



## **Review on Research and Developments of Sinks for Various Applications**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author WWS performed a comprehensive review on research and developments of sinks for various applications. Author UN supervised the work and designed the content layout for this article. Authors MNEE and AAS proposed future research pathways on the subject of interest. All authors read and approved the final manuscript.*

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### **ABSTRACT**

In 21st century, kitchen sink is no longer a luxury for a house but has become a necessity. Human nowadays are pursuing for an advance kitchen sink with multiple function and ergonomic to the user. This work is a dedicated review on the design evolution of sinks from year 1973 till 2016. According to the patents review from year 1973, kitchen sink or faucet with multiple functions compiled with ergonomic features are invented and improved in its design from time to time. The patents discusses on the stand alone sink, portable basin that can be packed, use of flexible braided metal hose, sensor operated faucet, foldable kitchen sink and others design features which is crucial to the user. As part of an initiative to predict user needs in the future, future research on state of the art design and development of a smart ergonomic sink for home applications has been included in this work.

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## 1. INTRODUCTION

In this sophisticated world, we can obtain the running water easily by opening the sink faucet or even use the touchless sensor. With the onset of running water, sink has become an indispensable and contemporary appliance in kitchen, second line to the stove. Sink, or we called it as basin and lavatory is used to perform most of the activities in home: washing, cooking, preparing food, household chores and others. As a result of conventional significance, we can observe that the sinks today are advancing compared to last decade. Today's sinks are available in variety of size, shape, material, height and include a numerous different features and accessories such as faucet, cutting board, light, hand dryer, seal stopper, soap dispenser, utensil tray, colanders and others.

In today's world, sink has become part and parcel in our daily life that can symbolize the status of a man and it shows the vanity of the kitchen bathroom. Sink is used in our daily life to wash, rinse, cook, and prepare food hence our daily activity cannot be completed without the presence of sink. Why is sink so important? With the present of sink, we can easily get the clean running water by turning on the faucet to complete our daily task. With an advancing and nice looking sink, it will also improve one's sense of taste for the kitchen fashion.

However, the trend for sink doesn't change as frequent as compared to the trend for clothing fashion. Fashion clothing style come and go with season while trend for home sink can last considerably much longer than clothing. Since one won't be changing the counter top faucet or sink as often as changing the fashion style, hence it is more crucial that choosing a sink styles with lasting trend. As the trending for the global now is going green, it is the time for the nature to meet the industry [1]. Natural material is used to build a sink so that the user can feel the warmth of wooden surface resonates within the natural environment. Although the maintenance for natural material is time consuming, the butcher block looks awesome when contrast with the utilitarian faucets. Moreover, double sink is also a trending for the sink nowadays [1]. When an extra sink is added, there are extra space to prepare the food, wash, rinse and use for other activities. It can also be connected to a filter so

that the drinking water is obtained directly from the faucet of the second sink. It provides much convenient to the users. In addition, under-mount kitchen sink has been one of the most trending kitchen sinks [1]. As the sink is installed below the counter top, sweeping crump and spills into the sink has been an easy task for the user. People today are very busy with their own task and sometime become forgetful to the little things around them like turning off the faucet of the sink, hence accessories in touch comes in with a very important role to automatically shut off the flow of water when it remain inactivate for minutes. This function is very practical when the hands are busy or dirty. A soap dispenser with touch accessories is added by most of the users. Furthermore, product with bold finish is sought after for kitchen hardware especially the sink. Opt for warmer hues like bronze, copper or matte black which is more to the traditional style, it bridge the gap between decorative traditional and sleek modern style [1]. Mixing hues with same shine or finishes it with same polish, it makes the sink eclectic with flair. Choosing a sink that suits with the kitchen or bathroom style will sure maintain a cohesive and fresh look in your kitchen.

As we are living in a high technology era, generation nowadays is looking for a lifestyle that incorporate with ergonomic factor. Ergonomic is a branch of science that apply systemic method or knowledge about human to learn about human abilities and limitations and evaluation the interaction between individual, organization and technology [2]. Ergonomic aims to minimize the work rise and maximize the work efficiency and maximum worker health and safety. For this proposed ergonomic sink, it has corporate with a design that suitable for human body requirement. The height of sink is one of the considerations for the ergonomic factor, hence, an adjustable height sink is proposed to fulfill the requirement of human factor. Whether a user is left-handed or right-handed, body size, basic requirement for a sink are taken into account when designing a smart ergonomic sink. All these factors will directly affected the sink's width, sink's depth, drain location and most dominantly, the comfort of the user. The additional accessories like double bowl, soap dispenser, lighting, sensor, temperature control and mirror are taken into consideration when designing a sink.

Prior to the design, review works on sink design and their accessories are performed starting from year 1973 to year 2016. From this review works, it can be summarized that multi features accessories embedded to the sink design is crucial. Hence, the following section after the review works will be on the proposed state of art Design and Development of a Smart Ergonomic Sink for Home Applications. An improved design for a sink will be coming out after the review works and researches to improve the living lifestyle of human.

## 2. DESIGN EVOLUTION OF SINKS

Thousand years ago, the people in that era obtain the clean water from well, spring or stream for washing, cooking, drinking or other purposes. They need to travel for a long distance in order for them to get the clean water. Sometimes, rainwater is collected in a receptacle to be used as soft water like washing or bathing. Taking bath along the river side has been a normal daily lifestyle for them. During that era, only some of the advanced cities such as ancient ROME have kind of running water that can be carried from the nearest sources to the house [3]. The water was hand-carried by using buckets where it was transferred through various tubs and bowls. It might be a formidable task for today's generation, but it was very normal to the people living thousand years ago. Hence, the forerunners of our modern sink is any container that can fill water such as bowls, tubs, troughs, buckets and so forth which most of them is made up of wood, porcelain, metal or stone.

In the late 18<sup>th</sup> century, something assembles the bathroom sink has been invented: the washstand. It is made up of a simple table with a bowl placed at the hole cut through the table top. From 1820 to 1900, the dry sink with low, wooden cabinet and a trough built into the top is commonly used in American homes. The trough is normally lined with lead or zinc sheets, and the

bowls of water is held to use for washing purposes. As shown in Fig. 2.1, this dry sink comes with an introduction hot and cold running water faucets through the backboard and a drain into the zinc-line trough [3]. Thus, we learned that the washstand was the precursor of the bathroom sink while dry sink is the forerunner of the kitchen sink.

In the 19<sup>th</sup> century there is a major development in sink design called "sanitary movement". In this case, kitchen and bathroom designs are explain in different parts with a great deal of "scientific" thinking regarding efficiency, sanitation and modern study. As we can observe, white has become the prevalent colour for sink or other feature in bathroom or kitchen as it associate with the sanitary. Fig. 2.2 shows the evolution of sinks for both kitchen and bathroom. As shown in Fig. 2.2, it divided the evolution of sink into 2 parts: kitchen sink and bathroom sink. The kitchen sink has evolved from dry sink style with wooden cabinet, metal line trough in Pre 1880, from year 1880-1920, it is enameled cast iron with supporting legs and enameled cast-iron, wall- hung with build in drain boards. While for the evolution for bathroom sink, it is the common style, wooden base, porcelain basin in pre-1880, during year 1880-1920, it comes with pedestal style and porcelain and lastly, in year 1900-1940 the bathroom sinks is normally design with wall-hung and porcelain. From 1930 onwards, the kitchen and bathroom sink has been combined together with a drop in basin, base cabinet and mixer faucet [3].

In this advancing world, people has invented more sophisticated sink with the latest technology to provide comfortability and vanity to benefit the user. Since year 1973, people have started to incorporate the concept of ergonomic and human body factor in to the invention of sink. This has benefited the user in the way of using the sink. Hence, the following section is a compilation on patent review works starting from year 1973 till 2016.



Fig. 2.1. The 19<sup>th</sup> century dry sink, the precursor of kitchen sink [3]

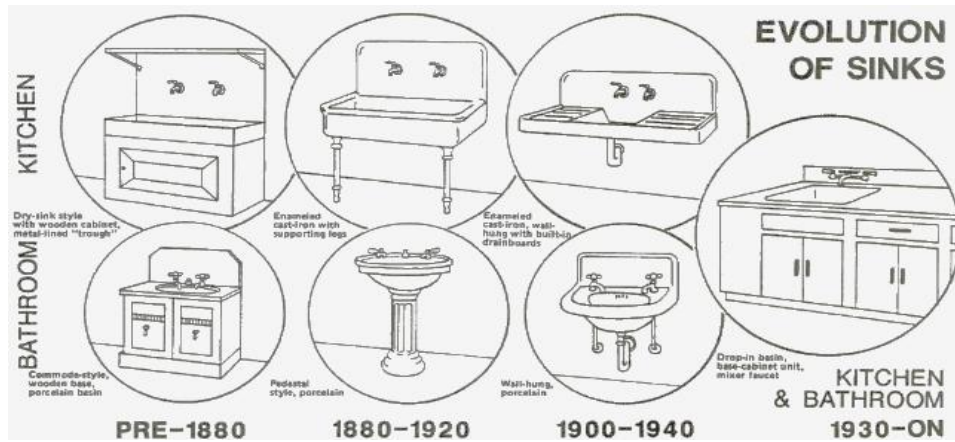


Fig 2.2. The evolution of sinks [3]

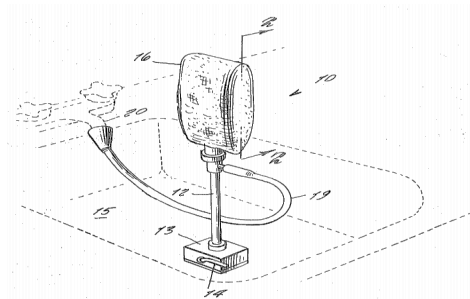


Fig 2.3. Perspectives view of invention set up for the use of wash bowl basin [4]

Remark: 10 – A hand and arm washer; 12 – Chromium plated pipe; 13 – Mechanical vacuum cup; 15 – Wash bowl basin; 16 – Interchangeable bags; 19 – Rubber hose; 20 – Wash bowl faucet

### 3. PATENTS REVIEWS

#### a) Year 1973

The design as shown in Fig. 2.3 is invented by Ralph E. Gore [4]. It is a Hand and Arm Washer which is specially designed for the disabled or one armed person to assist them to wash their hands and arms in an easier and convenient way. Its lower end is secured with a flipped over mechanical vacuum cup to evacuate the air from underneath so that it is rigidly secured on the basin. It consists of the series of inverted, interchangeable bags in which the bags are made up of form fitting terry wash cloths and towel material to use for soaping up, rinsing, rubbing and drying operation. The central vertical opening formed is opened on the upper end of form and the lower part is communicated with a sideward nipple connected to one end of rubber hose while the other end is connected to the wash bowl faucet so that the water can flow through when the device is in use. Hence, the user can rub, soap up, rinse off and dry his

hands against the bag-covered form in a convenient way. This basin can be set up easily and removed for normal person to use in home.

#### b) Year 1974

There are few patents regarding ergonomic sink released in the year 1974. One of the patents is the Quick- Change Faucet invented by Joseph Keane [5]. He has invented a quick-change faucet in which it can be attached to a sink that worked entirely from above, except for attaching the riser pipes to the shut off valves. This allows the workman to work in a visible and ample room instead of working behind the wash basin. This invention has allowed the hot and cold riser pipes to attach their respective valves on the faucet before it is installed into the sink and simplify the installation on the sink. Fig. 2.4 shows the vertical section through a lavatory wash basin. The figure shows that the quick-change faucet is mounted on the horizontal lavatory which is located at the rear of the sink. The hot and cold water valves are also

connected by the riser pipe to the respective shut off valves. Moreover, the faucet is designated to comprise a water mixing manifold in which it enclosed and covered by an ornamental shell.

At the same year, Jacob J. Hamburg has invented a Kitchen Sink Strainer and Drain Bowl Unit in which the drain bowl is fastened within the drain opening of the sink. A keyhole slot type opening is provided at the bottom with a wedge shaped cam formed around the open surface of drain bowl's opening [6]. In order to seal the strainer downwardly against the interior wall of drain bowl, a bowl- shaped strainer is nested within the drain bowl with an integral central stem extending downwardly through the hole with a radial projection engaged with the drain bowl bottom. When the projections are disengaged from the cam, a coil spring is positioned between the bottom of the strainer and the upper surface of the bottom of the bowl to make the strainer to pop up and remain spaced above the lower end of the bowl for drainage purposes. When operating the sink, the bowl is mounted with the sink as shown in Fig. 2.5 as the strainer is put into the bowl with the stem arranged align with the elongated portion as keyhole shape opening. In addition, the handgrip is manually grasped, the strainer is pushed downwardly to compress the spring until the projections clear the bottom of the bowl, at a point that the handgrip is twisted to rotate the strainer and the stem, it is the time to stop the sink drain opening.

#### c) Year 1977

In year 1977, a Kitchen Cutting board which is positioned directly over a sink basin is invented by Ellis Shamoan [7]. This light weight stabilized cutting board is used in simultaneous washing and preparation of vegetables. The advantage of the cutting board is that it can be placed directly on the kitchen basin and thus, it improves the sanitary configurations. For the design of the kitchen cutting board, the cutting board serves as a general cutting planar adapted to lie on kitchen sink and placed beneath arcuate rotation path of sink faucet as shown in Fig. 2.6a. Flange is adapted to abut the counter face and held the weight of the user of cutting board for food preparation. A basket which is used for washing or storing those vegetable is constructed to mate the engagement in aperture to depend in open – ended communication with sink basin. However, as shown in Fig. 2.6 b, the basket can be easily

removed from the aperture. A pair of handles is provided on the rim for securement and easy handle of the basket.

#### d) Year 1985

Mr. Alfred M. Provost has invented a Portable Basin Apparatus that can be packed, transported and set up easily for outdoor activities in the year 1985 [8]. This Portable Basin Apparatus have a vertical support member to the top to affix an upward-facing open-topped support as a section of regular arcuate shape like a semi-circle. The top of the arm is pivoted mount to a basin support ring of closed configuration in which the shape maybe a regular arcuate geometric such as circle of dimension according to the supporting yoke. This is to ensure that it can revolve freely about the axis between the yoke arm ends by means of supporting pins. The Portable Basin Apparatus consists of a vertical oriented pole structure as the support base in which the supported base is a plurality of tube segment that can be assembled by means of mounting pin which is affixed to the segment and inserted to the interior bottom segment. This structure is used to simplify the production and storage of the basin. In addition, a soap dispenser holder is positioned at the top end of top segment while the tower holder is placed at the vertical support as shown in Fig. 2.7. The semi-circle mounting yoke is configured to provide dual arms oriented in vertical form from the base element for an upward opening continuum. The unique structure of the basin apparatus has made it unusually stable against tipping over as it enables the center of gravity of assemblage, so the weight of basin increase as water is being placed in it.

#### e) Year 1989

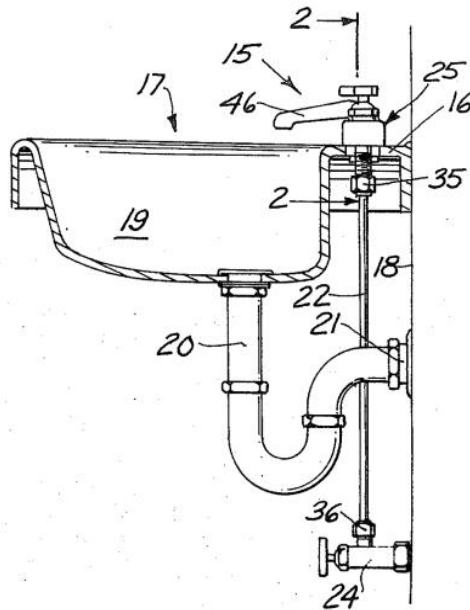
The first Automatic Faucet Sink Control System has been invented by Frank S. Piersimoni in the year 1989 [9]. As shown in Fig. 2.8, this automatically controlled faucet-sink system consists of a fluid dispensing faucet which is controlled by the means of a light source-photo-sensor pair placed within a housing mounted on or near the sink for the cone of vision and light beam to focus at the intersecting point of the fluid flow path from the faucet. The electrical circuit and valve apparatus are provided to actuate and cut-off the fluid flow from faucet in response to the object below the faucet reflect light from the light source to photosensor. The light beam as an emitter will transmit the internal

volume of the sink to the so called detector, photosensor which has been coupled to a light source to enable the intercepting of the light beam emanated from the light source. These will act through a control circuit which to energize the solenoid controlled ON/OFF valve. In short, when the emitter detects ant light beam, the water is allowed to flow freely, while there is no light detected, the faucet will prevent the water from flowing. However, the flow of fluid of the faucet will be terminated after a predetermined period has timed out to reduce wastage and overflow of fluid form the faucet.

f) Year 1991

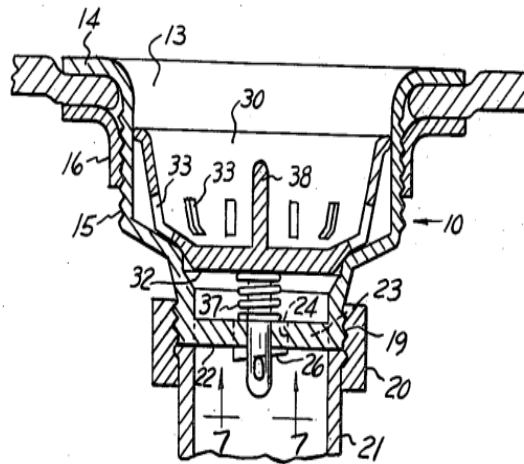
An improved faucet connector with flexible braided metal hose assembly has been invented by Philip Mulvey in the year 1991 [10]. Fig. 2.9b shows that it comes with water supply fitting assembly at one end while the other end is assembled with a universal faucet fitting to connect the faucet to a water supply tubing, pipe or even shutoff in a safe, efficient and structural sound manner. This sink consists of a hot water

faucet, a cold water faucet, a swivel water outlet and discharge and both of the water faucets are connected via pipes to the respective water supply as shown in Fig. 2.9a. The assembly of novel faucet connector comprises of a flexible composite conduit hose assembly which has a rotatable coupling to surround a special tubular cone-style connector. This style of connector has a convex faucet fitting head with the converging end portion facing downward. The composite conduit includes a flexible braided metallic hose assembly with flexible inner tube consist of a flexible outer sheath or shell comprising 3 to 18 interlocking strands of wire and a water-impervious elastomeric core. The advantages of novel faucet connector assembly are that it is adaptable and usable with all the standards of faucet, shutoff valves and water supply line worldwide, it has excellent structural strength and integrity, outstanding resistance to stress and failure, stronger longevity and wear, better protection against leaks, easier to manufacture, store, ship, assembly, remove and use and lastly it is very convenient, reliable, economical effective and efficient.



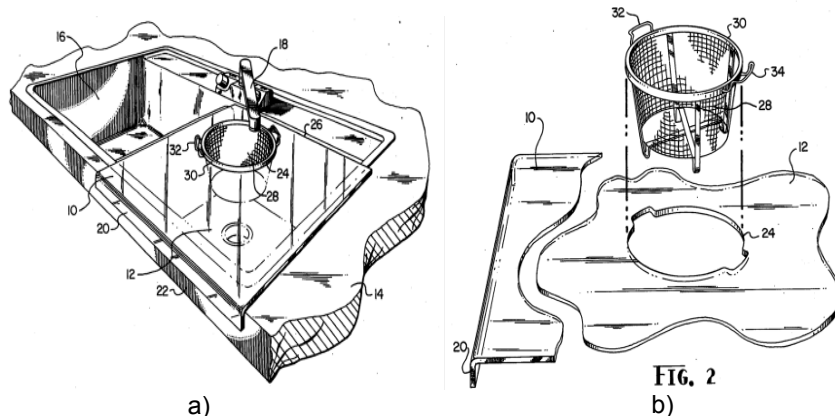
**Fig. 2.4. Vertical section through a lavatory wash basin, showing a quick change faucet embodying the principle of the invention [5]**

*Remark: 16 – Lavatory ledge; 17 – Rear of lavatory; 18 – Wall; 19 – Wash basin; 20 – Drain ; 21 – Sewer outlet; 22 – Riser pipe; 24 – Shut-off valves; 25 – Cast brass housing; 35 – Connector fitting; 36 – Connector fitting; 46 – Discharge spout*



**Fig. 2.5. Sink strainer and drain bowl unit mounted within a sink and connected to drain pipe, with strainer in sealed position [6]**

*Remark: 10 – Improved strainer – drain bowl unit; 13 – Drain bowl; 14 – Upper flange; 15 – Exterior threads; 16 – Ring nut; 19 – Exterior thread; 20 – Conventional threaded coupling; 21 – Conventional drain pipe; 22 – Bottom of drain bowl; 23 – Arcuate drain slot; 24 – Hole; 26 – Wedge-shaped cam surfaces; 30 – Bowl shaped strainer; 32 – Base; 33 – Drain slots; 37 – Coil spring*



**Fig. 2.6. a) Perspective view of the embodiment of a kitchen cutting board in accordance with the principle of the invention and b) illustration of the wire basket removed from the cutting board [7]**

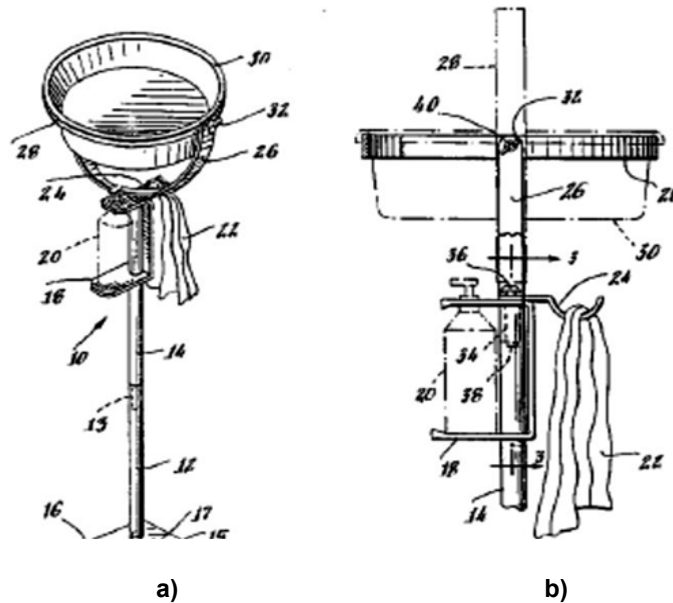
*Remark: 10 – Cutting board; 12 – Planar cutting surface; 14 – Kitchen counter; 16 – Kitchen sink basin; 18 – Sink faucet; 20 – Flange; 22 – Face of a counter; 24 – Circular aperture; 26 – Rear edge; 28 – Basket; 30 – Top rim; 32 – Handle for basket; 34 – Contoured arm*

In the same year, Martin J. Laverty has also invented a Sensor Operated Water Flow Control to control the flow of water from a faucet head and drinking fountain by using an ON/OFF switch responsive to individual activation [11] as shown in Fig. 2.10a. The enlarge view of the faucet is shown in Fig. 2.10b. This design included a control to prevent the continuous flow of water, and prepare the faucet head and drinking fountain to supply water in the future, the material used to isolate the water from controls

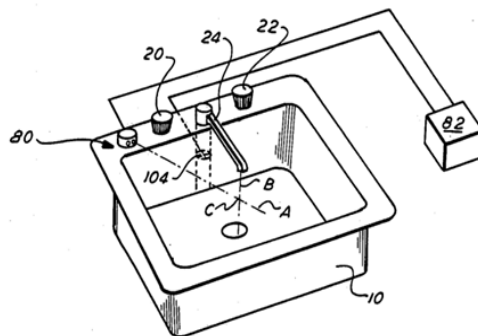
and use different filters to operate the circuit with control and simultaneously render the switch responsive to individual activation. In this design, electrically operated solenoid valve and infrared sensor is used for activating the water supply from drinking fountain by determining the presence of the person. The sensor is used to transmit the pulsed of infrared light and when it detected the presence of a person, the light is reflected back from the user and then reflect again to the sensor receiver. In short, the sensor

is connected with three control circuit: the first is to determine the user has stopped or passed by within the range of sensor (this sensor include built-in delay before second circuit is activated), the second circuit will be activated after the aforesaid delay of the first sensor and a solenoid valve activation is included to start the water flow, the third sensor is then used to avoid excess flow of water caused by tempering or other damage to the infrared sensor by setting a range, preferable 30s to shut down the sensor and solenoid valve automatically and stop the

water flow immediately. The infrared plastic filter and the filter holders have the cooperative element that permit to allow the filters to remove and insert easily while the filter is hold in secure manner to the filter holders. This is to simplify the changing process infrared filter if occur to any damage or vandalism. All the electronics are suggested to be put in a vacuum-form case and inject with a potting compound to form an electronic module to isolate from water and other contamination.

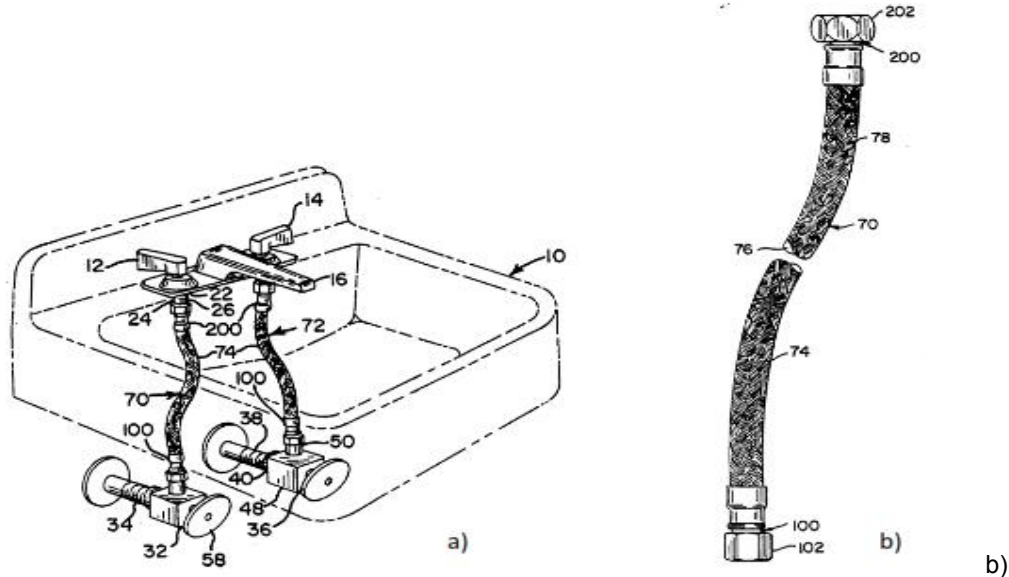


**Fig.2. 7 a) Perspective view of the embodiment of the invention and b) it's cross section [8]**  
 Remark: 10 – Wash stands apparatus; 12, 14 – Tube segment; 13, 15, 34 – Mounting pin; 16 – Plate-like base member; 17 – Lower end of lower segment; 18 – Soap dispenser holder; 20 – Soap dispenser; 22 – Towel; 24 – Towel holder; 26 – Mounting yoke; 28 – Basin support; 36 – Mounting pin bolt; 38 – Mounting pin nut; 40 – Support pin

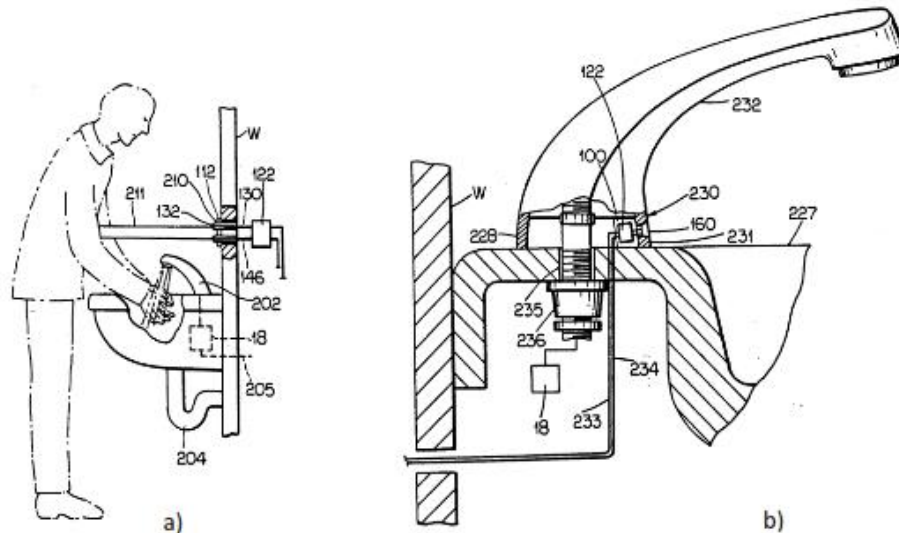


**Fig. 2.8. Perspective view of a sink faucet embodiment with light source photosensor pair embedded in opposite side wall of sink [9]**  
 Remark: 10 – Side of sink; 20, 22 – Hot and cold water control valve; 24 – Nozzle; 80 – Sensor assembly; 104 – Solenoid actuated valve





**Fig. 2.9. a) Perspective view of a sink equipped with a faucet connector assembly in accordance with principle of the invention and b) the fragmentary side view of the faucet [10]**  
 Remark: 10 – Sink; 12, 14 – Hot and cold water faucet; 16 – Swivel outlet and discharge; 22 – Base of faucet; 24 – Inlet; 26 – External threads; 32 – Hot water shutoff valve; 34 – Pipes; 36 – Water valves; 48 – Immediate body portion of valve assembly; 50 – External threaded compression outlet; 58 – Manual rotatable handle; 70, 74 – Flexible hose assembly; 76 – Elastomeric core (hose); 78 – Metallic outer shell; 100 – Valve fitting; 102 – Compression nut; 200 – Faucet fitting assembly; 202 – Hexagonal female cutting nut



**Fig. 2.10. a) Side view of faucet, basin and sensor device with b) partial sectional view of faucet [11]**  
 Remark: 18 – Solenoid valve; 100 – Sensor unit; 112 – Front cover; 122 – Circuit Board; 130 – Electrical Connection; 132 – Infrared filter; 146 – Wire from photodiode sensor; 160 – Interchangeable filter; 204 – Conventional drain pipe; 205 – Water supply line; 210 – Sensor; 211 – Infrared ray sender; 227 – Basin; 228 – Base; 230 – Placement of sensor; 232 – Spigot; 233, 234 – Wire; 235 – Conventional hollow bolt; 236 – Nut

*g) Year 1993*

An automated Cleansing Chamber is invented by Howard Sage, David Newton, Gary Cooper, Donald Berns and Christopher Maybach in year 1993 [12]. Fig. 2.11a shows that it is a cleansing chamber with rotating nozzles in a cylinder consists of an automatic hand washing system that provide the function of purge, wash, dwell, rinse and self clean cycle. By using this cleansing chamber, 99 percent of bacteria and germs are killed in 10 seconds without hand irritation with multiple hand washes every day. The objective of the invention is also to provide a highly efficient low-water and energy consumption stating nozzle cleaning system without touching activation a rotating nozzle cleaning system. The whole cleansing unit is a free standing hand unit that includes a pair of parallel cylindrical hand opening with L.E.D. panel that provide the interfacing of user and the cleansing unit. As demonstrated in Fig. 2.11b, the user will only need to insert his/her hands into the cylindrical hand opening and will be given a purge (wait for the water to reach proper temperature), soap, dwell(allows soap or disinfectants to kill bacteria) and rinse (removes the soap) cycle within 10 seconds. The diffuse photoeye is DC powered and infrared signal is sent toward the hands and signal is reflected to the diffuse photoeye sensor. The current sink line is active when photoeye senses the reflected light of its own frequency. For the operation of automation self cleaning cycle, the number of wash cycles is counted by the self clean circuitry before actuating cleaning agent path to actually open along with the motor and the water valve.

*h) Year 1994*

In year 1994, a Foldable Kitchen Sink that is suitable for outdoor activities is invented by Hae-Sup Lee [13]. Fig. 2.12a shows that the foldable kitchen sink includes a pair of supporting members hinged one another that can be folded, a pair of support member having a dish water bucket and a grille that can be detachably mounted on the support member. At the end of both support member, there is a pair of upper panel provided so that they can selectively cover the dish water bucket and the grille. A pair of foldable twin legs and foldable legs is hinged to the lower surface of the support member so that the respective twin legs are diagonally opposed to each other. When the sink is completely folded as shown in Fig. 2.12b,

it can be carried easily to elsewhere, hence, it is convenient to the user.

*i) Year 1995*

Joan M. Holloway and Jeter L. Ridley have invented a contoured basin that is adapted to receive and support selected part of human body for isolatable cleansing and treatment in order to provide minimal discomfort to the person [14]. The disclosed sink is built up of unitary, continuous sideway construction with self-stabilizing features and certain body supporting the contour on its top and bottom edge as shown in Fig. 2.13. To be exact, this sink has provided an integral elevated platform portion feature in the bottom to receive and support body part during cleansing or treatment within the sink's interior part and minimum one seat is defined at the top edge of the sideway contoured to receive and support the body part concurrently. The example of disclosed preferred sink embodiment is adapted for cleansing and treating the head and limbs of a person.

*j) Year 1996*

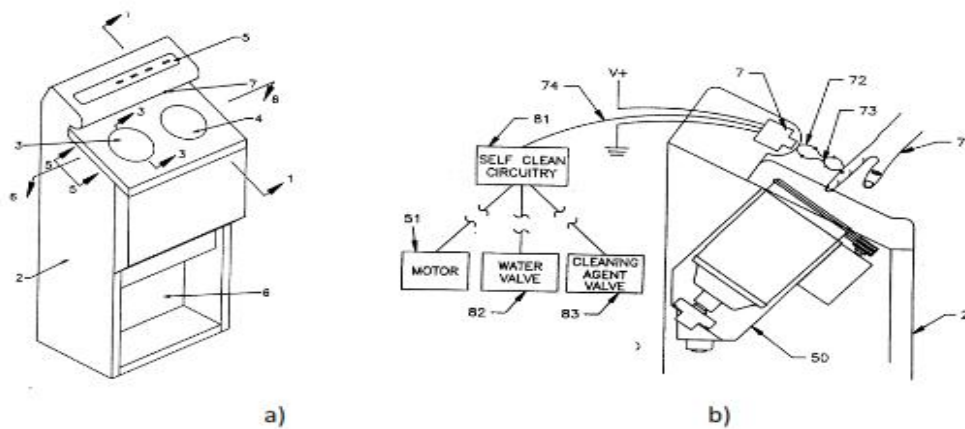
Another type of portable wash basin was invented in year 1996 by James P. Cowan [15]. It is a Portable Garden Work Station that is used for outdoor activities by using the common garden hose as a water connection between the nearest plumbing and the stand. This invention is to provide a stable and sturdy portable station that can supply fresh and portable water far from a source of plumbing and the additional features that can make life more pleasant and comfortable. In this design, the stand has a shape of circular weighted base and four upright posts to support the sink as shown in Fig. 2.14. The basin has a drain hole to allow the threaded hose inlet fixture attached to the basin while the length of drainage hose is long enough to remove the waste water away. In order to support a variety of accessories such as the garden umbrella, paper cup dispenser, soap dispenser, paper towel dispenser, working shelf and so forth, a number of bayonet arrayed on the upright posts is used.

*k) Year 1997*

There is a different type of portable sink called Portable Stand-Alone Sink Unit invented by Richard Leach Tagg in year 1997 [16]. As shown in Fig. 2.15a, this portable wash basin that constructed using lightweight molded plastic consists of an outer water tank, a flexible inner

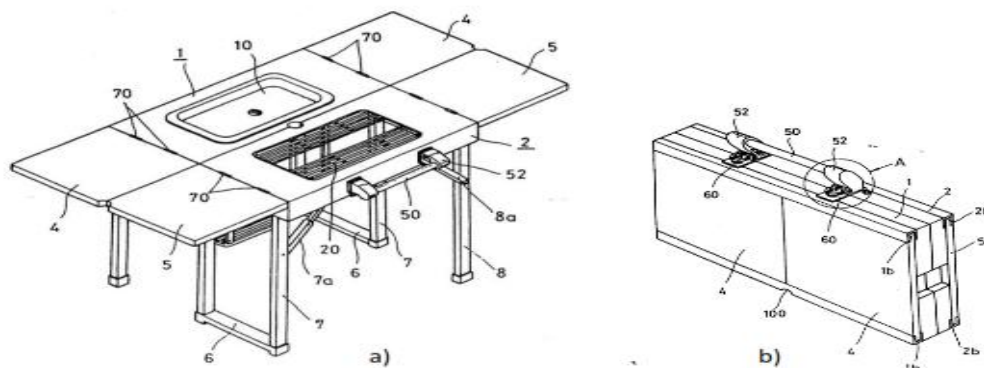
water tank secured within the outer tank and a sink that attached at the top of outer tank, one water faucet to let the water dispense from the outer tank and one drain to drain water from the basin into the inner tank. The rigid outer tank of this design is to store fresh water. The flexible inner tank can be expanded to an associated volume when dispensing the water from outer tank into it, that contracts as the water removed there from and minimized the hydraulic pressure from the dispensing water. The advantages of this portable sink are that its weight is light, durable and can be transported easily. This multi

feature stand along sink comprises of many additional feature such as soap dispenser, paper towel dispenser, trash receptacles and umbrella that can provide shade. As shown in Fig. 2.15b, this design consists of four sink unit having dual two sink unit that are the mirror image to one another. When comes in cleaning process, the sink basin can be removed and the flexible inner tank can be separated from the rigid inner tank. This is important to maintain high sanitary standards and reduce the chance of germs and bacteria spreading through the contaminating water.



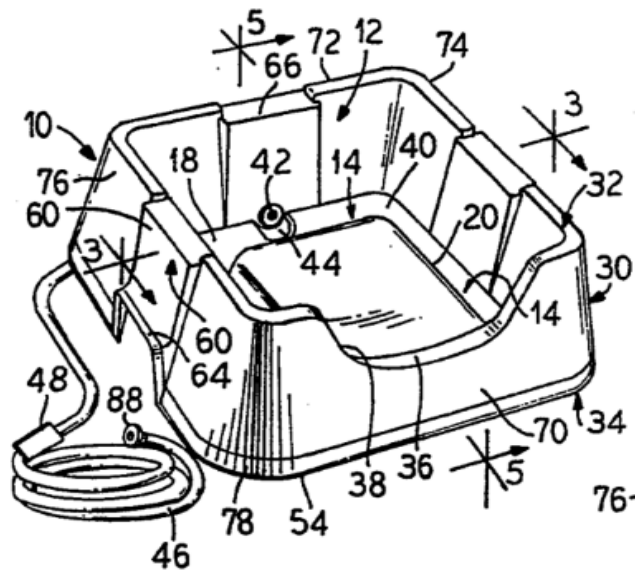
**Fig. 2.11. a) Perspective view of free standing cleansing unit and b) left side view of a foot activated no touch system [12]**

Remark: 1 – Cleansing unit; 2 – Cabinet; 3,4 – A pair of parallel cylindrical hand opening; 5 – LED panel ; 6 – Soap container storage area; 7 – Photoeye; 50 – Basin; 51 – Motor; 71 – Hand; 72 – Infrared signal sending; 73 – Signal bounce back; 74 – Current sinks line; 81 – Self clean circuitry; 82 – Water valve; 83 – Cleaning agent valve



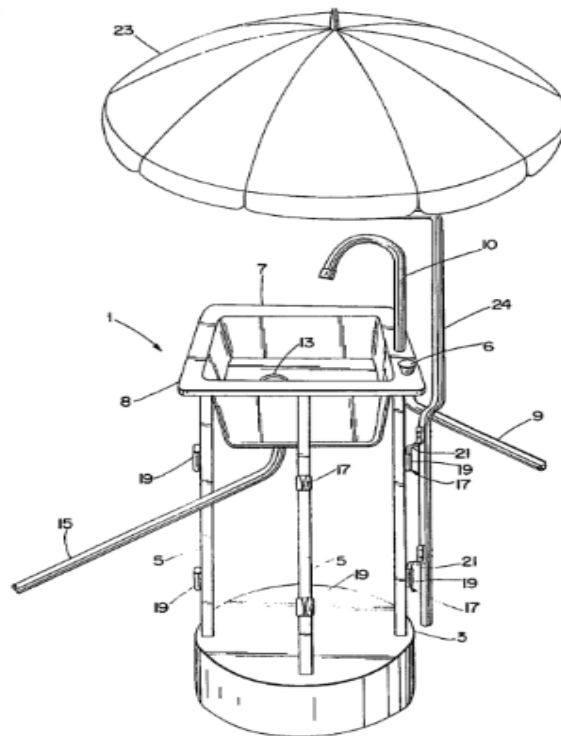
**Fig. 2.12. a) Perspective view of foldable kitchen sinks in accordance with primary embodiment and b) the completely folded state [13]**

Remark: 1 – First support; 1b, 2a – Upper surface of the guide rails; 2 – Second support member; 4 – First upper planar; 5 – Second upper planar; 7 – Twin leg; 7a, 8a – Links; 8 – Two single legs; 10 – Washer bucket; 20 – Center of the grille; 50 – Handle; 52 – Handle fixing member; 60 – Lock; 70 – Hinge connection



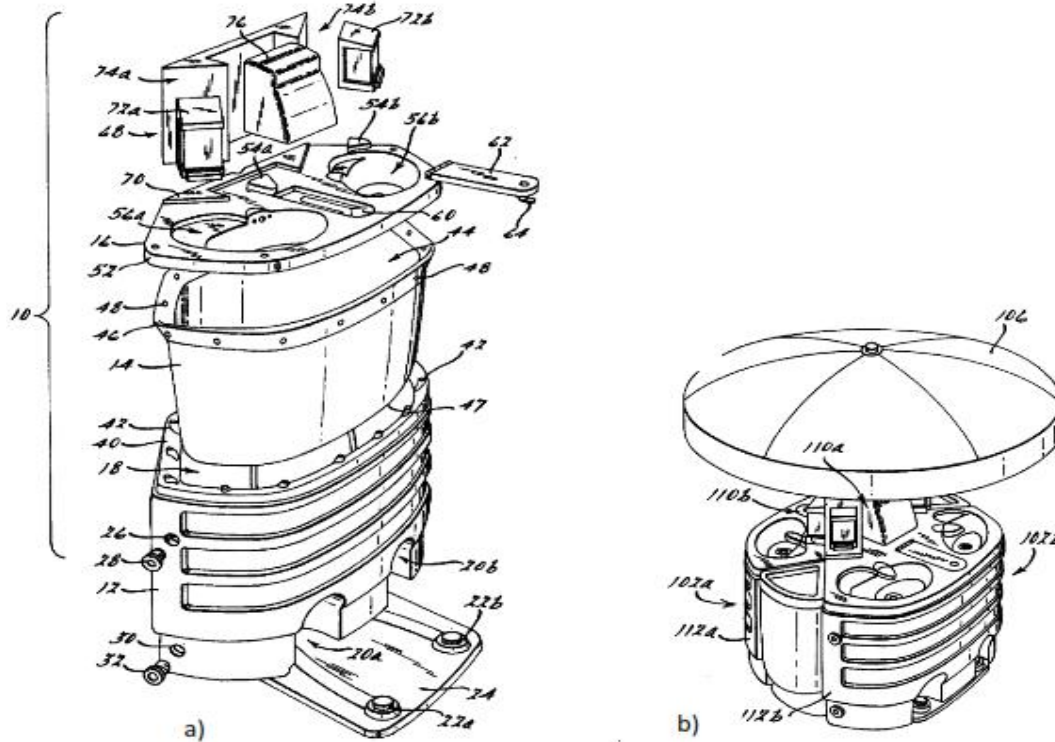
**Fig. 2.13. Perspective view of the embodiment of a basin [14]**

Remark: 10 – Basin; 12 – Continuous side wall; 14 – Bottom of the basin; 20 – Elevated platform portion; 30 – Outer side wall portion; 32 – Top edge; 34 – Bottom edge; 36 – Seat; 40 – Channel; 42 – Outlet; 44 – Sump; 46 – Hose; 48 – Clamp; 54 – Rim; 60 – Hand gripping; 70, 72, 74, 76 – Inner side wall portion of planar



**Fig. 2.14. Perspective view of portable garden work station [15]**

Remark: 1 – The station; 5 – Upright supporting post; 6 – Faucet; 7 – Flange of sink; 8, 17 – Mount; 9 – Water inlet hose; 10 – Goose necked spout; 13 – Basin drain hole; 15 – End of hose; 19 – Socket bracket; 21 – Spade firing; 23 – Umbrella



**Fig. 2.15. a) Exploded view of portable sink unit and b) perspective view of portable stand-alone sink unit [16]**

12 – Outer tank; 14 – Flexible inner tank; 16, 52 – Sink basin; 18 – Interior liquid retaining cavity; 20a, 20b – recesses; 22a, 22b – whale foot pumps; 24 – Skid panel; 26 – Fill port; 28 – Fill plug; 30 – Drain port; 32 – Threaded drain plug; 40 – Shoulder; 42 – Studs; 44 – Cavity; 46 – Band; 47 – Double – lined layer; 48 – Snap buttons; 54a, 54b – faucets; 56a, 56b – Sinks; 60 – Inner tank disposal access port; 62 – Access port lid; 64 – Lock; 68, 110a, 110b – Dispenser unit; 70 – Dispenser unit plate; 72a, 72b – Soap dispenser unit; 74a, 74b – Soap dispenser mounting; 102a, 102b – Dual two sink units; 106 – Umbrella

*l) Year 1998*

In year 1998, Mark W. Herrick and Jim D. Garner has invented another type of portable wash stand, that called Moveable Washstand and Associated Folding Cart [17]. This movable washstand include of a device that supply water by a spray nozzle, a sink, a headrest, drain and bladder using for temporarily storing the discharge water as shown in Fig. 2.16. It comprises of effluent and an electrical outlet which is mounted on the C- shaped frame with wheels to allow the movement of wash basin. This remote basin is connected to a dual line extension hose with an inlet line, outlet line, and quick connect capabilities. There is an on board extension cords that allow the unit to be plugged into a remote electrical supply. The base of the cart is slid under a bed and the catch sink is placed under the user head. The height of the catch basin can be adjusted according to different bed configuration. To

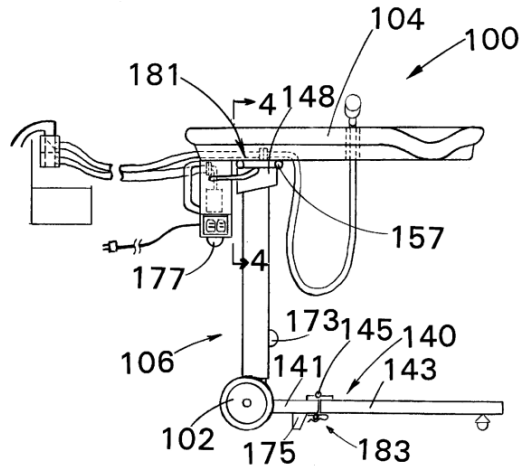
transform the unit into a portable, the upper and lower member of the cart are hinged and self-supporting movable sink is disclosed to reduce the displacement of the user.

*m) Year 2000*

An Automatic Faucet Assembly with Mating Housing and High Endurance Finish has been invented by Graham H. Paterson and Willard A. Denham in year 2000 [18]. This device comprises a chasis and a removable cover connected to the chasis where both the chasis and cover are extended above the deck surface of a sink as shown in Fig. 2.17. The chasis has a mounting section to mount the chasis to the surface of the deck while the deck plate is mounted between the surface and the mounting section to support and stabilize the faucet assembly. In addition, the assembly of faucet has included a fluid conduit extending through the chasis and connecting a fluid discharge

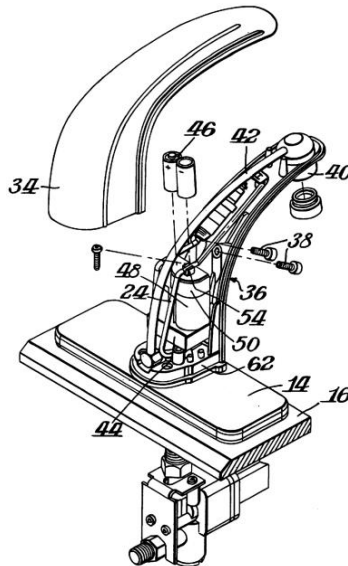
port through a fluid supply, an infrared sensor mounted on chasis to sense the presence of user of the faucet assembly and an electrical connector extending from infrared sensor, through the opening in the deck, to the solenoid valve that will turn the fluid supply on when the infrared sensor has sensed the presence of the user and lastly, the battery power supply to supply power for the infrared sensor. The covers that cover the chasis has

provided a sealed chamber for the fluid conduit, electrical connector wire, power supply and the infrared sensor. By the way, a switch actuator extending from the cover has activated a mechanical micro-switch to enable the power supply to energize the infrared sensor upon the connection of cover and chasis. This design has been a reliable, easy to assembly and can maintain automatic faucet installment device.



**Fig. 2.16. Side view of movable wash stand [17]**

Remark: 4 – Catch basin; 100 – Movable washstand; 102 – Large diameter wheel; 106 – C-frame; 140 – Lower horizontal member; 141 – Fixed piece; 143 – Folding piece; 145 – Full length hinge; 148 – Upper horizontal member; 157 – Hinge pivot; 173, 177 – Rubber bumper; 181, 183 – Folding and locking means



**Fig. 2.17. Exploded isometric view of the automatic faucet assembly with a cover portion removed [18]**

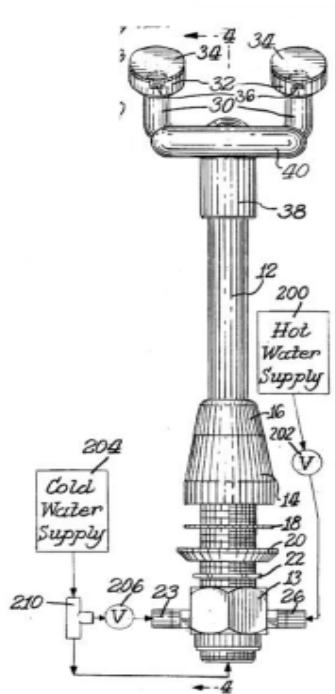
Remark: 14 – Deck plate; 16 – Deck; 24 – Connecting wire; 34 – Cover; 36 – Chassis; 40 – Fluid discharge means; 42 – Fluid conduit; 44 – Sensing; 46 – Supplying power; 48 – Battery case; 50 – Battery cover; 54 – Two wire clips

n) Year 2002

Fig. 2.18 shows an Integrated Eye Wash and Sink Faucet that has been invented by Chris Miedzius, Robert S. Varney and Imants Stiebris in year 2002 [19]. This integrated eye wash and sink faucet is connected to cold and hot water supply comprise of a valve having body with first and second opening provided and a spindle with an arm integrally connected to a chamber. The faucet of this invention comprises of minimum one eye wash spray nozzle connected to the body of the valve and in fluid communication with cold water supply through second opening of valve body when the spindle chamber is provided at a preset location of the valve body. The purpose of this invention is to provide an integrated eye wash and sink faucet to replace the existing sink faucet, save place by not using additional counter space and prevent scalding to the eyes when the eye wash portion of faucet is used.

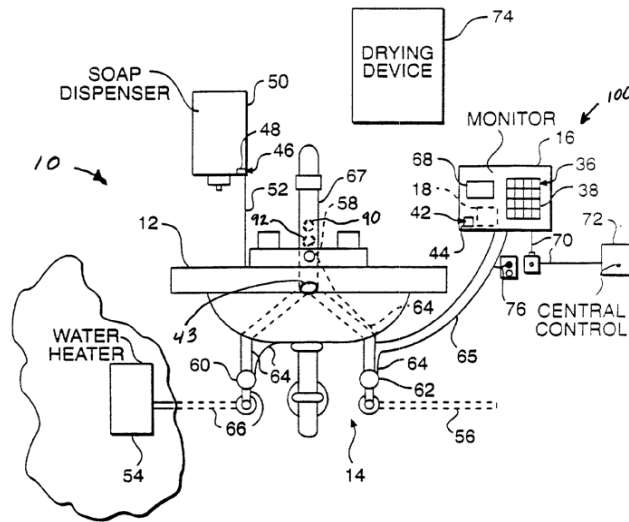
In the same year, Noel B. Segal has invented a System for Controlling operation of a Sink that

include a valving device used to couple to the plumbing of the wash basin to selectively allow water to flow into the sink [20]. In Fig. 2.19, it shows that this valving devices is configured to actuated in response to wireless control signal to tentatively allow water to flow into the sink and vice versa by actuating the valving devices to a specific position. This invention comprises of a system to monitor and control the operation of a sink, an acknowledgment operators such as the activation devices, a timing device to determine the data used, and lastly, a completion input device for generating wash completion data after the user used the sink. A memory storage is used to store the operation data sets and preset frequency of parameter used for operator of the sink. In order to monitor the usage of sink and treating water supply to the sink, a monitoring devices configured to monitor usage of sink is used. In addition, a water treatment devices that include a ultrasonic generator to generate ultrasonic waves in water supply to the wash basin and an eletrolyzer configured is used to decrease the pH value of water by ionizing water molecules.



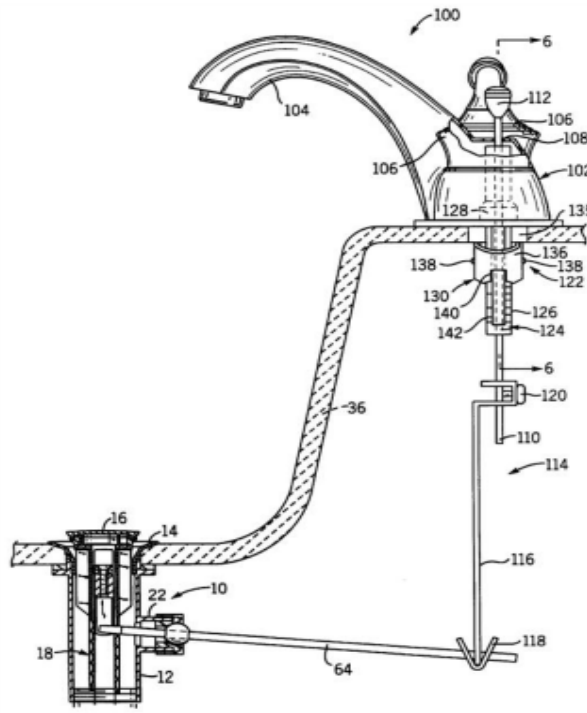
**Fig. 2.18. Front elevation views of integrated eye wash and sink faucet [19]**

Remark: 12 – Gooseneck pipe; 13 – Adapter; 14 – Flange; 16 – Top collar; 18 – Washer; 20 – Bottom cup washer; 22 – Nut; 23 – Threaded connection; 16 – Top collar; 30 – Branch line; 32 – Eye wash spray nozzle; 34 – Dust cover; 36 – Hinge; 38 – Sink faucet; 40 – Pull handle; 200 – Hot water supply; 204 – Cold water supply; 206 – Cold water



**Fig. 2.19. Schematic view of an embodiment of the invention coupled to sink [20]**

Remark: 10 – System; 12 – Sink; 14 – Plumbing assembly; 16 – Monitor box; 18 – Compliance controller; 36 – Activation device; 38 – Keypad; 42 – Completion input device; 43 – Mixing union; 46 – Ancillary input device; 48 – Vibration sensor; 50 – Cleansing agent dispenser; 52, 64 – Wiring; 54 – Water heater; 56 – Cold water supply line; 58 – Temperature sensor; 60 – Flow control valve; 66, 67 – Piping; 68 – Display element; 70 – immunization link; 72 – Central control device; 74 – Drying device; 90 – Ultrasonic generator; 92 – Electrolyzer



**Fig. 2.20. Side elevation view of a combined faucet and drain assembly system [21]**

Remark: 10 – Drain assembly; 12 – Drain body; 14 – Flange; 16 – Stopper; 18 – Stopper guide; 22 – Radially extending nipple; 36 – Basin; 64 – Drain valve stem; 100 – Faucet; 102 – Faucet body; 104 – Spout; 106 – Handles; 108 – Single central upper opening; 110 – Lift rod; 112 – Pull knob; 114 – Bracket assembly; 116 – Connector bar; 118 – Clip; 120 – Set screw; 122 – Fastening Assembly; 124 – Sleeve bolt; 126 – External threads; 130 – Toggle fastener; 136 – Arms; 138 – Posts; 140 – Inner guide opening; 142 – Guide posts



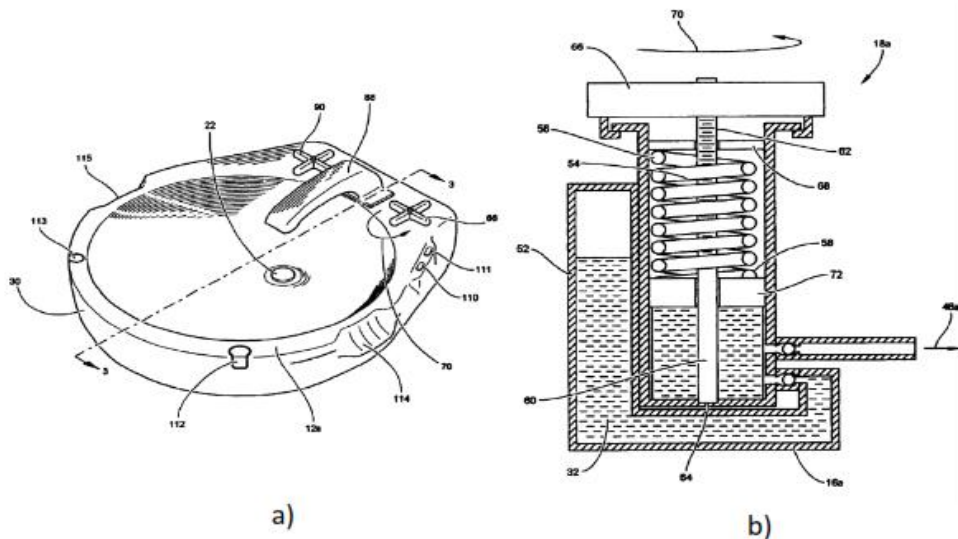
o) Year 2004

Richardo O. Gray, Jeffery L. Mueller, Perry D. Erickson, Mark F. McMullen had invented a Combine Faucet and Drain Assembly that can be assembled above the basin in year 2004 [21]. This faucet comprises of a quick-connect fastening assembly with a threaded sleeve bolt that doubles as life rod guide. In this invention as shown in Fig. 2.20, a spring-biased toggle fastener is threaded onto the sleeve bolt and collapsed and inserted through an installation opening from the top of the basin. The faucet will then automatically unfolds and engages an under- surface when the sleeve bolt is turned. The drain assembly is mounted on the drain opening of the basin and during the installation, a movable stopper guide is used to align the drain flange to the drain body above the sink. The method of installing a combined faucet and drain assembly to a plumbing fixture is disclosed.

p) Year 2005

A different types of Portable Wash Basin has been invented in year 2005 by Scott Patterson [22]. The details of the invention is shown in Fig. 2.21a. This unit comprises a sink for receiving fresh water and defines an open top to receive

the fresh water. A container is disposed adjacent to the sink to contain the fresh water and a pump is connected to it to pump the fresh water from container to the sink. A lid is secured to the sink such that it is accessed to the sink by user when it is disposed in open disposition and the lids cover the sink when it is in close disposition. There is also a drain to drain out the waste water from the sink and a receptacle which is disposed in fluid communication with the drain to collect the waste water. Moreover, a compression spring as shown in Fig. 2.21b is disposed within the container have a first and second eternity and the threaded spindle is extended and disposed coaxially relative to the cylinder and spring with two ends. The first end of the spindle is secured by the handle and washer is cooperated with spindle and disposed between the first eternity of the spring and handle. The usage of the pump is like when the handle is rotated, the washer is urged against the eternity of spring to compress the spring. Then, the piston is disposed within the cylinder next to the second eternity of the spring so that when the spring compressed, the piston urged axially along the cylinder to pump fresh water from container to sink. There are also some additional features on this sink such as mirror, toothbrush holder and others to enhance the quality of the invention.



**Fig. 2.21. a) Perspective view of the embodiment of the portable wash basin and b) the enlarged sectional view of an alternative type of pump [22]**

Remark: 12a – Sink; 16a – Container; 18a – Pump; 22 – Drain; 30 – Receptacle; 32 – Pumping fresh water; 46a – Arrow; 52 – Cylinder; 54 – Spring; 56, 58 – Second extremity; 60 – Spindle; 62 – First end; 64 – Second end; 66 – Handle; 68 – Washer; 70 – Arrow; 72 – Piston; 88 – Faucet; 90 – Control valve; 110, 111 – Aperture; 113 – Latches; 114, 115 – Lifting handles

q) Year 2006

In year 2006, Patrick Jonte had invented a Multi-mode Hands Free Automatic Faucet that include a logical sensor, a proximity sensor, a handle with a first touch control, a second touch control and a model indicator [23]. The logical control has manual mode when the proximity sensor is inactive and the water flow is toggled on and off by positioning the handle and with hands-free mode when the water flow is toggled on and off in response to the proximity sensor. The faucet is in the hands-free mode when touched by a user in the first touch control while the second touch control will toggle the logical control between the hands-free mode and manual mode when touched by a user. The present mode of the faucet will be indicated by the mode indicator. Furthermore, the water flow has a flowrate and temperature that can be determined by the position of the handle. In short, this invention has pervaded a hands free kitchen type faucet that have a touch control to control the water flow activation through the faucet with respect to the user contact with handle.

r) Year 2007

A more advance Portable Wash Basin has been invented by Mohammad Bolton and Michelle Bolton in year 2007 [24]. Fig. 2.22 shows that this multi features wash basin and pedestal lavatories comes with functional plumbing features with a concealed interior removable water reservoir for temporarily hold of used dirty or soapy excess water that can be locked for child safety. This sink is equipped with built in pull out step underneath the pedestal and a pull out adjustable towel rack on the pedestal. A storage compartment is invented to place first aid kits, dry clean hand towels and so forth. The mobility apparatus is where the safety latches is placed to prevent the wash basin from moving when the child is washing their hands. This portable wash basin can add on for two additional sink and lavatory pedestals that are manufactured back to back or horizontally side by side. Moreover, three or even four portable wash basin can be added and connect it in a circular design. This portable wash basin has incorporated various designs for commercial use in public place, hence, it can be used in either indoor or outdoor.

A Used Water Removal System for A Portable, Hand-wash Sink Station was invented by Jamie Philip Kostelyk in the same year [25]. The

objective of this invention is to provide immediate removal used of water from the waste water storing tanks on the portable wash basin stations by using the vacuum equipment or conventional suction which usually used by portable chemical toilet maintenance vehicles to clean portable toilet waste holding tanks. As shown in Fig. 2.23, this removal system is used for stand-alone hand-wash sink station with vertically elongated used water storage tank and placed within a fresh water tank which is also vertical elongated. A sink basin that used to drain used water above the into the used water tank is placed above the used water storage tank while the water is conveyed from the fresh water tank by a water line to a faucet positioned above the sink basin. When the fresh water tank is empty, simultaneously the water storage tank is full, fresh water is needed to be filled in to the fresh water tank while the used water must be drained from the used water storage tank. In the station alongside the fresh water tank, a vertical elongated, inverted, U-shaped tube is arranged with one of the end open into the used water storage tank near the lower end while the other end is opened to the exterior of the station to form a water intake. A conventional suction hose 'wand' is connected to the pipe that will be further connected to a vacuum system to suck out the contents of portable chemical toilet waste-storage tanks. The suction process started by a siphon action within the tube and continue to drain the waste water from the interior of waste water storage tank to a conventional waste water storage tank on a maintenance vehicle. To minimize the time needed to service a wash basin unit, filling the fresh water tank need to be done together with siphon tube drain to accelerate the rate of refilling the fresh water tank and emptying of waste water storage tank.

s) Year 2009

An Electronic Faucet with Voice, Temperature, Flow and Volume Control had been invented by James L. Wolf and Stephen O. Gregory in year 2009 [26]. It is an ergonomic water conserving faucet assembly that turns around a cognitive central point that comes with touchless water temperature, volume control, flow rate and spray pattern adjustment through multiple and hygienic means. This device includes a pivo-table, ball-shaped spout, ergonomic that can be used hand-held or statically as shown in Fig. 2.24. In addition, this assembly comprises of a retractable water delivery hose that can connect

the spout to a water source, a water mixing valve at the water source to deliver water at preselected temperature, a solenoid valves controlling flow, proximity and object detection sensor that used to map the sink area and input signal detection. This device has attached with a voice control system that is sensed by the speech sensor with microphone, a LED to display the water temperature, an internal speakers delivering audible prompts and an electronic controller to organize the speech and supervising operations.

*t) Year 2010*

In year 2010, Judith Mocerri and Micheal Mocerri had invented a Portable Training Sink and Vanity for Children [27]. The objective of this invention is to teach the children to learn and appreciate cleanliness and personal hygiene without the need to having a drainage hookup or special pipe. This wash basin comprises a sink, drain hole disposed in basin, back splash panel basically adjacent and protecting above the sink as shown in Fig. 2.25. The main housing is built up of supporting legs with minimum one front and one rear supporting leg. Those legs are spaced apart to adapt to the width of a normal household bathtub. Meanwhile, a reservoir is disposable in the back splash panel and the spigot in fluid communication with the reservoir is extended to allow selective running water and empties into the sink. A receptacle is used to collect the waste water and to be drain out from the portable basin for emptying and cleaning purposes. There are also additional features added in this portable wash basin to shows its vanity such as mirror, toothbrush holder, soap dispenser, tissue holder and so forth. A locking mechanism is included to maintain the reservoir in the back splash at the discretion of adult user and help the user in moving the unit in a stable condition.

A different types of sensor faucet, Capacitive Sensing Apparatus and Method for Faucets is invented by Robert W. Rodenbeck, David M. Burke, Timothy J. Ensor, Lindsey Hall and Paul D. Koottunggal in the same year [28]. In Fig. 2.26, it shows that this device consist of a spout positioned next to a sink basin, a capacitive sensor that comes with the spout, a fluid supply conduit supported by spout and a sink basin. In order to control the amount of water supply to the fluid supply conduit based on the output of capacitive sensor, the capacitive sensor is coupled with the controller.

*u) Year 2011*

In year 2011, Graeme S. Bayley, Mark A. Figungski, Timothy E. Perrin, John M.Loberger, Jason M. Renner, Kevin M. Kohlwey, Jon A. Dommissie and Thomas E. Pelt had invented a Lavatory System with Hand Dryer [29]. Fig. 2.27 shows that the basic mainframe for this device is a basin, faucet and a hand dryer with housing in which all are supported by countertop. The housing of the hand dryer include a cavity which allow the user's hand to be inserted when drying and a motor configured for generating blown air supplied to the cavity and a reservoir to collect the blown of water from the hand of a user. The collecting water reservoir has a fluid communication with main drain line by having a contour to directs water into the basin.

*v) Year 2012*

Fig. 2.28 shows a Portable Wash Basin Cart and Disposable Personal Wash Basin which is configured to carry a user's personal wash basin invented by Shamirra Slayton in year 2012 [30]. A lid is invented to cover the personal sink in the cart when it is moving from one place to another so that the water in the wash basin will not splash out from the floor if the cart strike any obstruction. A flexible tube is provided to fill up the basin while a drain pipe is used to drain out the used water from the basin without lifting out the wash basin to the toilet bowl or elsewhere. In order to minimize the contamination, a disposable thin personal wash basin with a funnel shaped outlet is used. This cart has included a wheeled frame to carry the base basin in which the base basin that is fixed to the cart frame and used to receive the user's personal wash basin. In addition, telescoping legs is provided to allow the user to adjust the device's height.

*w) Year 2014*

In year 2014, Marcus Lee Hartley and Thomas Andrew Weston have invented a Hand air Dryer with title of Developments relating to washing/drying stations in washrooms [31]. This is a combined washing/ drying station for washroom that consists of a water outlet which is connected to main water supply to discharge water for washing purposes. An air flow outlet is included in the station to discharge airflow for drying purpose. The airflow is generated by a blower module connected to main electricity supply. A hand-wired to the electricity mains as

shown in connector unit 19 as shown in Fig. 2.29 is used to connect main electricity supply. An additional connector unit, which is plumbed into the water main is used to connect the main water supply and a flow control valve is used in a connector unit 81 to isolate the main water at the connector unit. In addition, a solenoid valve is used to automatically trigger in response to a sensor signal generated by one or more sensors. Sealing process is important in this design as it aids in preventing hazardous contact of water with live component especially the high-voltage component. This invention is aimed at improving the installation, repair or service of a washing / drying station in a washroom.

x) Year 2016

Fig. 2.30 shows a Hand Cleaning Station had been invented by Drew Hamilton and Aaron Spurlock in year 2016 [32]. It is a hand cleanser controller which can receive a hand cleanser trigger and reflects the response by dispensing hand cleanser and transmits a reset command. A water dispensing trigger component is included in a water dispense device to detects the presence of user hands to the water faucet. A reset command is received by the controller from the hand cleanser device based on the dispensing of hand cleanser, timer is reset in response to receive the reset command, water dispensing trigger from the trigger component and actuates the electrically actuated water valve to dispense water based on a determination that the timer has expired. Audio, video is included in the wash station to increase its vanity.

**4. SUMMARY OF REVIEW WORKS ON SINK EVOLUTION**

Based on the review works done on sinks and their evolutions from year 1973 to 2016, a few important points can be highlighted which is as follow:

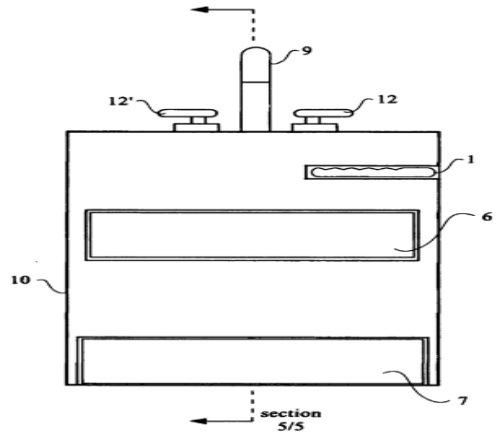
- Ergonomic design of sink was implemented since year 1973. The main ergonomic feature is that the sinks are invented to benefit mankind. Consideration of hand and arm washer was invented specially for the handicapped or one armed person by Ralph E. Core.
- Design of sinks took into consideration for placing kitchen cutting board on top of the sink for washing and food preparation in year 1977 by Ellis Shamoon.

- Mr. Alfred M. Provost has invented a portable basin that can be packed, transported and set up easily for outdoor activities in year 1985.
- The first automatic sink faucet was invented by Frank S. Piersimoni in year 1989, namely to reduce wastage and overflow of water.
- The idea of using Flexible braided metal hose came into picture in year 1991 by Philip Mulvey, this is namely to ease the plumbing work for the installer or plumber.
- In year 1991, a sensor operator water flow control is invented by Martin. J. Laverty to control the flow of water from a faucet head and drinking fountain by using ON/OFF switch responsive to individual activation.
- Howard Sage and his team have invented an automated cleansing chamber that provides the function of purge, wash, dwell, rinse and self cleaning.
- In year 1994, the idea of having a foldable kitchen sinks which can be folded completely into a brief case size is invented by Hae Sup Lee.
- An integrated eye wash sink faucet is invented by Chris Miedzius and his team in year 2002. This invention is used to prevent scalding to the eyes when the eyes wash portion of faucet is used.
- The idea of ionizing the water molecule namely to decrease the pH value of the water was taken into account by the Noel B. Segal in year 2002. This is achieved by building in a built in electrolyzer of the sink. The ultrasonic generator is also included in this invention to generate ultrasonic waves in water supply to the wash basin.
- Child lock that is used to ensure the safety of the child access to used dirty or soapy water in a portable basin has invented by Mohammed Bolton and Michelle Bolton in year 2007.
- James L. Wolf and Stephen O. Gregory have invented an ergonomic water conserving faucet operated with voice, temperature, flow and volume control.
- Prior to the reviews above, additional accessories to the sink were taken in consideration to most of the invention. These accessories were soap dispenser, toothpaste dispenser, towel hanger, hand dryer, trash receptacles, umbrella that provides shades and others. The main

reason why these accessories were taken into consideration into sink design is to improve the quality of the invention and make the sink user friendly.

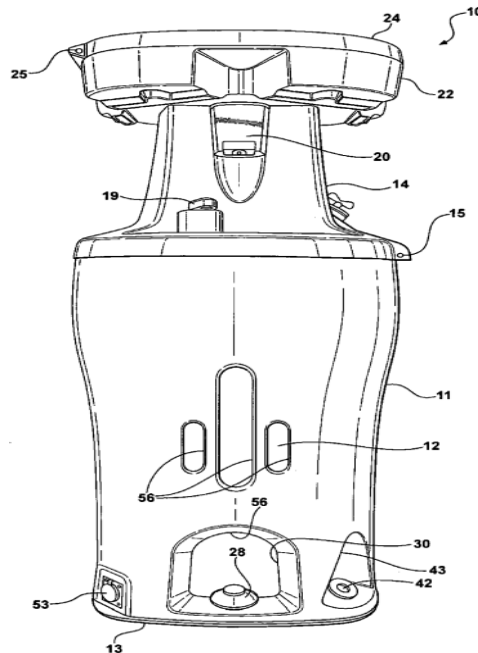
To the best of author's knowledge and from past review works, it can be summarize that sink

evolution is crucial for mankind. However, the idea of incorporating a smart ergonomic sink for home applications has not been reported in the literature. Hence, the following section will be on the state of art of Design and Development of a Smart Ergonomic Sink for Home Applications.



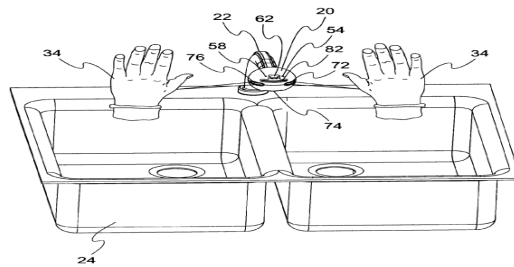
**Fig. 2.22. Front orthographic view of a portable wash basin according to the preferred embodiment [24]**

Remark: 1 – Towel holder; 6 – Storage compartment; 7 – Height assist; 9 – Source water regulator; 10 – Portable wash basin; 12, 12' – Stationary faucet



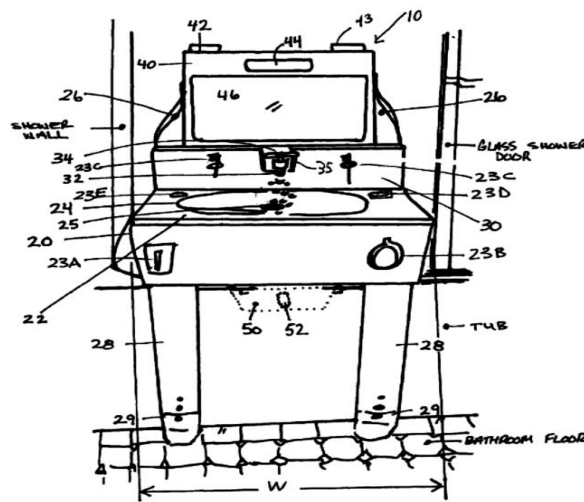
**Fig. 2.23. Side Perspective view of a portable stand-alone wash station [25]**

Remark: 10 – hand-wash sink station; 11 – Water holding tank; 12 – Fresh water tank; 13 – Lower base; 14 – Upper column; 19 – Spigots; 20 – Soap dispenser; 22 – Hood or cap; 24 – Lid; 25 – Hinge; 28 – Two foot operated pumps; 42 – Siphon fitting; 43 – Recess; 53 – Optional electrical connector; 56 – Windows



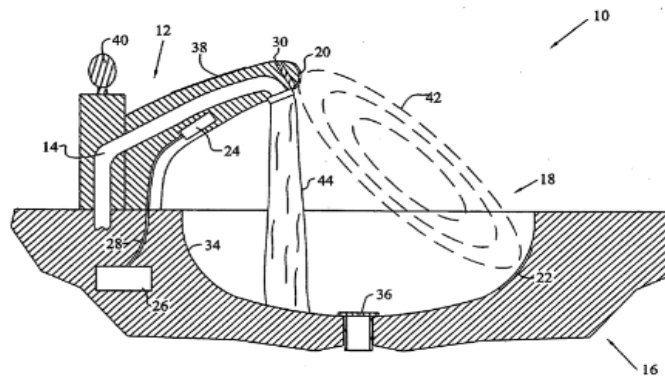
**Fig. 2.24. Perspective front isometric view of faucet with spout head attached through the stem to a sink with user's hands in front of the forward facing sensor [26]**

Remark: 20 – Spout head; 22 – Head end of stem; 24 – Back of a sink; 34 – Hands; 54 – Speaker port; 62 – Button; 72, 74, 76 – Three distances measuring infrared proximity sensors; 82 – Color LED



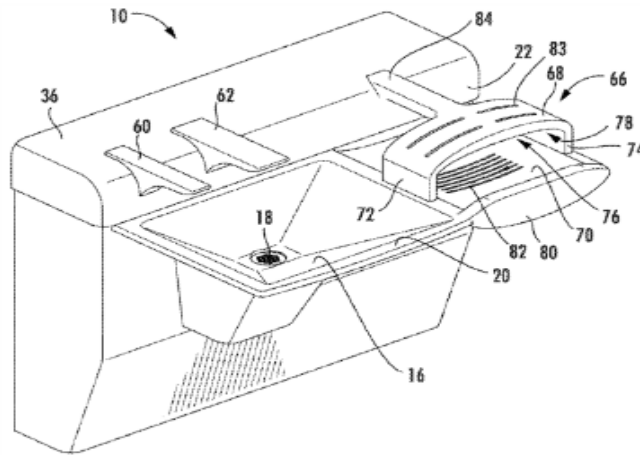
**Fig. 2.25. Front perspective view of portable children's training sink [27]**

Remark: 10 – Children's sink; 20 – Main housing; 22 – Counter top; 23b – Tower ring; 23c – Toothbrush holder; 23d – Recessed soap dish; 23e – Cup receptacle; 24 – Basin; 25 – Drain; 26 – Vertical support; 28 – Legs of the wash stand; 29 – Feet of the wash stand; 30 – Back splash; 32 – Spigot; 34, 52 – Handle; 40 – Reservoir; 42 – Fill holes; 43 – Cap; 44 – Recessed handle; 46 – Mirror; 50 – Waste water receptacle



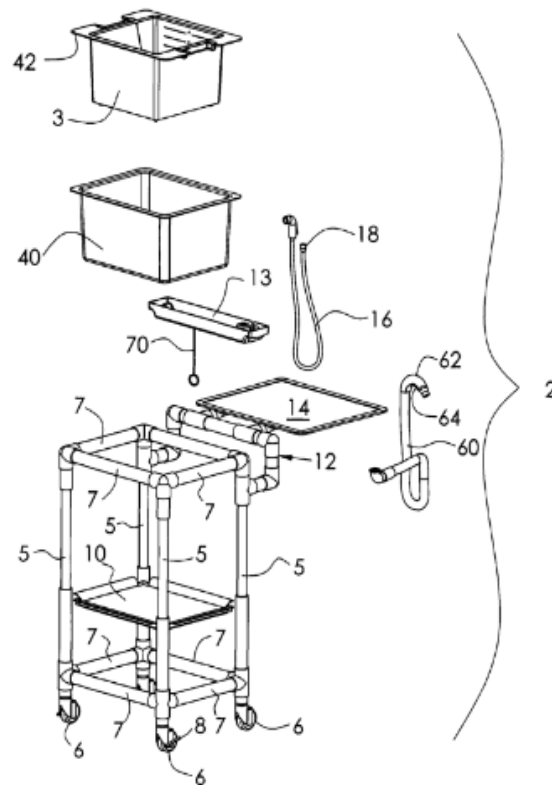
**Fig. 2.26. Cross sectional view of a fluid delivery assembly and a sink basin with sensor system [28]**

Remark: 10 – Sensing faucet system; 12 – Spout; 14 – Water supply conduit; 16 – Sink basin; 18 – Capacitive sensor system; 20 – First sensor probe; 22 – Second sensor probe; 24 – Electronic circuit; 26 – Controller; 28 – Electrical connector; 30 – Metallic plate; 34 – Water bowl; 36 – Drain plug; 38, 40 – User input device; 42 – Sensing field; 44 – Bowl



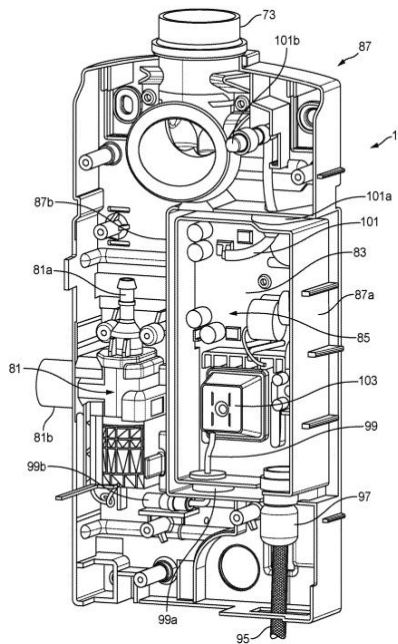
**Fig. 2.27. Top perspective view of a lavatory system [29]**

Remark: 10 – Lavatory system; 16 – Sink; 18 – Drain; 20 – Countertop; 22 – Backsplash; 36 – Horizontal shelf; 60 – Soap dispenser; 62 – Faucet; 66 – Hand dryer; 68 – Top wall; 70 – Bottom wall; 72, 74 – Sidewall; 76 – Cavity; 78 – Opening; 80 – Front wall; 82 – Exhaust ports; 83 – Slots; 84 – Section



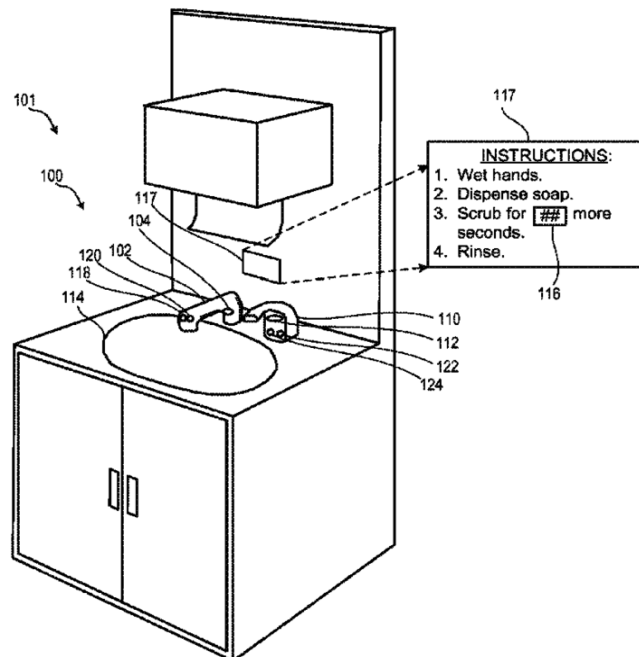
**Fig. 2.28. Exploded perspective view of the portable wash basin cart [30]**

Remark: 2 – Cart; 3 – Personal wash basin; 5 – Legs; 6 – Wheels; 7 – Arms; 8 – Brake; 10 – Shelf; 12 – Handle; 13 – Tray; 14 – Lid; 16 – Tube; 18 – Faucet adapter; 40 – Basin; 42 – Flange; 60 – Drain pipe; 62 – Outlet; 64 – C-shaped bracket; 70 – Support



**Fig. 2.29. Perspective view of a back plate forming part of the connector unit [31]**

Remark: 19 – Connector unit; 73 – Catch; 81 – Solenoid valve; 83 – PCB; 85 – Compartment; 87 – Back-plate; 87a – Inner perimeter wall; 87b – Outer perimeter wall; 95, 99, 101 – Wiring loom; 97 – Cable gland; 99a, 101a – Sealing grommets; 99b, 101b – Plug connector



**Fig. 2.30. Perspective views of hand wash station incorporating a hand washing apparatus to enforce a proper hand washing technique [32]**

Remark: 100 – System; 101 – Hand washing station; 102 – Automatic faucet; 104 – Infrared sensor; 110 – Soap dispenser; 112 – Sensor; 114 – Sink; 116 – Screen; 117 – Instruction placecard; 118, 120, 122, 124 – LED



## 5. FUTURE RESEARCH PATHWAYS ON STATE OF THE ART ON DESIGN AND DEVELOPMENT OF A SMARTERGONOMIC SINK FOR HOME APPLICATIONS

Based on the review works done on design and development of smart ergonomic sink and their evolutions especially in their additional accessories and ergonomic feature aspect from year 1973, we can still see that the development of sink can be further improved opening new research pathways. As such, certain areas worthy of exploration may include (but are not limited to) the following:

- What is the design or technology that can be used in adjusting the height of the sink so that it can be adjusted according to the user's height and ergonomic to user when using the sink?
- Can the size of sink and working area around the sink be adjustable according to the nature of work so that it is always ergonomic to users?
- Can the temperature in water faucet changing to a suitable temperature automatically according to the surrounding temperature? (E.g.: When the surrounding temperature is high, water temperature is a little bit low and vice versa in order for the users to be comfortable)
- Can all the technology features in the sink controlled by using a smartphone as it can control the height, size, temperature, number of sinks and etc.?
- Can the sink have the auto-cleaning function as it can be cleaned up automatically without the help of user by the controlling of a smartphone?
- Can the grey water from the sink be filtered and recycled for other purposes as "going green", has become a movement across the world?
- Can we attach a garbage disposal to the sink itself so that it can directly digest the scraps of foods into soil or other natural material for appropriate recycle use?
- Can there be a smart faucet invented to deliver the filtered water, carbonated water, ice and customizable drink cartridges to the user and the smart faucet is able to detect the germs and bacteria having on the fruits and vegetables?

In light of the conservation and composting goals of future users, Future research in these areas would not only a smart and ergonomic sink faucet that can bring your life more comfortable and read your needs, but ensure that it is environmental concern which convert the grey water efficiently recycled into composting efforts. In addition, the findings from these explorations may also thoroughly affect the future sink in which it is a huge step in making our life more efficient, sustainable and environmental friendly.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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