# Thesis

ON

# The Disposal of Sewage

IN

# England



BY

Thomas Nelson, M.B. C.M.

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Ladywood Dispensary,
Birmingham.

# Historical Sketch of Sanitation.

In the 23rd Chapter of Deuteronomy 10th 11th 12th & 13th verses we find special reference made asto the disposal of human excreta under the Mosaic law:- "Thou shalt have a place also without the camp whither thou shalt go forth abroad, and thou shalt have a paddle upon thy weapon and it shall be when thou will ease thyself abroad thou shalt dig therewith and shalt turn back and cover that which cometh from thee."

Such, asthe Mosaic Sanitary law which finds its analogue in the dry Earth System of the present day. From the quotation given it must be inferred that personal cleanliness was a part and parcel of the religion of the Jews.

The early history of Sanitation can only be learned from scraps here and there throughout the writings of Herodotus, Journal and other ancient authors and by antiquarian discoveries made during recent years.

Sir Henry Layard, a prominent explorer, says that every room in the older palace at Nimrod was drained and the drains emptied into a Sewer which probably discharged

itself into the nearest river. In one of the chambers he found an earthenware pipe connecting the floor of the chamber with a drain, the whole being cemented with bitumen. In digging a trench a main Sewer was discovered with which others communicated formed of baked bricks with Coverings of large Slabs or tiles.

The Babylonians are said to have used un-glazed Earthenware pipes for their tubular drains.

Sir Henry Dyke Acckland says that, while travelling in Asia Minor, he came to the Conclusion that poetical historians were not quite right when they said that the great towns of antiquity such as Sardis, Laodicea, & Hierapolis came to an end thro' what they were pleased to call political causes which they could not define. He believed they came to an end because it was impossible longer to inhabit these filthy and fever Stricken places.

Such a condition has been found in India in later years.

The Cloaca Maxima at Rome affords the oldest Example of drains which are in use at the present day. It was first used to drain the low-lying ground

including the Velabrum and the Valley of the Circus, and this portion of it discharged into the Tiber through a gate in the Quay- - the gate being used for the purpose of damming off the river when in flood from the Velabrum.

It consists of three vaults one within the other. The innermost one is a Semicircle 18 Roman palms in height and width.. This is enclosed within a Second and again within a third. It is all formed from hewn blocks of a Stone called peperino Each block being 3/4 palms long and 4 1/2 palms high fixed together without cement. Peperino is a volcanic Stone taken from the neighbourhood of the Sabii and Alba. In 1742 A.D. a Second vault was discovered forty palms below the present Surface, which led from the Velabrum under the forum as far as S. Adriano. From the form of the ground it is said that it might be traced under the forum of Augustus up to the Subura. The latter part is said by Ficaroni to have been built of travertine Stone, and this material did not come into use till long after the time of the Kings, who used the Alban and Gabine Stone.

Earthquakes, pressure of buildings, the neglect of 1500 years have not moved a

Stone out of place.

Dionysius who wrote after 5 70 B.C. that 1000 talents, Equal to £200,000 of our money was once spent by the Censors in improving the Cloacae. The work of the first part of the Cloaca is said to have been executed under the direction of Tarquinius Priscus about 600 B.C. but it is not certain.

Other Sewers Equally well made were discovered in the time of Pope Benedict XIV made of Travertine Stone, and were referred by him to the first half of the fifth Century of Rome Shortly before the Hannibal-ian war. These Sewers were originally Constructed in the midst of the Streets; but, after the destruction of the city by the Gauls, houses were built in an irregular manner over the Sewers.

Although only intended originally for Sur-face drainage and not for receiving the refuse matters of the population, its Convenience for the latter purpose was Soon found out and up to the present time it has been used as a public Sewer, the Soil around having become Saturated with the infection of ages.

In the Streets of Rome were gullies for the admission of dirty water and other refuse into the Sewers.

On account of the large Supply of water constantly flowing through the Cloaca Imural in his Fifth Satire Says that fish could live in it even in the heart of the city.

At the earliest period of her history the Romans deposited Excretal matter in the middle of the Streets, whence they were removed by Scavengers appointed for the purpose. The Same was done in Madrid upto 1760 AD. As Early as the Fifth Century B.C. the depositing of Excreta in the public road was prohibited in Rome.

The public Latrines in Rome were 144 in number in the time of Diocletian at the end of the third century B.C, but they fell off at the end of the following one to 44. They were farmed out to publicans who made a charge for admission. The primitive water Closet is said to be of Asiatic origin and was introduced into Rome during the Republic. Privies were always placed near the Kitchen So as to be close to the water Supply.

It was a fortunate thing for ancient Britain that a Roman occupation took place. At Such places as Silchester

Colchester & Dorchester we see the remains of towns regularly planned and many buildings of Solidity, decency, & order. The largeness of idea characteristic of the Saxons in carrying out all their undertakings in an orderly spirit is no doubt due to their Roman traditions & remains. Of the Sewage arrangements at the time of the Roman occupation we can get no satisfactory history. The Roman works were mostly destroyed on their withdrawal from this country. A Roman Sewer discovered at Lincoln shows that they were made of good masonry.

Before the advent of the Christian Era cleanliness and religion went hand in hand, but the pride of the Early Priests in their external filth and wretchedness, which they believed to be emplify the purity of the Soul, militated sadly against their usefulness and the adoption of their principles.

During the Saxon period we find records of the careful building of the Confessors Monastery and other houses. The Normans covered the land with castles and Keeps, in the ruins of which we can only conjecture what must have been their method of Sewage Disposal.

Of the buildings in England during the middle ages, Substantial remains exist in Conway Castle, Penshurst, Warwick Castle, and Haddon Hall in Derbyshire. and many of them are still inhabited. Monastic buildings from long before the Conquest down to the reformation afford examples of well arranged buildings for the accommodation of large numbers of inmates, the general idea of which Survives in Oxford and Cambridge.
During the early part of Henry VIII.'s reign, Erasmus wrote to Wolsey's Physician Complaining of the bad ventilation of houses, and also of the dirty Clay floors covered with rushes.
The latrines of the castles of the twelfth century were placed at the top or some other convenient Situation on the outer walls, on Corbells, and the faecal, & other refuse fell into pits underneath.
A hundred years afterwards what were called Garderobe towers were built, in which privies were ranged one above the other to Suit the requirements of each story, the contents of each being usually received in a common cesspool at the bottom. An Example of this exists in Ludlow Castle in Wales.

Before the commencement of this century there was no regular System of public or general drainage existing. There were open Gutters in the middle of the Streets which received rain water from projecting Spouts round the Eaves of houses, and household refuse as well. There were also closed Sewers, So called, but these were on the cloaca principle, only much worse Constructed, So that it may be generally stated that from the Roman period upwards the end of the 18th Century Sanitation as a Science was "in Statu quo."

Before 1815 it was illegal to conduct any foecal matter into these drains. After that date Cesspool overflow was allowed to pass into them - In London these Sewers were under the control of the Commissioners of Sewers for the Several districts for Centuries till about 1855 when an act was passed forming what is called the Metropolitan board of works which is in existence at the present time -

Without any proper Sewers then, there was an unavoidable necessity that Conservancy plans were the only method open to householders in large towns - when it became illegal

to throw refuse into the Streets Cesspools were had recourse to which might be connected with Sewral privies and which were usually cleaned out at night. The water Closet was introduced at the Commencement of this Century, and the drains then were constructed of brick, of the barrel shape, with mortar and Sometimes cement, and they still discharged into cesspools which had overflows into the Sewers - with the development of these Sewers water Closets came into Sewral fashion. According to Mr Corfield - Professor of Hygiene - University College - the first patented W. C. on record, was that of Alex. Cumming in 1775 - It Consisted of a basin, the bottom of which was covered by a Sliding valve and a handle actuated both this valve and the water Supply at the Same time - The water basin or receiver was recurved So as to form a trap. The Second patented was that of - Samuel Prosser the only description of which was that it would always remain free from offensive Smell - Then came the Bramah Closet patented 1778 which had a hinged valve, instead of a Sliding valve, & which has been the

basis of all water closets since.
With the introduction of water closets
in houses came the trouble of foul
smells from the sewers into the dwelling.
These were corrected by enormous dip
traps placed on the drains being often
as big as cesspools, the idea being the
larger the trap the less chance of bad
smells getting into the house. Sometimes
the water closets opened into cesspools
which might be placed under the house
or in an adjoining yard. When one
was full to avoid the stench and trouble
of cleaning it out, another was made.
In a Surgeons house in Birmingham
a cesspool was discovered in his cellar
which had not been emptied for
at least thirty years if ever. When
cleaned out it was 30 feet deep & looked
like an old disused well.
Before the above mentioned patented
closets came out the usual form of
such appliances was a simple receptacle
capable of being washed out from which
a pipe was carried to the drain having
a plug to close the upper end. It was
fitted up anywhere so that it should
be out of sight. The darkest corner
being generally selected.

About the same time as the above Unpatented patents came out the pan closet was presented, and was, and has been much used on account of its cheapness as compared with the others. The literature of Sanitation abounds with invective against this closet at the present time. In an article in Scribner's Magazine describing the Sanitary Condition of New York it says:- "The cardinal fault of all not even surpassed by the unventilated Soil pipe is the W.C. which is in almost universal use all over Christendom. This is known as the pan closet. It probably is not, but it certainly might be an invention of the Devil".

When the water closet came into general use it was not only required for new houses, but for old ones as well, and on the principle that they were no more objectionable than a night commode, for which they were substituted, they were placed at first in bedrooms or as near them as possible. I have seen in a house in Melville Street in Edinburgh a water closet opening directly into a bedroom and this room was used by a patient who had just undergone a serious operation by the late Prof. Spence

up till 1850 drains were generally constructed on the principle above mentioned - At that time the use of Earthenware glazed pipes came into operation and have, with improvements from time to time, held their place. The laying of these pipes was at first very defective - no proper fall being given, joints being imperfect, Traps and water Seals, including the D trap, were unknown in vogue and such a thing as proper drain ventilation was not troubled about - In 1847 Compulsory powers were given to the Westminster Commissioners of Sewers Enabling them to require that all houses should be properly drained into the public Sewers, and privies & Cesspools no longer used or constructed - It is no uncommon thing to find Cesspools in the Cellars of houses now, as is shown by Mr Prudgen Seale's curious diagram "Where's the bubble" and to find dip traps and water closets without water supply laid to them — not used perhaps but which have never been emptied nor cleaned - Whatever of the old Cesspool and other insanitary Sewerage arrangements Still Exist are now only

regarded by Sanitarians as
monuments of the Stage of progress to
which our forefathers attained and
which at the present time, we hope,
happily for the community at large,
surpassed and overcome.

In proceeding to describe the arrangements requisite for the disposal of Sewage I chose simply to work upon what are laid down as correct rules and not to go into at length the mistakes of generations through which we have come to our present position.

I The Wet Method.

The position of the W.C.

1. The position of a water closet and its construction.

Whether in an old house or in a new one it should, if possible, be constructed so that all offensive matters should be got outside by the shortest route & kept there, so as to prevent too great a surface of artificial ventilation becoming defective - all such arrangements being fallible. On this principle they are placed against an outside wall. Further - ventilation is much facilitated by this method.

The room containing a W.C. supplied should have the floor throughout, both underneath the closet and elsewhere well finished as regards its carpentering. The walls should either be papered with a varnished paper or painted so that they can easily be washed. The floor covered with Linoleum or some such material

A window should always be present of good size for lighting purposes. In new houses it is well to have separate towers or abutments built for the purpose, solas still more to separate them from the rest of the house - In every case double spring doors are an advantage - the one shutting before the other opens preventing the access of a colder atmosphere from the W.C. into the warm atmosphere of the house. Two things absolutely requisite about a water closet room are, that it should be shut off from the rest of the house, and that it be easily, rapidly, and well ventilated.

Water Closets 2 Water closets.

Two kind are before the public - Valve and Valveless closets - the principle ~~the~~ for guidance in the choice of them being Simplicity of construction and certainty of action at all times - Every closet is now provided with a trap of some sort shutting off the soil pipe -

Valve Closets a. Valve closets -

The still most popular closet is the Pan closet which consists of a basin inserted into a receiver, and having a

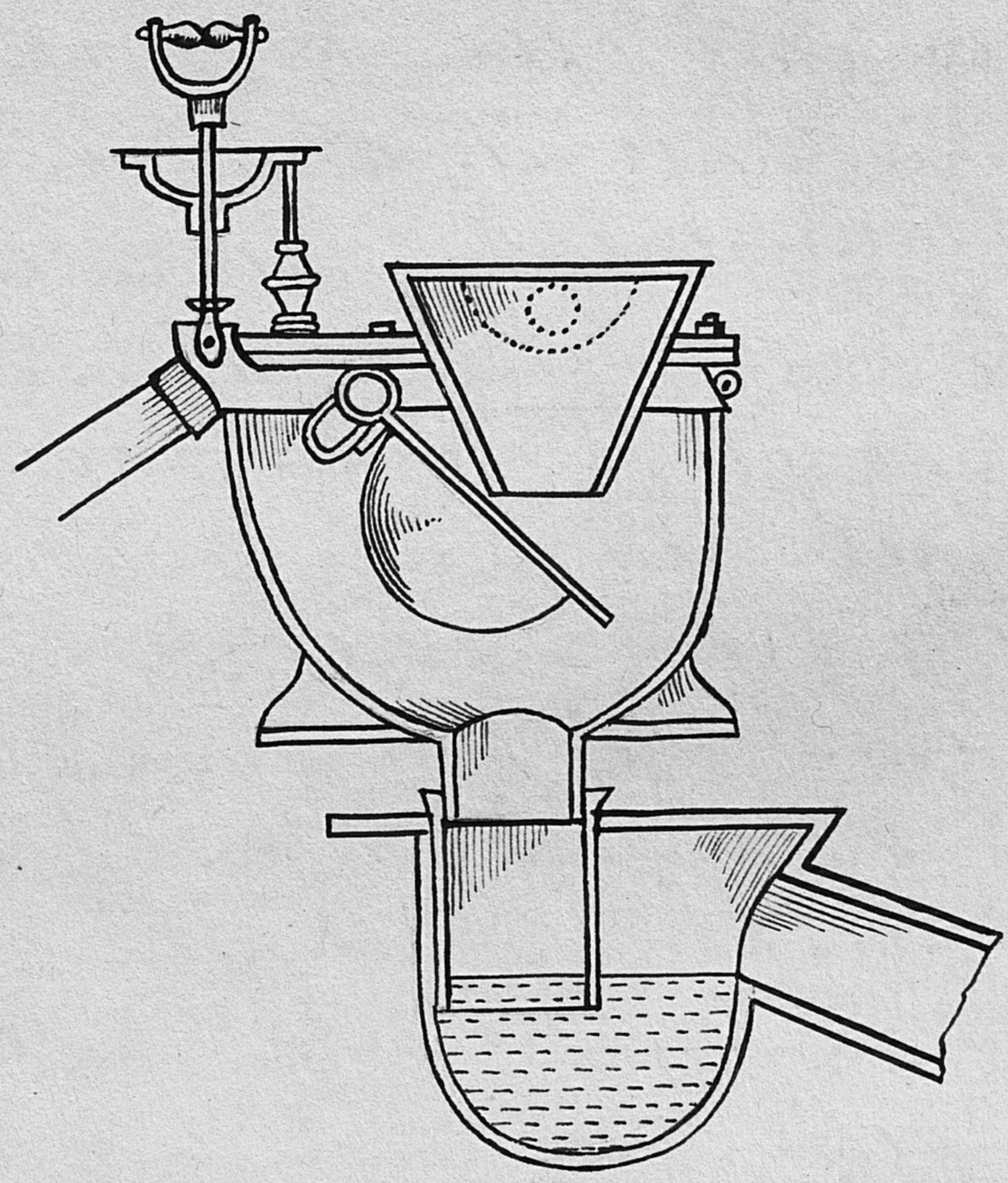

*Fig. 1.*

cup at the bottom of the basin, which is really an inverted Bell trap. At the bottom of the receiver is the trap generally a D. trap. The large area of the receiver, over which forces &c are simply splashed when the closet acts, at once condemns it from the fact that it does not afford a quick exit for all the materials dangerous to health. Ventilate this receiver as we may and do its present allowances do it does not get rid of the fact that there are retained inside unhoused materials which are dangerous to health, and some of the emanations from which must, by the natural law of displacements, find their way into the house when the closet is put in action. Although this defect is sufficient to condemn it unheard still another vile D trap of which mention is made later on.

Many forms of valve closets are now before the public which conform to the principle above mentioned as far as valve closets can.

Jennings of Lambeth, Doulton of Lambeth, Tyler of Newgate St, Underhay of Farringdon St. Stidder

of Southwark Bridge Road and other
have Closets which have received
medals and awards of merit at various
exhibitions.

The general construction of these may
be described as an improvement on
the pan;- doing away with the re-
-Cistern, and, by Sensual patent devices,
providing for the quick removal through
a trap of the contents of the basin, &
after this has been accomplished
the extra or after flow of water being
retained in the basin by means of a
plug or valve - Hence the name -
Every Common fault of the any of
these Closets is the insufficient allowance
made for ventilating the Soil pipe.

Tylor's Valve Closet. Fig 2.

Tylors patent valve Closet, with bottom
outlet, has the advantage that it is trapped
above the floor line, an advantage
which ought never to be lost sight of,
because it provides for the floor of the
room not being interfered with, and
also for everything being open to in-
-spection. The overflow pipe from the
basin is also trapped before it enters the
W.C. trap and, when in action, this pipe
is covered by the valve So as to prevent
the Entrance of Soil into the trap-

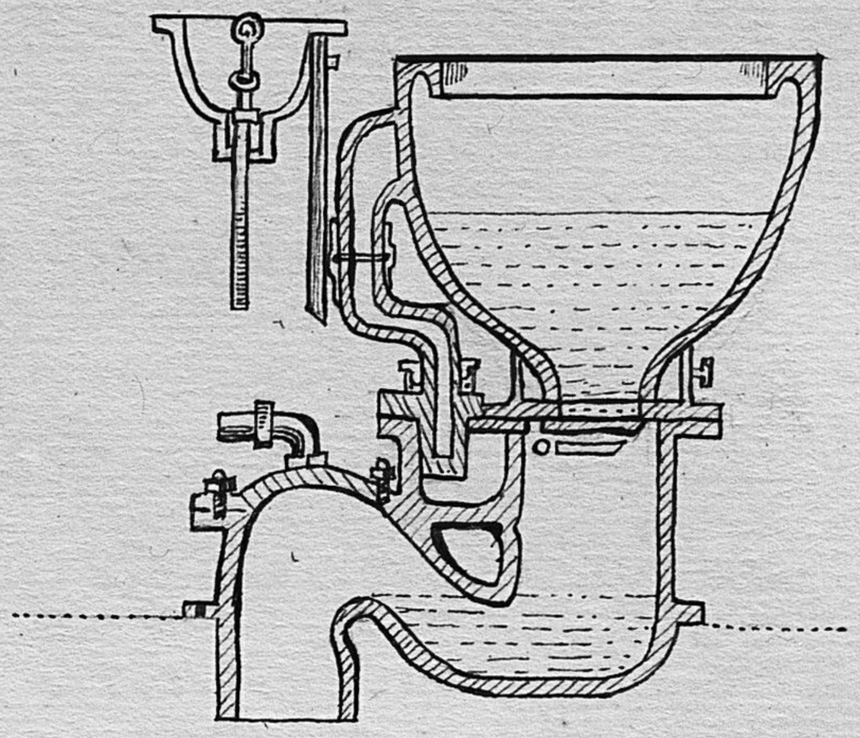

Fig. 2.

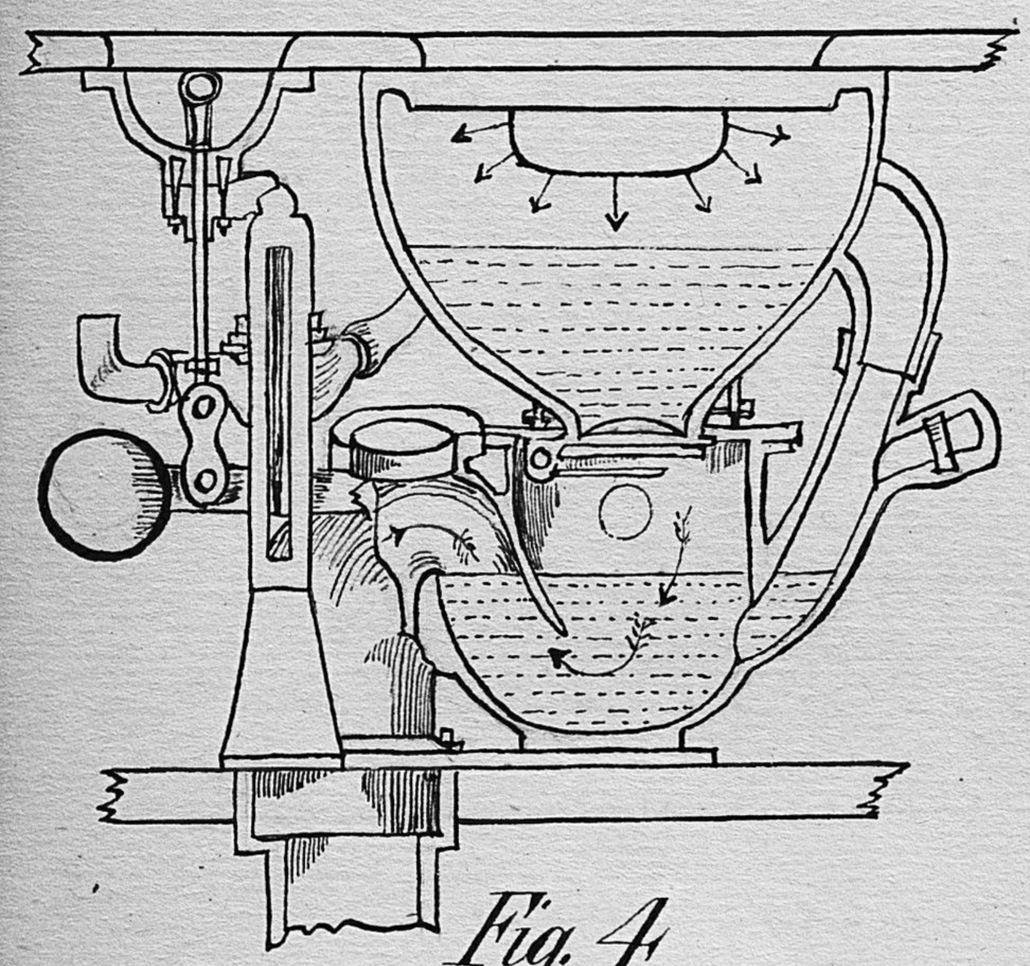

Fig. 4.

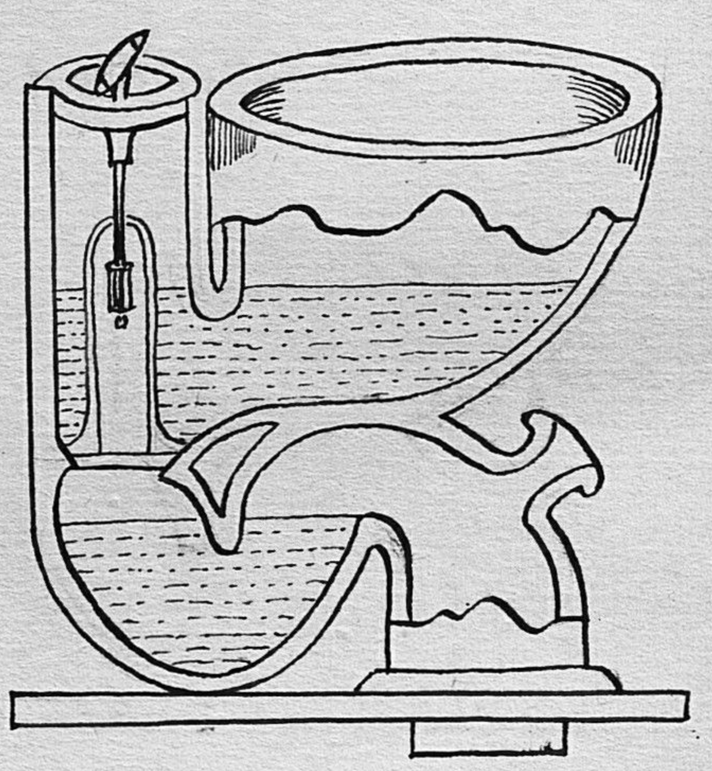

Fig. 5.

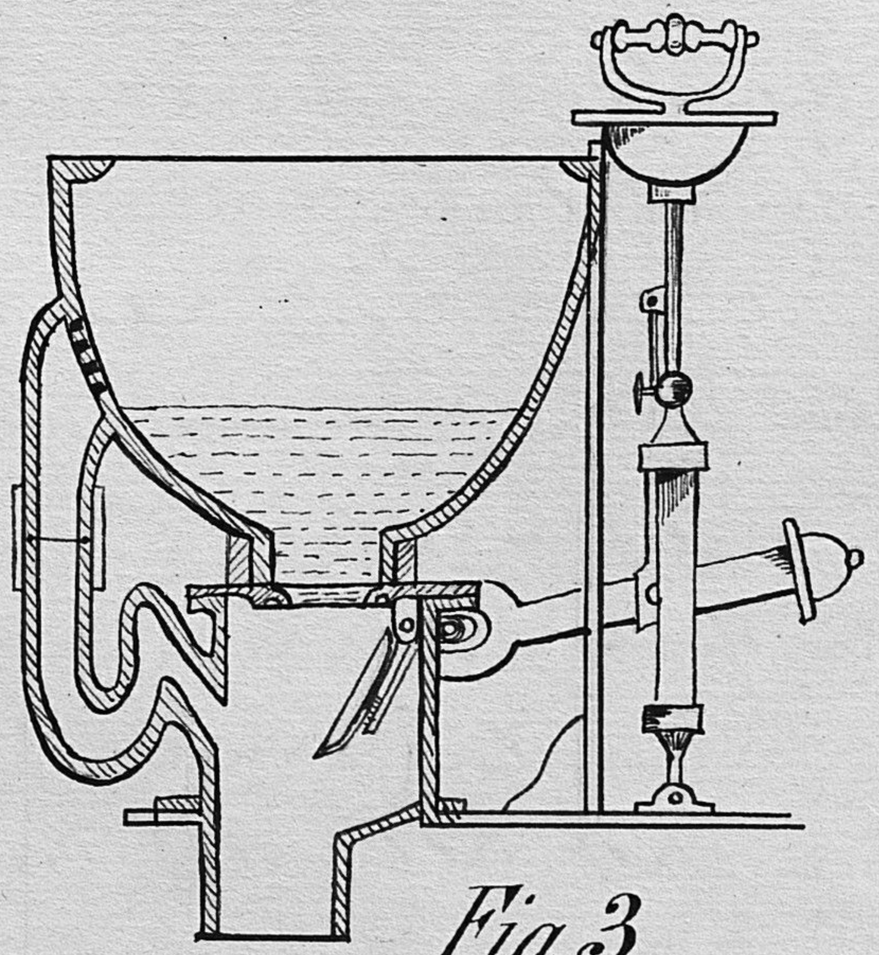

Fig. 3.

Its disadvantages are the, insufficient ventilation of the Soil pipe, and the presence of a Chamber - Small, it must be admitted - Still large enough to Collect Gases from materials lying in the trap.

Underhays Closet Fig. 3.

Underhays Closet is of a Similar Construction only trapped below the floor line this being an additional disadvantage.

Doultons Valve Closet Fig. 4

Doultons best valve closet only differs from the forgoing in that the Small Chamber between the basin and the trap is ventilated.

Jennings Closet Fig 5

Jennings' closet consists of a Solid piece of Earthenware, so arranged, that a plug with a handle to it takes the place of the lever machinery of the others. This plug at the back of the basin and when raised allows the water in the basin to flow into the trap underneath - As originally Constructed this plug was a hollow tube and ventilated into the house the Small Chamber between the trap & the basin - how this tube is trapped and the Space ventilated -

According to Mr Lassie in his Essay on healthy Houses, published in the Medico

Exhibition literature, a Similar Kind
of Closet described as Underhays was
invented by Brannan - Mr Easie
advocates Valve Closets, and gives to the
Class Comprising Syphons and Underhays
a decided preference -
Almost all the Valve Closets have
Metal Seats underneath them for the
purpose of receiving and carrying away
any fluid that may fall over the Side
of the Closet but when all matters of
detail as to water Supply and plumbing
are properly carried out they are not
usually considered Necessary - If adopted
the overflow pipe Should always be taken
Straight through the wall and not led
into the Soil pipe as is often done.

(b.) Valveless Closets.

Valveless Closets. As the name implies, they rely Entirely
on the trap for the Exclusion of gases &
No valve arrangements are Necessary.
For Simplicity of Construction and as
being the Easiest Means of removing
offensive matters from the interior
of the house they have by far the
advantage - well made and fixed at
first, they cant get out of order and will
Stand much rougher usage than any
Valve Closet - One thing however they

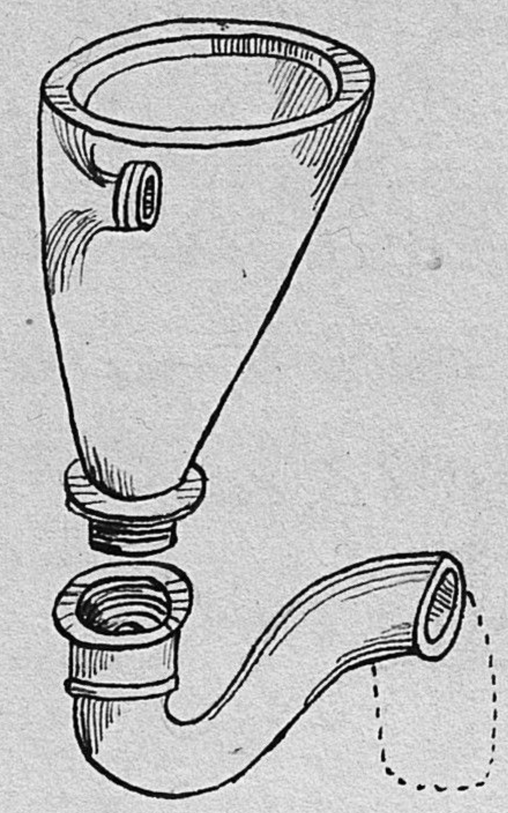

Fig. 6.

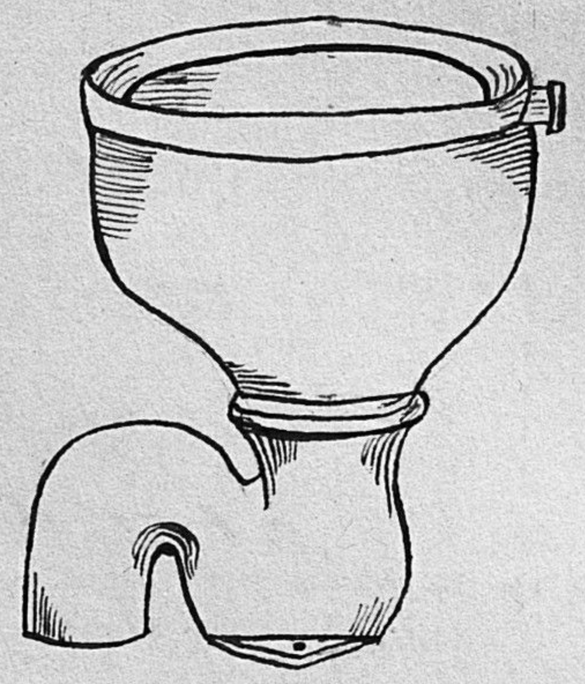

Fig. 7.

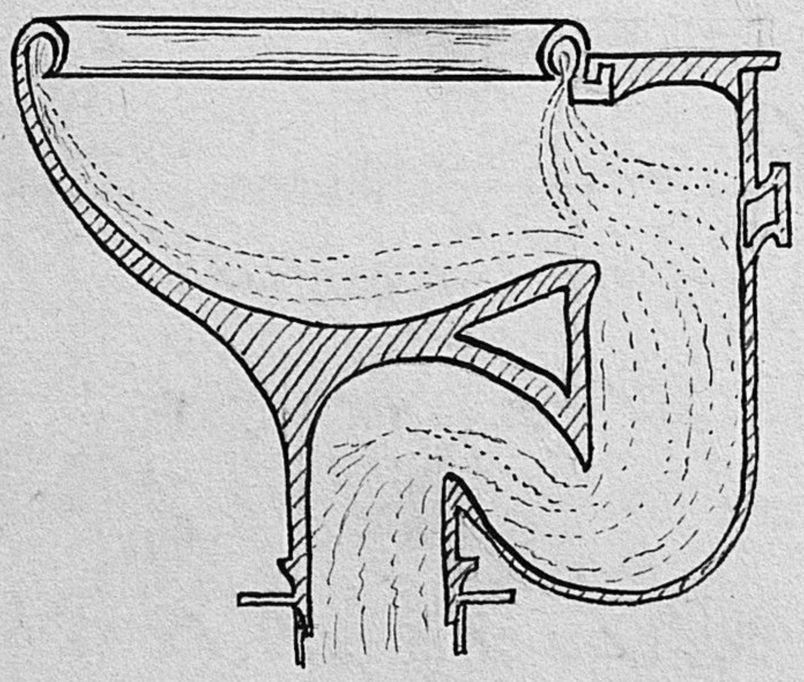

Fig. 8.

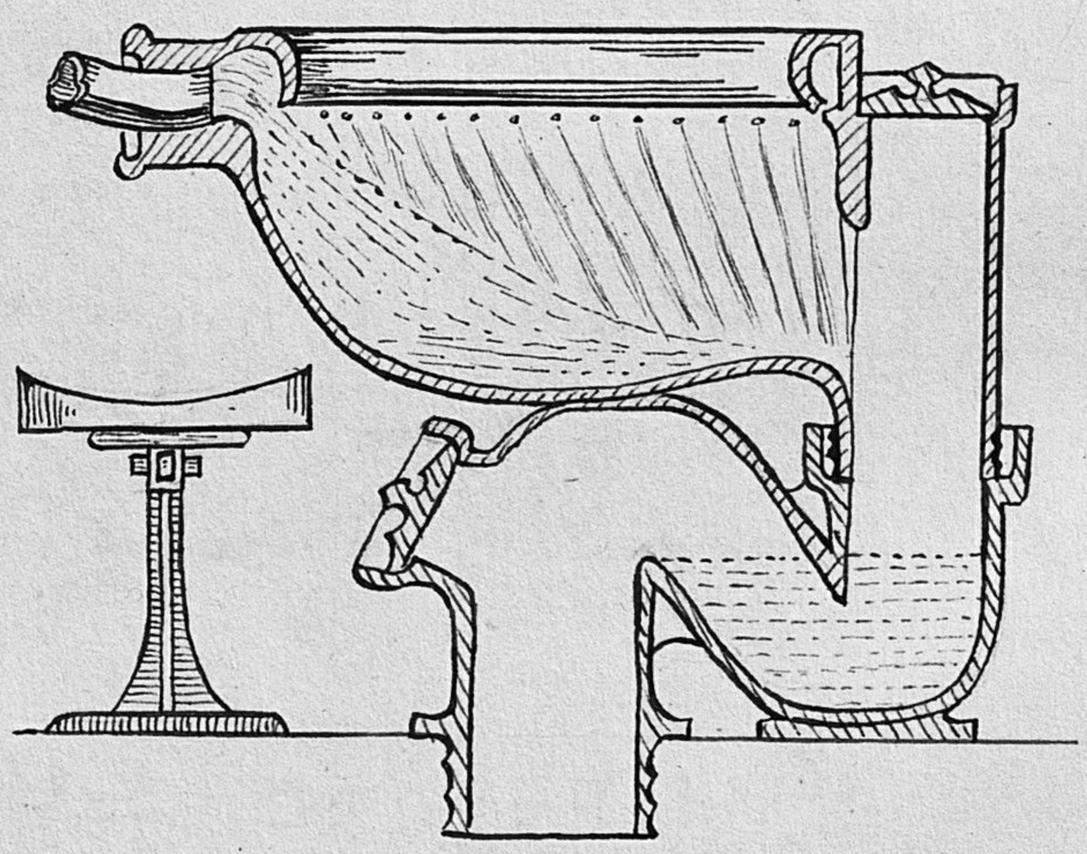

Fig. 9.

must have, and that is a large well
Applied flush of water 1st To clean
the basin 2nd To empty and clear
out the trap, which if it retained
any foecal matter might very readily
become a nuisance - Their Simplicity
of Construction makes them cheaper
than valve closets -
Bostel of Brighton, Doulton, & Shrimpton
are amongst the chief makers -
The original of this form of closet is
like its colleague among the valve
Closets a most insanitary apparatus
but with the advantage that it can
easily be corrected. The "Hopper" closet
The Hopper Closet. Fig 6 in its old form was Simply a Conical
basin Set into a trap and washed out
or rather attempted to be washed out by
an ordinary trap. The "Hopper" as
modified with a proper flushing rim
and a good water flush from 1¼ inch
pipe is a much used appliance for
Saveries and outhouses but it has the
disadvantage that it requires careful
looking after as to cleanliness, the
depth of it and the small surface of
water presenting the proper floating &
Consequent easy and quick discharge,
through the trap of the closet contents.

In principle however it is accurate, and to remedy its defects the closets now sold under the name of Cottage closets by Messrs Doulton are much patronised

Doultons Cottage Fig 7

They consist of a wider and shallower trap with a wide bottomed basin inserted into it, so that the surface of water is much increased and, with a good flushing rim, are very easily kept in order. Again the water from the cistern has its entire force directed against the contents of the trap and this is a distinct advantage over the double wash out appliances.

Double wash out

Double wash out closets are constructed either in one solid piece or in two. Bostel's of Brighton is an example of the former - Doultons of the latter.

Figs. 8 & 9

From the side or any other convenient place is the outlet into the trap. As the trap may require to be turned in various directions to suit circumstances those constructed in two pieces are most usually chosen. There is also on the side of most of them a cap for the purpose of giving direct access to the trap should it happen to get blocked. Careful plumbing with these closets is indispensable. The flow of water

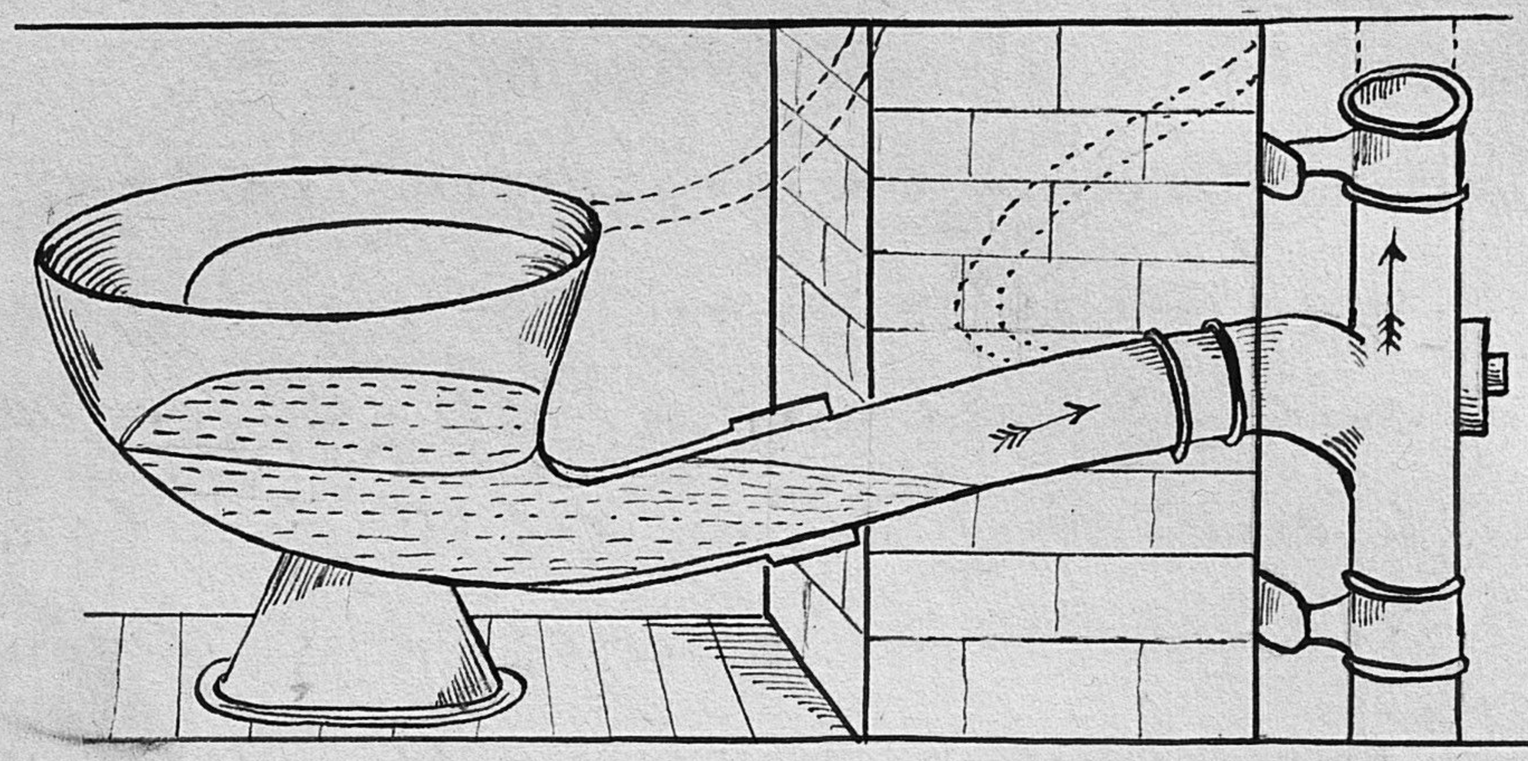

*Fig. 10.*

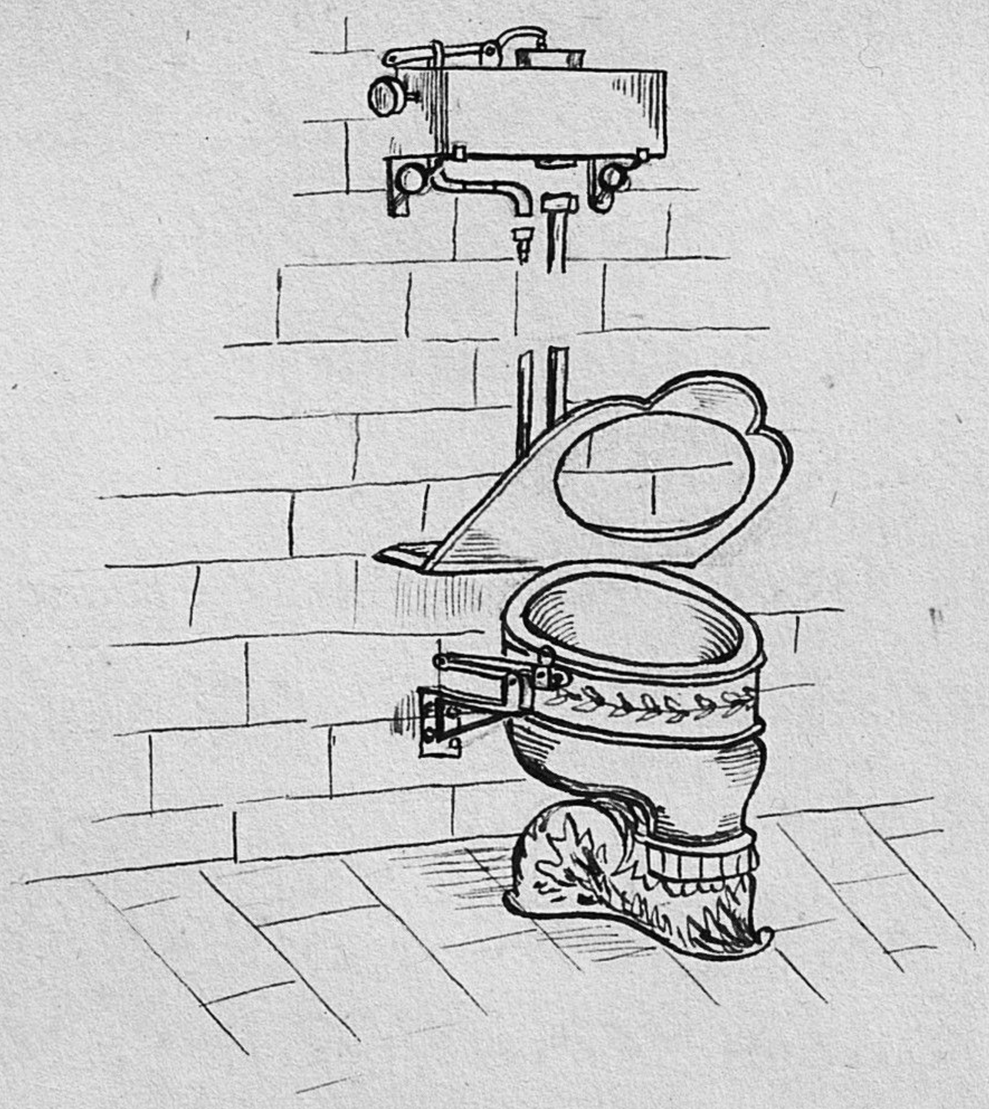

*Fig. 11.*

should always enter the flushing rim opposite the outlet, and be of such force as, not only to empty the basin, but also the trap, leaving only clean water. This form of closet is often unjustly blamed on this very account. Through bad plumbing the water is sometimes so directed as to cause, not a flush out, but a whirl of the contents of the basin, and this soften set down as an objection to the closet which ought not to be. The closet when properly fitted answers every sanitary requirement. From time to time various improvements on these typical closets come out.

Reuss & Hagan Fig. 10

One invented and patented by Messrs Reuss and Hagan of Hull has for its peculiarity an elongated trap which passes almost horizontally through the wall into the soil pipe, and in the soil pipe opposite the entrance of the trap is a chamber for cleaning out should that be required. The length of the horizontal arm, and the large amount of water contained in the trap is a drawback to the flush.

Twyford Fig 11

Mr Twyford of the Staffordshire Potteries has invented a closet of this class which he calls the "Unitas".

It is a distinct advance on other closets in so far as it can stand by itself without any wood covering or enclosing. All that is required being a wooden seat and a cover, if required, both capable of being lifted up. This allows every part to be open to in-spection and cleanliness. All forms of enclosure are insanitary in so far as that we cannot see whether things are clean or dirty without much dis-turbance and expense

The traps of the valve closets have assumed various forms - The Edinburgh
See Fig 1 D trap used with the pan closet being very common. The disadvantage of its great depth, the tail of the pipe from the receiver catching paper and other materials, thus causing blocking leave it far behind the more simple "S" trap of modern times - It is now a thing of the past from a Sanitary point of view - The Simple "S" trap is now the one almost universally adopted & the seal is such as to allow only a depth of from 1½ to 2½ inches of water above the upper surface of the trap - When the Soil pipe is ventilated, more depth is

unnecessary, less would bring it too close to the margin allowed for insyphonage produced by its various causes the consideration of which come after Water Supply.

Water Supply to the Closet.

Mr Prosser Teale in his illustrated work has shown by diagrams the usual defects of this branch.

Disconnection of the W.C. water Supply from the General Supply is now the invariable rule.

In a letter to the Sanitary Record in 1885 Page 397 Mr D.J. Edlis deprecates the amount of dogmatic teaching which prevails and asks the question "Given a well ventilated Soil pipe what danger is there of gases finding their way into the Common cistern? But he then adds that the End of the Supply pipe should be bent so as to form a trap before Emptying into the closet.

The two objects aimed at with Separate cisterns and all other appliances are disconnection of the water from the main Supply and Economy or prevention of water waste.

They are, according to Mr Bailey Denton, of three Classes. First - Those fixed in a

general cistern and which discharge a fixed quantity of water into each closet which such cistern is intended to serve. Second:- Those which let free the contents of a small cistern - say two gallons - or a compartment in a larger one holding a fixed quantity. and - Third - Those that effect the same purpose less directly, by means of a regulator placed intermediate the seat of the closet, allowing only a fixed quantity to pass through.

All these contrivances when used for valve closets require to have a means of securing the trapping of the basin by admitting sufficient water for that purpose after the valve has re-assumed its closed position.

When a waste preventer is fixed in a large cistern the first difficulty with it is its inaccessible position. Still this does not prevent such a machine as Messrs Wallace and Connell's Sure water waste preventer being much in vogue.

See Figs 12 & 13

With it a certain quantity of water is secured to flush the closet, and after the valve is closed an after flush comes to trap the closet. It consists of two pistons working within cylinders a main one

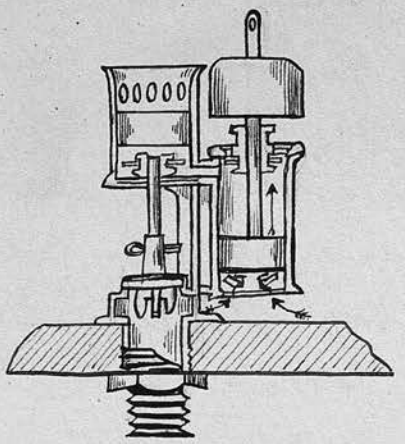

*Fig.12.*

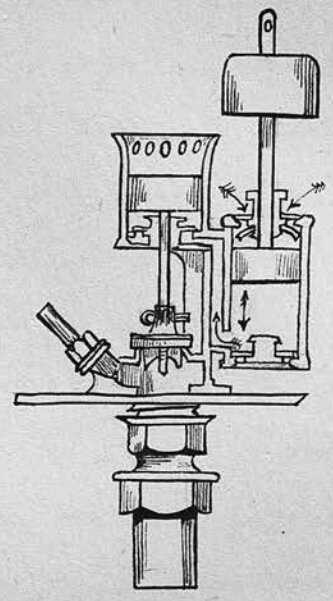

*Fig.13.*

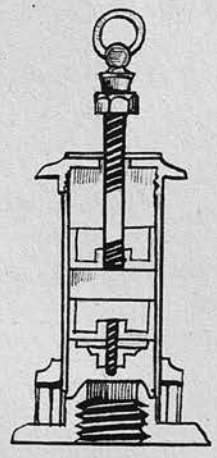

*Fig.14.*

which has at its bottom a plug fitting into the top of the Supply pipe to the Closet, and a lateral one which is connected with the handle of the W.C. The two cylinders are connected together by Small Side tubes, one at the top & another at the bottom - when the lateral piston is raised water rushes into its cylinder and thence, by the upper connection, to the drum of the piston over the Supply pipe to the Closet which fits loosely into its perforated cylinder. This piston is so weighted that the water rushing in under neath the drum raises the plug over the W.C. Supply pipe the water falls through. By its gradual subsidence the plug again closes and when the handle of the Closet is let down another rush of water takes place, this time from the full of the piston in the lateral cylinder, through the bottom connecting tube, causing the main piston to be again raised thus giving an after flush to trap the Closet. The perforations in the main cylinder are for the purpose of letting off Superfluous water.

See Pg 14 Messrs Tylor's waste not cistern valve is on the Same principle but it does not provide for an after flush - It consists of a Spindle and piston working

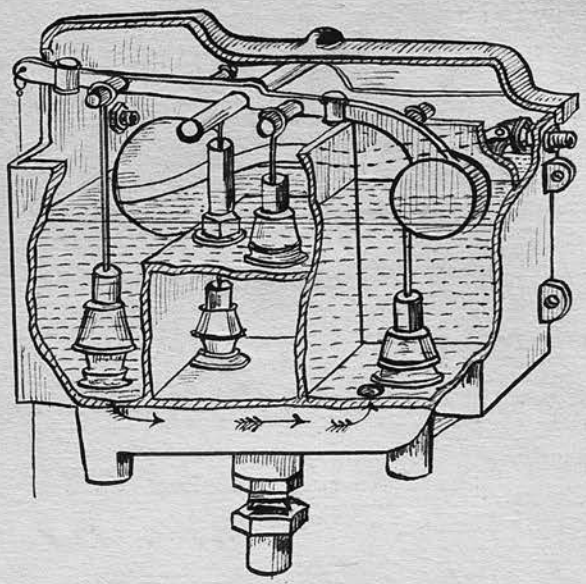

*Fig. 15.*

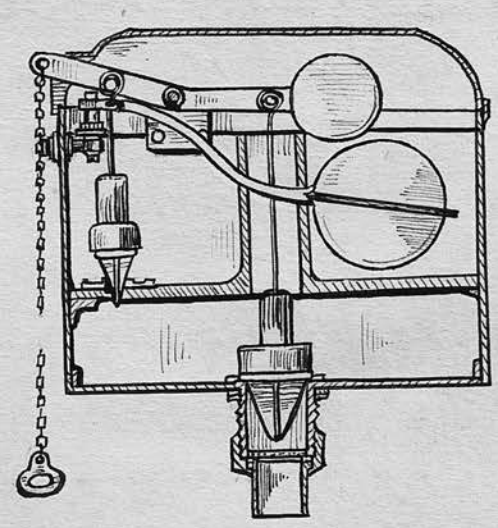

*Fig. 16.*

in a cylinder with, underneath it, a loose piston regulating valve which goes up with the Spindle and balls by its own weight in a given time thus Shutting off the water.

Separate Cisterns

Amongst the Separate waste preventing Cisterns fitted one to each closet which are of easy access, and are much to be preferred to the apparatus above described, Mr Bailey Denton fixes preference to Silvers "After flush waste preventing Closet Cistern." It consists of three compartments -. The first is a reservoir in connection with the Supply ball Cock. It Communicates by a tube with the flushing compartment. The third division is the after flush compartment It is so arranged as to valves that when at rest the after flush tank is empty, and when in action the flushing tank discharges, and the valve attached to the lever opening the after flush tank to the reservoir opens & allows it to fill. The drop of the lever opens another valve, by means of which the after flush tank is emptied & the flush tank again filled from the reservoir. It is a costly & complicated but efficient apparatus when in order

See Fig 15 Valve Cistern

but with four valves which are liable to constant wear it cannot be re-commended -

Mr Tylor has a cistron which he calls "a double valve waste preventing cistern" It will discharge a given quantity of water and allows an afterflush -

Fig 16 Stone & Co's cistron is a much simpler apparatus - It consists of an upper chamber and a lower one, which is filled by means of a valve from the upper chamber, & this is in connection with the ball tap - The pipe to the W.C. opens out of the lower portion by means of a valve, and these two valves being placed one on each side of the fulcrum of the lever cannot both be open at the same time -

All valve arrangements require the lever to be held down during the entire time of the water discharge, and as this is often not done, it must be regarded as a disadvantage to the cistron -

Syphon cistrons Simplicity itself - is seen in many of the Syphon working cistrons which are arranged so that they discharge a fixed quantity & cannot allow any more water to pass through the pipe - These cistrons are much less liable to leakage & derangement generally than are the valve cistrons.

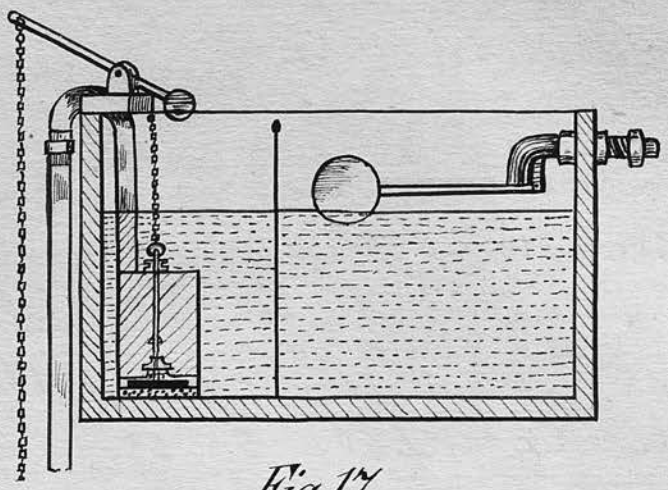

Fig. 17.

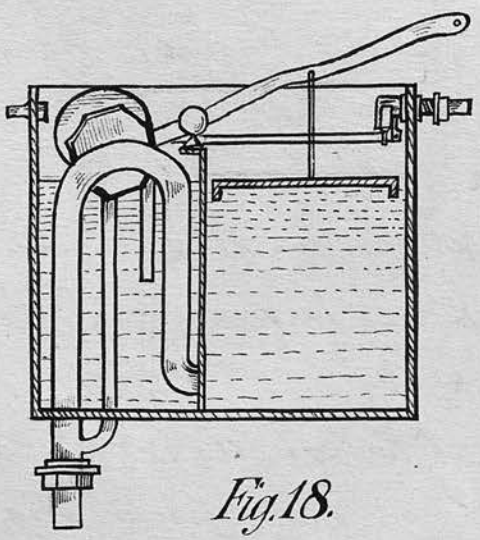

Fig. 18.

Fig 17. Messrs Braithwaite of Leeds have a very simple cistern divided into two compartments, communicating by means of a small hole. The one division being for the ball tap, the other containing the syphon which ends in a bore, in which is a loose plate attached to the lever. When this plate is drawn up it forces the water into the syphon and sets it in action, and by one touch the whole contents of the cistern are discharged.

Fig 18 E. Emanuel of Marylebone Lane, London has a double syphon cistern which provides for an after flush for valve closets. The large flushing syphon is put in action by a downward pressure plate attached to the lever and the smaller syphon, which is attached to the large one, and works in the ball compartment, and has a shorter arm than the flush syphon, is made to work by the suction of the water rushing down the large syphon.

One of the latest designs is the "Westminster patent valveless syphon water mark preventer." It consists of a bore in which is placed the ball valve. Inside this there is a triangular shaped hollow air tight chamber which has its base at the top

Fig 19

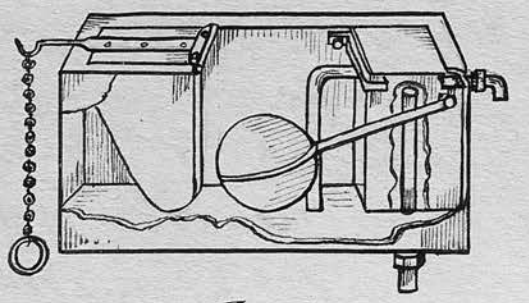

Fig. 19.

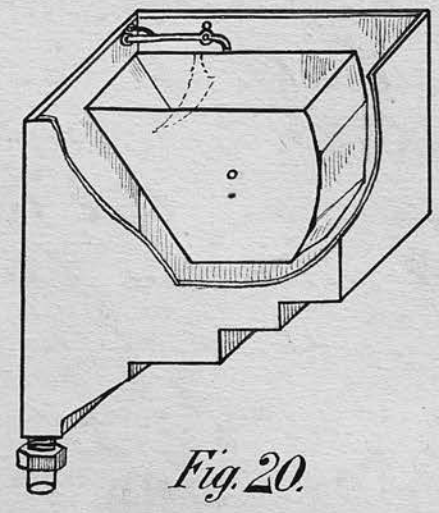

Fig. 20.

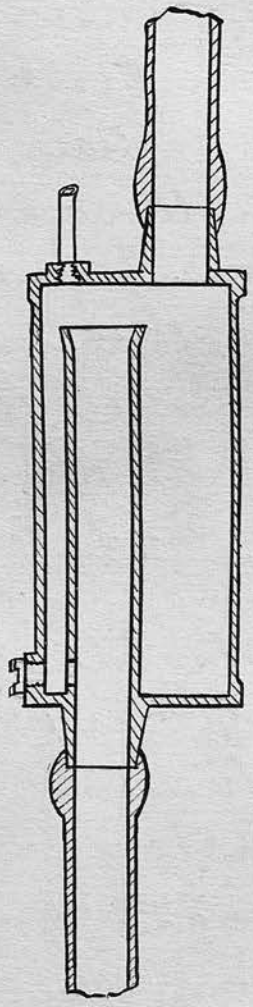

Fig. 21.

of the lever and is hinged to a rod pro-
-jecting across the cistern. The chain
of this lever is attached to the side near
the side of the cistern. When the water
flows in at the ball valve this chamber
is forced up into the air & the chain end
is raised with it. In another part of
the cistern the syphon is fixed. When
the chain is pulled the descent of the
hollow chamber causes the water
to rise over the syphon & put it in
action.

There are many modifications of
the syphon principle but ~~one~~ these
typical ones suffice.

The principle of the tipping lever has
also been used by Mr J Braddon McCallum.
Fig 20 His cistern acts precisely on the same
lines as do tipping tanks of water
meters. It consists of one vase fitted
within another - the inner one being
connected with the supply tap. When
full it slightly tips over thus shutting
off the water supply, and when the
chain is pulled it tips entirely up
thus causing the instant discharge
of the fixed quantity of water into the
supply pipe.

A double syphon cistern has been

lately invented by R.F. Dale & Co of Southwark. In it when the lever is pulled one Syphon Chamber is discharged & when dropped the other is discharged thus trapping a water closet.

Of water preventers and regulators fitted under the Seats of closets Bailey Denton says that they possess the following advantages and disadvantages:-

1 They occupy less room in the closet.
2 Any number of closets can be supplied from one cistern by one Service pipe.
3 There is no interval between the rush of water into the closet and the lifting of the handle.

As opposed to this they give less force in flushing out the basin - The arrangement is not mechanically secure, and there is not a thorough disconnection of the general water Supply.

Tylors waste preventer is, to say the most for it, a safe appliance of the kind, and is constructed on the same principle as his water waste preventer within the cistern - It consists of a lever attached to which is a piston with a Socket working inside above through which the water must pass - Into

this Socket fits a loose plunger which acts as a plug to the water Supply. The raising of the lever raises this plunger and Should the lever be kept up the weight of the plunger causes its descent, thus in a regulated time Shutting of the water Supply. The Speed of the descent of the lever is regulated by a Small jet of water which comes in thro' a Small tube provided for the purpose on the closet Side of the apparatus re- -gulated by a Screw. It is a complicated apparatus & one not much used.

Underhay's regulator is used in connections with the closet of that name and Simply consists of one tube working within another. The inner one being open at the bottom and having a regulated air inlet at the top. When the closet handle is pulled up the inner tube which is attached to it is also pulled up, and the Slow Escape of air from this allows it to fall gradually, thus Shutting off the water Supply with which it is in connection. This arrangement allows of an amount of water to pass through the closet but the amount is not certain.

To add to its Security a device on a

Similar principle is added which consists of two cylinders - the inner one being connected by a lever with a cap on the end of the supply pipe. A small aperture in the outer cylinder admits water slowly which floats up the cylinder & thus shuts off the supply - The cylinder water runs off by a small hole at the bottom. It is an arrangement very liable to get out of order.

In order to obtain an after flush for water closets the trapping hose of Messrs Chandler of Mile End is a very simple and efficient apparatus.

Fig 21

It consists of a bracket with supply pipe round which a hose is fixed. Each time the closet is worked the hose is filled before the pipe is reached, which stands several inches high in the hose - when the handle is let down the water in the hose finds its way, through a small hole at the bottom of the hose, into the supply pipe thus giving sufficient water to trap the closet.

House maid Sinks and Slop Sinks are of many and various forms. The ordinary Kitchen Sink requires no further mention than that it ought to be disconnected immediately outside the house when possible and its contents run into a grease trap. Slop Sinks fitted up in Lavatories and bath rooms are quite recent inventions and are simply modified wash out closets for the special purpose.

As to the water from baths, Some take the discharge pipe straight through the wall down to an open grating. When possible it is much to be preferred that an open brick, or other gutter, should convey this water from the pipe and to the grating at some distance.

In most new buildings now open gratings are placed at the foot of the bath and the water is conducted to another open grating on the ground surface.

Neither Slop Sinks, House maids Sinks, baths, nor Lavatories should empty into a Soil pipe used for water closets.

Traps.

No form of water Seal will withstand the pressure of gas. Soil pipes are therefore left open at the top to allow of the Sewer gas, if any be present, to escape. To prevent the Entry of this Gas into the house Water Seals or traps are had recourse to. What is required of them is, that they must be so constructed that they will prevent the ingress of air into the house, and also the Syphonage. They must be also Self cleansing.

Syphonage. The Subject of Syphonage next to blocking up altogether is of great importance and requires attention.

Mr Putnam of Boston has performed a Series of Experiments on this Subject and has invented what he calls an anti Syphonic Sanibas trap which has occupied the recent attention of Sanitary Engineers.

The results of his Experiments are as follows:- An unventilated "S" trap is Easily unSealed. Ventilate an ordinary "S" trap in the usual way from its crown and it is Still possible to unSeal it by a largely increased number of discharges from a closet overhead into the Same Soil pipe.

- In an "S" trap ventilated from its crown a frequent cause of unsyphoning is Evaporation, which may be com-
-plete in a day or two during hot weather- In a well ventilated pipe he sees no advantage, except in certain forms of W.C., from trap ventilation, but rather the above disadvantage together with the following:- The vent pipe does not accomplish its object and hence affords a false security - It increases the unscoured area of the trap making it a cesspool, as when the trap is some distance below the basin used, the water is shot up through the trap into the vent pipe, thus
Fig 22 causing a Sediment which thickens more or less rapidly according to circumstances - It retards the outflow of water about 33 per cent owing to the friction of the air current Entering with the water - It com-
-plicates plumbing, and adds to the number of joints; and last it adds to the danger of capillary attraction.
From this he is Satisfied that the ventilation method of preventing Syphonage is unSatisfactory

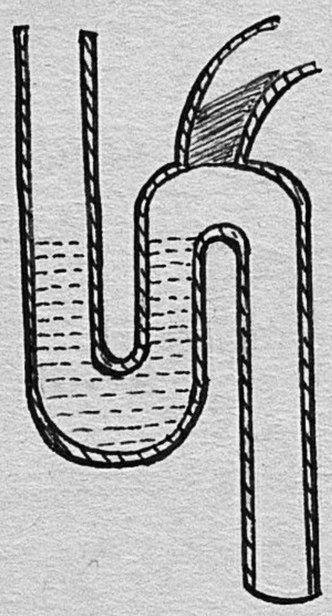

*Fig. 22.*

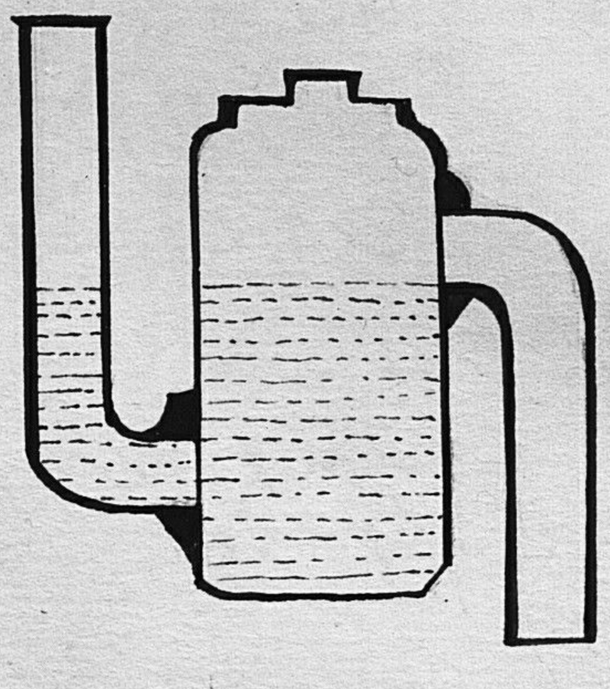

*Fig. 23.*

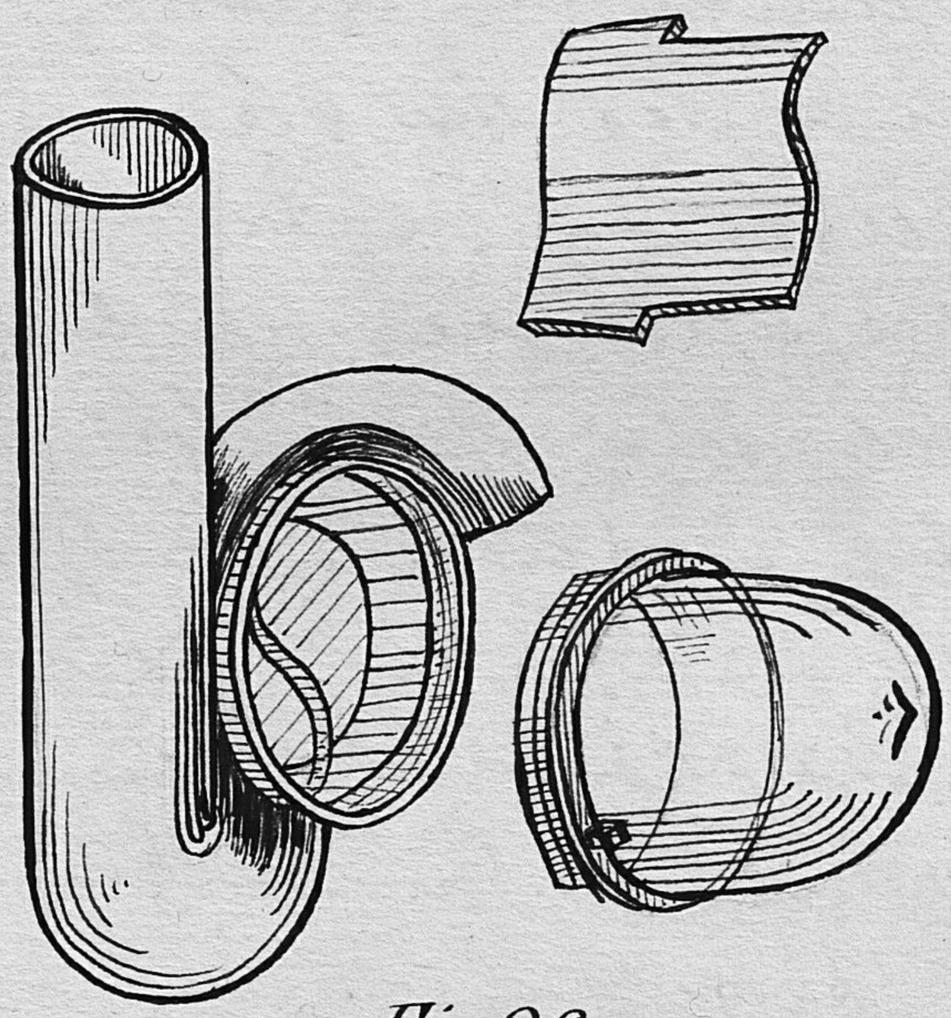

*Fig. 26.*

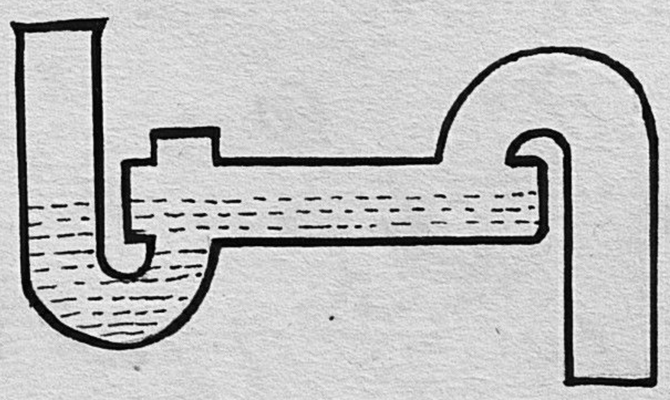

*Fig. 24.*

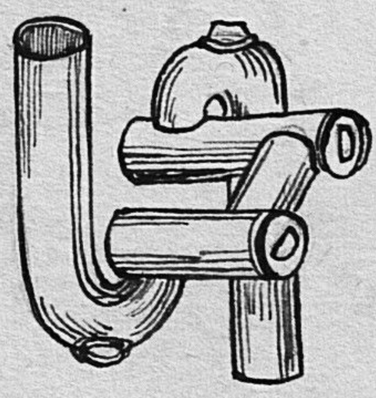

*Fig. 25.*

His Second method is to take the
Fig 93 unventilated American Pot trap as
an example - The larger this trap
is the more effectually it resists
Syphonage, and the more inspection
it requires, as it soon becomes a
foul cesspool - The same thing applies
to the "D" "Globe" and "Bottle" traps
which belong to the same class -
In obtaining an anti Syphonic trap
he examines the causes of Syphonage
First Suction - In the pot trap the
water is splashed up by the current
of air passing through it, and part of
the water is sucked out into the
soil pipe - The "S" trap is more
easily unsyphoned because the top of the
trap conducts the water straight into
the soil pipe -
In constructing a trap which re-
Figs 94 & 95 - flects back the water so sucked
Show Stages. out he goes through a long Series of
Experiments which have their end
in a trap which is really a com-
- bination of the "S" & "Pot" traps -
Fig 96 shows Interrupting the straight course of the
Complete trap upward arm there is a cylinder, set
horizontally, with a cleaning out cap
at one end which is generally made of glass.

Across the inside of this is set a central partition about $\frac{2}{3}$rds of its length, or ex-tending from one end to the face of the cleaning cap, which cap at the other end, forms about one third of the length of the cylinder. When air is sucked through this trap there are, 1st The deflecting Surface of this central plate. 2nd Of the cleaning cap & 3rd The Surface of the horizontal Cylinder, which prevent the trap being unsealed. On account of the impossibility of its unsealing it does not require to be ventilated at the crown or so near it as others do. Experiment has proved that without any ventilation at all the trap is incapable of un-Syphoning by Suction. This trap had Coals, Ashes, Clay, Loam, & Soap & all manner of dirt thrown into it, and it is claimed that these materials were all washed out at the first flush So that it must be a Good Self Cleansing trap. This of course was done with a waste pipe nearly the full size of the trap.

Capillary attraction, the insidious enemy of water traps, is one of the most powerful known factors in

producing Syphonage in traps, whether Ventilated or unventilated, and all of the usual forms are habitatort. During his experiments (Mr Putman's) he found that water will not carry above three inches in height through small pieces of fibrous material found in traps generally - The "Sanitas" trap being over that depth prevents it - If the Sanitas trap holds about one pint and a half of water, and if the pipe on which this trap is placed be not ventilated too close to it, the Seal will remain for over a year without being replenished -

On these grounds Mr Putman claims for his trap the advantage of being the Safest Known water Seal under the most disadvantageous circumstances —

The fact that when traps are left for a long time standing they do absorb and give off onto house side a certain amount of Sewage gas has led to the invention of an absolute Sewer gas Excluder by Mr Withington of Manchester. It is placed between the Soil pipe and the trap and Consists of a hose Con-

Figs 27 & 28

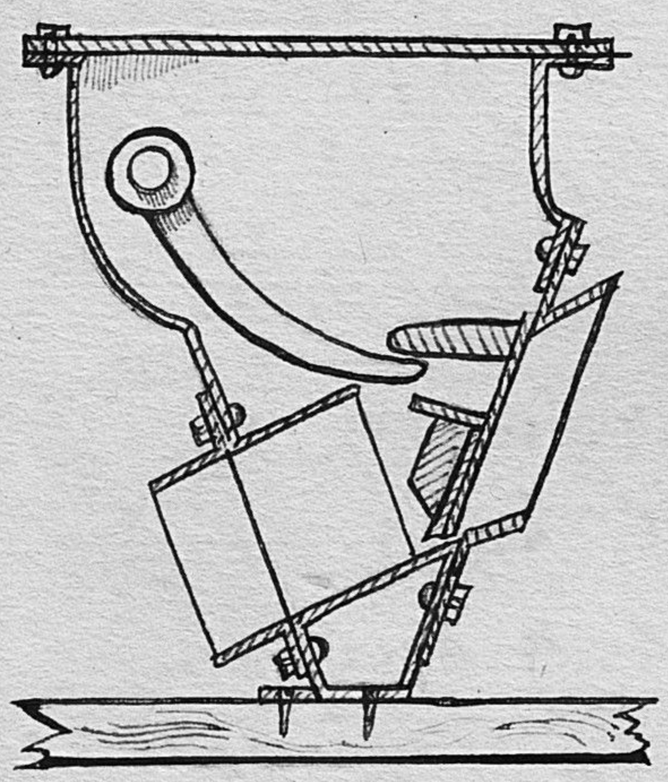

*Fig. 27.*

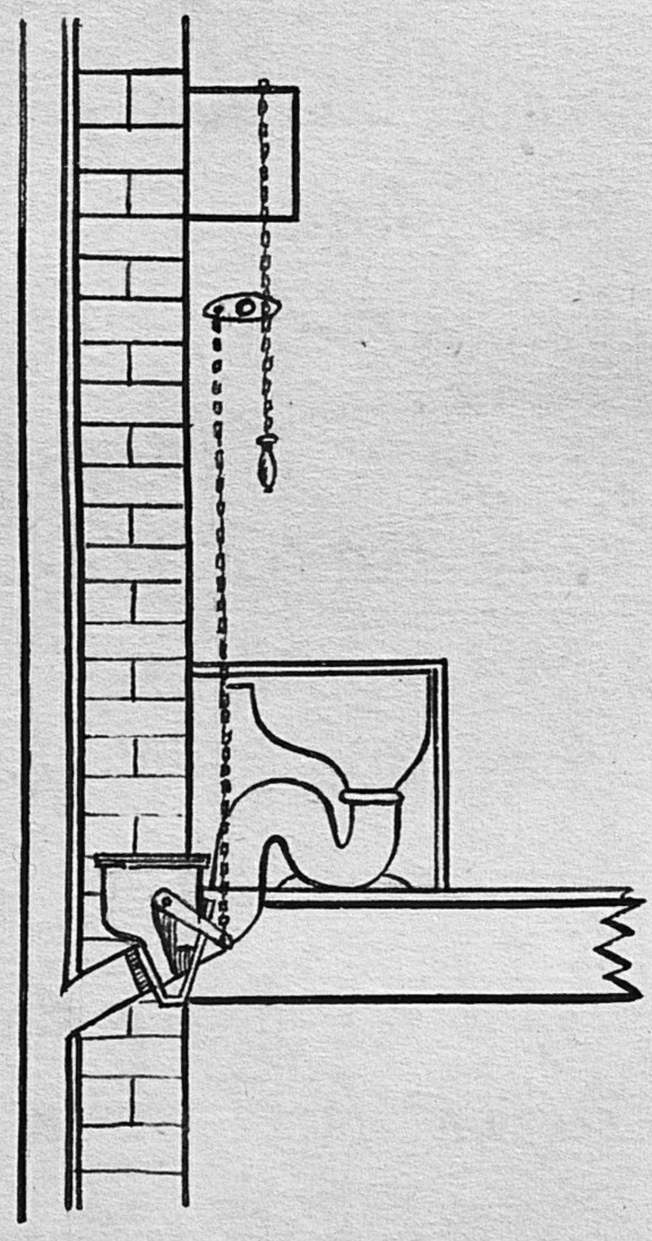

*Fig. 28.*

taining a lift up door or valve, placed at a certain angle with a wedge shaped edge fitting into a groove of the same form - Being connected with the lever that opens and shuts off the water Supply it is easily worked.
The first trap used for W.C's was the Edinburgh "D". Generally made of lead and shown on diagram 1. It is now a thing of the past - The "S" trap is the one now in most general use and from its simplicity only for the best.
When a closet is in daily use there can be no doubt that the ordinary "S" trap, with ventilated soil pipe, is perfectly sufficient for all ordinary purposes - when the flush is sufficient, not only to clear out the closet, but also the trap, the danger of Syphonage is comparatively slight - There is neither time nor opportunity for sewer gas to be absorbed in sufficient quantity to do harm, and altogether with our modern appliances, now so common, we may fairly claim to have an efficient, and sanitary method of removing excreta outside the house into the soil pipe.

Soil pipes.

It may yourmont argument that all Soil pipes should be outside the house.

During the entire reconstruction of the Sanitary arrangements of the Montrose Royal asylum, where the old fashioned plan prevailed of having all the Soil pipes inside the house, made of lead, and running through the basement of the building in all directions, and in all conditions. These pipes were all cased round with wood in wall recesses and the whole house was infested with rats.

In the Sanitary record for Nov.r 15.- 1880 a long letter from Dr Howden describes the ravages of these rodents. In 1879 I placed in the Edinburgh University Museum Several Sections of lead pipes. one of them a hot water pipe. which had been gnawed through by rats; Also a portion of a lead pipe which had been perforated by the corrosion of Sewer gas. The corrosion had taken place in a part of the Soil pipe which was difficult of access and caused much loss of health before it was discovered and remedied.

For these and other minor reasons it may be laid down as a rule that every Sanitary appliance should be placed Sothat it can be seen and easily dealt with if defective -

The materials of which Soil pipes are generally made are - Glazed Earthen ware pipes - Cast iron pipes, either Coated with Dr Angus Smith's Solution, or prepared by the Bower - Barff System with Superheated Steam - and Lead en pipes not Soldered but Solid drawn. In Buck's treatise Specially prepared iron pipes, either porcelain lined, or otherwise are given as the most durable. Iron pipes for this purpose were used fifty years ago - Lead en pipes are easily dented and Soon get out of repair - Porcelain pipes have too many joints to recommend them these being liable to injury from vibrations, house Subsidence &c. Iron is what is almost immensally adopted -

The usual diameter of a Soil pipe is four inches and the pipes should be Supported on the walls by firm bracings. The traps of Closets are usually made of porcelain, Sometimes of lead, & Sometimes of iron - The jointing of these to the Soil

pipe require very careful management.
When a leaden pipe has to be joined
to an iron one, it should be remembered
that these two metals in contact are
subject to galvanic action whereby
the iron sooner or later turns out by
corrosion thus perishing by local
oxidation. The iron suffers before the
lead from this cause because the
lead is electro-negative to the iron.
Some assistant packing is therefor
required, such as a previous fibrous
stuffing with the old fashioned putty,
and finished off with portland cement.
Iron filings and acid also make good
joints for iron pipes.
With iron and porcelain joints the difficulty
lies in the relative expansions of the
metal and the earthen ware.
Mr Roger Field prefers drawn lead soil
pipes and gives as his reason (See
his treatise in the Health Exhibition
literature) that the jointing can be
much better done than in iron pipes.
His defence of lead does not however
seem to be complete. In one part he
says" Drawn lead must be used &
not milled sheet, with its necessary
upright Solder joint. These Solder-joints

are the very first places attacked by Sewer gas and lamentable have been the results of the perishing of these joints to the inmates of a house."
He also says that they require to be more carefully braced to the walls on account of their weight-
The joints in drawn lead pipes must be of Solder and if this is easily eaten through by Sewer gas, which it is, it cannot be claimed that the pipe is any better than any other- Lead then can only claim for itself its more perfect joint pro. tem. as against its disadvantages of its greater weight, greater liability to corrosion, and softer consistence than iron-
Iron is said to be liable to crack but this fault should be laid at the door of the maker of the pipe in many instances.

Given a well made joint and a well prepared pipe we have a thoroughly reliable outside Soil pipe.

The Soil pipe of whatever material it is made of should be carried above the roof 2 ft to escape the eaves & thus act as a ventilator to the drain-

## Ground drains from Soil pipes.

The junction of the Soil pipe to the drain should always be made at an acute angle. Direct Entry at right angles or nearly so causes silting in the pipes, and is one of the most common causes of stoppage. The ground drains should never be made of brick or porous earthenware. Glazed Stone- or Earthenware is what is almost always used - They require to be very carefully laid in well puddled clay, or Concrete; the joints packed with tarred gasket or some such material, and headed in cement, or concrete. Sometimes these pipes have to go a considerable way before they can enter the Sewer and the question of the velocity of water flow and the amount of fall require attention - Mr Cassie says (Health Exhibition Literature) the amount of fall in the pipe should never be less than 1 in 40 or 3 inches to the 10 feet - Six inch, or 9 inch pipes - in rare cases of large Establishments, - are generally used -

Mr Bailey Denton says that the velocity of flow should not be less than three feet, nor more than ten feet per second.

Pipes ought always to be laid in a straight line when practicable. This however is sometimes impossible, and where a curve takes place an extra dip should be given to aid the velocity of the flow. There are special pipes constructed for these bends, and for the entrance of one pipe into another, which should always be selected with the greatest care as to their correct construction. Traps at the bottom of Soil pipes are not generally used; from the fact that Sewer Gas, if it does escape from the Sewer is better let off at the top of the house than on the ground surface.

Should it be necessary, as in some old houses, to have the Soil pipe inside the house, then perhaps Lead en ones may be useful; because they are not liable to be acted or interfered with. When it is absolutely necessary to take a pipe through the bottom of a house it should be exposed in its whole extent. Either an iron one Specially prepared with strong joinings, or Salt Glazed porcelain, or Stoneware set hard in Concrete

When these pipes pass through a wall, a Special Casing area has to be provided for the purpose to protect the pipe from the danger of breaking through the Subsidence of the wall.

Rain water pipes should only be used for rain water and not as Soil pipes. In their construction it should be remembered that rain water acts most powerfully on lead So that it ought never to be used in their manufacture. Before their contents are allowed to enter the drains they must be disconnected by gully traps.

House hand Sinks require very Careful attention, because the water from them Contain much melted fat. Soap Suds &c which Solidify on the Surface of the drains and cause blocking.

Fig 29 Field Grease trap is a most effective method of preventing this. It Consists of a galvanised tank, varying in Size, and made to contain a large quantity of water. At the Side is a Syphon dipping nearly to the bottom of it and Coming over the Side to the drain, when it is trapped before

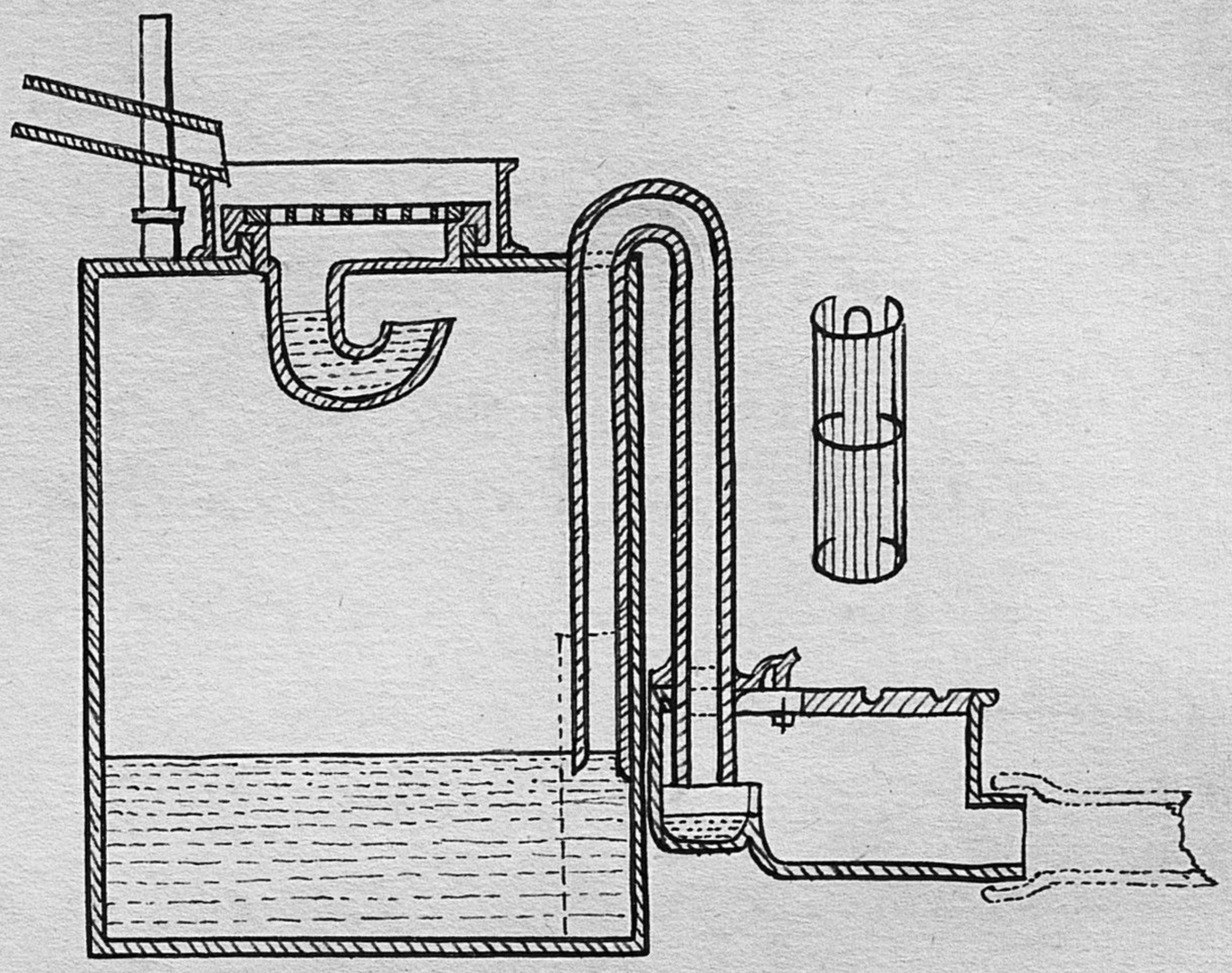

*Fig. 29.*



*Fig. 30.*

entering it. On the top is placed a straining grate which also is trapped underneath. By the time it is filled the fat has all solidified out, and when the Syphon is put in action automatically by the filling up of the tank, all the dirty water is taken away with great velocity and acts as a scour to the drain. With regard to the fat that remains when collected it is said that when sold to tallow merchants it will at least repay the cost of cleaning. Messrs Stidder of Southmarsh have a grease trap on this principle.

Fig 30 Mr Hellyers arrangement is very simple and free from the noise of the others caused by the Syphon action. In it he places the inlet pipe & the outlet pipe several inches below the surface of the standing water so that the fat rises to the surface before it reaches the outlet pipe.

If a grease trap be not used a house maids sink like baths &c requires to be disconnected immediately outside the house.

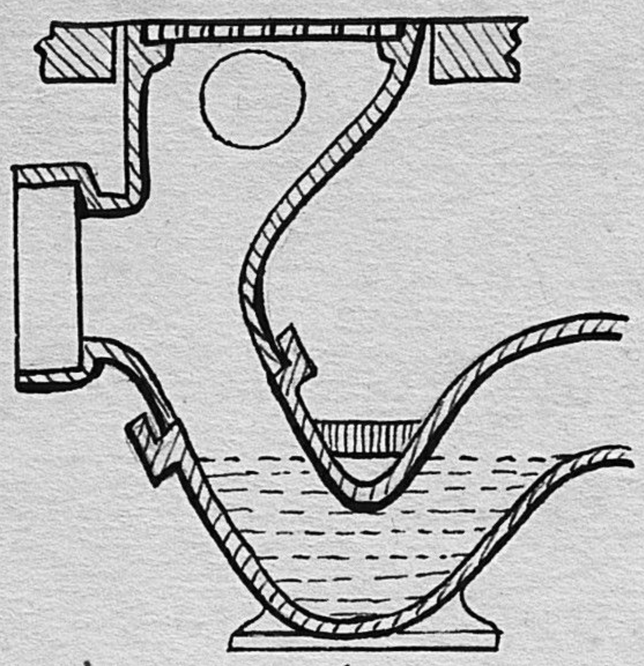

*Fig. 31.*

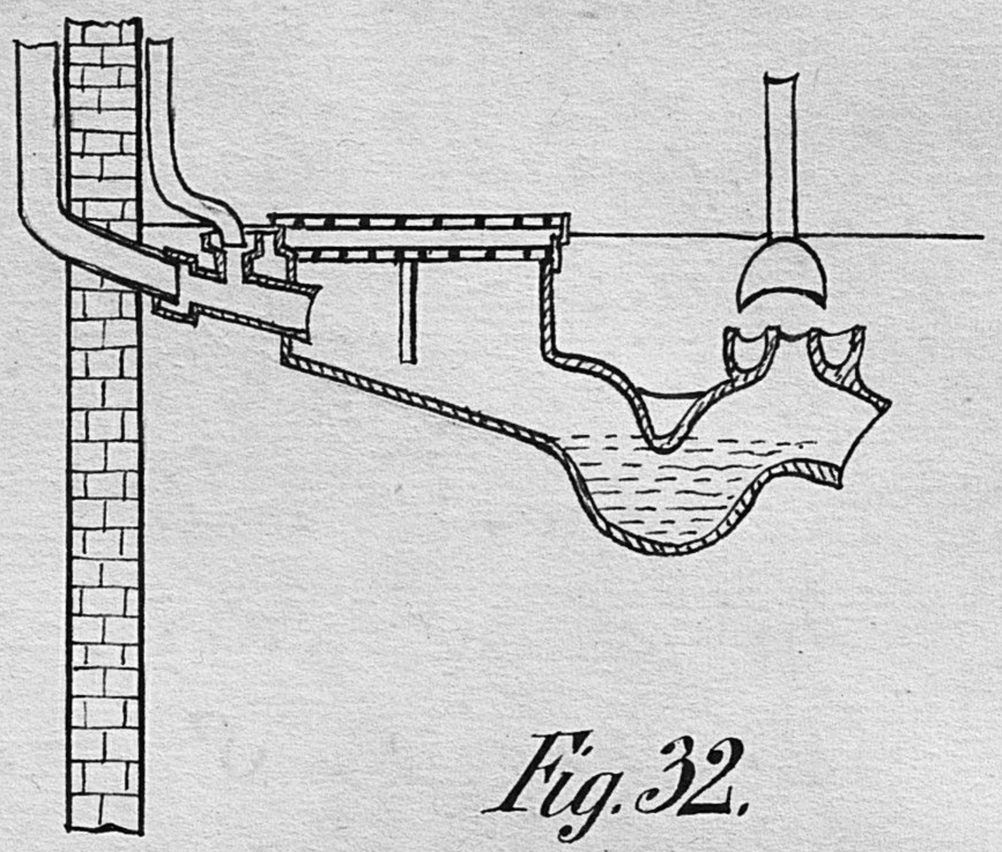

*Fig. 32.*

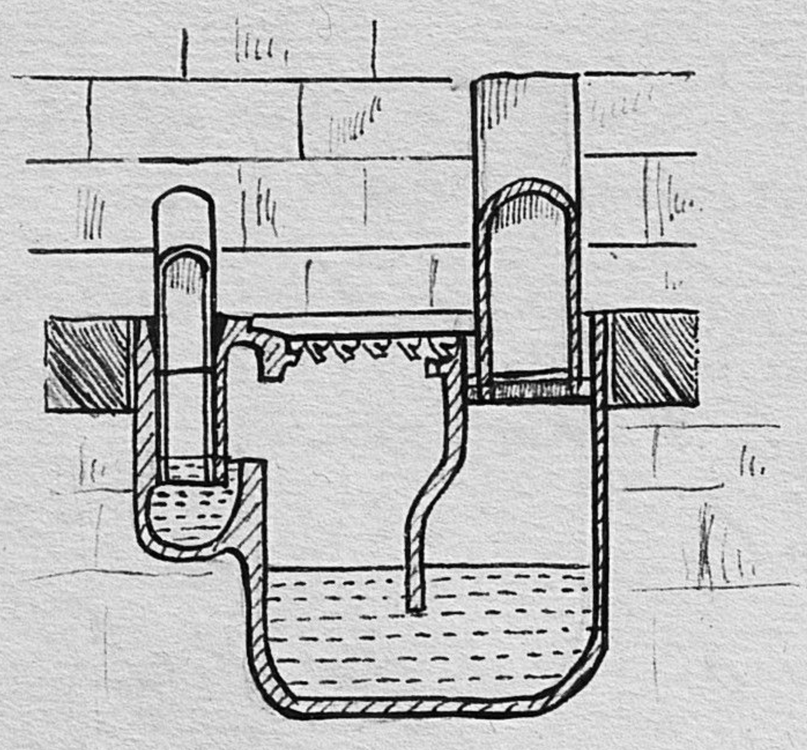

*Fig. 33.*

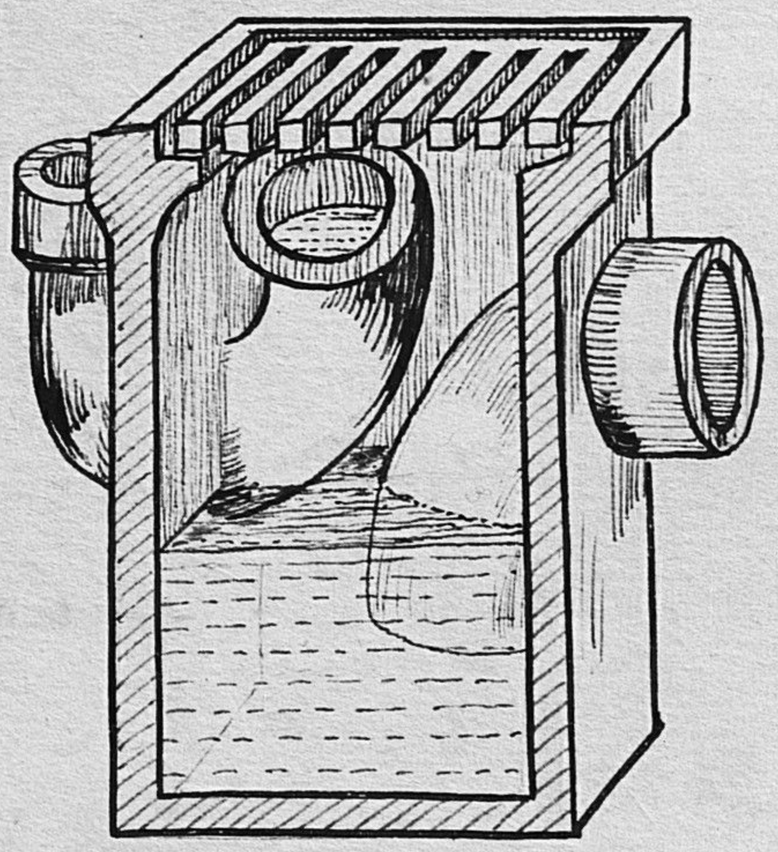

*Fig. 34.*

Having now brought away ready for the Sewer all noxious materials the question of disconnection and Ventilation arises. In the Case of badly ventilated Sewers it is often necessary to disconnect Soil pipe and everything from the drain. Should this be requisite

Fig 31 Kellaways trap is the one most usually had recourse to - Buchans trap, on the Same principle, is also used - It is Simply an "S" trap modified - a grating being placed over the top of the open trap - It should be placed at Some distance from the house -

Fig 32 Of all the inventions however at present in the Market None Equal Potts "Edinbro' traps" manufactured in Birmingham. - a Strange anachronism that Edinburgh Should claim the "D" trap Said to be the worst in creation & Potts' Said to be the best -

Its chief characteristics are that it has a long and large ventilating Chamber on the house Side of the Syphon leading to the Sewer - This Syphon can be ventilated if desired from its Crown - This trap is in Effect neither more nor less than a refinement of the Sutler Syphon used

for baths. The effluent fluid being allowed to pass over this open grated space before passing into the Sewer trap - It has also the advantage that, when placed parallel to the wall, a ventilating pipe can be carried from the crown of the trap to the top of the house.

The number of traps devised for this purpose are very numerous, Some are Single Sealed Some double Sealed

Fig 33 Mansergh's trap - the principle of which the late Professor F. Sutkin adopted - is a double Seal - In it there are two water Seals with a ventilating Space between them. Messrs Stidder, and also Messrs Stiff, of Lambeth, have both traps on the Same principle as Mansergh's, but perhaps more refined.

Single Sealed traps all act on the principle of Potts Edinburgh trap, but none of them give such pro- -minence to the air chamber - their disadvantage being that in all the water lies at the bottom of the air Chamber, whereas in Potts trap the

bottom is quite dry, and the incline
ow'd being always sufficient to
prevent putrid matters being de-
posited. In an almshouse in
Birmingham, containing 70 old
women, frequent outbursts of
diarrhoea used to take place, for
which no other cause could be ascribed
than badly ventilated drains. Each
house was properly disconnected
from the drain by a Potts' trap.
Since which time there has been
no recurrence of the disease.
Some traps have claimed for
them that they not only act well
as Sewer traps, but also as grease
traps. As grease traps ought to
be kept for their special purpose
they are not generally recommended.
Fig 34 The "Wetherley trap" as given in Mr
Bailey Dentons book is one of this
class. It is simply a glazed bore
into which the apparent pipe is
brought by an upward curve, thus
causing a water seal on the apparent
pipe. The effluent pipe dips below the Sur-
face of the water, and the intermediate
space is the grease trap.

For Surface traps, iron being the Strongest metal, is generally used in their Construction - Iron fully traps on the principle of the double Seal are much used -

Amongst the older forms is the old Edinburgh dip or leadfeather trap which is a Single Seal -

The Syphon trap with or without a Central ventilating tube is not always reliable being very difficult to clean out -

Fully traps both Singly and doubly Sealed are of very numerous designs. These are most useful outside houses & used inside Kitchens, as is sometimes done for baths, (Eg. Birmingham Eye Hospital) the water from them ought to enter another fully trap outside the house.

One of the oldest & the worst is the fig. 35 Bell trap - It has been called by Someone the Death bell trap, & Surely a better name could not be found -

If the bell cover over the mouth of the drain pipe is broken or removed (whether the Sewer in direct Communication with the house),

Two forms of traps used for wash

basins &c as some notice but are only useful or necessary when the Soil pipe is unventilated.

Fig 36. The first is the Bower trap - Around the outlet pipe from the basin is placed a cup shaped Chamber, which contains a hollow ball - This ball is kept closely applied to the mouth of the outlet by the water and forms an additional protection from Sewer gas Entry.

Fig 37 Colonel Waring's trap is on the same principle - At the distal End of a Syphon trap is a cup, with weight attached, fitting closely to the pipe - Pressure of air on the trap comes on this cup and saves the water from being forced back.

Ventilation of Soil pipes The question of the ventilation of Soil pipes has been the Subject of considerable discussion - The arrangements just described provide for circulation of air either up or down the Soil pipe - The inlet from the traps, and the top of the pipe allowing the air to either ascend or descend -

Mr D. J. Elliott in a paper published in the Sanitary record for Dec 15th 1884 Criticises this method adversely, and

with much show of reason.
He says that every time a discharge
of water passes down a pipe, the
current of air, which, in the majority
of pipes, is upwards is reversed. The
open traps, sometimes placed in close
areas, are sometimes most offensive.
His object is to do away with as
many traps as possible, and to get
the ventilation current to travel
in the direction of the water. His
method is as follows:- He places
a disconnecting trap on the drain
at its point of departure from the
premises, and carries up a pipe shaft
to the surface of the ground & securely
covers the top of it with a stone.
From the upper part of this pipe a
shaft, four inches in diameter, is
carried up close to some fire flue to
the top of the house, and an extraction
cowl is placed on the top. All the
soil pipes join the drain before they
reach this trap and the heat of
the fire flue, together with the aid of
the extraction cowl, cause a constant
downward current of fresh air, &
fresh air only, through the soil pipes.
The discharge of water down them

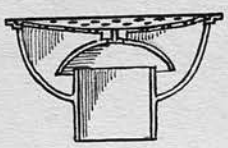

*Fig. 35.*

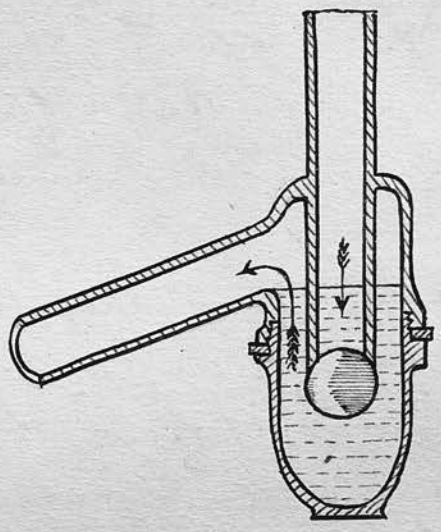

*Fig. 36.*

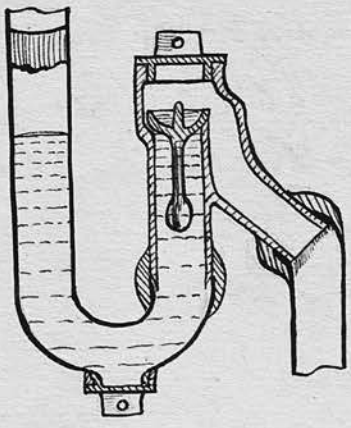

*Fig. 37.*

increases the current. This has tested fully and will ever take a more Scientific, Simple, and Effective method than with a multiplicity of protective traps.

Mr Henry Masters of Clifton Claims this method as a child of his and calls it by the name of "The double check System" Mr Buchan of Glasgow also claims the authorship of it. The principle is certainly not new. Those who claim it all show apparatus on the Same principle but differing in Style. There can be no doubt that the fewer possible ground outlets for Sewer gas in drain pipes inhouse, Consistent with proper ventilation, the better. This plan turn to whomever it may belong claims especial attention.

Main and Branch Sewers.

When King Richard Spoke of "That little pin which deaths bores through the Castle wall and - farewell King" - the wall to which he referred need only to have been a badly constructed Sewer to make his Gothic phrase no metaphor but a grim reality.

Buck Says that the conditions
necessary for Sewers are that:-
They Should not leak. They Should
have a proper fall throughout
their whole course. They Should be
properly Ventilated, Easily inspected,
and flushed. They Should be adjusted
to their work So that the any weather
flow may be Sufficient to keep
them free from Silt or deposit. &
that the workmanships Should be
unexceptionable.
The three kinds of Sewers used are
the Circular - either made of glazed
Earthenware or glazed and cemented
bricks - the Egg Shaped Sewer & the
perpendicular Sided arched roofed
Sewer.
Glazed Earthenware tubes are always
selected when a Sewer of Eighteen inches
diameter or less will Suit the purpose.
They have the advantage of being
very Smooth inside thus giving Small
resistance to the flow. The tests for
their efficiency are that they Should
resist fracture by being made of a
vitreous unperishable material
which is tenacious, hard, homo-
geneous, impervious in character

uniform in thickness, true in section and perfectly straight, uniformly glazed inside and out, free from fire and other cracks and when struck should ring clearly - (Buck)

The salt glazed pipes are the best because the process requires more thorough burning than either the lead or glass method.

In laying them the bed requires to be very carefully prepared, so that when the pipes are jointed there shall not be any unevenness in the line. New made ground is not at all safe for this purpose as it always sinks and the sewer with it. When new made ground has to be traversed, piles should be struck into the ground and a good bed of puddled clay, or better still, of concrete should be prepared. The jointings of these pipes vary very much in kind. Some are divided horizontally, and are thus made to do duty for manholes - the top part being lifted off and the rest of the sewer not interfered with should an obstruction take place.

The still most popular joint is the old form. A shoulder made on

One end of each pipe, just large enough to allow the end of the other pipe to fit into it & allow the inner surface to remain level. These joints are first touched with cement to fill up the unevenness on the inner surface. Then they are packed with tarred yarn and finished off with cement, & sometimes headed in concrete. This method has been found perfectly efficient - no tree roots - the great enemy of imperfectly jointed sewers have ever found their way into them.

Cunningham of Dunbeth has another method - The pipes are all of one piece and they are laid 6, 9, or 12 inches apart, according to their diameters, in chairs which are made to fit. The upper part called the saddle is easily removed when required - It is claimed for this method that a whole sewer can be laid at once in a prospected street and as new houses are added these saddles are placed on, with inlet joints attached, and thus a saving in expense effected.

Another form is to have the end of the pipe slightly bevelled and fitting

into a shoulder made for the purpose, having a bituminous compound attached so that cement &c is not required. This plan has been carried out by Mr Stanford. Sometimes great trouble may be caused by ground water bursting into the drains. To obviate this they are sometimes laid on blocks of hollow terra cotta, Stoneware, fire clay or other material which allows the water to drain away. The inverts of brick Egg Shaped Sewers are often made of this material. The Egg Shaped Sewer - narrow end downwards - is declared to be the best form of main Sewer, as recommended by Mr Baldwin Latham, & Mr Bailey Denton. In this the horizontal diameter should be two thirds of the vertical, the radius describing the invert being one fourth the horizontal diameter.
Circular Sewers are said to be better than the Egg Shaped ones, only when the flow of Sewage is regular in quantity. They are constructed either of bricks, bricks and cement blocks or concrete.

The object of the Egg Shaped Sewer is to obtain the maximum velocity, with the minimum of resistance, and as a consequence a greater cleansing power.

The question of the proper Size for Sewers is one of great difficulty owing to the almost necessary addition of Storm water to the regular flow. This varying condition of the quantity of Sewage renders the adoption of the Egg Shaped Sewer more general. If too large and with too little face they become Sewers of deposit. The velocity of flow to prevent this has been variously estimated. Mr Bailey Denton Says 150 feet per minute. Baldwin Latham Nine less than 120 + almost always more. In pipes 6 or 9 inches in diameter, never less than 3 feet per second, and in larger diameter Sewers never less than 2 feet per second. To provide for this Smaller Sewers require a greater face than large ones. Special tables are prepared in various Sanitary Engineering works for guidance as to the laying of pipes to produce

Certain velocities.
The pipes should always be straight from manhole to manhole, but when curves cannot be avoided there should be an extra fall to counteract friction. Where two sewers meet there ought always to be a manhole, & the junction ought to be oblique. Various methods have been devised for flushing sewers, but none act so well as those on Field's principle. The tip up flush tanks are sometimes used also. Half tides have been used to dam up sewers and, by increasing the quantity passing at a given moment, to increase the flushing power; but they are not recommended. As regards the ventilation of sewers, Baldwin Latham lays down the rules which ought to be observed in the choice of a method.

1 The system should be simple and independent of mechanical aid.
2 It should admit of the expulsion of all sewer air and the supply of fresh air at all periods.
3 Escaping gases should be so

diluted with fresh air as to be harmless, or be arrested, or destroyed.
4 That it shall not impede natural ventilation.-
The temperature of the air in Sewers is subject to great variations owing to the admixt of hot water and steam which is emitted into them. The air in the Sewer is generally warmer than the air out of it. If not well ventilated then the pressure on house traps &c is simply much more than they are able to stand, and without good ventilation to the Sewers our house traps avail us nothing- The variations in the quantity of Sewage, wind, barometric pressure, all affect the pressure of the Sewer air.-
Amongst the most popular method now in vogue are ventilating manholes, ventilating pipes, either carried up the side of houses or through lamp posts- The ventilating places require to be closer together in low lying districts of towns, than in higher- The largest distance allowable between two being 200 yards, or about 8 to the mile.

Mr Baldwin Latham's Spiral Charcoal traps are Sometimes used inserted into Special manholes for the disinfection of Sewage gas before it reaches the Surface. They are only beneficial when kept perfectly dry and when they do not interfere with the air current. Mr Rawlinson has also used this method, he having two chambers for the manhole - the one, containing flat charcoal trays, being covered - the other with a grating over it being the air chamber. Sometimes lightly balanced hanging valves are placed over the mouths of the afferent pipes in the manhole to prevent Sewer air from rising to higher levels and thus compelling its discharge through the grating.

# The Chemistry of Sewage and its Disposal.

Before considering the various methods for the disposal of Sewage its chemistry demands attention.

The method described of combined carriage, namely the Sewers containing both excreta and storm water, being that adopted in most towns.

Chemical investigation shows that, whether Sewage contains or does not the washings of roads &c, it does not make any marked difference in its composition, or in its tendency to putrescence.

Taking one gallon of average Sewage it is found to contain 89·81 grams of Solids, 27·72 of which are organic and 62·09 mineral (Buck)

Mixed excrement in a fresh state is acid in its reaction, but within twenty four hours it becomes alkaline from the formation of Ammonia. The fact of its admixture makes decomposition more rapid - The gases which are held in suspension and given off are Carburetted hydrogen, Nitrogen, Carbonic acid & Sulphuretted hydrogen.

The quantitative analysis given

by the Rivers Pollution Commissioners report on the Mersey and Ribble basins (1870) for the Sewage of Matter closet towns. was as follows:-

Solids in Solution 72·2 per 100,000 parts
Organic Carbon 4·696
Organic Nitrogen 2·205
Ammonia 6·703
Nitrogen as Nitrates ·003
Total Combined Nitrogen 7·728
Chlorine 10·66

Suspended Matters { Mineral 24·18 / Organic 20·57 / Total 44·69

Faeces contains besides water and special excrementitious constituents, such as Excretin and Stercorin, Phosphates of Magnesium and Calcium with small quantities of iron, Soda, Lime and Silica; also the insoluble residues of food, Mucous, Epithelium, bile and other derivatives.

Urine contains, according to Parkes, besides water,- urea, uric acid & other organic acid, Sulphuric acid, phosphoric acid, Chlorides of potassium

Sodium and Ammonium, and free Chlorine, Lime, and Magnesia, and Extractives.
These are nothing like the number of materials contained in Sewage.
The presence of fats &c from Kitchen washings, dirt from the Streets.
Fluid refuse from Manufactories, go to add to the multitude and give a Chemical composition of which an average Estimate is Sewage alone.
Here then we have a material Cast upon the Earth. By act of Parliament it cannot be passed unpurified into the rivers, and the most general way of dealing with it is, either to prepare it chemically, or to pour it onto land, which acts as a filter and the drained water from which is fit for discharge into the rivers.
What are the Chemical Conditions of plant life which allow them to feed upon this material?
Taking a grain of wheat as a type of all Graminants, the first process through which it must go before it can grow at all is a combination

with the Elements of water, and a transformation into grape Sugar of its Starchy compounds. The Essential Conditions for this are the presence of Moisture and a certain temperature. The Seed absorbs oxygen and gives off Carbonic acid, the Carbon being contained in the vegetable fluids of the Seed. The Soluble diastase and grape Sugar give to the Sprouting germ a vehicle through which it can absorb the necessary Constituents of its fuller growth.

To Sustain this. Carbon, hydrogen, nitrogen, oxygen, Sulphur, Phosphorus, Chlorine, Silicon, Potassium, Sodium, Calcium, Magnesium, iron, and manganese are required. Various of these exist in plants Singly, others in Combination, Such as Chloride of Potassium, & Sodium, Sulphate of lime, Silicates of potash & Soda, Phosphates of iron, lime, magnesia, & ammonia, & compound of Some of these with vegetable acids.

Plants can absorb either through their leaves. gaseous materials; or by their roots - matters in Solution.

Carbon is taken up as Carbonic acid. Hydrogen from water & ammonia,

and from the nitrification of nitrates by processes going on in the Soil itself, namely the Conversion of Substances into nitrates. These processes have been investigated by Mr R. Warrington of Rothamsted. The result of his Experiments is to show that when Sewage is passed through land the Conversion of the organic dust into nitrates takes place by the action of a living ferment of the Bacteria family which is created by, and feeds on, the impurities of Sewage and these organisms both Consume the impurities and convert them into nitrates - The organic matter of Sewage is thus oxidized by living agents just as worms, larvae fungi & insects feed on the vegetable matters in the Soil, increasing the amount of nitrogenous matter in it. The addition of Chemicals to Sewage is said to stop this process -
Sulphates and phosphates are chiefly derived from the Soil -
As Examples of these Chemical processes we find the ashes of peat turf, Coal &c living mineral matters.
Sulphate of Lime, & Magnesia are

useful not only because of their own constituents but because they decompose carbonate of ammonia created by putrifaction, and which is volatile, fixe it in the soil as a Sulphate.

Bone ash gives phosphate, Carbonic acid and ammonia.

Urine and fæces give their constituents which, as has been seen, contain all the necessary fertilizing ingredients.

The Chemical tendency of vegetable growth is to reduce to a lower State of oxidation the substances presented to their food — whilst animals exhibit a reciprocal tendency to oxidise the materials on which they feed.

These being the conditions under which Sewage is useful, the consideration of the various methods of disposal claim our next attention.

Before doing so it may be well to review the results of Frankland's experiments on Sewer gases.

He has shown that moderate agitation of Sewage does not make it fæter off gases with morbific germs when in a

fresh State, but if putrifaction sets in, and bubbles of gas rise to the Surface of Stagnant Sewage, these are the causes of the Spread of disease. The main object then is to treat the Sewage in as fresh a State as possible.

The methods of disposal of water carried Sewage are legion -

That by transmission to the Sea may be passed over with the Statement that the pipe must be taken out to low water and that some method, such as ball Stoppered valves, be used in the pipes to prevent regurgitation.

Disposal into rivers is now illegal in England, except under certain Conditions, Such as prevail at Manchester, Liverpool & London - that is - the authorities have the temporary power to discharge it into the river until they can devise Some Economic process for its previous purification

The two methods for inland towns now prevalent are the Chemical, and what might be called the Natural, namely irrigation & filtration.

devices ?

chemical methods.

The Chemical devices comprise methods of precipitation and the conversion of Sewage into various useful materials.

In the precipitation methods Lime has been used from the first & Seems to hold its own with all other reagents even now.

When the Lime process is adopted, the Sewage is collected in tanks, and mixed with lime in certain proportions. The usual amount is from 10 to 13 grains of lime to one Gallon of Sewage. The addition of lime renders Sewage alkaline, forming lime carbonate, which, being insoluble, falls to the bottom, carrying with it matter in Suspension, and part of those in Solution. This is Said to reduce the amount of organic carbon in Sewage very considerably. The fluid obtained by this method is fairly clear, and can be Strained off. It is generally disposed of by filtration through Some Suitable ground and then passed into the nearest Stream. The objections to it

are, that the drying of the Sludge is very offensive and the water itself, if it Stands, Soon becomes putrid and malodorous. The Rivers Pollution Commission declared this method of treatment is without the additional filtration – a failure; the product-ed Sludge being of very Small value as a manure.

Alumina has been, and is used, as a precipitant, but it forms insoluble compounds with organic matters, and its use is very expensive.

By this process consists in the addition of phosphate of magnesia, in combination with other precipitants, The object was to get a Soluble ammonio-phosphate of magnesia, but its results are entirely negative.

The A.B.C. or Dillons process for a long time was held in high repute. It consists in the addition of alumina Blood & Clay – Alumina two parts, Clay 1900 parts, Magnesia 5 parts, Permanganate of potash 10 parts, Animal Charcoal 15 parts, Vegetable Charcoal 20 parts, and magnesian lime

Stone 2 parts, "(Buck?) The quantity of this mixture used is usually 4 pounds to 1000 gallons of sewage - After the settling has taken place the water is said to be clear, but to contain 9·17 grains of dissolved organic matter per gallon.

Dr Folsom, before the Rivers Pollution Commission, says that it is not of the slightest service in purifying sewage. Holden uses Sulphate of iron, lime, Coal dust, & clay. The iron acts as a powerful precipitant - the precipitate containing about 43 per cent of organic matter. This method was tried at Bradford and failed - It was found that the organic putrescible matter in solution was really increased by treatment and the solid in solution also increased. The effluent water was rendered so hard as to be useless for any purpose whatever -

Anderson's process consists in the addition of Sulphate of Alumina made by adding Sulphuric acid to clay in the proportion of 1 to 2 - One pound of this added to 100 gallons

of Sewage and then agitated. After which ¼ lb of lime is added - Precipitation is said to be very well effected by this method, and the supernatant liquid is the clearest yet produced -

Iron Perchloride has been much praised, and was introduced by Messrs Hoffman and Frankland in 1859 - In the Second report of the Commission of Enquiry into the distribution of Sewage for profitable uses in 1861, iron Perchloride as a precipitant was Carefully Ex- -amined - It throws down an abundant precipitate, composed of the Peroxide of iron, precipitated by the Alkalinities of the Carbonate of ammonia, and other Similar Compounds in the Sewage - This deposit Contains all the Suspended matter in the Sewage, also much phosphoric acid, and the Sulphuretted hydrogen - which great advantage is Claimed for it over the lime process. It exists as Sulphuret of iron, and as Such is not So offensive in the Sludge, which is used afterwards as manure.

The Phosphate process consists in the addition of phosphate of Alumina brought from St Domingo, and costing about £3-10- per ton. It is claimed for this material that it is a good precipitant, and adds to the value of the resulting manure - The water is filtered off after Subsidence, and the deposit placed in Shallow pans, air dried, & made into bricks - Chemical analysis of this Method Showed that the raw Sewage contained 73·64 grains of Solids per Gallon and the Effluent contained 63·45 grains -

The organic nitrogen in the raw Sewage was 1·60 grains of which ·96 was in Solution - The Effluent had Simply ·47 in Solution Equal to 1·94 grains of ammonia in raw Sewage and ·57 in the Effluent. Saline ammonia in raw Sewage was 2·66 grains, & in the Effluent 3·32 grs. The total Nitrogen calculated as Ammonia was 4·60 grains per gallon in raw Sewage and 3·89 in the Effluent. Therefore this Method, according to Professor Voelcker, deprives Sewage

of by far the greater proportion of its nitrogenous organic matter. The chief recommendation of this process is that it is inodorous - The effluent fluid containing, as it does, so much matter in solution, is not fit to be passed into streams and requires to be filtered through land. Mr Marshall says this process is profitable the cost of production being £3 per ton & the sale price £4.
In general Scotts process there is a departure from the general rule of methods - Lime & clay are introduced into the sewers some distance from the outlet. The sludge is collected in tanks dried burnt pulverised & used as cement - This method has been tried at Ealing -
Not one of the processes above enumerated enable us to obtain from the sewage all its fertilising ingredients, and leave a good and pure effluent water - At the best chemical methods can only be looked upon as a help to disposal where land is difficult to obtain -

The Parliamentary Committee of Inquiry into the best Method of disposal of the Sewage for a future population of 350,000 in the Thames Valley Sine as a positive opinion that even with the best Chemical methods at hand for preparing Sewage a land filtration area, however small, should be provided for the further purification of the effluent- As regard the number of other Chemical methods they might be referred to indefinitely. In France and Germany the precipitating process has been given up as inefficient and in England a new "Successful" patent process is hawked about every few months, soon to be found as only an addition to the number of failures.

At the Birmingham Sewage Works at Saltley the Contributions of a population roughly estimated at 350,000 have to be disposed of. There is a tank capacity of 300.000 gallons and the dry weather flow is 13.000.000 gallons per day, which is much increased in wet weather.

Milk of lime is added to the Sewage

before it reaches the tanks, the amount of lime used being about 14 or 15 tons of lime daily, which is about Equal to one ton per 1,000,000 Gallons of Sewage treated. The Sewage when Partially Clarified is transmitted to the land, of which on the Sewage farm there is a total area of 1,209 acres. The Sludge intercepted in the tanks, Estimated at 582 Cubic Yards, and Containing about 90 per cent of water, is raised by Steam to an altitude, by means of dredging buckets from which it gravitates in raised conduits (movable) to beds dug for its reception. These beds are made about 8 Yards Square and 18 inches deep - After this Sludge has remained for about a week to allow the water to drain from it it is dug into the Soil, and 5½ acres per annum are required for this purpose alone - It is calculated that one Yard of Earth can take one ton of Sludge every three Years - This Quantity of Sludge being produced by 1000 persons - Altho this high proportion exists in Burmingham in

other places it is found to leas low as one ton to 4 or 5 000 persons. Here the Chemical treatment is limited to the interception of the Suspended matters, with the aid of lime, which helps precipitation, and also the neutralization of the acids in the Sewage, and the Superjacent liquid, full of dissolved impurities, passes on to land for its further purification. In the Aldershot district, under the guidance of Mr Ed. Pritchard C.E. & further Chemical treatment is had recourse to - The Sewage is first strained and the Solids removed - It is then mixed with milk of lime and stirred well up with baffle machinery - the proportion of lime to the gallon being about 5 grains. The Sewage then passes on to another tank where Sulphate of alumina is added in about the same proportion - After agitation the Sewage is passed on to the Settling tanks where, as soon as one is full another is started - The Sewage being held in a State of rest soon precipitates, the

Alumina Completing the Chemical process described at the Commencement of this part of the Subject under line as a Precipitant.
By means of floating valves, which are so arranged as only to allow clear top water to flow off, the top water is taken to the filtration area of land before Complete Subsidence has taken place.
Messrs Johnstone & Company's Compensating Sludge filter presses are used, which reduce the amount of water in the Sludge from 90 per Cent to about 45 per Cent. This Press Consists of a number of narrow cells constructed of cast iron held in a frame. Their interior Surfaces are provided with drainage grooves, covered by a filter medium, permitting moisture to pass through.
When the Sludge has Settled in the Tanks, it passes into a deep well, from whence it is forced by atmospheric pressure into a vacuum chamber, and thence, by various ingenious Contrivances, which provide that

when this Chamber is full the Supply Stops, and a valve opens which allows it to pass into the press. When the press is full a powerful wheel Screw brings about the removal of water by pressure, thus reducing the bulk of the Sludge from 5 to 1. After it is pressed it is removed in Solid blocks which Sell for a moderate Sum. The total Cost of preparation is Estimated at 2/6 per ton of dry cake or 6° per ton of wet Sludge. As regards the Constant burying of Sludge in land it is Said by Some that it clogs it. Dr Pritchard to Combat this Says that he had to make an outfall Sewer Some 60 or 12 feet deep through land that had received three dressings of Sludge in 9 years, Each dressing being from 16 to 18 inches deep, and he Scarcely found any traces of its existence.

These Methods just described partially are called the Combined Methods whether the Chemical does so much, and the Natural or filtration Now to be described Do as the rest.

Irrigation & filtration

The Natural process may be divided into Downs and Filtration, Irrigation and Subirrigation.

Down and filtration of Sewage was first brought into prominence by Dr Dankland and also by Mr Bailey Denton.

It Simply Consists of the passage to Lands of the Sewage previously Strained - which filters down to drains, at least Six feet deep, and in its passage it parts with its Suspended matter by the mechanical action of the Earth and by the Spreading of it over a great Surface, it is rendered freely accessible to the oxidising influence of the atmospheric air. Nitrification is thus brought about.

The Chemical interchanges have been carefully examined by Liebig in "The Laws of Husbandry" by Warrington and others.

The Chemical Constituents of the Earth play a most important part in this matter.

Parkes Says "The Hydrated Ferric oxide and Alumina absorb phosphoric

acid from its salts, forming a highly basic compound of the acid and metallic oxide. The hydrated double silicates absorb bases. Silicates of aluminium and calcium absorb ammonia & potassium from all the salts of these bases and a new hydrated double silicate is formed in which calcium is more or less perfectly replaced by potassium or ammonium. The absorption of the two latter is usually attended by the separation of lime which takes the form of carbonate"

Frankland after numerous experiments found that the sewage from 3,300 persons might be cleansed by filtration through one acre of land suitably drained. Bailey Denton intermitted the flow, and used three acres for the same population with the result of allowing the land more intermittent time for oxidation between each supply.

The plan has been objected to for the following reasons:-

The manurial ingredients are wasted

The greater portion of the Soluble
mineral Salts, with the products
of oxidation of nitrogenous Constituents
of fæces and urine, cannot be re-
- moved by filtration through any
amount of land, and the effluent
water is not fit for use blended
with other pure water - This latter
objection is given against it by
Professor Voelcker. As against this
may be placed Liebigs unqualified
praise in his letter published in
Bailey Dentons work page 34, where
he says that the collected water was
perfectly pure and could be used
over again -

In carrying out this method
practically Several things are now
done which did not prevail when
the System was first introduced -
Mr Bailey Dentons new method of
Collection at the outfall has first a
Sluice Chamber - Small in proportion
to the rest of the tanks - From this
there goes a pipe away from the
ground used for filtration to allow
Storm water when in excess to
pass into the river.

After the Sewage passes through this Chamber, it Comes into the Screening Chamber - one for each tank - where the Solids are retained It then passes into the Settle tanks. These are constructed so as to hold a certain quantity of Sewage. They are very deep, so as to give as small a surface as possible for Effluvia to rise from.

Into each of these tanks a Field Syphon or Some other Similar apparatus is fixed so that the Con- -tents of the tank Can be discharged very rapidly over a given area - the object of the rapidity of the discharge being the even dis- -tribution of the Sewage over the land -

The land itself requires to be drained deeply to 5 or 6 feet or more - laid out in terraces and the surface ridged the Conduits for the Sewage running along the tops of the ridges and the Sewage running down the Slopes from them - Plants may be grown on the ridges. Two thirds of the time is generally given for rest & recreation.

Irrigation.

Edinburgh is quoted as the earliest example of a town whose Sewage was dealt with by this method As early as 1561 there was a Sewage farm near Edinburgh and the Craigentinny meadows have been used for this purpose since 1760. At Norwood and Croyden and many other places the same method prevails and to show how fully this method meets the case as regards land - The lowes Craigentinny Estate was originally a barren Sea Shore - Now it yields enormous profits - 1yr grass fetching from £25 to £40 pr acre each yr. At Norwood the land is clayey and at Croyden open soil, with gravelly subsoil, & with good slope. Mr Baldwin Latham planned the works. Croyden, and part of upper Norwood, drain to the Beddington irrigation farm and there the works are so profitable, as to have yielded £18 pr acre, whilst at Norwood £27 per acre is given as the yield in 1892 - The cost of the Norwood

works on 33 acres was £2500
and Beddington which is worked
by a company which paid in
1872 £1894 for rent and Sewage
to the local authorities, whilst the
gross receipts for the land with
£4818 or Equal to £18 per acre
there being 400 acres under
irrigation. The gross outlay on the
farm was £4209 thus giving
a profit of over £600 per annum.
of this method the Royal Commission
of 1865 said "This is the right way
to dispose of Sewage and the only
way by which Pollution of rivers
can be avoided -
The method Simply consists in
bringing the Sewage under the
influence of growing crops - At
Carlisle and other places Carbolic
acid was added for the prevention
of putrifaction. The loss of
ammonia by putrifaction damages
very Seriously the fertilising pro-
-perties of the Sewage - Further the
temperature of Sewage is always
higher than that of running water
So that growth takes place even in

winter - On most farms the Sewage before passing onto the land is previously Strained, and the most recent Strainer is that of Mr Rogers Field. The advantages Claimed for it are that it is not a receiving tank but Simply a Strainer - the bottom being on a level with the drain - The bottom is an inverted arch into which are placed two Series of iron rods Short distances apart which act as Strainers. The Solids Can be Easily raked out, and mixed with Earth and dug into the ground - This arrangement is far better than any tank wher Settling Can take place because putrifaction takes place very rapidly in them. Much has been written about the Kind of land to which Sewage Should be applied - Should the natural Conditions be Such as to give a good Slope on freely porous land of Sufficient extent then no par- -ticular drainage need be required; but this is not always So, and one of the Chief objections to this Method is:-

If it is necessary to drain many farms under only Climatic Con-
-ditions, Surely it must be more needful to drain it well when a great increase of water comes on to it. Flat lands & Stiff clay lands re-
-quire very careful draining.
Clay land used to be prescribed for this purpose but Professor Henry Robinson says that when clay land has been properly treated it answers the purpose very well. The process he advocates is digging out the clay to a depth of Six feet - burning it into ballast, and replacing it with alternate layers of alluvial soil and giving a well drained outlet for the effluent - By this method he claims to raise the purifying power of clay land from one acre to 100 people, up to one acre for 1500 people - He fixes the cost of such preparation as from £700 to £1000 per acre.
On ordinary porous soil well drained he says one acre takes Sewage off from 600 to 700 people - Even if clay land

Can be made towork in the way above mentioned the cost is very large, and clay therefore can only be had recourse to under dire necessity.

Parkes Says the best kind of land is a loose marl containing Hydrated iron oxide and alumina, but Sand and Chalk give good results. One Cubic Yard for Eight Gallons of Sewage every twenty four hours being the least that can do its work well.

On well conducted farms the land is always improved in productive quality by Sewage application.

In experiments on the Rugby Sewage reported on by the Royal Commission of 1861 are contained the results both as regards the land and crops on Sewage farms.

It was found that by the application of large quantities of Sewage to meadow land during Spring and Summer, the Grass crop was in-creased by four tons of green Grass (Equal to three quarters of a ton of hay)

for each 1000 tons of Sewage applied, until the amount approached 9 000 tons per acre per annum - The largest produce being 33 tons Green Grass per acre per annum - the Grass being available for five and Six months.

(2) Oxen tied up and fed on grass alone gave a lower rate of increase than animals fed on good fattening food, but when the grass fed oxen had a few weeks of oil Cake given in addition a good average was attained

(3) Milk to the gross value of £32 per acre was obtained where the largest quantity of Sewage was applied - the Sewaged Grass giving a slight increase of milk Supply over unSewaged.

(4) Rugby Sewage Composition varied very much, giving an average over Seven months of 21½ cubs. of Solids to 1000 tons of liquid - about 212 pounds of Ammonia.

(5) Sewaged Grass contained, as cut, a smaller proportion of dry and Solid Substances than unsewaged, but they were more highly nitrogenous in Quality

In the third report 1865 it is stated that Sewage should be applied all the year round.

Taking an average over three years in two fields - one Sewaged the other not - In the former with 3000, 6000, and 9000 tons of Sewage per acre per annum, gave respectively 22¼, 30¼, & 32¼ tons of green grass. The latter or unSewaged field gave an average of 9½ tons green grass. The amount of increase per acre was the greater the greater the amount of Sewage applied upto 9000 tons per acre, but the increase of produce obtained for a given amount of Sewage was the less when the greater amount was applied.

The greatest returns were obtained from milking cows rather than from fattening ones.

The milk producing quality of Rye grass varies much with the season, being inferior in wet and cold seasons.

By the aid of Sewage the time an acre would keep a cow, and the amount of milk yielded from the produce of an acre, were increased between 3 & 4 fold.

These were the conclusions arrived at upstill 1865 - Now all manner of vegetables including mangolds, which flourish luxuriously on Sewage, onions, Cabbages, Broccoli, Celery, potatoes, parsnips, turnips, Beetroot &c. are grown - It has been also used for the growth of cereals, & when applied in winter to the ground intended for this purpose the result has been Satisfactory. From this it must be concluded that porous Soil however poor in quality with a good slope and a free effluent is the best for the purpose.

That land is directly benefitted by Sewage - It is best to Strain the Solids because when left on the land they putrify and lose in ammonia - the loss of ammonia is the first twenty four hours being very Slight in Sewage, but when left for three or four days it reaches 13 per cent.

The money results in produce if not directly profitable gradually may to pay the cost -

Any kind of land can be prepared for the purpose.

Sewage can be dealt with by this Method in much larger quantity and at

less Cost than by any of the other methods.

The Effluent, according to the Rivers Pollution Commissioners report, of the Croydon Sewage after it entered the river Wandle near Mitcham was purer than the Thames above Reading.

The influence of Sewage farms on the health of the population round them from all experience is not prejudicial. Around the Birmingham farm within half a mile there are over 3000 inhabited houses and no complaints are ever registered of nuisance.

Folsom who describes the Edinburgh Sewage Meadow as a most filthy and offensive plot of ground, says that no cases of Enteric fever have been traced to the effluvia from the irrigated meadow.

Dr Cobbold at one time thought that Sewage farms would increase Enbozoic diseases amongst Cattle but last experience induced him to withdraw his theory -

Another method yet remains namely Subirrigation as advocated by Mr Roger Field -

It consists in the placing of pipes from

the outlet, where a Field flush tank may, or may not, be placed, nine inches or so below the ground with Spaces between them to allow the Sewage to Soak into the ground. These pipes are laid on half pipes - Split longitudinally - Socks to form a bed.

The originator of this method only Claims for it that it is to be very much preferred to Cesspools, and can be used in Country houses where irrigation cannot be resorted to.

The pipes are liable to become choked by Sand and Grease &c but this can be easily remedied by taking up one pipe and clearing the way with a rod. This method is largely used in America for Warning of Newport U.S.A. has used it for a Village of 1500 inhabitants & with Success.

Another objection to the method from an Economic point of view is that it feeds plants by the upward rising of moisture accompanied with all the Chilling influences which are injurious to Vegetation as well as to human beings.

As regards the comparison of results obtained by different processes, it may be said that no chemical method short of distillation will remove the impurities from the Sewage - The Natural Method must always be adopted, and the only good of Chemical treatment has been shown to be; when sufficient land is not available, it assists in removing impurities but very largely hinders and prevents the transformation of Sewage into plant life.

The Method now carried on in Birmingham, namely treatment first with lime & then Subsidence being allowed to take place. The effluent passing onto the Sewage farm, is practically the Method which has been recommended by the Royal Commission on Metropolitan Sewage Discharge 1884.

The Average results of these Methods is as follows.

| Processes | Percentage of dissolved organic pollution removed | | Percentage of Suspended organic impurity removed |
|---|---|---|---|
| | Organic Carbon | O. Nitrogen | |
| Chemical processes | 28·4 | 36·6 | 89·8 |
| Upward Filtration | 76·3 | 43·7 | 100·0 |
| Downward ... | 72·8 | 87·6 | 100·0 |
| Irrigation | 68·6 | 81·7 | 94·4 |

From this it will be seen that as far as removing impurities Filtration has the highest Standard but small farms laid out for dealing with Sewage now, Downward intermittent filtration Combined with irrigation is the Method Employed.

Therfor given a Sufficient Surface of land, of proper Quality, Sewage Can be purified, and the Effluent from the drains turned Safely into Rivers without any danger whatever of River Pollution.

## The dry method.

What may be described as the dry method has in certain Essentials been handed down from all time - As Seen in the historical Sketch it was a part of the duty of the Jewish communities to dispose of their Excreta by digging it into the Earth - No doubt the occurrence of the principle of admixture with Earth in Biblical literature, Started in the mind of the Rev Dr Moule the idea of again taking to it as a Sanitary measure, altogether and apart from a religious observance; in the Same way as Dr Shield in later years revived the idea of pouring oil on the troubled waters - first experimented on at Aberdeen - adopting Biblical language in its literal Significance. Taking circumstances as we find them it cannot be denied that there are many large properties inhabited by the poor where water closet arrangements would be utterly inapplicable - The rent obtained is insufficient to allow of the Erection of proper Sanitary closets for their Supply. Two ways then are only open to the proprietors for dealing with the difficulty

Either to have recourse to the old midden heaps, or to adopt some method of removal at regular and stated intervals, with or without the admixture of earth or other disinfectant.
The old privy with its deep ex-
-cavation behind, lined with bricks, and containing the excreta, ashes, garbage, broken ware - the collection of perhaps many months - uncovered and augmented in its dangers by the rainfall, has been in times past a fertile source of typhoid & other poisons - These midden heaps often not being drained at all, or if so, the drainage being most defective. In Birmingham in 1871 there were over 20.000 of these, and the soakage of their contents into the ground, & thence into the Sunk wells, is ample justification for the condemnation of this town as a most unhealthy centre. These conservancy method were had recourse to not from a consideration of Sanitary requirements but from necessity

One of the first Sanitary dry methods is that of the Revd Mr Moule, and which

is at present used at Ewing. In this town 150 of Moules patent Closets are used - Special drying apparatus is provided for the preparation of the Earth, or Chalk detritus, which is sometimes used as a Substitute.
Carts go round once a week delivering dry Earth and collecting Soil. The Soil after being dried is fit for use a second time and when it is fully charged with fæces and urine, it is removed to the fields & woods around the Rothschild Establishment and used as manure.
Lord Rosebery, on his Mentmore Estate, has adopted the same method and it works admirably.
The value of the material is valued variously. Some say it is worth £2 or £3 per ton. Professor Corfield says it is only worth the value of good alluvial soil, whatever that may be.
Although this method works well in the Country it is not available for large towns owing to the great amount of Earth requiring to be used.
The House System consists in the use of closets with small cylinders inside them, the interspaces being stuffed with

Straw, or other waste material, and treated with some disinfectant. This method is used in manufacturing districts in Lancashire & also at Aldershot.

The Eureka System, which was tried at Hyde near Manchester, consisted of a similar arrangement - Boxes containing a small amount of deodorising mixture were placed at the back of the privy. These when full were covered with an air tight lid and replaced by empty ones.

The full boxes were taken to the manufactory, where the rags &c were sorted out and sold to rag merchants. Disinfectants were added and distillation was had recourse to - the distillate being sold to bleaches and dyers - The thickened residue was mixed with coal ashes, powdered up, and sold as a manure - It was found that this manure on analysis contained only 2 percent of ammonia. The process of manufacture was a nuisance and it was abandoned as not repaying the Cost.

The dry Earth System of Mr Morris

is the only one of the older methods which has held in favour, and the only advances made with it have been in the machinery rather than in the method itself.

There are several patented dry closets which are much patronised.

Some of these receive urine and faeces together, others separate them.

Those are most sanitary which, instead of having a pit or ground receptacle, contain a pail which only holds a limited quantity.

Mr Gibson of Clapham has a "Separate" closet which keeps the urine separate from faeces. The urine passes down a special pipe for the purpose. The separation cannot be called satisfactory, as the smell from decomposing urine in the pipes is very obnoxious.

The delivery of the earth onto the pail contents is the subject of various patents. The majority of these consist of reservoirs placed behind & above the closets, with automatic spring or handle delivery boxes at the bottom. Each time the closet is used, by the action either of the lid or a special handle a certain quantity

of earth is delivered into the pail
Messrs King. Victoria Rank. London.
Dr Bond of Gloucester, & Moser of
Southhampton, have all Special
arrangements of this Kind - that of
Moser finding favour by Dr Carpenter
of Croydon - The former work by
arrangements of Springs - The latter
by a pair of bellows attached by a
Lever to the Seat - the inflation of the
bellows providing a puff of air to
throw out a certain quantity of the
dry material -
Various others are in the market.
Morells patent cinder Sifting arrange-
-ment, which is Simply a Screen for
Sifting the Cinders, allows the dry
dust to fall into the hose -
In the Sanitary record for June 15th
1885 a Russian modification is given,
patented by Dr K. Proussack -
It is Simply a flap acted on by
a Spring - This flap, when the
closet is being used, fits to the
aperture and prevents the ingress of
draughts & foul air -
Various materials are used instead
of dry Earth as disinfectants -
Ashes, Charcoal, Sawdust, Spent dye

wood &c mixed up dry in various ways to suit local industries.
The Sewage Committee of the British Association found that ordinary field soil gained only about .015 per cent in nitrogen when the soil was used.
The only advantage that can be claimed for the method is that it is satisfactorily sanitary, and very useful when water carriage cannot be obtained.
For the thorough carrying out of this method Parkes says:- The earth must be dry. It must contain clay, organic matter, or iron oxide to be sufficiently powdery to give enough absorbing power. Sufficient earth well sifted of stones must be used. If the earth be used a second time fermentation must have ceased and the moisture be evaporated No extraneous water such as slops must be poured over it.
As regards charcoal as a deodoriser, it is claimed by Stanford that a very small amount of the material suffices. It can be obtained from burning seaweed at little expense

After impregnation it can be reburnished in a retort and used over again - The distillate, containing Ammonia liquor, Tar acetate, tar & Gas, this being Sufficient when Sold to give a Small profit -

Fryer's method is one which has Commanded Considerable attention and was tried at Manchester & Leeds. The house dustbin refuse is burned, the Slag ground and Sold as mortar, Condemned food, and vegetable garbage torn up by a machine called the "Warrington Devil" and Carbonised - The Excreta are dried in a concretor placed over this furnace, - the ammonia being Said to be freed by the fumes from the other processes. The Contents of the pails are reduced to ½ of their bulk and a valuable manure remains,

The method of mixing ashes with excrement was used in Birmingham up till 1880, and is partially used now, and as year by year the Quantity increased the price diminished - the difference from 1876 to 1883 being £4·864 for a boat load of 25 tons in 1876, to £1·7 for the Same quantity

in 1883. Farmers find that ashes clog the land, whilst the fertilising properties of the manure are very small. Transit became a difficulty with the Canal Companies, who require a higher tariff for the conveyance of such material - with transactions on a very large scale reaching nearly £45000 in 1883 it was found that this Sewers diminution in price told very heavily on the finances of the Health department and it became necessary to find some more profitable method if possible. Enquiries throughout Great Britain in all towns, in any way resembling Birmingham, were made over a period of seven years - that is from 1843 till 1850. Nothing at all applicable could be obtained, and the principle on which the Committee started was the original recommendation of the Birmingham Sewage Enquiry Committee - namely - "The exclusion of annual excreta from the Sewers is Essential, both to the effectual treatment of Sewage, and to the health & Comfort of the population, and they

have arrived at this conclusion that this object may be attained by a reform of the System of Exposed privies and open middens now prevailing in the town, and which defile the air, poison the water, and by means of connecting drains pollute the Sewage"

The first principle with which the Committee started was to keep excreta and house refuse entirely separate - For this purpose dust bins are provided to each house, consisting of water tight barrel shaped boxes with a lid -

Pails made of galvanised iron are used in the privies - They have a lid with an india rubber flange, and a strong spring which makes them fit air tight - Carts are provided which remove and replace them at frequent intervals - The carts hold each 18 pails and at the back part is a receptacle, capable of holding about a ton of ashes &c. Most of these cans are taken to the Central depot in Montague Street -

At other wharves the old process still goes on - The new System not

yet being fully developed-
The plan adopted is to make the one kind of material act upon the other. The Solid ash tub refuse amounting to about 42 000 tons per annum is burnt in furnaces Specially Constructed for the purpose- No other material being added to it. It is reduced to one quarter its original bulk, resulting in a Silicious Clinker which is used to make roads, and for paving blocks, also to erect horses with, make Staircases, horse troughs, tables & ornamental fire places-
Steam boats per week of 25 tons each used to be sent out to the Country, the cost of transit being £500- Burning the Same amount costs £270- Of the total amount burned, 45 per cent is dissipated in heat- This is used to dry the contents of the pail Stuff in the following manner:-
Boilers are placed in the furnaces and the heat is transferred by means of Steam to large machines into which about 16 tons of pail Stuff are emptied, with Sufficient

Sulphuric acid to fix the Ammonia.
A hot air blast is drawn through the machine by means of a blower, and the Steam is applied by means of a Steam jacket and hollow rotating Spindles - After about twenty hours of this process the material is reduced to one Sixteenth of its original bulk - one ton of Solid Poudrette being obtained, absolutely inodorless, and which contains, according to analysis, from 7 to 9 per cent of ammonia, and from 2 to 3 per cent of phosphates.
This process is carried out at Warrington now as well as in Birmingham and the material produced fetches at the present time from £5 to £7-10 per ton.
As the amount produced increases the cost of production must di-minish.
In these Estimates the cost of Collection has been Eliminated because under the old System Collection had to take place and this being a Common factor falls.
The manure is reckoned to be the finest top dressing for Grass to

and other vegetables known -
It has recently been proposed to apply it to Sugar cane and Cotton.

Various criticisms have been passed on the method of an adverse nature - Why is a water carriage System not adopted? -
Birmingham is a midland town. Every ounce of water used has to be pumped up from 200 to 600 feet high at enormous expense. The Supply, although good, is only sufficient for the maximum requirements of a growing population for all purposes exclusive of a water carried System.
Water Carriage adds greatly to the amount of polluted fluid to be dealt with at the Sewage farm, where land is dear and drainage difficult owing to the Smallness of the river, or rather Stream, which in its present State is as polluted as it can reasonably be.
It is further claimed that although large Crops are realised on the farm they cannot be Sold to advantage.
Alderman Avery in his Evidence

before the Royal Commission said. "For every £/6 we make we have to spend a similar amount" or words to that effect.

The System now requires to be finished and, when fully carried out, it is estimated that, instead of there being any loss on the undertaking, large profits will accrue to the town, and an addition to the health rate obtained - Already since the inauguration of the Sail System, the closing of polluted wells, the death rate has fallen over five in the thousand, and the average age at death has been raised Six years. Birmingham by this Sanitary Method has been raised from one of the most unhealthy to one of the most healthy towns in the whole of England.

## Books Consulted.

The Bible,
Niebuhr's History of Rome.
Parkes' Hygiene.
Buck's Hygiene and Public Health.
Baldwin Latham's Sanitary Engineering.
Bailey Denton's House Sanitation.
Priagen Teale's Dangers to Health.
Health Exhibition Literature.
Burke's Sewage Utilisation.
Aitken's Manual of Public Health.
Smith's Manual for Med. off. of Health.
Dr Farges on The Sewage Question.
Sanitary Record.
Corfield's Dwelling Houses.
Kirke's Physiology.
Bloxam's Chemistry.
Franklin's Water Analysis.
Social Science Congress Reports.
Royal Commissioners Reports.
1858, 1861, 1865, 1870, 1871, 1884.

A book of notes, taken from various books and journals during the last seven years.

The Diagrams copied from Bailey Denton, Buck, The Sanitary Record and other Sources.

Nelson of Despotism of Sewage

A good thesis with meeting a thesis but containing no argument whatever