water conservation and the mist experience

the problem is no.9
water conservation and
the mist experience

by
alex morse, vikram bhatt & witold rybczynski

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ACKNOWLEDGMENTS
The work on mist washing was initiated by Alvaro Ortega, the founder of the Minimum Cost Housing Group, in 1971 and much of the credit for the work that follows belongs to him. The work described in Chapters 4, 5 and 6 was carried out by Alexander Morse in 1976 and appeared in slightly different form as his Master of Architecture thesis "The Use of Automation for Washing and Showering to Conserve Water", McGill 1976. Many members of the Minimum Cost Housing Group contributed to this project since it began, particularly Genti Ayad, Wajid Ali and Bernard Lefebvre. Arthur Scheinman took part in the design of the Mini-Mister with Vikram Bhatt.

We also acknowledge the early work of Rudolph Fuller and his "coral cup" which inspired us all. On a visit to Montreal in 1972 Dr. Fuller had the opportunity to try the drainage hand washer, and his words of encouragement are appreciated.

This publication is a companion volume to Stop the Five Gallon Flush and we hope that it finds as wide appeal, and usefulness, as that book did.

Witold Rybczynski
Director, Minimum Cost Housing Group

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Foreword

Since its inception the Minimum Coat Housing Group has, amongst other interests been concerned with water conservation and sewage and in the summer of 1971 published its first book on alternative sanitation systems entitled “Stop the Five Gallon Flush”. This present book, published five years later, reports the results of studies carried out by members of the group on methods of controlling water usage in everyday activities by means of various mechanical aids. In addition, methods of controlling the water supply to ensure that the amount and flow of water is directly related to the specific need have been researched and carefully catalogued.

For many regions of the world which suffer extreme shortages of fresh water, at least seasonally, such methods of control can be useful in reducing wastage. In other regions, the discharge of polluted effluents into the fresh water supply has threatened its quality and has necessitated expensive alternatives of providing usable water. In such cases, a reduction in the quantity of water used would also be welcome.

Perhaps a new generation, inspired by a conservation ethic, will welcome methods of reducing wastage of what has increasingly become practically a non-renewable and dwindling resource and demand that such controls become mandatory. Members of the Minimum Coat Housing Group have provided directions for those so inclined and, one hopes, the motivation for others to follow.

Swank Drummond, Director
School of Architecture
McGill University

1. World Water

1. Water Economy

Water shortage is generally the result of two major man-made causes: population growth and industrialisation. There are more people wanting to use the available water supply while often the water is polluted.

In many areas which depend on regular rainfall for their water supply, another cause for water shortage is drought. This is a regular occurrence in arid regions of the world.

We should have a clear picture of the context of the water problem. The idea of a water shortage is deceptive. According to a leading Soviet scientist, V.I. Levovich, the water resources on earth fully suffice to meet all of man’s steadily growing needs for an indefinite time. But man, he says, must strictly adhere to a correct policy of using water and reshaping the hydrologic cycle, which links up all parts of the atmosphere (the seas, lakes and streams, groundwater, soil moisture, atmospheric vapor) into a single whole; and water balance, the quantitative expression of the hydrocycle and its components. Man must practice extended reproduction of suitable water resources. The water problem, Levovich believes, cannot be solved by one-sided measures but by an integrated program of technological, biological, and organizational measures. This report deals with a technological measure. Thus the water problem is one of water economy.

A 1971 World Bank Report, Water Supply and Sanitation4 in 17 countries, reveals the following facts which bring the problem into focus: urban populations have been increasing by an average 5.9% per year, reflecting substantial immigration from rural areas. This creates an abnormal load on the water supply. In one third of the 26 cities studied, the majority of consumers are served by public taps rather than by house connections. Most taps are not metered, and this results in careless drawing of the water, which makes for much wastage. In half of the cities, more than 25% of the water produced is unaccounted for. Here is more waste.

City sewage and waste from mines and factories may be regarded as the chief cause of water pollution. A lesser cause, but a growing and important one, is the pollution created by chemicals used to kill insects and to fertilize crops. The water polluted by these chemicals finds its way into lakes and rivers - bodies of water upon which people rely for drinking, cooking and washing. Increasingly, radioactive wastes, from factories using uranium, have become a considerable cause of water pollution. Pollutants are absorbed into the earth where they disappear from sight, but move slowly and pervasively poison new streams and water. The result is outbreak of disease.
3. Water Demand and Costs

In areas of greatest scarcity, water is sold from carts. For example, in Hubut in 1973, a water-seller was charging $60.00 for 3,375 liters (750 gallons) i.e. 18¢ per liter of 8¢ per gallon. That was enough water to serve a household of 15 persons for one month. Only a fraction of this is used for washing; most of it is used for cooking and drinking.

<table>
<thead>
<tr>
<th>Country</th>
<th>Price charged by water-seller</th>
<th>Typical urban water supply pumped or metered rate per m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>£1.12-1.22</td>
<td>£0.99</td>
<td>Denpas Sompala</td>
</tr>
<tr>
<td>£1.64-3.88</td>
<td>£0.18</td>
<td>Jakarta Kepala</td>
</tr>
<tr>
<td>£0.92</td>
<td>£0.09</td>
<td>Jakarta Jakarta</td>
</tr>
<tr>
<td>£0.90</td>
<td>£0.08</td>
<td>Singapore</td>
</tr>
<tr>
<td>£0.77-0.12</td>
<td>£0.07</td>
<td>SGP Punggol</td>
</tr>
<tr>
<td>£0.11-0.19</td>
<td>£0.09</td>
<td>German city</td>
</tr>
</tbody>
</table>

Water supply is also critical on ships where a sufficient quantity must be carried for long voyages. The latest super-liners ships never put in to ports but are supplied at sea. Caravans and trailers, too, often need to carry their water supply along into areas of arid desert or where water is polluted. For example, in controversy housing for works at locations for resource development.

Recreation vehicles such as campers also need to store water. Aircraft, too, must carry their own water, although its time away from a supply source may be short as the need is less critical except in case of emergency.

Of great need also is emergency water supply in disaster zones not only because of shortage due to broken mains but also because the impossibility of usual treatment results in a polluted water supply.

Spacecraft are the extreme example of the need for water economy. Here, compartment is more critical. The least volume and weight the water supply uses, the better. Accordingly, Martin Marietta, designers contracted by the National Aeronautics and Space Administration came up with a water re-circulable atomized shower which, except for its zero gravity requirement, would be applicable in any of the cases cited above.

The atomizing system used on the NASA Skylab is not on the market; however, similar components are available and these could be combined for bathing and washing devices. Further on in this study some such products will be reviewed along with tests and evaluation of their effectiveness.

Wore such atomized water devices to be used in places of scarcity and pollution, then water demand and with it relative water costs would be greatly reduced.

---

**Note:**
- Data for corned, irrigation, and non-irrigation categories include water loss.
- Data for irrigation and non-irrigation categories include water loss.
- Data for irrigation and non-irrigation categories include water loss.
- Data for irrigation and non-irrigation categories include water loss.
Of most interest to official surveys is the total water use and its breakdown into domestic as well as other uses as shown in the following table from H.F. Valentine’s book Water In The Service of Man.

Whereas general water use has been measured by various agencies, seldom in the raw broken down by type, i.e., the differentiation between water used for cooking and drinking, on the one hand, and water used for washing and cleaning, or for toilets, on the other. Little documentation is available, which explains why findings given here are so disparate. This is understandable, since this degree of statistical refinement has apparently not yet been required by official agencies. (An exception is the private study by the Utilex Corporation in comparing their water-saving system (see page 52) to conventional water use.) Most data is supplied from reports by such bodies as the World Health Organization of the United Nations, the World Bank, and the Department of Health, Education and Welfare of the United States.

About half the water consumed in urban homes is used for flushing toilets. The remainder is used for domestic purposes, i.e., drinking, cooking, cleaning, washing and bathing. Washing (face and hands) and bathing (whole body) account for 30% of total domestic water used.

Domestic water use on world surveys varies, but the average recommended by Wagner and Lanex in WHO Report 48, and the one most used for planning criteria is 250 liters per person per day (55.5 gal.). Of course, needs vary for cultural and regional reasons.

It is interesting to note the water-use standards adopted by the World Health Organization in the following statement for emergency programs for disaster areas; also, their preference for showering over bathing: “As soon as the early days of emergency have passed and the water supply has been increased, restrictions should be lifted, since there is a correlation between water consumption and cleanliness on the one hand, and between cleanliness and the incidence of diseases on the other. With no restrictions the use of water may approach 100 litres (22 gal.) per person per day.

Recommended standard for showers is 20-30 litres/person/day (4.4-6.6 gal.). Recommended fixture distribution is 1 hand basin/10 persons; 1 shower head/50 persons in temperate climates, and 1/30 persons in hot climates.

Showers are preferable to baths both for sanitary reasons and to save water. . . . everybody in camp bathes at least once a week. In hot climates cold water should be sufficient. If hot water is provided, 20 litres (4.4 gallons) should be supplied for each bath; over-all consumption of water for bathing should be calculated on the basis of 30-50 litres/person for a week (6.6-7.7 gallons).”

### Daily Water Consumption per Person

<table>
<thead>
<tr>
<th>Use</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet flushing</td>
<td>150 &quot;</td>
</tr>
<tr>
<td>Handwashing</td>
<td>74 &quot;</td>
</tr>
<tr>
<td>Laundry</td>
<td>250 &quot;</td>
</tr>
<tr>
<td>Cooking</td>
<td>15 &quot;</td>
</tr>
<tr>
<td>Dishwashing</td>
<td>12 &quot;</td>
</tr>
<tr>
<td>Garden</td>
<td>8 &quot;</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>250 liters</strong> (55.5 gal.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Use</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic: Sanitation</td>
<td>14%</td>
</tr>
<tr>
<td>Cooking, laundry, etc.</td>
<td>18%</td>
</tr>
<tr>
<td>Household gardens</td>
<td>18%</td>
</tr>
<tr>
<td>Industrial</td>
<td>10%</td>
</tr>
<tr>
<td>Commercial</td>
<td>10%</td>
</tr>
<tr>
<td>Public (park, street cleaning, etc.)</td>
<td>7%</td>
</tr>
<tr>
<td>Hospitals and institutions</td>
<td>5%</td>
</tr>
<tr>
<td>Primary production (market garden, poultry)</td>
<td>4%</td>
</tr>
</tbody>
</table>

### Allocation of Water in a Large City

<table>
<thead>
<tr>
<th>Use</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic: Sanitation</td>
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<tr>
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<tr>
<td>Commercial</td>
<td>10%</td>
</tr>
<tr>
<td>Public (park, street cleaning, etc.)</td>
<td>7%</td>
</tr>
<tr>
<td>Hospitals and institutions</td>
<td>5%</td>
</tr>
<tr>
<td>Primary production (market garden, poultry)</td>
<td>4%</td>
</tr>
</tbody>
</table>

A water-vendor in the United Arab Emirates replenishes his stand in trade.
### 2. Atomization

**1. Definition of Atomization**

Atomization is defined as the mechanical subdivision of a bulk liquid. Spraying implies production of coarse drops (100 to 1000 Microns). Sprinkling suggests very coarse drops larger than 1000 Microns. The term misting is applied to the production of fine drops (10 to 100 Microns). Nebulizing is applied to very fine drops (under 10 Microns), and is usually used in inhalation aerosol therapy.

Except where otherwise specified, the term “spray” is used further on in a general sense.

**2. Drop-production Techniques**

**a) Geometry of devices: Nozzles**

"Drop-production techniques are distinguished by either the geometry of the atomizing device (i.e., nozzles), or by the source of the external motivating force employed" says the McGraw-Hill Encyclopedia of Science and Technology. The first three categories of atomization techniques which they list are pertinent to this study. They are: Hydraulics (pressure), Acoustics, and Rotory. The Encyclopedia goes on "Under normal operating conditions (30-200 ps) (2-13.6 atmospheres) hydraulic nozzles produce relatively coarse drops 100-100 Microns diameter, the finest ones being produced by small orific nozzle wherein pressure is converted into high relative jet velocity. Hydraulic nozzles are exemplified by garden hose nozzles, insecticide spray nozzles, and nozzles in humidification and scrubbing towers.

Pneumatic atomizers normally use compressed air (10-190 ps) (7-68 atmospheres) and produce drops in the 5-100 Microns diameter range. They are used in spray painting and fine misting applications, scrubbers or reactors (Venturi atomizers), and aircraft application of insecticides." Pneumatic nozzles are two-fluid internal mix, external mix, and combination mix types. These could be, for example a mixture of liquid and air, using the slip flow principle.

Rotary atomizers (spinning discs) are basically hydraulic atomizers, in which the pump and nozzle are combined and normally produce drops in the 30-300 Microns diameter range. They are widely used in spray drying because of their ability to handle viscous liquids or slurries.

The Betz-Top nozzle Inc. of Greenfield, Massachusetts states in their catalog: "When selecting a nozzle, consideration should be given to desired capacity, pattern, fineness of spray or fog, available pressure and orifice size where clogging may be a problem. Smaller nozzles, wider angle patterns and higher pressure result in a finer drop size. They go on to explain spray pattern selection: "There are fan or flat spray patterns for washing, applying chemicals, or flooding an area. The narrow patterns are used where a hard scrubbing action is desired. Hollow cone nozzles are usually used in multiple where their patterns overlap for wide coverage and high capacity. Full cone nozzles are most widely used and are recommended for fire protection, scrubbers, cooling and other applications because of their uniform coverage. The exclusive patented Betz spiral nozzles, for full or hollow cone sprays, feature high efficiency and are non-clogging. (these have a corkscrew-like spiral at the front of the nozzle). Flow rate is described by the term "nozzle capacity"."

<table>
<thead>
<tr>
<th>Source</th>
<th>Water Use</th>
<th>Bath</th>
<th>Handwashing</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Surveys of Domestic Water Use</td>
<td>56 litres (12 gal.)</td>
<td>5 litres (1.3 gal.)</td>
<td></td>
</tr>
<tr>
<td>Water &amp; Waste</td>
<td>8.8 litres (2.0 gal.)</td>
<td>8 litres (2.0 gal.)</td>
<td></td>
</tr>
<tr>
<td>The World's Water</td>
<td>10.0 litres (2.6 gal.)</td>
<td>10 litres (2.6 gal.)</td>
<td></td>
</tr>
<tr>
<td>Water Supply &amp; Sewage</td>
<td>20 litres (4.4 gal.)</td>
<td>20 litres (4.4 gal.)</td>
<td></td>
</tr>
<tr>
<td>Water Pollution</td>
<td>34 litres (9.0 gal.)</td>
<td>34 litres (9.0 gal.)</td>
<td></td>
</tr>
<tr>
<td>Water Use in the U.S.</td>
<td>75 litres (16.3 gal.)</td>
<td>75 litres (16.3 gal.)</td>
<td></td>
</tr>
</tbody>
</table>
The Spraying Systems Company of Wheaton, Illinois, also a nozzle manufacturer, goes into more detail. Their useful spray performance characteristics chart from their current catalog is reproduced on page 9 of this study.

Solid cone spray patterns can be produced with nozzles which are swirl jet, impinging jet, or rotary (spinning disc). Hollow cone spray patterns can be made with tangential swirl and impinging jet types. The two-hole simplicity of the tangential swirl type is relatively cloistered. Flat sprays can be made with a jet on a deflector plane or planes; or with a slot orifices.

Fog patterns can be made with a jet deflected by a turned back pin interrupting the stream or by the combination of a small orifice and high pressure.

1) External motivating forces: Pressure

The source of the external motivating force employed for atomization may be manual or mechanical. The force creates the pressure to move the liquid. There are four cases:

1) Manual force makes instant pressure
   e.g., household sprayers using siphon or pump principle
2) Manual force makes stored pressure
   e.g., garden sprayers
3) Mechanical force makes instant pressure
   e.g., water-pick toothbrushes
4) Mechanical force makes stored pressure
   e.g., paint sprayer using siphon or pump principle

BUCKMASTER FULLER AND THE FOG GUN

Fuller considered the dynamism bathroom as an interior, mass-producing, auxiliary facility. His fog gun, pictured here, offered a new method of bathing. It combined compressed air and atomized water with variously cold solutions. The kinetic force of the high-pressure air stream was utilized without the skin-damaging effect unavoidable in high-pressure needle-pointing of water streams. Generalizing from his Navy experience, in which engine room showers on the decks were almost unanimously removed by wind and fog on deck, Fuller reasoned that the feeding of atomized water and air at high pressure on the skin surface would accelerate the surface adhesion, and release the surface oils themselves, along with the attached dirt.

Research students at the Institute of Design, Chicago, in 1949 testing the Fog Gun. (Subsequent experiments were conducted at Yale and other universities.) A one-hour running pressure bath used only a pint of water. If fog gun bathing were done in front of a heat lamp, all the sanitary and muscle-relieving effects of other types of bathing would be effectuated without the use of any bathroom. Since there were no runoff systems, none of plumbing and enclosing walls would be eliminated, and bathing would become as much an “in-the-bedroom” process as dressing. Fuller holds that the other functions of the bathroom may be effected by odorless, dry-packaging machinery, employing solid plastics, electronic sealing, dry-conveying systems.
3. Early Work

In 1971, the Minimum Cost Housing Group, in its first year of research chose to investigate the worldwide problem of domestic water shortage. Buckminster Fuller's early work with the Fog Gun (see p.10) suggested a direction for proceeding. The first work was concerned with manual sprayers. A number of different types of manual spray equipment and hand-held atomizers were collected and tested for pressure, fineness of spray, and rate of water utilization. Also, a number of different fog nozzles and adjustable garden spray nozzles were tested. We were interested in finding atomizers that gave the finest spray coupled with the minimum water used, and minimum physical energy. Later, in the NOM house (1972), an experimental integrated alternative energy house, the bathroom was equipped with an atomized handwasher using a footpedal, much like those found in hospital operating rooms. Recent work has concentrated on the design of a shower device using components readily available in the industrial market. Further investigation was involved with the nature of atomization as well as with the question of washing related to health. This work presents the combined research studies of the Minimum Cost Housing Group with respect to water conservation and washing. Investigation of sanitation and waterless toilets is included in the book entitled *Stop the Five Gallon Flush*.
**DIASPRAY**
Japan: ¥0.69
Volume: 0.2 litre (0.5 gal.)
Height: 15 cm (6")
Capacity (flow rate): with regular spraying
2.2 litre/hr. (0.5 gal/hr.)

**SUPERSPRAY 30**
U.K.: £10.00
Volume: 5.0 litre (1.4 gal.)
Height: 70 cm (27")
Capacity (flow rate): at .34 atom (5pal)
(20 strokes of pump):
Standard nozzle: 15.6 litre/hr. (2.9 gal/hr.)
P-20 nozzle: 5.7 litre/hr. (1.5 gal/hr.)

**SUPERSPRAY 20**
U.K.: £2.00
Volume: 0.5 litre (0.15 gal.)
Height: 23 cm (9")
Capacity (flow rate): with regular spraying
5.5 litre/hr. (1.4 gal/hr.)

**SUPERSPRAY 10**
U.K.: £1.00
Volume: 1.0 litre (0.26 gal.)
Height: 30 cm (12")
Capacity (flow rate): at .34 atom (5 pal)
(17 strokes of pump) 5.7 litre/hr. (1.5 gal/hr.)

**WINDEX**
Canada: $0.20
Volume: 0.6 litre (0.15 gal.)
Height: 28 cm (11")
Capacity (flow rate): with regular spraying
2.2 litre/hr. (.56 gal/hr.)

**THREE FLOWERS**
Hong Kong: $1.80
Volume: 0.3 litre (.07 gal.)
Height: 15 cm (6")
Capacity (flow rate): with regular spraying
8.2 litre/hr. (1.2 gal/hr.)

**KILLASPRAY**
U.S.: $1.00
Volume: 0.8 litre (2.1 gal.)
Height: 56 cm (22")
Capacity (flow rate): at .34 atom (5 pal)
10.4 litre/hr. (1.5 gal/hr.)

<table>
<thead>
<tr>
<th>#DIASPRAY</th>
<th>#SPRAYMIST</th>
<th>#THREE FLOWERS</th>
<th>#WINDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Stroke</td>
<td>0.6 ml</td>
<td>1.3 ml</td>
<td>2.5 ml</td>
</tr>
<tr>
<td>Water required for washing hands</td>
<td>10-20 strokes</td>
<td>7-14 strokes</td>
<td>4-8 strokes</td>
</tr>
<tr>
<td>Average</td>
<td>9.0 ml</td>
<td>13.5 ml</td>
<td>15 ml</td>
</tr>
</tbody>
</table>

- Number of hand-washings with one litre of water
- 111

- Number of strokes per minute
- 62

- Amount of water spray per minute
- 37 ml  93 ml  137 ml  37 ml

- Amount of water spray per hour
- 2.2 l.  5.5 l.  8.2 l.  2.2 l.
There have already been a number of small field trials on the feasibility and the acceptability of mist washing. These have been thanks to the initiative of Alvaro Ortega, a Colombian architect who has worked for a number of years for the United Nations, and who was also the founder of the Minimum Cost Housing Group, in 1971.

The first application took place in Peru in 1979 as part of the PRODE (Proyecto Experimental de Vivienda) project, a UN sponsored program in experimental housing. A number of pesticide sprayers (Villspray type, see p.31) were distributed to people in Lima who did not have water supply. Further field applications took place in Manila, the Philippines, in 1976 (see photo below) using the Diaspray hand-held washer. The most recent application has been in the United Arab Emirates, where a considerable number of piston-type pesticide sprayers has been distributed to immigrant workers. The result of this recent experience is favourable and indicates that public acceptance of this novel form of washing is less problematic than skeptics would have us believe.

There is a great potential for improving health in areas where water supply is scarce, or expensive. Experience with popular use of mist washing is limited but so far indicates that if the devices are inexpensive and convenient to operate they will be used (especially for washing children), and that the advantage of using a very small quantity of water is readily appreciated.
4. Nozzles

1. Nozzles

The nozzle assembly described above was simple. Complex types such as the two-liquid and solid vehicle ones used in the paint and food industries have been omitted since the requirement is for a simple technology for developing countries and at low cost. However, those tested range from a garden hose nozzle to household sprayer nozzles.

The problem was to find a nozzle of adequate capacity to ensure a given duration of flow with a minimum supply of water and b) whose spray velocity was sufficient to reach the skin surface from a comfortable distance (about 8") and c) of sufficient impact to remove away water in the rinsing process. To get the skin wet does not require much impact, but convenient distance of nozzle from skin is desirable. To remove the mud requires a more forceful spray.

The nozzle tests were based on matching the performance of the nozzle used in the NASA Skylab shower. Using a duplicate nozzle we were never able to achieve that standard, possibly because the NASA nozzle performance was based on zero-gravity; however, our main goal was to sustain pressure to give a 5 to 10 minute shower using as little water as possible.

For air pressure, an electric compressor was used, and some tests were repeated with a bicycle pump. The compressor had a constant pressure of 2.0 atmospheres (about 20 psi). Eighteen strokes on the bicycle pump produced a pressure of 3.3 atmospheres (about 48 psi) but after 12 minutes it was 1.7 atmospheres (about 25 psi).

2. Test Equipment

The test equipment comprised:

1. Black & Decker paint sprayer compressor
   - This was rated at 6.2 amperes, 115 volts, and the pressure was capable of reaching 4.0 atmos (60 psi), although we were using about 1.3 atmos (20 psi).

2. Volkswagen tsiom window washer tank
   - Having a volume of 2.5 liters (.55 gallon), this was filled with 1 or 2 liters of water.

3. 1/4" vinyl hose
   - Fit over the nozzle on the VW tank. 1/8" hose was used for tests on the NIAGARA and ESTRA nozzles.

4. Chapin garden hose hand control valve with off-on device. This was adapted to receive all except the NIAGARA and ESTRA nozzles which had built-in hand controls.

5. Stopwatch for timing the flow.

Nozzles:

- 1. Black & Decker Paint Sprayer
- 2. Spraying Systems Whirljet 1/8A .1
- 3. Beta P20
- 4. Beta V5050F
- 5. Beta V200
- 6. Niagara 71
- 7. Steilens TM21
- 8. Steilens TM51
- 9. Extra 6400
- 10. D.B. Smith 147

3. Specifications

Specifications assumed for selecting a water nozzle:

- 1. Capacity (flow rate): 0.25 liters/minute (.06 gal./min.)
- 2. Spray pattern: hollow cone
- 3. Material: brass
- 4. Connection: 1/2" o.d. male
- 5. Orifice: 1/64" to 1/16" (a)
- 6. Right angle head
- 7. Spray angle: 80° - 90°
- 8. Atomization (droplet size): "Spray" = 100-1000 microns (see p.8 for definitions)

Determinants for above specifications:

- 1. Capacity (flow rate) - based on NASA standard: 2.5 liters/10 min. (.66 gal./9.7 min.)
- 2. Spray pattern - hollow cone preferred over solid
- 3. Material - brass selected for its durability and non-corrosiveness
- 4. Connection - for convenience. In some cases nozzles were available only in this size
- 5. Orifice - small orifice helps produce fine droplets
- 6. Right angle head - convenient for directing spray
- 7. Spray angle = narrow angle better to conserve water and prevent overflow at 8°
- 8. Atomization (droplet size) - this should be between "sprinkle" which is over 1000 microns, and "mist" 10-100 microns, to wet evenly and quickly.

4. Preliminary Tests of the Armed Water Device

First test of the atomized water device: December 5, 1975.

Set-up: Black & Decker compressor

Plastic jug of 4.5 liters (1 gal.)

1/4" vinyl hose

Brass fittings at hose ends

Beta V5050F Nozzle

Chapin garden hose control valve.

Procedure:

- Jug filled with 2 liters (0.5 gal.) water
- Jug sealed
- Compressor turned on
- Sprayer functioning okay, but flow appears very fast. About 1 liter/minute (0.25 gal./min.)
- After about one minute, jug had swelled to a rounded form, then burst.

Conclusion: Test demonstrated that the device will work.

Test too weak to withstand 1.3 atmos (20 psi) air pressure from compressor.

Nozzle performed well. Hose control performed well. Hose performed well.

A second test, December 12, 1975 substituted for the water tank a windshield water tank made for the Volkswagen bus. The tank was made of 6.3 mm. (1/4") thick, and could contain 7.5 liters (2.0 gal.) of water. It proved to be sufficiently strong to withstand the pressure of 1.3 atmos (20 psi) and was able to hold some pressure for at least 2 months.

5. Record of Tests

Record tests of nozzles for capacity (flow rate). Tests were made between December 1975 and July 1976.

Method: Tank was filled with 1 liter of water, compressor was turned on and sprayed until all water was out of the tank.

6. Nozzle Test Results

The results of the tests showed that nozzles with smaller orifices (as on the Niagara and Extra) helped sustain the flow of water for a longer period than nozzles with larger orifices; however, the quality of spray was finer with the small orifice and the impact, less. Nozzles with larger orifices yielded capacities too high for a workable shower.
The goal criteria of 1 liter in 5 to 8 minutes (0.15 gal./min.) was achieved, but at the cost of very low impact.

The Beto P20 nozzle performed at .33 liters/minute (.07 gal./min.) but its projecting pin would disqualify it on the basis of safety to the bather as well as its liability to damage. However, a protective collar-cap attached to the nozzle would be a simple corrective. Although having very good capacity, the Extra’s spray impact was less satisfactory in removing sudsy water.

The best performance in both impact and duration was found in the Steinen TM01 and the Beto P200 nozzles.

7. Reassessment of Goals

Since nozzles with the required range are rarely manufactured, perhaps the use of standard components is impractical, and since the goal of a nozzle capacity of .25 liters/minute (.05 gal./min.) i.e., a shower using 1 liter (.22 gal.) of water and lasting about 8 minutes, is too extreme, the goal should be revised. A more practical standard would be to employ 3 or 4 liters (6 or .8 gal.) of water for showers lasting about 8 minutes. This would require a nozzle with the capacity of .5 liters/minute (.03 gal./min.) which is readily available from manufacturers. The water-saving would still be enormous: a saving of over 90% of current average water-quantity used for showering (50 liters or 11 gallons).

The other alternative, and one which would keep the original capacity goal, and perhaps lower still more the cost, would be to develop Niagara and Extra type plastic nozzles. This, of course, requires additional engineering design which would be the next step in the development of atomized shower devices. This study has only explored the possibilities and merely sought to establish standards for atomized showering.

<table>
<thead>
<tr>
<th>Nozzles in order of testing</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Capacity Litters/min</th>
<th>Water used in hypothetical 5 min. shower</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.B. Smith</td>
<td>56 sec</td>
<td>1 min.5 sec</td>
<td>50 sec</td>
<td>.10</td>
<td>5.0 liters</td>
</tr>
<tr>
<td>Spraying Systems</td>
<td>2 min.19 sec</td>
<td>2 min.18 sec</td>
<td>2 min.18 sec</td>
<td>.43</td>
<td>2.17 &quot;</td>
</tr>
<tr>
<td>Whirljet 1/44.3</td>
<td>1 min.12 sec</td>
<td>1 min.</td>
<td>1 min.</td>
<td>1.4</td>
<td>7.0 &quot;</td>
</tr>
<tr>
<td>Watts 5000</td>
<td>2 min.18 sec</td>
<td>3 min.</td>
<td>3 min.</td>
<td>.56</td>
<td>1.8 &quot;</td>
</tr>
<tr>
<td>Beto P20</td>
<td>10 min.45 sec</td>
<td>10 min.30 sec</td>
<td>1 min.</td>
<td>.08</td>
<td>.435</td>
</tr>
<tr>
<td>Niagara</td>
<td>6 min.</td>
<td>4 min.15 sec</td>
<td>7 min.45 sec</td>
<td>.17</td>
<td>.86</td>
</tr>
<tr>
<td>Extra 6400</td>
<td>59 sec</td>
<td>1 min.</td>
<td>1 min.</td>
<td>.50</td>
<td></td>
</tr>
<tr>
<td>Black &amp; Decker Paint nozzle</td>
<td>3 min.2 sec</td>
<td>3 min.2 sec</td>
<td>3 min.2 sec</td>
<td>.43</td>
<td>2.17 &quot;</td>
</tr>
<tr>
<td>Steinen TM01</td>
<td>3 min.3 sec</td>
<td>3 min.2 sec</td>
<td>3 min.3 sec</td>
<td>.3</td>
<td>1.5 &quot;</td>
</tr>
<tr>
<td>Steinen TM001</td>
<td>2 min.15 sec</td>
<td>2 min.15 sec</td>
<td>2 min.15 sec</td>
<td>.38</td>
<td>1.92 &quot;</td>
</tr>
<tr>
<td>Beto P20</td>
<td>5 min.</td>
<td>1 min.</td>
<td>1 min.</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

* NASA claim for this nozzle

.25 .25 "

D.B. Smith No. 147
Manufactured by: D.B. Smith Co., Utica, N.Y.

Type: hydraulic swivel nozzle with grooved entry.
Orifice Size: approximately 4.78 mm. (3/16")
Capacity (Flow rate): as tested: 1 liter/min.
Spray Angle: 70°
Atomization Size: spray (100-1000 microns)
Impact: very good

This nozzle is adjustable from full spray to closed. It is primarily used for garden houses. Not satisfactory for capacity.

Steinen TM01

Type: hydraulic
Orifice Size: .59 mm. (0.28")
Spray Pattern: hollow cone
Capacity (Flow rate): as tested: .1 liter/min.
Spray Angle: 70°
Atomization Size: spray (100-1000 microns)
Impact: good

This nozzle performed well in both flow rate and spray force. Satisfactory.

Beto P20

Type: hydraulic
Orifice Size: .59 mm. (0.2")
Spray Pattern: fog
Capacity (Flow rate): as tested: .33 liter/min.
Spray Angle: 90°
Atomization Size: mist (10-100 microns)
Impact: good

The projecting pin on this nozzle which is easily subject to damage disqualified it for shower use.
Whirljet 1/8A.5
Manufactured by:
Spraying Systems Co.,
Vescon, Ill.

Type: hydraulic swirl nozzle with tangential entry
Orifice Size: 1.2 mm, (3/64")
Spray Pattern: hollow cone
Capacity (flow rate): as tested: .4 liter/min.
mfg's claim: .27 liter/min.
Spray Angle: 53°
Atomization Size: Spray (100-1000 microns)
Impact: good

This nozzle is the simplest in construction. The body has one eccentric hole. The cap has a central hole. Not satisfactory for capacity.

Niagara #71
Manufactured by:
FMG,
Colmar, Pa.

Type: rotary disc
Orifice Size: approximately .0135" (.30mm)
Spray Pattern: fog
Capacity (flow rate): as tested: 0.08 liter/min.
mfg's claim: 0.04 liter/min.
Spray Angle: 90° at nozzle
Atomization Size: mist (100-1000 microns)
Impact: weak

Like the Extra this nozzle has a built-in trigger control, which did not function. Impact not satisfactory.

Extra 6400
Manufactured by:
The Afa Corporation,
Miami, Fla.

Type: rotary disc
Orifice Size: .0135" (.3mm)
Spray Pattern: fog
Capacity (flow rate): as tested: 0.06 liter/min.
mfg's claim: n/a
Spray Angle: 90° at nozzle
Atomization Size: mist (10-100 microns)
Impact: weak

This nozzle with built-in trigger control produced the smallest spray. The trigger control did not function under mechanical pressure of 1.3 atmos.
(20 psi.) Impact not satisfactory.

Stelmen WML - 1/8"
Manufactured by:
Wm. Stelmen Mfg. Co.,
Parlaquy, N.J.

Type: hydraulic
Orifice Size: 1.17 mm, (3/64")
Spray Pattern: hollow cone
Capacity (flow rate): as tested: 0.4 liter/min.
mfg's claim: .54 liter/min.
Spray Angle: 90°
Atomization Size: Spray (100-1000 microns)
Impact: good

This nozzle did not prove satisfactory in flow rate.

Bete WSB0F
Manufactured by:
Bete Fog Nozzle Inc.,
Greenfield, Mass.

Type: hydraulic
Orifice Size: 2.38 mm. (3/32")
Spray Pattern: solid cone
Capacity (flow rate): as tested: 1.4 liter/min.
mfg's claim: 1.35 liter/min.
Spray Angle: 60°
Atomization Size: Spray (100-1000 microns)
Impact: good

This is the same type of nozzle used on the NASA Skylab. We were not able to achieve the capacity claimed by NASA, possibly because they used it under zero-gravity conditions. Not satisfactory for capacity.

Bete F200
Manufactured by:
Bete Fog Nozzle, Inc.,
Greenfield, Mass.

Type: hydraulic
Orifice Size: .59 mm (.02")
Spray Pattern: fan
Capacity (flow rate): as tested: .33 liter/min.
mfg's claim: .33 liter/min.
Spray Angle: 60°
Atomization Size: spray (100-1000 microns)
Impact: very good

This nozzle performed best in capacity and impact. The advantage of the fan spray pattern is its ability to move soap suds on the skin surface. Satisfactory.
5. Hygiene

1. Bathing and Health

Bathing has usually been regarded as related to health but it is also a pleasure, a social activity, a ritual. Baths were used for cooling and warming. The Turkish steam bath, the Scandinavian sauna, the American Indian sweat, were intended to open the pores of the skin and to promote sweating, thereby removing poisons and dirt and leaving one feeling exhilarated.

The bath as it is now practiced, except in Japan, uses soap, leaves the dirt in the bathwater, from which the bather emerges with some of the dirt clinging to his skin (the Japanese bather rinses outside the tub). Showers are a relatively recent innovation, and an improvement, hygienically, on the contemporary bath. In a shower, the dirt is washed away down the drain while the bather is continuously wet with clean water. Also, the shower is more stimulating to the skin, because of the impact of a needle-like spray. This mild massage leaves the bather feeling invigorated. Another advantage of the shower over the tub is the ease with which hairwashing is accomplished.

In both the bath and the shower, the purpose is to use clean water (with soap) to produce clean skin. But what are clean water and clean skin? The measure is relative, so the concept is deceptive. To understand this relativity, we must look to the science of Microbiology. Clean water is often measured by the amount of E. Coli bacteria present. Skin cleanliness has not been so easily measured.

Reports of water shortages seldom refer to the effects on bathing habits. Most deal with cooking and drinking needs. In many developing countries, bathing is carried out in nearby rivers and ponds, often where floods alternate with droughts. In some cases villages are not near bodies of water where bathing is permissible, most of the bought water being used for cooking and drinking.

Most diseases associated with the drinking of polluted water can also be got from bathing with that water since it has the opportunity of entering all of the nine orifices of the human body as well as through pores and cuts. Pores of the skin also are likely to absorb pathogenic microbes. A case in point is seen in Hassan Farhy’s book Architecture for the Poor. All the water of Egypt is infected with cryptos, or bilharzia worms, and every peasant works and bathes in this infected water. In the hot summer everyone bathes in the canals and ponds. Children especially paddle and splash about in every patch of water they can find, in ditches, puddles and stagnant ponds. Since it is practically certain that anyone who stands for ten minutes in an Egyptian canal will contract bilharzia, it is not surprising that the incidence of disease is so high.

Even if disease does not enter the body in this way there is still the possibility of disease resulting from lack of washing. A USN space flight hygiene report on prolonged restriction of washing notes this clearly: “An active source of contamination of the skin is the skin itself. Products excreted by the sweat and sebaceous glands and also particles of desquamated epithelium and hair constitute an important source of contamination of the skin. The samples of microflora on the test subjects’ skin surface and underwear consisted mainly of saprophytic species—Staphylococcus aureus, Staphylococcus albus, Diplococcus, and Sarcina. The test subjects developed (after 60 days) skin lesions which are fairly widespread under normal conditions of life. The commonest disease encountered was foliculitis mainly in the regions of the buttocks and thighs. Other diseases found were: furunculosis; staphylococcal intertrigo; acne vulgaris; dermatitis and fungus diseases of the feet.”

2. What is Clean Water?

The WHO Guide to Sanitation in Natural Disasters describes water treatment in emergency situations: “The purpose of disinfection is to kill pathogenic organisms and thereby prevent water-borne diseases. The disinfection of water can be accomplished by boiling or by chemical treatment. Chlorine and chlorinated liberating compounds are the most common disinfectants.

Until the laboratory facilities of urban water supply systems can be restored to normal operation, complete tests of water samples should be made at laboratories in the vicinity of the disaster area. The most important tests to be carried out under emergency and field conditions:

1. determination of residual chlorine (free and combined)
2. bacteriological examination for coliform bacteria
3. determination of hydrogen-ion concentration.
4. determination of type of alkalinity.

Clean water is a relative term involving chemical and bacteriological quality and quantity. The standard, for disease prevention, is the count of E. Coli present—a bacteria found in the typical human faeces.

The following table shows the relative amounts permissible and desirable.

<table>
<thead>
<tr>
<th>Surface Water Criteria for Public Water Supplies</th>
<th>Microbiological Factors</th>
<th>Count of coliform organisms (total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. Coli</td>
<td>2,000/100</td>
<td>10,000/100</td>
</tr>
<tr>
<td>permissible count</td>
<td></td>
<td></td>
</tr>
<tr>
<td>desired count</td>
<td>20/100</td>
<td>100/100</td>
</tr>
<tr>
<td>NOTE: read as 2,000 colonies of E.coli per 100 cubic centimeters of water</td>
<td></td>
<td>10,000 colonies of combined pathogenic and non-pathogenic organisms per 100 cubic centimeters of water</td>
</tr>
</tbody>
</table>

From Report on Sanitation on Water Quality Collection, 1972 USA.
Viable skin has the capacity to destroy many organisms implanted on its surface. The bacterial action of the skin has been attributed to pH and also to the presence of fatty acids and soap fractions. The normal skin surface has a pH of from 5 to 6. The acid reaction has been attributed to excess sweat, which has a high content of lactic acid and a low pH of 5.5 to 6.0. This lactic acid which accumulates as the sweat evaporates.

The amino acids released or discarded in the formation of keratin also contribute to the low pH of the skin surface. Fatty acids and soaps may contribute to the sterilizing action of the skin. Potentially, the action of residual free fatty acids is of importance in the bactericidal action of the skin. — Medical Technology Anti-Microbial Agents — Hedgcock 1967.

4. Washing with Antisud Water

Nasa research has been very helpful in supplying relevant information on the subject of hygiene. Their primary concern was the quality of cleanliness achieved with antiscud water. Portions of the NASA report Speak Shower Habitation Technology follow:

“There are three items that are basic for cleansing the body of foreign matter, dead skin and body secretions:

1. A mechanical action which helps to dislodge and break down the foreign matter and dead skin.
2. A chemical agent which breaks down and emulsifies the oils.
3. A solvent to pick up and carry off the accumulated materials.

This is accomplished by using the hands or a washcloth for a massaging and lathering action, soap or an emulsifier, and water as the solvent.

The cleansing agent used must cleanse the body and also control the bacteria on the skin. Presently there are emulsifiers available that have varying chemical compositions. These different agents act in biodegradable soaps that do not build bacterial growth and can be broken down by biological soap which control the growth of bacteria, and as bacterial soaps which actually deactivate bacteria. (A shower generally described as refreshing and revitalizing. To enhance this feeling, the cleaning agent should not only help control bacterial growth after each shower.) Ordinarily bar soaps are not considered because of their high auditing and their toxic effects on the eyes. Ideal cleansing agents should not be toxic on the skin, should not sting or irritate the eyes, and should not cause internal toxicity.” The NASA Skydell designers were particularly concerned with the ability of the attemted shower to remove bacteria.

5. Bacterial Removal

Samples of bacteria were taken to determine what types were added to the shower waste water, what types were found on various parts of the body, and to examine the effectiveness of showering to remove bacteria from the body. Samples of bacteria were taken of inflow shower water and from the left axilla, the groin, and between the toes, both before and after showering. A definite ten-fold reduction of bacteria in the groin and under the foot occurred when the subject washed, using a bar soap as a cleansing agent. A definite seven to ten-fold reduction of bacteria occurred in the groin and toe wash area when a bar soap, Miranol, was used as the cleansing agent.

Not all the bacteria were removed from the subject in the actual showering process, as demonstrated by the efficient water samples. A good portion of the bacteria was removed in the toweling (drying) off process where the newly washed was not removed taking some of the bacteria with it. Typical bacteria found in these tests were E. coli, staphylococcus, haemolytic, and streptococcus.

A definite correlation exists between the way a person showers and the quantity of bacteria recovered. The difference in the amount of total bacteria removed in the showering process is demonstrated between the different methods of bathing by the same subject in replicate showers. The mere scrubbing and friction created by the soap and water to break down surface tension, the greater the total number of bacteria recovered (or removed) from the subject. Soap and warm water are definitely required for a person to take an adequately clean and comfortable after showering. Greater bacterial removal justifies making soap a requirement in showering.”

In a discussion on the question of a standard with Dr. J.L. Nebleton of the Department of Microbiology of the University of California, it was said there is no specific measureable standard for removing cleanliness prior to surgery. But he went on to say, classic instructions are for a ten minute scrub, particularly of forearms and fingers, with strenuous vigor of scrub over duration. Although rubber gloves are used, they are known to develop holes, so that any contamination could thereby easily be transmitted.
6. Mist Showering

The first series of tests with atomization concerned hand-washing, both with manually operated atomizers and later with electric atomizers such as the Black and Decker paint sprayer. These experiments proved convincing enough that we felt we could proceed to the next step: a test of full body showering.

A test apparatus was constructed which was also the first step in developing a prototype mist shower that could be manually pressurized. The pressurized container is a Volkswagen window washing reservoir, which incorporates a water outlet tube as well as a pressure valve that can be connected to the Olympus TVscope, or in our case, to a bicycle pump. The water outlet tube is connected to a variety of nozzles.

The procedure is as follows. The reservoir is filled with water (about 2.5 litres). A bicycle pump is attached to the tank and the tank is pressurized with about 20 strokes. The mist shower is now ready to be used.
### Table: Water Consumption and Observations

<table>
<thead>
<tr>
<th>MOZZLE TYPE</th>
<th>PRESSURE</th>
<th>SHOWERING TIME</th>
<th>WATER USED</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whirljet 1/8A.5</td>
<td>1.3</td>
<td>3.5</td>
<td>2.0</td>
<td>Started by wetting body from flow dump then stopped rinsing and soaped-up. The vinyl hose filled because of water temperature (40°C). Extra water used to finish removing soap.</td>
</tr>
<tr>
<td>Extra 6400</td>
<td>3.3</td>
<td>10.0</td>
<td>2.0</td>
<td>Showering completed after 3.6 mins. Difficulty encountered with removing soap due to falling pressure. Twenty additional showering places in pump, and rinsing them completed painstakingly.</td>
</tr>
<tr>
<td>Steinen TM 71</td>
<td>1.3</td>
<td>8.0</td>
<td>2.0</td>
<td>After wetting and soaping the water was used up before rinsing was completed. Extra water had to be used to finish. Soap was measured and found to be only 0.75 l. out of 1.0 l.</td>
</tr>
<tr>
<td>Steinen TM051</td>
<td>1.3</td>
<td>6.0</td>
<td>2.0</td>
<td>Setting, soaping and rinsing were successfully completed.</td>
</tr>
<tr>
<td>Bote F200</td>
<td>2.4</td>
<td>10.0</td>
<td>1.9</td>
<td>Setting required as much as 5 mins. The pressure dropped before rinsing was completed.</td>
</tr>
</tbody>
</table>

2. Conclusions

The performance of the nozzle is the single most important factor affecting showering. The more forceful (i.e., larger droplets) nozzles used water too rapidly, while the too fine droplet nozzles produced a spray too weak to remove soap in the required time. The Steinen TM051 nozzle achieved a good compromise, obtaining a 6 minute shower with 2 litres of water. In addition, the right-angled head proved comfortable for handling and wetting all parts of the body.

Another nozzle that satisfied the requirement is the Bote F200, whose greater impact was more effective than the Steinen TM051 in removing soap. The greater pressure would however require additional pumping.

The normal showerhead uses about 25-30 litres/minute. Special water-saving showerheads with flow restrictors and partial atomization can use as little as 6 litres/minute. The mist shower uses only 0.33 litres, quite a drastic reduction! Of course the mist experience cannot be directly compared to the conventional shower, or even to a "water-saving" shower.
In many parts of the world water supply is a problem and water may be a scarce and expensive commodity. This may be due to climate (arid), geography (far North), location (sea water only available) or circumstance (spacecraft, mobile homes) and also in emergency situations where water is polluted. In all these cases the low cost of a portable atomized shower or washing unit has distinct advantages. Existing water supplies could be greatly extended and, where water needs to be brought in, less of it would be required than before.

As a basic necessity of man, not only for survival and maintenance, but also for health resulting from adequate washing and showering, the atomized device would be a boon. This would lead to increasing the individual's energy and strength and raise both the standard and quality of life in other respects, since he would be freed from immobility caused by disease.

Economic growth potential increases rapidly as water becomes more plentiful, even in this way.

What chance of public acceptance has the atomized shower?

In localities where bathing is minimal and disease a common condition, only by a long-range educational program can any new technology be accepted. In Domestic Water Use in the New China Highlands Richard Fauche reports on introducing new technology into a Highlands clan. He reports that cultural habits inhibit improvement of the water supply. Cited were fear of personal loss or remote contamination in the water source. These accounted for minimal water use, for example, total per capita usage being 0.48 litres daily of which 75% is drunk.

### Possible Applications of the Mist Shower

<table>
<thead>
<tr>
<th>Location</th>
<th>Water Supply</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban I</td>
<td>Water main with pressure reducing valve</td>
<td>Domestic shower, Institutional shower</td>
</tr>
<tr>
<td>Urban II</td>
<td>Street vendor or public standpipe</td>
<td>Domestic shower, Public bathroom, Manual or mechanical pressure</td>
</tr>
<tr>
<td>Rural I</td>
<td>Pumped water with pressure reducing valve</td>
<td>Domestic shower, Institutional shower</td>
</tr>
<tr>
<td>Rural II</td>
<td>Village pump</td>
<td>Domestic shower, Public bathroom, Manual pressure</td>
</tr>
</tbody>
</table>

Mobile Tank  
Showers on planes, boats, buses and vans, Manual or mechanical pressure.
It was believed that a wash test of bacteria on the skin before and after washing could demonstrate that the atomized shower had as good a cleansing capacity as the normal shower. With the help of the Director of the Child Health Section of Health Laboratory, Mr. Maurice, he made such tests were made of our skin using Bell-Parker reagent material. This is used to measure total bacteria present in any test, and was performed in a normal test. The results were as we had expected. The count of total bacteria increased from 260,000 colonies before washing to 450,000 colonies after washing. We were thus told that this test had been done many times before so our results were not unique.

Strongly, no one knows why this happens. Scientists say it does not prove that there is more bacteria present on the skin after washing, but that there is more bacteria in the samples of the water after washing. The theory is that bacteria which lie deep in the pores of the skin are stirred up and come out when washing takes place. See sketch.

Soap is classified in three types, each having varying chemical compositions. These different agents act as biodegradable soaps which do not halt bacteria growth and can be broken down by bacteria, biostatic soaps which control the growth of bacteria, and biocidal soaps which actually deactivate the bacteria.

Only by using biocidal soap can the count of bacteria remaining after washing be less. Tests show, said Mr. Boulton, that 98% less bacteria are present after one washing with soap containing Hexachlorophene, so we made a second test with the atomized shower device again but this time a bar soap, Camohol, containing 2% Hexachlorophene, (obtained on prescription from Dr. Boudreau of the McGill Medical Department) was used.

As expected, sample results taken after 48 hours in incubation showed a high absence of bacteria: about 90% less. Thus it has definitely been shown that washing by atomized water with biocidal soap reduces bacteria as much as normal washing with biocidal soap does. That is to say, the atomized shower device can be considered to give a hygienic a wash as a normal full water wash. Tests were made at the City of Montreal Department of Health Laboratory on August 11 and 17, 1976.
Mini-Mister

It is possible to build a small portable mist shower for well under ten dollars, and this section deals with the information required to build and operate your own Mini-Mister.

It would be possible to utilize a Volkswagen windshield washer reservoir, which already has a built-in pressure valve, but as a car accessory this is quite expensive (about $20 for the reservoir alone). Instead we have developed a design that uses ABS (or PVC, though this costs more) plastic tubing and closures. The main component is a piece of 75 mm (3") diameter tubing. This forms the reservoir whose capacity will depend on the length of the tube: 50 cm (20") contains about 2.3 litres (0.3 gallons) of water.

The ends of the tube are closed with threaded clean-out caps, also of ABS plastic, which are cemented. A bicycle pump valve is attached to one of the caps, while a vinyl hose is attached to the other. At the end of this hose is the hand-operated control valve and handle, to which the atomizer nozzle is fixed. The vinyl hose can be made as long as desired, usually about 1.8 meters (6').

ABS plastic is an ideal material for the Mini-Mister since it can be easily cut and drilled, is non-corrosive and readily cleaned, and can be glued and sealed with available plumbers’ products. When not in use the hose and handle can be stored inside the reservoir.
Assembly of the MINI-MISTER is as follows:

a. Cement the two caps (2 & 3) to the tube with ABS cement.
b. Drill a hole in the clean-out (4) to receive the insert (6). Place the insert in the hole and fasten the nut (7). Push the bicycle valve (8) snugly onto the insert.
c. Screw the completed assembly into one end of the reservoir.
d. Drill a hole in the second clean-out (5) to receive the insert (9). Place the insert in the hole and fasten the nut (10). Push the end of the hose (11) over the insert and tighten the hose clamp (12) over the hose.
e. Insert the other end of the hose onto the control valve (14) and tighten a hose clamp (12) over the hose.
f. Screw the adapter assembly (15,16) into the control valve (14).
g. Screw the nozzle (17) into the adapter assembly.
h. Now screw the entire assembly into the other end of the reservoir.

Noses:
- Steem Spray Nozzle Model TML 1/8"
  available from: Meadow Corporation Ltd.
  83 Sunrise Avenue
  Toronto, Ontario M4A 1X1
- Or, where F 200
  available from: Bates Fog Nozzle, Inc.
  box 311
  Greenfield, Massachusetts 01301

We recommend either one of these nozzles which have a flow rate of 0.3-0.4 liters per minute.

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**Mini-Mister**

**PARTS LIST**

1. TUBE, ABS
   75 mm (3") diameter
   Length as required (approx. 50 cm, 20")
2. THREADED CAP, ABS
3. THREADED CAP, ABS
4. CLEAN-OUT, ABS
5. CLEAN-OUT, ABS
6. INSERT, COPPER OR BRASS
7. MUT, COPPER OR BRASS
8. BICYCLE VALVE
9. INSERT, COPPER OR BRASS
10. MUT, COPPER OR BRASS
11. HOSE CLAMP
12. HOSE CLAMP
13. HOSE, VINYL
    6.3 mm (1/4") diameter
    Length as required (approx. 1.6m, 6')
14. CATCH CONTROL VALVE
15. ADAPTER ASSEMBLY, COPPER OR BRASS
16. ADAPTER ASSEMBLY, COPPER OR BRASS
17. ATOMIZER NOZZLE, BRASS

Almost all of these parts are available from plumbing suppliers. The ABS parts are for water drains and could be of PVC plastic as well, though ABS is cheaper. The hose and control valve could be common garden variety... depending on the ingenuity of the builder.
8. Catalogue

The MIST EXPERIENCE affects a drastic cut in water consumption, however there are a number of more conventional devices that are currently available that will also conserve water. We have prepared a catalogue of such devices, ranging from very inexpensive Pikie Resisters in sophisticated Temperature Selection systems. Also included are Metering Faucets, Faucet Aerators and water conserving Showerheads. This Catalogue is not a consumer guide as we have not had the opportunity to test all these devices, and though some are well known, others are quite recent innovations. The information given is taken from the manufacturer’s literature.

We feel that devices such as these deserve wider application. No longer is water conservation an issue that is restricted to only arid regions, though of course it is most serious there. Today, as water treatment and sewage treatment become increasingly expensive, the conservation of water has become increasingly important all over the world, whether in Arabian Gulf boom towns, squatter settlements in Southeast Asia, or in North America. This Catalogue indicates the variety of water conserving devices that already exist – it only remains to apply them.
Pressure Reducing Valve

This valve maintains a steady flow of water from the mains at a pre-selected pressure, thereby reducing wastage due to excess or varying mains pressure. It is also useful where there is a wide variation in line requirements, and where it is necessary to have a constant supply as well as equal capacity at all fixtures. Supply pressures of up to 50 kg/cm² can be reduced to within a range of 4.5 - 13.5 kg/cm², and water savings of up to 50% are claimed.

Flow Restrictor

This three-chambered cylinder type restrictor has no moving parts and regulates the flow at a predetermined rate. It automatically compensates for varying pressures. The 5P-3 reducer cuts down the flow in a conventional 2 cm pipe from 25-30 lpm to 11-13 lpm.

Flow Restrictor

This valve limits water flow to 7.5 lpm for lavatory sinks, and to 11.4 lpm for show heads. It is available in both male and female threads to fit into any standard fixture.

Flow Restrictor

A volume control valve, normally connected between the showerhead and the main line, which allows the user to turn off the flow of water while soaping up, and then return to the normal flow of water without affecting the temperature.

Flow Restrictor

This restrictor reduces water flow to about 9.5 lpm from standard pressures of 25-30 lpm. It can be introduced into standard fixtures by the user without professional help.
Flow Restrictor

The NO-76 reduces the water pressure while automatically compensating for varying line pressures. The water flow is reduced from an average of 25-30 lpm to about 9.5 lpm - a saving of 15-20 liters of water per minute. This restrictor fits into most standard fittings.

The NO-77 is a concave type restrictor that fits into most ball-joint type shower heads. It is stainless steel and reduces water flow from 25-30 lpm to about 11.5 lpm.

EASY-PUSH

Metering Faucet

Manufacturer: Speckman Co.
Address: Wilmington, Delaware 19899, USA
Price: $2.50

This faucet is not only self-closing but also meters water accurately - the amount of water being predetermined by adjustment after installation.

KLO-SELF, NAIAD, TIP-TAP

Manufacturer: Chicago Faucet Company
Address: 3100 South Racine Avenue
City: Chicago, Illinois 60614, USA
Price: $8.00

This faucet line incorporates slow-closing, drip-tight self-closing faucets that will conserve water in homes, schools and hospitals and office buildings. The TIP-TAP has an adjustable closing time.

FORDILLA

Manufacturer: Ford Motor Co., Inc.
Address: PO Box 943
City: Wayne, Michigan 48095, USA
Price: $21.58

The Fordilla is a spring-loaded valve with a cast-iron body that is specially designed for use in public fountains. When the push button is pressed and held down approximately 2 seconds of water are delivered. The flow then stops and the button must be pressed again to obtain more water. As the faucet cannot be left running inadvertently, water wastage is considerably reduced.

The large majority of the urban population of the Third World is supplied not from house connections but from public standpipes. The adoption of metered faucets would not only reduce water consumption, but would also reduce flooding of the public standpipe areas.

1. PUSH BUTTON
2. SET SCREW
3. PUSH BUTTON SPRING
4. SPACER BUSHING
5. CYLINDER CAP
6. LEVER (O-RING)
7. LOWER O-RING
8. PISTON AND PISTON ROD ASSEMBLY
9. BALL CHECK VALVE
10. CYLINDER
11. SILICONE FLUID
12. MAIN BODY
13. PACKING CAP
14. RUBBER PACKING
15. PLASTIC PACKING
16. LOWER WASHER
17. VALVE STEM
18. VALVE SPRING
19. RUBBER DISC
20. VALVE DISC NUT
21. VALVE BASE

PULL-RATOR

Manufacturer: Moen, Division of Standby
Address: Elyria, Ohio 44035, USA
Price: $1.49

This aerator reduces water flow to about 11.3 lpm. A cone-screen reduces clogging. Model 3919 (male thread) and 392A (female thread) fit all Moen faucets.
CONSERVAFLO, S-4430

Manufacturer:
Spaldon Company
Wilmington, Delaware 19899, USA

Price: Nonostable

This is a spray outlet water saving device that is used in place of an aerator on lavatory faucets. It reduces the flow to approximately 1.9 lpm. A more conventional aerator (S-4450) reduces flow to 7.5 lpm and fits most regular (13/16" dia.) faucets.

DINKEL-STREAM

Manufacturer:
 kişiler GmbH
1300 Central Avenue
Park Forest, Illinois 60466, USA

Price: $12.95 (complete kit)

This "kit" (SKK 300) consists of a showerhead (B-406-50), a faucet aerator (MK-100-19) and a swivel aerator (MK-100-19). At a standard water pressure the showerhead reduces the flow rate to about 9 lpm, and the aerators to about 8.5 lpm.

CONSERV-A-TOE

Manufacturer:
Eaton Industries Inc.
6100 N. Devon Avenue
Schaumburg, Illinois 60173, USA

Price: $3.98

This is a self-compensating constant flow restrictor and aerator which provides a water flow of approximately 7.5 lpm. It fits regular (15/16" dia.) faucets and a number of models are available for sale (C-306), female (C-316) or dual thread (C-324). Adapters are available for conversion to 13/16" dia. small faucets.

ECO-FLY

Manufacturer:
Chicago Faucet Company
3100 South Racine Drive
Brookfield, Illinois 60513, USA

Price:

This aerator screws into a regular faucet and reduces water flow to about 2.8 lpm. Four models are available: E-24 and E-24-5 for Chicago faucets (male and female) and E-24M and E-24F for other makes (male and female).

NEW CONSERVAFLO

Manufacturer:
Re-Dei Corporation
1960 S. Western Ave.
Chicago, Illinois 60622, USA

Price: $9.98

A self-compensating faucet aerator for regular (15/16" dia.) faucets that reduces flow from 20-30 lps to about 7.5 lpm. It is estimated that with such an aerator in the kitchen and bathroom, daily water usage from these two sinks can be reduced from 300 liters to 50 liters.

CONTROL-A-FLY

Manufacturer:
Chicago Faucet Company
3100 South Racine Drive
Brookfield, Illinois 60523, USA

Price:

This device is a "cartridge" that fits inside the faucet and allows the user to select the required water flow rate by a simple manual adjustment.
FAUCET WITH RESTRICTOR

This is a built-in flow restrictor used on showerheads as well as lavs. It maintains a constant output flow rate in spite of varying line pressures. Various restrictors are available for 5.0 lpm, 7.6 lpm, 9.5 lpm and 11.3 lpm flow rates.

ANTISTREAM

These brass showerheads incorporate the “Ultrasound” restrictor in the conventional shower head design. This will effect considerable savings in water and energy (i.e. hot water). A variety of showerheads are available, all with adjustable spray selectors (5-2252 AP, 5-2254 AP, 5-2255 AP, 5-2260 AP, 5-2270 AP).

321 MARK III

This anodized aluminum showerhead is designed to deflect the jet of water against the interior of the ‘lens hood’, breaking up the stream to a conical pattern which gives the effect of a much larger flow of water. The flow is rated at 7.5 lpm.

WATER SAVING SHOWERHEAD MODEL 550-11

This ABS plastic showerhead reduces water flow to 9.5-11.3 lpm. The spray can be adjusted.

KENTFLO

This company manufactures a wide variety of showerheads of chrome plated brass, all of which are available with an optional 11.3 lpm flow control. The flow control kit for converting conventional brass showerheads to this reduced flow is available for $1.50.

NOVA

This solid brass chrome-plated showerhead reduces water flow to 6 lpm and the nozzle can be adjusted from “fine needle” to “soft rain”. There is a control that permits the user to cut off the water flow while soaping up, without affecting the temperature of the water.

RADA 972

This showerhead has built-in flow control that maintains an even spray in spite of varying line pressure. It fits 1/2", 3/4" and 1" and is available in male and female threadings. In a controlled experiment in Toronto it is reported that the annual cost saving for an apartment building was $11.68 for water and $47.11 for water heating, per apartment unit.
WATERSAVER

Manuf. by:
Burke Mfg. Co.
14439 North 7th Street
Scottsdale, Arizona 85260, USA

Price: $5.95

This ABS plastic showerhead contains a valve that reduces the water flow to 11.3 lpm. It is estimated that the average household could thus save 200 liters per day.

HYDROPIESE

Manuf. by: Chicago Faucet Company
2100 South Narcissus Drive
New Haven, Illinois 60975, USA

Price: $11.50

A single control permits the user to select the desired temperature beforehand. A pressure balancing valve automatically holds the water temperature. This not only increases comfort but decreases water wasted while adjusting the water temperature.

NEOBROL

Manuf. by: Menvi, Division of Standadco
Elgin, Ohio 44022, USA

Price: Wide variety

It has been estimated that single handled control can reduce water consumption by 30% over the conventional two handled faucet. The user can adjust temperature and flow more quickly, and turn the faucet on and off more rapidly, thus reducing water wasted. The Menvi "cartridge" in addition virtually eliminates drips, since there is no washer and seat to wear out.

ULTRAFLO

Manuf. by Ultraflo Corporation
PO Box 1534, Sandusky, Ohio 44870, USA

Price: Approximately $80.00

(kitchen and bathroom, installation not included)

This is a centralized water distribution system that eliminates the use of manual mixing valves (i.e. faucets) to control the flow rate and water temperature. The conventional hot and cold pipe supply is replaced by a single line. The user selects a combination of pressure/temperature (e.g. WARM-LO FLO) and blending takes place at the water heater. The supply line is a small diameter (7 mm) flexible tubing. The amount of water saved by a single family could be as much as 500 liters per day. In addition, as hot water does not "stand" in the pipes, energy is also saved.

OMATAP II

Manuf. by Walter Crumwell & Co. Ltd
Wadding Works, Cheltenham GL50 3EF, UK

Price: $68.84

This faucet generates a fine spray of water at a flow rate of 2.4 lpm. A flow adjuster is built-in and can be preset for any head. Finally, a single handled faucet allows the user to pre-determine the temperature of the water. The handle is pushed to turn the water on and off, and is rotated to vary the temperature. The combination of aerator-flow restrictor and temperature selection is said to effect water savings of up to 78%, which affects not only the cost of the water but also the cost of hot water.

Supply Pressures

The diagram illustrates the typical water pressures between 250 and 1380 lbs per sq. in. The outlet flow can be adjusted with the valve regulators to suit individual needs. The outlet flow rate is adjustable to provide either the required flow.
9. Bibliography

Serious students of water conservation, as well as researchers and engineers will be interested in this abstracted bibliography of thirty papers, books and reports dealing with saving water in the home. This chapter is adapted from a study that was carried out at the International Development Research Centre (Canada) with the collaboration of the World Bank, and is part of an extensive bibliography of over 200 references dealing with low cost sanitation. This entire study is available for a nominal price from :

International Development Research Centre
Publications Division
Box 1066
 Ottawa, Ontario K1S 5R6, Canada.

The report is entitled :


*AWM: Award winning characteristics of the Flushmate Tank with those leading water closets have been investigated. Water supply and discharge characteristics of both Flushmate and gravity tank operated water closets have been measured and compared. Performance tests and backflow prevention tests have also been conducted on both Flushmate and gravity tank flush mechanisms. The results of the testing program have shown:

1. Flushmate operated water closets place a substantially lower water demand on the water supply system (30% less water usage).

2. Both discharge flow rates were influenced primarily by head design, and Flushmate and gravity tank operated flushmechanism had similar discharge peak flow rates, however, the Flushmate discharge time was 60% shorter.

3. Flushmate operated units were good performance water closets.


This article describes work done in developing a shower which operates for 10 minutes using only 1 liter of water. A composting toilet which allows for the hygienic disposal of waste without an elaborate plumbing system is also described.


Research on water-saving devices for British homes is described. A recomputed drain reduces flush-water consumption in toilets by 4%. Bathroom wastewater is recycled to be used for toilet flushing. Atomic laser water is proposed for washing. It is estimated that savings of up to 10% could be achieved by various combinations of these devices.


Based on electronic monitored programs in actual households, data compiled on water use and water habits demonstrated with the Ultraflo publication, one line system that there was a saving of 15 to 20% of total water consumed compared to households with conventional two line systems. The Ultraflo system eliminates waste or heated water normally left standing in lines between users.


Three reasons for water saving are given: (1) The fact that water resources are limited, (2) water rates are rising because of increased processing required to meet governmental standards for water, and costs of wastewater disposal; and (3) to reduce the load on treatment and treatment systems potentially dangerous for pollution.

Many helpful hints for more effective use of conventional plumbing fixtures are offered. Mention is also made of water saving devices which attach to existing fixtures as well as alternative fixture enclosures. Water use figures are quoted to point up actual volumes of water use and waste. Hints are given for water saving outside the house, and a table of plant watering guide is shown.


This study indicates practical means of waste flow reduction for American households. Commercially available devices for water saving are described and literature on advanced water and wastewater treatment is reviewed. A consumer survey was conducted and showed that water used in household functions such as bathing and toilet flushing can be substantially reduced by the use of more efficient appliance and plumbing devices.


Water saving devices such as the dual flush toilet tank system and the vacuum toilet system are currently available. These systems are reported to provide at no overall cost penalty to the homeowner, a water savings (total waste flow reduction) of 30 to 60 per cent. A limited survey indicated that the use of such water saving devices would be readily accepted by homeowners.


The conservation of energy is related to energy conservation. Water requires energy for treatment, which in turn affects the physical environment. Water savings in toilets, water reduction devices, toilet redesign, use of compact toilets, and use of such items as plastic soap suds and plastic toilet seat covers and other items that can be used in water households. Design of clothes washer and even clothing material can affect the amount of water used. Heated water is a great energy consumer. Use of solar water heaters, proper water heater location and insulation can save 30% heat.


This is a system which effectively accomplishes an improvement in public health and sanitary conditions in those areas in developing countries. The problem was to provide a permanent, healthful water supply, with adequate amounts of clean water available at all times in all areas, in return for a small amount of monthly fee. The solution was the installation of a one-piece water supply line serving a group of dwellings, each provided with a "Forsill" spring-loaded
This device restricts the3 volume and water of users such as the hand pump does. Details of water distribution and uses are data presented, as well as public acceptance of the system.

A report of two studies conducted by General Dynamics and by the Washington Suburban Sanitary Commission of equipment available for saving water in the home. This equipment includes reduced-flush toilets, flushometers for showers and faucets, etc. It is concluded that there is a Justification for installing such devices to save water.


A two-year demonstration program was conducted to evaluate water savings, costs, performance, and acceptability of various water-saving devices. Reduced flush toilets, and flush limiting shower heads were installed in eight single-family dwellings. In three of the homes both bath and laundry water was filtered, disinfected, and reused for toilet flushing and/or laundry. The experimental portion of the program was conducted from July 1972 to May 1973.

Water requirements for toilets, flushing, were substantially reduced in an environmentally acceptable and aesthetically acceptable manner. Shallower- and flush dual flush toilets resulted in average decreases in water use of 38 and 58%, respectively. Flush only showers had proved to be relatively ineffective, however this result may have been due to use patterns unique to this study. Wash water reuse for toilet flushing and bathtub operation through the hot water lines is a potential source of water savings, but further investigation is needed.

In summary, the consumption for toilet flushing was reduced from 20% to 30% of total water usage. In addition to household savings as a supplement to the overall reduced waste flow from home by 10% to 15%. For single-family dwellings, water use systems could result in marked cost savings in high water and sewer rate areas. They are definitely suggested when septic systems with your disposal due to soil or topography.


Differences in U.S. and European domestic water consumption are attributed to personal habits, water-consuming appliances, and mostly water closet design. Pressure and fitting minimum flow rates based on water conservation equipment used in the U.S., but two criteria for saving potential for water saving in appliances and fixtures are given.

Energy savings amounts to reduced efficiency of water heaters, from reduced consumption of hot water. Indirect benefits of use flow conservation measures and can be minimal savings. Precipitation of energy use was measured using a comprehensive study of energy use in water supply and water treatment systems; and from the point of view is the economic impact in terms of water conservation, the effects of some economic quantities of water and water quality on water consumption that may be achieved, noise and fire performance of fixtures, safety of householders, etc. Without thorough evaluation of water-saving fixtures and fittings, the result may be a biased and double evaluation of toilets. In a year, research should establish energy impact of water conservation by energy-benefit analysis as well as impact of water saving measures.


The author concludes the Dynamic bathroom as an interior sanitary facility. F eigenen combines water and materials to release skin cells and dirt. Illustrations show laboratory set-up and three magnified photographs of skin surface, and students searching for gan use in bathing. With such eye gins of plumbing will be saved as well as bathroom washing vials.


A spray faucet system is reported to provide savings for both water and energy. Investigations conducted ed in London show that an average time taken for washing with spray faucets in less than 60 seconds, compared with 80 seconds for the traditional method. Future use of this system is expected to increase.


The development of wastewater treatment systems in households by individual users, by reducing the amount of water that flows through plumbing fixtures, and by recycling water used to certain functions reduces wastewater use. One way this is to be accomplished is to be earned by water systems of extra systems. The survey of available systems includes illustrations, identification manufacturers, show performance, characteristics, and includes comments.


Land development in many parts of the country is endangered by inadequate water resources or by inadequate availability between water supply and waste treatment plans. Many established areas cannot satisfactorily keep pace with rapidly expanding urban populations for the same reasons. In addition, the cost of additional water supply and waste management in such areas can be extremely high. Practical alternatives for the development of water and waste treatment systems are needed in newly constructed or redeveloped communities where such difficulties exist. This report evaluates the accuracy in which current and additional technology can be applied to develop practical solutions to existing and emerging water supply and waste disposal problems.

In overview of water resources factors as they affect new community planning, and the requirements imposed on residential wastewater treatment systems are presented. The results of equipment surveys contain information describing: commercially available devices and appliances designed to conserve water, devices and technology for monitoring water quality and controlling salt contamination; and advanced water and waste processing equipment system concepts are developed and compared on the basis of current and projected costs. Economic evaluations are based on community populations of from 5,000 to 260,000. Presenting concept systems is defined in sufficient depth to initiate detailed design.


Methods of residential wastewater flow reduction, devices and practices, are presented and discussed in detail. The author concludes a trend of future shortage of high quality water supply and suggests acceptance of new technologies by both public and government agencies in order to effectively carry out a program to reduce household water consumption.


Water reduction can be achieved through introduction of flow reduction and recycling devices that encourage development of new or improved water-saving devices. Some water recycling devices have been isolated into the following: a) a name for type, operation, effectiveness, cost, and maintenance of manufacturer. Recycling domestic systems are different quality only if a sufficient for the manufacturer, and develop a continuous approach to wastewater treatment in water-saving toilets, which are described as to their nature, operation, advantages, and disadvantages. New water conservation systems were suggested by the Washington Suburban Sanitary Commission. Such water conservation systems would shift water consumption to off-peak hours, they could be particularly effective in decreasing required water and wastewater treatment plant capacities.


The paper describes various hand-operated pesticide spraying and dusting devices for use in the home, in the garden, or on farms. Continuous sprayers discharge the spray material only with each forward stroke of the pump. Continuous sprayers maintain a constant speed, and develop a continuous spray discharge of uniform pattern while the pump is being operated. Useful information such as operating instructions, tank sizes and spray pattern to give as a well as information on maintenance and pest control handling.

In the following, the significance of liquids to be used as a vessel in aerating the inside of a tank. The influence of aerating the organic matter and its characteristics are given. The design and operation of the aerator, pressure morsel, are presented. The use of pressure morsel in aerating the inside of a tank is discussed.


A number of devices to reduce domestic water consumption are available on the market. These include spring-loaded self-shutting faucets, pressure-reducing showerheads, and various flushing devices. The devices are based on the use of water in a house. There is a need for devices that allow filling with automatically controlled water. This is not available within the home. In order to reduce the amount of water needed for individual bathing, and, in turn, decrease the water pressure in the system, a new device is tested for washing and flushing purposes.

Aeration is the mechanical subdivision of a bulk liquid (e.g. water) into a fine droplets spray. This enhances the water's capability by increasing the surface area available for adsorption. The test of a number of nozzles indicates that the best performance of industrial hydraulic nozzles has flow rates of 0.13 - 0.25 liters/minute at 1.1 - 1.8 cm water head has enough capacity to remove soap scum from the skin.

A prototype shower was built utilizing a 5.6 liter water tank in which pressure could be manually induced with a bicycle pump. A series of flushing tests indicated a 6-8 minute shower utilized 6 liters of water. Some problems were encountered with rinsing across soak-up and half-wet washing.

The most efficient water use is possible by the water system of over 30% compared to a conventional
toilet. In order to determine the efficiency of a domestic system, a test was taken before and after aerating the water with a bicarbonate soap. Sample results after 48 hours showed a reduced absorption of about 281.


The final report describes (a) compiling information needed to establish the water recovery system and (b) developing environmental for dwellings and (c) developing environmental for dwellings and (c) developing environmental for dwellings and (d) developing environmental for dwellings.

The system as described herein was sized for a group of 100 dwelling units.


A comprehensive report on reducing water demand in four sections: economic, institutional, economic, and technological. Includes extensive bibliography and a directory of American manufacturers.


The book is a survey of alternative domestic waste disposal systems. Part I reviews the schematic methods for the disposal of household waste, noting the advantages and disadvantages with special interest in self-contained systems and ones that use little or no water. Part II is a catalogue of data emphasizing, in a single comprehensive table of manufacturing in various countries. Part III describes the operation of composting toilets, and ends with a tax cost survey for the mowers for use in temperate climates, which can be made for 100 or less. A useful summary of available data on all toilets listed herein.


Initially, the results of theoretical and experimental investigations to establish design parameters for a specific test bed for further experimental investigations in both one-g and zero-g environments. This report describes these efforts and the resulting conclusions concerning feasibility, shaker design concepts, liquid-gas separation techniques, and their related zero-g design criteria.

Part 1, an analysis of zero-g air-water behavior, small configuration, and related habitability parameters were made before the test tank was constructed. The test 2 effort investigated and refined these concepts to establish the minimum impact on the contract baseline mission model.

Based on Part 1 and Part 2 test results, basic design criteria were established for too zero-g whol body shaker concepts. The amount of water required to wet the whole body, including the head, averages approximately 1.5 gallons, which is due to the use of hand-controlled nozzles, the nozzle design, operating procedures, and the tendency of the water to splatter to the body.


This paper describes the three tests effort to design, fabricate, and demonstrate test of a zero-g whol body shaker for the Space Station Prototype. Conceptual designs for various sub-systems of the shaker were established as part of Test 1. Test 2 involved the formulation of preliminary and final design. Test 3 has conceived of a shaker for the space station and has developed a conceptual and mechanical component. Test 3 included the fabrication and test of the shaker assembly.


A report on the conservation of water supply and waste water in given. What is given are the types of water meters and of waste water meters on a case by case basis. There are a few cases of water saving devices for taps, toilets, and showers; as well as a table showing waste water and cost saving water in toilettes. Non-every, summer and handkanle toilets are also discussed.


This paper describes the construction of a dual-Flush cistern, and the way it saves water. Details of trials carried out, to determine the saving likely to be achieved are given.


Installation of inexpensive constant-flow valves at 2.5 per cent. In the supply lines to individual houses in Illinois, Lombard reduces the water use by 20 to 30 per cent. No complaints regarding inadequate supply have been received. Cost of the constant-flow valve is approximately U.S. $1.50 to $2.50.
References

17. The NRC has not published results of its work with atomized sprays. The information given in this book is the result of a personal visit by one of the authors.

FLASH

Lilco Gains 800,000 Water-Saving Devices

MONTREAL, March 11 - The Lilco Corp. said today that it had signed contracts with 20 companies to provide water-saving devices to 800,000 homes in the United States and Canada. The devices, which are designed to reduce water consumption, will be installed in homes during the next 12 months.

Lilco's new product line includes shower heads, faucets, and other fixtures that use less water than conventional models. The company estimates that its devices will save 50 million gallons of water annually.

The contracts were signed with major home improvement chains, including Home Depot and Lowe's. Lilco will also sell the devices directly to consumers through its own retail outlets.

The deals were announced at the annual convention of the National Association of Home Builders, which is being held here this week.

Robert D. Lilco, the company's president, said that the contracts were a significant milestone for the company. "We are very pleased to have secured these major contracts," he said. "We believe that our water-saving devices will be a major factor in helping to conserve water and resources for future generations."