipe threads are of 3/4 inch diameter; the PVC pipe is of 1/2 inch diameter. The connections between the filter and the blower could be simplified with the use of a filter having 1/2 inch diameter pipe threaded openings.

List of References

1. Cortes-Comerer, Nhora. **In Search of the Perfect Flush.**, Mechnical Engineering Magazine, Feb. 1988, pp.40-47
2. Fuji Electric, Technical Guide to **Fuji Ring Compressors.**, Fuji Electric Corp. of America, Frassetto Industrial Park, 6A Frassetto Way, Lincoln Park, N.J. 07035

Appendix A. Patent Listing

Taken from **The Official Gazette of the United States Patent and Trademark Office,** Newman Library, VPI&SU.

- Patents listed in reverse chronological order.
- Copies of all patents marked with a * were provided in full by Sunrise Engineering

1. **4,556,999 Apparatus for Removing Noxious Fumes and Gases From a Commode Bowl and Preventing Their Escape to the Immediate Vicinity.** John E. Lindley, 1410 20th Ave., Meridian, Miss. 39301. Filed Nov. 15, 1984, Ser. No. 671,787. Int. Cl. EO3d 9/05; Eo3d 9/052; A47k 13/00. U.S. Cl. 4-217. 16 Claims *

2. **4,551,867 Toilet Bowl Which Washes.** Joseph Gurevich, and Alex Gurevich, both of 64-49 99 St., Forest Hills, N.Y. 11374. Filed Nov. 4, 1983, Ser. No. 549,207. Int. Cl. A47k 4/00, 3/20. U.S. Cl. 4-420.4. 14 Claims

3. **4,472,841 Bathroom Air Sanitizer and Deodorizer** David L. Faulkner, Rte.2, Box 54-A, Pevely, Mo. 63070. Filed Mar. 22, 1982, Ser. No. 352,113, Int. Cl. EO3d 9/05, U.S. CL. 4-213. 1 Claim.

4. **4,442,555 Toilet Bowl Odor Removing Suction Control** Yoshitaka Aoyama, 20-11 Makitsukadai 2-chome, Sakai-Shi, Osaka 590-01, Japan. Filed Jun. 3, 1981, Ser. No. 269,973. Claims priority, application Japan, Jul. 6, 1980, 55-76812. Int. Cl. EO3d 9/05, U.S. Cl. 4-213. 3 Claims.

5. **4,439,874 Watercloset Rim and Venting Process Therefor** Donald C. Schrock, Carmel, Ind., assignor to Masco Corporation of Indiana, Taylor Mich. Filed Sept. 7 1982, Ser. No. 415,355. Int. Cl. EO3d 3/00. U.S. Cl. 4-300. 19 Claims. *

6. **4,433,443 Self-Contained Flow Through Sewage Waste Disposal System.** Kenneth J. Degraw, Montvale; Brian Wilcockson, Wayne; Earl W. Nickerson, Ocean City; William R. Bocchini, Wyckoff; Armen Bogossian, Teaneck; and Steve Proios, Northvale, all of N.J. Assignors to American Standard Inc., New York, N.Y. Filed Nov. 12, 1981. Ser. No. 320,599, Int. Cl. EO3d 5/019, U.S. Cl. 4-213. 12 Claims.

7. **4,433,441 Water Closet-Odor Neutralizer.** Warren C. Schroeder, Gellett Suite d-603, 2400 Virginia Ave. NW., Washington, D.C. 20037. Filed Dec. 30, 1981, Ser. No. 335,846, Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 6 Claims.

8. **4,402,091 Toilet Evacuation Device.** William D. Ellis, 4702 W. Maukling Ave. and Raila S. Ellis, 4704 W. Maukling Ave., both of Las Vegas, Nev. 89119. Filed Jul. 9, 1983, Ser, No, 396,923, Int. Cl. EO3d 9/05, U.S. Cl. 4-217. 8 Claims.

9. **4,393,524 Self-Contained Sewage Waste Disposal System.** Clifton F. Briner, Lafayette, Ind.; William R. Bocchini, Wyckoff, and Brian Wilcockson, Long Beach Island, both of N.J., assignors to American Standard Inc., New York, N.Y. Filed Nov. 12, 1981, Ser. No. 320,595, Int. Cl. EO3d 5/016, U.S. Cl. 4-317. 10 Claims.

10. **4,375,704 Unitary Assembly for Attachments to a Toilet for Ventilating the same.** Donald L. Smith, 452 Nassau, Bolingbrook, Ill., 60439. Continuation of Ser. No. 124,221 Feb. 25, 1980, abandoned. This application Apr. 28, 1982, Ser. No. 372,544. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 2 Claims.

11. **4,365,361 Toilet Bowl Odor Educting and Powered Exhaust System.** Grant H. Sanstrom, P.O. Box 138, Parker, Wash., 98939. Filed Mar. 23, 1979, Ser. No. 23,246. Int. Cl. Eo3d 9/052, U.S. Cl. 4-213. Claims.

12. **4,344,194 Toilet Seat and Lid Unit with Concealed Air Deodorizer.** Raymond H. Pearson, 627 Sherwood Dr., Richardson, Tex., 75080. Filed Dec. 12 1980, Ser. No. 215,801. Int. Cl. EO3d 9/04, U.S. Cl. 4-213. 6 Claims.

13. **4,318,194 Vented Toilet.** Jack D. Williams, P.O. Box 198, Gold Bar, Wash., 98251, and Howard V. Banasky, 1401 N. 26th, Renton, Wash., 98055. Filed Oct. 31, 1979, Ser. No. 89,763. Int. Cl. EO3d 9/04, 9/052, U.S. Cl. 4-213. 11 Claims.

14. **4,317,242 Device For the Removal of Foul Air From Toilet Bowls and the Like.** Robin H. Stamper, 1891 Westbourne Rd., Bryanston, Transvaal Province, South Africa. Filed Sept. 28, 1979, Ser. No. 80,014. Claims priority, application South Africa, Sept. 29, 1978, 78/5539. Int. Cl. EO3d 9/04, U.S. Cl. 4-213. 6 Claims.

15. **4,301,555 Replacement Filter For Deodorizing the Air From a Toilet Bowl.** Clarence E. Poister, P.O. Box 12232, Whichita, Kans. 67209. Filed May 27, 1980, Ser. No. 153,609. Int. Cl. A47k 13/00; EO3d 9/04. U.S. Cl. 4-217. 8 Claims. *

16. **4,251,888 Ventilating Toilet Seat.** William F. Turner, Box 156, Brandburg, Pa., 16619. Filed Apr. 20, 1979, Ser. No. 31,824. Int. Cl. EO3d 9/052; A47k 13/24, U.S. Cl. 4-213. 3 Claims.

17. **4,232,406 Water Closet Ventilating System with Vacuum Breaker Valve.** Lester R. Beeghly, and George E. Gilchrist, both of 4400 N. Paulins Ave., Chicago, Ill. 60640. Filed May 18, 1979, Ser. No. 40,432. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 8 Claims.

18. **4,222,129 Odor Extracting Apparatus and Combination Thereof with Toilet.** Ivan M. Baker, Martinez Castro 271, 407 Buenos Aires, Argentina. Filed Feb. 26, 1979, Ser. No. 15,549. Int. Cl. A47k 3/22; EO3d 9/04,13/00, U.S. Cl. 4-213. 7 Claims.

19. **4,202,061 Lavatory Wastewater Disposal System for Aircraft.** Kenneth I. Waters, Federal Way, Wash., assignor to The Boeing Company, Seattle Wash. Filed Dec. 29, 1978, Ser. No. 974,365, Int. Cl. EO3d 5/016 , U.S. Cl. 4-317. 28 Claims.

20. **4,200,940 Toilet Seat Volatile Gas Incinerator.** Wes Buchanan, 2703 Pine Ave., Manhattan Beach, Calif. 90266. Filed Nov. 13, 1978, Ser. No.986,463. Int. Cl. EO3d 9/05. U.S. Cl. 4-348. 4 Claims *

21. **4,175,545 Toilet Stool Ventilating Device.** Clarence E. Smith Jr., 1372 E. 107th St. Los Angeles, Calif. 90002. Filed July 13, 1978, Ser. No. 929,721. Int. Cl. A47k 13/00; EO3d 9/04. U.S. Cl. 4-217. 2 Claims

22. **4,175,293 Toilet Bowl Odor Removing Apparatus and Hinge.** Warren J. Stephens, 2970 S. 1735 East, Salt Lake City, Utah 84115. Filed Feb. 6, 1978, Ser. No. 875,215. Int. Cl. EO3d 9/05; A47k 13/00. U.S. Cl. 4-209 R. 1 Claim

23. **4,174,545 Toilet Stool Ventilating Device.** Clarence E. Smith, Jr., 1372 E. 107th St., Los Angeles, Calif. 90002. Filed Jul. 31, 1978, Ser. No. 929,721. Int. Cl. A47/k 13/00, EO3/d 9/04, U.S. Cl. 4-217. 2 Claims. *

24. **4,168,553 Toilet Odor Eliminating Device.** Carl W. Studer, 1307 Mill St., Midland, Mich. 48640. Filed May 12, 1978, Ser. No. 905,141. Int. Cl. EO3d 9/05. U.S. Cl. 4-348. 3 Claims *

25. **4,166,298 Deodorizer For Toilets.** Raymond H. Pearson, 627 Sherwood Dr., Richardson, Tex., 75080. Continuation-in-part of Ser. No. 742,218, Nov. 15, 1976, abandoned, which is a continuation-in- part of Ser. No. 659,961, Feb. 20, 1976, abandoned. This application Jan. 16, 1978, Ser. No. 869,815. Int. Cl. A47k 3/22; EO3d 9/04, 13/00, U.S. Cl. 4-213. 2 Claims.

26. **4,165,544 Odorless Toilet Stool.** Bill H. Barry, P.O. Box 607, Bartlesville, Okla. 74003. Filed May, 15, 1978, ser. No. 905,727. Int. Cl. EO3d 9/04, 9/05, U. S. Cl. 4-213. 2 Claims.

27. **4,153,956 Toilet Deodorizing Device.** Raymond C. Fischer, Sr., 525 Foster St., Marlin, Tex. 76661, and Raymond C. Fischer, Jr., R.R. #3, Box 135, Denton, Md. 21629. Filed Dec. 15, 1977, Ser. No. 861,849. Int. Cl. EO3d 9/04; F24h 3/04, U.S. Cl. 4-213. 7 Claims.

28. **4,133,060 Odorless Toilet.** Wayne Webb, 7531 Mountain Ave., Orangevale, Calif., 95662. Filed May 18, 1977, Ser. No. 797,948. Int. Cl. EO3d 9/052; FO4d 25/14c; GO5d 13/10, U.S. Cl. 4-216. 2 Claims.

29. **4,103,370 Odorless Water Closet.** Douglas L. Arnold, 111 Sorento Dr., Holland, Mich. 49423. Filed Sept. 13, 1976, Ser. No. 722,696. Int. Cl. EO3d 9/04; A47k 13/00, 3/22, U.S. Cl. 4-213. 4 Claims

30. **4,094,023 Ventilated Toilet Seat.** Donald L. Smith, P.O. Box 206, Salem, Ill. 62881. Filed Dec. 11, 1975, SEr. No. 639,772. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 7 Claims.

31. **4,087,871 Ventilated Toilet.** Johannes Benthin, Bremerhaven Germany, assignor to MFB Neuwerk Mechanische Fensterbehaengung Gmbh, Bremerhaven, Germany. Filed Mar. 8, 1976, Ser. No. 664,805. Int. Cl. EO3d 9/05; A47k 13/30. U.S. Cl. 4-217. 19 Claims *

32. **4,085,470 Ventilated Toilet Device.** George Roberts, 2219 Edward St., Regina, Canada. Filed Jan. 14, 1977, Ser. No. 759,421. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 6 Claims.

33. **4,071,915 Water Closet Seat Warmer and Ventilator.** Kuze Kurataro, No. 37-5, 1-chome, Sasazuka, Shibuya, Tokyo, Japam. Filed Aug. 16, 1976, Ser. No. 714,836. Claims priority, application Japan, Jan. 9, 1975, 50-105010. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-217. 1 Claim.

34. **4,059,857 Free Standing Toilet Stool Ventilating Device.** Clarence E. Poister, 2934 Lydia, Apt. 103, Topeka, Kans. 66614. Filed Dec. 20, 1976, Ser. No. 752,470. Int. Cl. A47k 3/22; EO3d 9/04, 13/00, U.S. Cl. 4-213. 9 Claims.

35. **4,044,408 Deodorizing Accessary for Water Closets.** Raymond H. Pearson, 627 Sherwood Dr., Richardson, Tex. 75080. Filed Sept. 27, 1976, Ser. No.727,174. Int. Cl. EO3d 9/05, 9/04; A47k 3/22, U.S. Cl. 4-213. 5 Claims.

36. **4,031,574 Timed Ventilator for Toilets.** Frank D. Werner, Box 5129, Jackson, Wyo. 83001. Filed June 17, 1976, Ser. No. 697,139. Int. Cl. EO3d 9/04, 13/00; A47k 3/22, U.S. Cl. 4-213. 8 Claims.

37. **4,017,916 Toilet Ventilator Including Motion-Responsive Electrical Transducer.** Raymond H. Pearson, 627 Sherwood Dr., Richardson, Tex., 75080. Continuation-in-part of Ser. No. 540,538, Jan. 13, 1975, Pat. No. 3,942,200 which is a continuation-in-part of Ser. No. 496,954, Aug. 13, 1974, Pat. No. 3,939,506. This application Dec. 4, 1975, Ser. No. 637,646. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 2 Claims.

38. **4,011,608 Toilet Deodorizer.** Raymond H. Pearson, 627 Sherwood Dr., Richardson, Tex. 75080. Continuation-in-part of Ser. No. 434,519, Jan. 18, 1974, Pat. No. 3,927,429. This application Dec. 22, 1975, Ser. No. 643,596. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 6 Claims.

39. **4,007,498 Ventilated Toilet Including Overflow Sensor.** Raymond H. Pearson, 627 Sherwood Dr., Richardson, Tex. 75080. Filed Jan. 5, 1976, Ser. No. 646,570. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 1 Claim.

40. **3,999,225 Ventilated Toilet.** Eugene O. Abies, 1200 Lower Silver Lake Rd., Topeka, Kans. 66608. Filed June 25, 1975, Ser. No. 590,301. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 8 Claims.

41. **3,953,901 Toilet Stool Ventilating Means.** Clarence E. Poister, Topeka, Kans., Phillip A. Tyrell, Knasas City, Mo., and Walker D. Hodge, Shawnee Mission, Kans. Assignors to PK Products/Inc., Wichita, Kans. Filed Feb. 11, 1974, Ser. No. 441,452. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 4 Claims.

42. **3,942,200 Odor Control Ventilator.** Raymond H. Pearson, 627, Sherwood Dr., Richardson, Tex. 75080. Filed Jan 13, 1975, Ser. No. 540,538. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 11 Claims.

43. **3,939,506 Odor Control Ventilator.** Raymond H. Pearson, 627 Sherwood Dr., Richardson, Tex. 75080. Continuation-in-part of Ser. No. 434,519, Jan. 18, 1974. This application Aug. 13, 1974, Ser. No. 496,954. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 12 Claims.

44. **3,938,201 Ventilator for a Toilet Bowl.** Dan McGraw, 533 Crockett St., Grand Prairie, Tex. 75050. Filed Nov. 4, 1974, Ser. No. 520,663. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 5 Claims.

45. **3,916,459 Toilet Ventilating Apparatus in Kit Form.** Marko Ivancevic, 423 N. Broadway, Redondo Beach, Calif. 90277. Filed Apr. 19, 1974, Ser. No. 462,400. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 8 Claims. *

46. **3,916,429 Toilet Deodorizing Accessary Including Leakproof Connection.** Raymond H. Pearson, 627 Sherwood Dr., Richardson, Tex. 75080. Filed Jun. 18, 1974, Ser. No. 434,519. Int. Cl. Eo3d 9/05, 9/04; A47k 3/22, U.S. Cl. 4-213. 1 Claim.

47. **3,913,150 Toilet Stool Ventilating Means.** Clarence E. Poister, Topeka, Kans.; Phillip A. Tyrrell, Kansas City, Mo., and Walter D. Hodge, Shawnee Mission, Kans. Assignors to PK Products/Inc., Wichita, Kans. Filed Mar. 11, 1974, Ser. No. 449,914. Int. Cl. A47k 3/22; EO3d 9/04, 13/00, U.S. Cl. 4-213. 21 Claims.

48. **3,902,203 Toilet Stool Ventilating Means.** Clarence E. Poister, 2934 Lydia, Apt. 103, Topeka, Kans. 66614; Phillip A. Tyrrell, 435 W. 88th Ter., Kansas City, Mo. 64114, and Walter D. Hodge, 5237 Delmar, Shawnee Mission, Kans. 66205. Filed Feb. 11, 1974, Ser. No. 441,453. Int. Cl. EO3d 9/04; A47k 13/00, U.S. Cl. 4-213. 10 Claims.

49. **3,900,908 Water Closet Evacuation Means.** Galen L. Stump, 915 N. Wheeler, McPherson, Kans. 67460. Filed Dec. 12, 1973, Ser. No. 426,644. Int. Cl. A47k 3/22; EO3d 9/04, 9/05, U.S. Cl. 4-213. 1 Claim.

50. **3,887,949 Ventilated Seating for a Water Closet.** John S. Osmond, 2467 Louella Ave., Venice, Calif. 90291. Filed Aug. 3, 1973, Ser. No. 385,406. Int. Cl. A47k 13/28, 13/00; EO3d 9/05, U.S. Cl. 4-217. 6 Claims. *

51. **3,887,948 Conditioning Device for Deodorizing and/or Odorizing Air.** Robin Harry Stamper, 1891 Westbourne Rd., Bryanston, South Africa. Filed Oct. 5, 1973, Ser. No. 403,879. Claims priority, application South Africa, Oct. 6, 1972, 72/7169; Oct. 6, 1972, 72/7170; Oct. 6, 1972, 72/7171. Int. Cl. A47k 3/22; EO3d 9/04, 13/00, U.S. Cl. 4-213. 1 Claim.

52. **3,869,737 Toilet Stool Deodorizing Structure.** Robert L. Stevenson, 7320 W. 87th St., Overland Park, Kans. 66212. Filed Oct. 23, 1973, Ser. No. 408,439. Int. Cl. EO3d 9/04, U.S. Cl. 4-213. 5 Claims.

53. **3,857,119 Ventilating Attachment for Water Closet.** Clyde, J. Hunnicutt, Jr., 3026 E. Garfield St., Phoenix, Ariz. 85008. Continuation-in-part of Ser. No. 301,581, Oct. 27, 1972, Pat. No. 3,824,637. This application Nov. 15, 1973, Ser. No. 415,964. Int. Cl. A47k 3/22;EO3d 9/04, 13/00, U.S. Cl. 4-213. 9 Claims.

54. **3,849,808 Toilet Exhaust Means.** Carl O. L. Olson, 745 N. 103rd Ave., Seattle, Wash. 98133, and Vernon Goodwin, Jr., 7334 44th Ave. S.W., Seattle, Wash. 98136. Filed June 21, 1973, Ser. No. 372,162. Int. Cl. EO3d 9/04, U.S. Cl. 4-213. 7 Claims.

55. **3,824,637 Ventilating Attachment for Water Closet.** Clyde J. Hunnicutt, Jr., 3026 E. Garfield St., Phoenix, Ariz. 85008. Filed Nov. 8, 1972, Ser. No. 301,581. Int. Cl. A47k 3/22; EO3d 9/04, 13/00, U.S. Cl. 4-213. 4 Claims.

56. **3,790,970 Toilet Stool Ventilating Means.** David Bendersky, Overland Park, and Clarence E. Poister, Fairview, both of Kans. assignors to PK Products, Inc., Whichita, Kans. Filed Nov. 15, 1971 Ser. No. 198,706. Int. Cl. EO3d 9/04, A47k 13/12. U.S. Cl. 4-217. 5 Claims. *

57. **3,781,923 Ventilating System for a Water Closet.** Hans Malsch, and Ernst Jung, both of Gaggenau-Rotenfels, Germany, assignors to Eisenwerke Gaggenau GMBH., Gaggenau/Baden, Germany. Filed July 27, 1971, Ser. No. 166,449. Claims priority, application Germany, July 30, 1970, P 20 37 830.7. Int. Cl. A47k 3/22; EO3d 9/04, 13/00, U.S. Cl. 4-213. 6 Claims.

58. **3,740,773 Method and Apparatus for Disposing of Human Waste in a Vehicle.** Charles L. Sargent, Ypsilanti, Mich., Assigned to Thermason Corporation, Ann Arbor, Mich., Filed June 24, 1971. Application No. 156,403. Int. Cl. B60r 15/04. U.S. Claims 12 (Cl. 4-114, 4-131)

59. **3,740,772 Ventilating Systems for Sanitary Systems.** Arthur Chester Paley, 21 Boldrewood St., Turner Canberra, Australia. Filed Dec. 15, 1970. Application No. 98,283. Int. Cl. A46k 13/00, EO3d 9/04. U.S. CL. 6 Claims (Cl. 4-217) *

60. **3,733,619 Ventilated Toilet.** Forrest D. Smith, P.O. Box 222, Orleans, Calif. 95556. Filed Jan. 3, 1972. Application No. 214,669. Int. Cl. EO3/d 9/04, 11/02, 11/18, U.S. Cl. 4/72, 4/213, 4/217. 7 Claims. *

61. **3,703,010 Ventilated Toilet.** Dale F. Russell, 6195 Rochester Rd., Troy, Mich. Filed May 12, 1970, Ser. No. 36,563. Int. Cl. EO3d 9/05, U.S. Cl. 4-216. 4 Claims.

62. **3,691,568 Ventilator for Water Closets.** William L. Martz, 15875 Woodacre Rd., Los Gatos, Calif. Continuation-in-part of Ser. No. 882,815, Dec. 8, 1969, Pat. No. 3,626,554. This

application Aug. 24, 1970, Ser. No. 66,346. Int. Cl. EO3d 9/04, 9/05, U.S. Cl. 4-213. 3 Claims.

63. **3,689,944 Toilet Deodorizing Apparatus.** Cyril Reginald Clayton, 20 Branksom Rd., St. Leonards-on-the-Sea, Sussex, England. Filed Nov. 2, 1970, Ser. No. 86,220. Int. Cl. 9/05, U.S. Cl. 4-213. 5 Claims.

64. **3,681,790 Ventilated Water Closets Automatically Affording Protection of its Ventilating Means From Water Damage.** John Dooley, Madison Gardens Bldg., 30, Apt. 603, Oldbridge, N.J. Filed June 15, 1970, Ser. No. 46,185. Int. Cl. EO3d 9/04. U.S. Cl. 4-216. 7 Claims *

65. **3,659,296 Toilet Seat.** Robin Harry Stamper, 1891 Westbourne Rd., Bryanstown, Transvaal Province, Republic of South Africa. Filed June 16, 1970, Ser. No. 46,655. Int. Cl. A47k 13/30 8 Claims. (Cl. 4-217)

66. **3,626,554 Ventilator for Bathrooms.** William L. Martz, 15875 Woodacre Rd., Los Gatos, Calif. 95030. Filed Dec. 8, 1969, Ser. No. 882,815. Int. Cl. EO3d 9/04, U.S. Cl. 4-213. 3 Claims.

67. **3,600,724 Toilet Bowl Ventilation.** Robin Henry Stamper, 1891 Westbourne Rd., Bryanston, Transvaal Province; and John Osborne McEwan Abbott, Johannesberg, Transvaal Province, Republic of South Africa. Filed Aug. 5, 1968, Ser. No. 750,037. Claims priority: Republic of South Africa, 67/4814. Int Cl. A47/k 13/30, U.S. Cl. 4/217. 4 Claims. *

68. **3,585,651 Odor Remover for Toilets.** David L. Cox, Jacksonville, N.C., assignor to The Cox Corporation, Jacksonville, N.C. Filed Aug. 27, 1969, Ser. No. 853,419. Int. Cl. EO3/d 9/04, U.S. Cl. 4-96. 4 Claims. *

69. **3,571,824 Toilet Stool Ventilating Means.** Clarence E. Poister, P.O. Box 68, Fairview, Kans. Continuation-in-part of application Ser. No. 634,969, May 1, 1967, now Pat. No. 3, 491,382. This application Dec. 18, 1969, Ser. No. 883,104. Int. Cl. EO3d 9/05, U.S. Cl. 4-213. 10 Claims.

70. **3,571,823 Toilet ventilating System.** John S. Lundberg, 30 Laburum Crescent, Rochester, N.Y. Filed Apr. 1, 1969, Ser. No. 811,949. Int. Cl. EO3d 9/05, U.S. Cl. 4-213. 9 Claims.

71. **3,571,822 Toilet Ventilation System.** Hugh E. Shaw, Jr., 2639 Russell Dr., Lower Burrell, Pa. Filed Jan. 10, 1969, Ser. No. 790,202. Int. Cl. EO3d 9/05, U.S. Cl. 4-213. 18 Claims.

72. **3,568,216 Toilet Flushing And Ventilating Device.** Joe M. Valdespino, 5023 Golf Club Parkway, Orlando, Fla. 32808. Filed Apr. 4, 1969, Ser. No. 813,447. Int. Cl. E)3d 9/05 2 Claims. (Cl. 4-72) *

73. **3,548,424 Ventilated Water Closet.** James A. Ducey and Williard G. Young, Robinson, Ill. Assignors to Case Manufacturing Company, Robinson, Ill., a corporation of Ill. Filed Feb. 29, 1968, Ser. No. 709,369. Int. Cl. EO3d 9/05, U.S. Cl. 4-215. 8 Claims.

74. **3,534,415 Automatic Ventilating System for Sanitary Toilets.** Robert G. Huffman, 117 Evelyn Dr., Anaheim, Calif. 92805. Filed May 5, 1965, Ser. No. 453,360. Int. Cl. EO3d 9/05, U.S. Cl. 4-213. 5 Claims.

75. **3,533,112 Toilet Stool Ventilating Means.** Clarence E. Poister, P.O. Box 68, Fairview, Kans. 66425 continuation in part of Ser. No. 634,969, May 1, 1967. This application Apr. 7, 1969, Ser. No. 813,979 Int. Cl. A47k 13/00, 2 Claims. (Cl. 4-217)

76. **3,533,111 Toilet Ventilating Device.** Bernard W. Bowman and Ruth W. Bowman, both of 318 S. 18th St., Springfield, Ill. 62703, Filed Apr. 3, 1968, Ser No. 721,912 Int. Cl. EO3d 9/05 4 Claims. (Cl. 4-211)

77. **3,523,309 Toilet Exhaust System.** Walter B. Munden, Charlotte, N.C., assignor of thirty-three and one-third percent to Luther N. Packer, Fayetteville, N.C. Filed Oct. 31, 1967, Ser. No. 679,363. Int. Cl. EO3d 9/05, U.S. Cl. 4-213. 14 Claims.

78. **3,495,282 Toilet Bowland Exhaust Device.** Allaird B. Taggart, Rte. 1, Box 251, Eureka, Calif. 95501. Filed Nov. 16, 1967, Ser. No. 638,708. Int. Cl. EO3d 9/05, U.S. Cl. 4-213. 3 Claims.

79. **3,491,382 Toilet Stool Ventilating Means.** Clarence E. Poister, P.O. Box 68, Fairview, Kans. 66425 Filed May 1, 1967, Serial No. 634,969 Int. Cl. EO3d 9/05; A47k 13/30 3 Claims (Cl. 4-217)

80. **3,469,267 Odor Removing Device for Toilets.** John Ray Kuklok, Rte. 1, Rice, Minn. 56367. Filed Sept. 15, 1966, Ser. No. 579,578. Int. Cl. EO3d 9/04, U.S. Cl. 4-213. 2 Claims. *

81. **3,436,767 Remoal of Odours From Toilets and Cleansing of Same.** Bela Balsay, 87 Crystal St., Petersham, Near Sydney, New South Whales, Australia. Filed Feb. 22, 1966, Ser. No. 617,281, claims priority application Australia, Feb. 22, 1966, 1,951/66. Int. Cl. EO3d 9/04, 9/02, U.S. Cl. 4-213. 10 Claims.

82. **3,416,167 Ventilated Toilet.** William R. Klemme, Rte. 1, 2721, Colfay, Calif., 95713. Filed Feb. 8, 1967, Ser. No. 614,582. U.S. Cl. 4-217. 1 Claim.

83. **3,386,459 Flushing Apparatus.** Richard D. Parkison, and Paul J. Klein, Louisville, Ky., assignors to American Standard Inc., a corporation of Delaware. Filed Feb. 5, 1964, Ser. No. 342,613. 1 Claim. (Cl. 137-216) *

84. **3,386,109 Toilet Deodorizing Device.** Thomas Christian, 602 W. Hively St., and Jack L. Youngblood, 401 Hively St., both of Elkhart, Ind. 46514. Filed Mar. 2, 1966, Ser. No. 531,125. U.S. Cl. 4-213. 5 Claims.

85. **3,366,979 Deodorizing Apparatus.** Melvin I. Johnston, 124 N. Lexington Parkway, St. Paul, Minn. 55104. Filed May 6, 1965, Ser. No. 453,594, U.S. Cl. 4-213. 1 Claim.

86. **3,357,029 Toilet Ventilating Apparatus.** Walter Schulz, 134 Westmount Ave., Toronto 10, Ontario, Canada. Filed Oct. 1, 1965, Ser. No. 491,913. U.S. Cl. 4-217. 1 Claim.

87. **3,335,431 Water Closet Ventilating Unit.** Charles E. Coates, Trevose, Pa., assignor of fifty percent to Walter A. Gay, Jr., Philadelphia, Pa. Filed July 15, 1965, Ser. No. 472,083, U.S. Cl. 4-213. 3 Claims.

88. **3,333,285 Deodorizer Integral With Toilet Seat.** Fay Edison Null, Choctawmar Subdividion, Okaloosa County, Fla. (Box 158, Shalimar, Fla. 32579). Filed Mar. 26,1964, Ser. No. 355,050. 8 Claims. (Cl. 4-217)

89. **3,332,089 Water Closet Ventilating Means.** Herb Wilton, 7800 SE., Luther, Portland, Oreg. 97286. Filed June 8, 1964, Ser. No. 373,331, U.S. Cl. 4-213. 1 Claim.

90. **3,295,147 Toilet Stool Ventilating Device.** Gustave Meyer, Fort Morgan, Colo., assignor to Meyer Products, Inc., Fort Morgan, Colo., a corporation of Colorado. Filed Apr. 24, 1964, Ser. No. 362,293, U.S. Cl. 4-213. 1 Claim.

91. **3,287,743 Water Ventilating Unit.** Charles E. Coates, Trevose, Pa. assignor of fifty percent to Walter A. Gay, Jr., Philadelphia, Pa. Filed Mar. 11, 1964, Ser. No. 351, 028, U.S. Cl. 4-213. 4 Claims.

92. **3,277,499 Device for Ventilating Toilet Bowls.** George L. Keefauver, Prineville, Oreg., assignor to Pure-O-Vac, Inc., Van Nuys, Calif., a corporation of California. Filed Oct. 22, 1963, Ser. No. 317,981, U.S. Cl. 4-213. 1 Claim.

93. **3,266,060 Flushing and Ventilating Toilet Unit.** Clarence E. Springer, 345 N. Sunnyvale Ave., Sunnyvale, Calif. Continuation-in-part of application Ser. No. 192,868, May 7, 1962, now Pat. No. 3,149,346 dated Sept. 22, 1964. This application Sept. 20, 1963, Ser. No. 310,313, U.S. Cl. 4-213. 1 Claim.

94. **3,230,552 Vent Adapted for Ventilated Commode.** Hugo Schulz, P.O. Box 278, Lakefield, Minn. Filed May 10, 1963, Ser. No. 279,402, U.S. Cl. 4-218. 4 Claims.

95. **3,230,551 Toilet Bowl Ventilating Apparatus.** Ruben A. Kopp, 1519 Beach Ave., Vancouver, British Columbia, Canada. Filed Mar. 25, 1963, Ser. No. 267,706, U.S. Cl. 4-213. 1 Claim.

96. **3,192,539 Ventilators for Water Closets, Kitchens and the Like.** William L. Martz, 20980 Canyon View, Dr., Saratoga, Calif. Filed Aug. 1, 1963, Ser. No. 300,414, U.S. Cl. 4-218. 4 Claims.

97. **3,188,658 Ventilated Water Closet.** Farris E. Dixon, Louisville, Ky., assignor to American Radiator and Standard Sanitary Corporation, New York, N.Y., a corporation of Delaware. Filed Dec. 3, 1962, Ser. No. 241,588. 7 Claims (Cl. 4-215) *

98. **3,149,346 Toilet Unit.** Clarence E. Springer, 345 N. Sunnyvale Ave., Sunnyvale, Calif. Filed May 7, 1962, Ser. No. 192,868, U.S. Cl. 4-135. 4 Claims.

99. **3,122,757 Toilet Ventilating System.** Edward W. Sowards, Campbell, Calif. (Rte. 1, Box 705, Love Creek Rd., Ben Lomond, Calif.). Filed Apr. 13, 1959, Ser. No. 805,787, U.S. Cl. 4-213. 4 Claims.

100. **3,120,665 Commode Bowl Vent Assembly.** Delores M. Kirkland, 2426 Silver St., El Paso, Tex. Filed Oct. 22, 1962, Ser. No. 232,207, U.S. Cl. 4-213. 4 Claims.

101. **3,120,006 Toilet Bowl and Bathroom Ventilating System.** Siegfried Knappe, 940 Whitestone Rd., Xenia, Ohio. Filed Aug. 1, 1960, Ser. No. 46,748, U.S. Cl. 4-213. 3 Claims.

102. **3,108,289 Toilet Ventilator.** Claude V. Smith, 1013 N. 25th St., Phoenix Ariz. Filed July 20, 1962, Ser. No. 211,305, U.S. Cl. 4-213. 4 Claims.

103. **3,087,168 Toilet Filtering Ventilator.** Mourice A. Huso, 5310 Los Lomas, Long Beach 15, Calif. Filed May 10, 1960, Ser. No. 28,120, U.S. Cl. 4-213. 7 Claims.

104. **3,083,377 Exhaust Attachment for Toilet Bowls.** Arthur W. Brown, 4019 Martin Rd. SW, and Kenneth E. Pope, 2720 Alavarado Dr. NE., both of Albuquerque, N. Mex. Filed July 24, 1961, Ser. No. 126,071, U.S. Cl. 4-215. 5 Claims.

105. **3,072,924 Air Venting Device.** Harold M. Fitzgerald, Detroit, Mich. Filed June 16, 1961, Ser. No. 117,708, U.S. Cl. 4-215. 26 Claims.

106. **3,072,275 Water Closets.** Fred I. Raymond, 459 Grove St., Glencoe, Ill. Filed Sept. 12, 1960, Ser. No. 55,515, U.S. Cl. 4-213. 2 Claims.

107. **3,066,317 Odor Escaping Means for Toilets.** Virgil N. Cawiezel, 124 E. Locust St., Des Moines, Iowa. Filed Mar. 31, 1960, Ser. No. 19,069, U.S. Cl. 4-213. 1 Claim.

108. **3,064,274 Ventilated Toilet.** Jay L. Gleason, Oxnard, Calif., assignor of one-tenth to Gadget-of-the-Month-Club, Inc., North Hollywood, Calif., a corporation of California. Filed Aug. 24, 1959, Ser. No. 835,468, U.s. Cl. 4-216. 2 Claims.

109. **3,059,245 Toilet Ventilating Apparatus.** Alfred D. Bell, 2573 University Ave., San Diego 4, Calif. Filed Nov. 18, 1960, Ser. No. 70,299, U.S. Cl. 4-213. 4 Claims.

110. **3,059,244 Ventilating Attachment for Water Closets.** George R. Jarrett, 1604 SE. 52cd Ave., Portland, Oreg. Filed June 13, 1960, Ser. No. 35,768, U.S. Cl. 4-213. 1 Claim.

111. **3,049,722 Toilet Fume Exhaust.** Bruce Oden Boggs, 4497 Pearl Lane, R.R. 5, Batavia, Ohio. Filed Apr. 28, 1960, Ser. No. 25,372, U.S. Cl. 4-213. 1 Claim.

112. **3,020,564 Toilet Ventilating System.** Joseph Chodacki, Wayne County, Mich. (12504 Charest St., Detroit 12, Mich.) and Roman Zdrojkowski, Wayne County, Mich. (3889 Sobieski, Detroit 12, Mich.). Filed Apr. 6, 1961, Ser. No. 115,223, U.S. Cl. 4-213. 5 Claims.

113. **3,003,157 Ventilated Toilet Seat.** Basil John Saunders Belcher, Pettswood, Orpington, England, assignor to Silavent Limited, Pettswood, Orpington, England, a British Company. Filed Oct. 20, 1958, Ser. No. 768,292. Claims priority, application Great Britain Oct. 22, 1957. U.S. Cl. 4-217. 3 Claims.

114. **2,990,557 Watercloset Ventilator.** Arthur E. Witherell, R. F. D., Northhampton, Mass. Filed June 23, 1958, Ser. No. 743,688, U.S. Cl. 4-213. 1 Claim.

115. **2,988,756 Fume Removing Device for Toilet Bowls.** Ralph P. Hartley, 4812 El Serento Ave., La Crescenta, Calif. Filed Jan. 26, 1959, Ser. No. 788,951, U.S. Cl. 4-213. 4 Claims.

116. **2,985,890 Toilet Bowl Ventilating Apparatus.** Harry Baither, 1907 E. 18th Place, Sterling, Ill. Filed May 24, 1957, Ser. No. 661,538, U.S. Cl. 4-213. 2 Claims.

117. **2,974,323 Toilet Bowl Ventilator and Sterilizer.** Earl L. Nofsinger, 715 N.C. St., Wellington, Kans. Filed Sept. 30, 1957, Ser. No. 687,207, U.S. Cl. 4-213. 1 Claim.

118. **2,951,250 Ventilator Switch.** Lewis E. Winn, 513 Cedar St., Leaksville, N.C. Filed Oct. 7, 1958, Ser. No. 765,917, U.S. Cl. 4-213. 1 Claim.

119. **2,949,615 Water Closet Ventilator.** John William Farrell, 10320 W. 14th St., Denver, Colo. Filed Jan. 2, 1958, Ser. No. 706,672, U.S. Cl. 4-216. 5 Claims.

120. **2,851,696 Ventilating Control Means for Water Closets or Toilets.** Joseph G. Schotthoefer, Detroit, Mich. Application Nov. 2, 1955, Ser. No. 544,391, U.S. Cl. 4-216. 4 Claims.

121. **2,849,727 Ventilating Apparatus for Closets or Toilets.** Edward N. Bollinger, and William J. Hauck, Sr., Erie, Pa. Application Apr. 16, 1956, Ser. No. 578,486, U.S. Cl. 4-217. 5 Claims.

122. **2,847,682 Toilet Ventilator.** William L. Shay, Reseda, Calif. Application Apr. 18, 1955, Ser. No. 501,904, U.S. Cl. 4-213. 2 Claims.

123. **2,846,696 Toilet Deodorizer.** James R. Herriott, Alamo, Calif. Application Mar. 22, 1954, Ser. No. 417,735, U.S. Cl. 4-213. 1 Claim.

124. **2,824,313 Electric Toilet Seat Exhaust Ventilator.** Richard L. Bulow, Royal Oak, Mich. Application May 20, 1954, Ser. No. 431,118, U.S. Cl. 4-213. 1 Claim.

125. **2,818,582 Local Vent for Toilet.** Charles J. Rosselle Detroit, Mich. Application Sept. 8, 1953, Ser. No. 378,924, U.S. Cl. 4-213. 5 Claims.

126. **2,817,099 Ventilating Device for a Water Closet.** Harold M. Fitzgerald, Detroit, Mich. Application Sept. 17, 1965, Ser. No. 610,307, U.S. Cl. 4-215. 5 Claims.

127. **2,778,033 Ventilated Water Closets.** Charles J. Majauskas, Chicago, Ill. Application July 11, 1955, Ser. No. 521,202, U.S. Cl. 4-213. 1 Claim.

128. **2,777,137 Closet Bowl Ventilator.** John P. McFadden, Sioux City, Iowa. Application Apr. 21, 1953, Ser. No. 355,527, U.S. Cl. 4-213. 2 Claims.

129. **2,747,201 Toilet Deodorizer.** James R. Herriott, Alamo, Calif. Application July 14, 1953, Ser. No. 367,920, U.S. Cl.4-213. 4 Claims.

130. **2,743,462 Hinge and Vent Assembly for Toilet Bowls.** Carl W. McMillan, Reno, Nev. Application Feb. 25, 1953, Ser. No. 338,688, U.S. Cl. 4-213. 7 Claims.

131. **2,728,921 Ventilated Toilet.** Emil J. Dorko, Bradenville, Pa. Application May 19, 1953, Ser. No. 355,913, U.S. Cl. 4-216. 1 Claim.

132. **2,728,088 Ventilated Seat and Cover Assembly for Toilet Bowls.** William Gudish, Los Angeles, Calif. Application May 27, 1953, Ser. No. 357,808, U.S. Cl. 4-217. 4 Claims.

133. **2,727,249 Toilet Ventilator.** Loenard P. Kochert, Palmyra, Ind. Application Oct. 31, 1952, Ser. No. 317,949, U.S. Cl. 4-213. 2 Claims.

134. **2,726,405 Forced-Draft Ventilator for Toilet Bowls.** Austin B. Smith, and Mack B. Smith, both of Salt Lake City, Utah. Application Nov. 24, 1951, Ser. No. 258,032, U.S. Cl. 4-213. 5 Claims.

135. **2,724,840 Ventilated Toilet Bowl.** William V. Scott, Bowie and Thurman F. Scott, Wichita Falls, Tex. Application May 6, 1952, Ser. No. 286,336, U.S. Cl. 4-216. 1 Claim.

136. **2,575,778 Ventilated Toilet.** Theodore R. Wilson, Seattle, Wash. Application Aug. 21, 1945, Ser. No. 611,755, U.S. Cl. 4-213. 2 Claims.

137. **2,526,278 Vented Toilet.** Charles C. Rosselle, Detroit, Mich. Application Feb. 1, 1949, Ser. No. 73,950, U.S. Cl. 4-215. 10 Claims.

138. **2,456,534 Ventilated Toilet.** Andrew P. Riedele, Los Angeles, Calif. Original application Dec. 2, 1941, Ser. No. 421,302, divided and this application Nov. 13, 1945, Ser. No. 628,243, U.S. Cl. 4-217. 5 Claims.

139. **2,452,282 Ventilated Toilet.** William F. Auer, Menasha, Wis. Application Dec. 20, 1945, Ser. No. 636,186, U.S. Cl. 4-216. 2 Claims.

140. **2,389,165 Ventilated Toilet.** Andrew P. Riedele, Los Angeles, Calif. Application Dec. 2, 1941, Ser. No. 421,302, U.S. Cl. 4-217. 3 Claims.

141. **2,297,935 Ventilated Toilet.** Harry Baither, Milwaukee, Wis. Application Feb. 3, 1941, Ser. No. 377,180, U.S. Cl. 4-213. 9 Claims.

142. **2,277,165 Ventilated Toilet.** Percy H. Stebbing, and Leon L. Wallace, Petaluma, Calif. Application Sept. 8, 1941, Ser. No. 410,012, U.S. Cl. 4-213. 2 Claims.

143. **2,227,920 Ventilated Toilet.** Harry Baither, Milwaukee, Wis. Application Mar. 15, 1939, Ser. No. 261,902, U.S. Cl. 4-213. 8 Claims.

144. **2,203,111 Toilet Venting Device.** Percy H. Stebbing, and Leon L. Wallace, both of Petaluma, Calif. Application Jan. 10, 1940, Ser. No. 313,210, U.S. Cl. 4-213. 2 Claims.

145. **2,124,017 Ventilated Toilet Seat.** C. Vandiver, El Paso, Tex., assignor of forty-nine percent to Robert L. Knie, El Paso, Tex. Application Sept. 18, 1937, Serial No. 164,578. 3 Claims. (Cl. 4-217)

146. **2,119,529 Toilet Ventilator.** m R. Dick, New York, N. Y. Application Oct. 23, 1936, Serial No. 107,174. 6 Claims. (Cl. 4-217)

147. **2,112,772 Toilet Ventilator.** Ellis D. Green, Rochester, N. Y. Application May 7, 1937, Serial No. 141,283. 1 Claim. (Cl. 4-213)

148. **2,072,493 Toilet Ventilator.** William Beard, Colorado Springs, Colo. Application Apr. 16, 1936, Serial No. 74,738. 2 Claims. (Cl. 4-213)

149. **1,979,736 Ventilated Toilet.** John H. Etter, San Francisco, Calif. Application Jan. 16, 1934. Serial No. 766,873. 1 Claim. (Cl. 4-217)

150. **1,972,076 Ventilating Device.** Guy C. Cross, Watervliet, Mich. Application Aug. 2, 1933. Serial No. 638,249. 16 Claims. (Cl. 4-217)

151. **1,931,052 Toilet Ventilator.** Harry Baither, Milwaukee, Wis. Application Nov. 6, 1931. Serial No. 573,475. 1 Claim. (Cl.4-213)

152. **1,915,776 Toilet Ventilator.** William J. Connors, San Jose, Calif. Filed Sept. 19, 1932, Ser. No. 633,731, U.S. Cl. 4-213. 12 Claims.

153. **1,887,498 Toilet Ventilator.** William J. Connors, San Jose, Calif., assignor to Sani-Toit Trust Association, Washoe County, Nev., a common law trust. Filed Jan. 2, 1932, Ser. No. 584,394, U.S. Cl. 4-213. 5 Claims.

154. **1,636,476 Device For Toilets.** Frank E. Lumley, Chicago, Ill., Filed Oct. 13, 1926. Serial No. 141,298. 6 Claims. (Cl. 4-216)

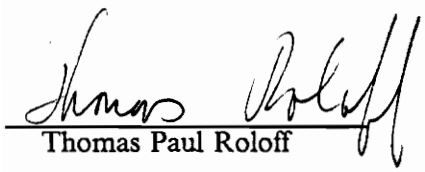
155. **1,629,401 Sanitary Odorless Toilet.** James H. McCall, Huntingdon, Tenn., Filed Dec. 19, 1923. Serial No. 681,613. 2 Claims. (Cl. 4-8)

156. **1,600,704 Toilet Ventilator.** John Albrecht, Kewaunee, Wis. Filed Apr. 25, 1925, Ser. No. 25,769, U.s. Cl. 4-217. 3 Claims.

157. **1,443,188 Ventilated Toilet.** Anton T. Lueckenbach, Neenah, Wis., Filed Apr. 3, 1922. Serial No. 548,896. 3 Claims. (Cl. 4-21)

Vita

Thomas Roloff was born in Vienna Austria in 1965. In the Summer of 1973, he moved with his family to the United States where he has now lived for 15 years. His parents as well as his family's Summer trips back to Europe have helped him retain his fluency in German. Tom's undergraduate studies were completed in May, 1987 at Lafayette College in Easton Pa. While at Lafayette, Tom majored in mechanical engineering and was a member of the college's Crew Team. His involvement with the crew continued for all four of his undergraduate years. In the Fall of 1988 Tom enrolled at Virginia Tech and furthered his interest in mechanical engineering by pursuing a masters degree.



Thomas Paul Roloff