

## **Specification of George MacKay : purifying water, sewage, &c.;**

### **Contributors**

Mackay, George.

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A.D. 1875, 11th JANUARY.

N<sup>o</sup> 91.

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SPECIFICATION

OF

GEORGE MACKAY.

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PURIFYING WATER, SEWAGE, &c.

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A.D. 1875, 11th JANUARY. N<sup>o</sup> 91.

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**Purifying Water, Sewage, &c.**

**LETTERS PATENT** to George Mackay, of Edinburgh, in the County of Mid Lothian, North Britain, Manufacturing Chemist, for the Invention of "IMPROVEMENTS IN PURIFYING LIQUIDS, IN OBTAINING OR PREPARING THE PURIFYING AGENTS, IN RECOVERING, TREATING, AND UTILIZING MATTERS CONTAINED IN SUCH LIQUIDS, AS WELL AS OTHER WASTE OR BYE-PRODUCTS OF MANUFACTURES, AND IN MEANS OR APPARATUS EMPLOYED THEREFOR."

Scaled the 6th July 1875, and dated the 11th January 1875.

**PROVISIONAL SPECIFICATION** left by the said George Mackay at the Office of the Commissioners of Patents, with his Petition, on the 11th January 1875.

I, GEORGE MACKAY, of Edinburgh, in the County of Mid Lothian,  
5 North Britain, Manufacturing Chemist, do hereby declare the nature of the said Invention of "IMPROVEMENTS IN PURIFYING LIQUIDS, IN OBTAINING OR PREPARING THE PURIFYING AGENTS, IN RECOVERING, TREATING, AND UTILIZING MATTERS CONTAINED IN SUCH LIQUIDS, AS WELL AS OTHER WASTE OR BYE-PRODUCTS OF MANUFACTURES, AND IN MEANS OR APPARATUS EMPLOYED THEREFOR," to be as  
10 follows, that is to say:—

This Invention relates, first, to the purifying of water, sewage, and



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other liquids effluent from paper pulp and fibre mills; from bleaching, dyeing, scouring, and finishing works; from cotton, woolen, and linen manufactories; from gas, tar, oil, glue, gelatine, and size works; from tanners', skimmers', and curriers' yards; and from works, manufactories, or other situations generally, from which there is an efflux of impure 5 water or other liquid, and to recovering, treating, and utilizing the matters or "sludge," whether animal, vegetable, or mineral, contained in such water or other liquids.

The Invention relates in the second place to the obtaining or preparing of the chemical or other agents employed in such purification and 10 recovery of the matters or "sludge," and to the recovery, treatment, and utilization of the waste or bye-products of manufacture in obtaining or preparing such agents, or for other purposes.

In purifying water or other liquids in accordance with this Invention an admixture in equal or other suitable proportions of per-chloride of 15 iron, commonly called sesqui-chloride or per-muriate, with per-sulphate or other suitable per-salt of iron, is employed. The said admixture need not be chemically or commercially pure, and it may or may not be further admixed or combined with any suitable sub-salt of iron, the sub-salts obtained from alum, alkali, and galvanizing works being 20 preferably employed. The water or other liquid to be treated is placed in a tank or receptacle, and the salt solution added thereto. These are then agitated or stirred together with the liquid for such length of time as is requisite to effect combination of the solution with the vegetable, animal, or mineral matters or "sludge contained in the liquid. The 25 duration of agitation in great measure depends on the amount of impurities or matters present, as well as on the nature of the liquid itself. When the combination of the salts with the matters has been effected a quantity of alkali or alkaline earth, lime being preferably used, is added, and the stirring or agitating continued until combination 30 or chemical union thereof with the salts is effected. The liquid is then allowed to settle, when the matters or "sludge" held in suspension are precipitated, and may thereafter be removed from the tank or receptacle as desired; or the supernatant and purified liquid may be decanted, and the precipitate or "sludge" allowed to remain in the receptacle. 35

The proportion of the iron-salt solution relatively with the impure liquid may be from 1 to 10 parts of the solution to 10,000 (ten thousand) parts of the liquid operated on, and a similar or other proportion of



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alkali or alkaline earth may be used, the total amount of such alkali or alkaline earth being sufficient to decompose all the free chloride and other salts of iron used. It is to be here understood that the Invention is not limited to the proportions herein given.

- 5 The greater number of precipitates obtained by the process herein-before described lose their affinity for water, and are thus easily dried by any ordinary means and reutilised. This is especially the case with the precipitate or "sludge" obtained from the effluent water of paper pulp and fibre mills, and to the utilization of such sludge this Invention is  
10 particularly applicable.

The said precipitate when obtained is dried in a centrifugal machine in a vacuum apparatus, or in any suitable arrangement of pressing or drying machine, and it may thereafter be returned into the paper engine either alone or in combination with fresh pulp or "strong stuff," such as  
15 old canvas, ropes, or other similar material and converted into paper; or it may be employed as a size in substitution for china clay in paper making, or for other purposes, such as manure or artificial fuel.

The deposit or "sludge" obtained by natural gravitation may be reutilized either by adding sufficient water to enable it to be agitated  
20 with the combined or admixed per-salts of iron, or a per-oxide of iron may be intimately blended therewith in the proportion of from 2 to 10 per cent. of the per-oxide, or in other suitable proportion when the admixture, either dried or not, may be utilized as previously described.

The per-chloride of iron employed in purifying the liquids may be  
25 obtained in any of the customary modes, or in accordance with the second part of this Invention. It may be obtained by digesting from 3 to 5 parts of that form of the hydrated per-oxide of iron known as bog ore or ochre with 1 to 2 parts of muriate or hydrochloric acid, and with or without the aid of heat. The digestion is continued for 48 hours  
30 or thereby, or until a saturated solution is obtained, which solution may be concentrated to any desired degree by placing it in a suitable vessel provided with condensing apparatus, and applying heat thereto when the free hydrochloric acid and water pass off and are condensed for further use.

35 Another deposit or bye-product in connexion with paper mills and other works is waste lime, variously called spent bleach, soda lime, gas



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lime, tanners' lime, soap lime, and varies according to the nature of the work at which it is produced.

The second part of this Invention further relates to the recovery and utilization of such lime which has a great affinity for water. To deprive it of its affinity and to render it available for building as a cement for 5 employment in the purification of gas for glass making, and for agricultural and other similar purposes, the refuse lime is mixed with from 10 to 20 parts of coal dust or other slack, and with a similar amount of soda liquor derived from the boiling of esparto grass or rags in the manufacture of paper; or other suitable spent alkaline liquor may be 10 used in lieu thereof. The mixture is effected by any suitable mechanical means and allowed to stand until of such consistency that when pierced with a rod the aperture remains when the rod is withdrawn. The mixture is then placed in a calcining kiln of suitable construction, preferably consisting of a cone, whose height is about double the base. 15 The cone rests on or is provided with a fire-grate, under which an ash-pit is situated. A fire is first kindled on the grate, and the lime mixture laid thereon and pierced with numerous apertures over its surface down to the live coal. A powerful draught is thereby caused in the kiln, whilst at the same time the products of combustion are allowed to pass 20 upwards, and these are followed by the flame, which first dries the lime mixture and then consumes the coal dust or slack, the heat produced by the combustion of which converts the lime from carbonate into caustic lime, which being effected the caustic lime gradually falls through the grate bars into the ash-pit, and is from thence removed. 25

The kiln may be provided with a pipe at its upper end, through which the waste heat may be conducted and utilized, or the pipe may be connected to a chimney. The kiln may or may not also be formed with holes around its base for the purpose of stoking.

As the combustion proceeds fresh quantities of the lime mixture are 30 added, so that the process is continuous.

The addition of soda liquor or ley to the lime compound as herein-before described may in some cases be dispensed with, and sawdust, spent bark, or other refuse may be used instead of coal dust.



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**SPECIFICATION** in pursuance of the conditions of the Letters Patent, filed by the said George Mackay in the Great Seal Patent Office on the 10th July 1875.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, GEORGE MACKAY, of Edinburgh, in the County of Mid Lothian, North Britain, Manufacturing Chemist, send greeting.

WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Eleventh day of January, in the year of our Lord One thousand eight hundred and seventy-five, in the 38th year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the said George Mackay, Her special license that I, the said George Mackay, my executors, administrators, and assigns, or such others as I, the said George Mackay, my executors, administrators, or assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "IMPROVEMENTS IN PURIFYING LIQUIDS, IN OBTAINING OR PREPARING THE PURIFYING AGENTS, IN RECOVERING, TREATING, AND UTILIZING MATTERS CONTAINED IN SUCH LIQUIDS, AS WELL AS OTHER WASTE OR BYE-PRODUCTS OF MANUFACTURES, AND IN MEANS OR APPARATUS EMPLOYED THEREFOR," upon the condition (amongst others) that I, the said George Mackay, by an instrument in writing under my hand and seal, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

NOW KNOW YE, that I, the said George Mackay, do hereby declare the nature of my said Invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement, that is to say:—

My said Invention relates, first, to the purifying of water, sewage, and other liquids effluent from paper pulp and fibre mills, from bleaching, dyeing, scouring, and finishing works; from cotton, woollen, and linen manufactories; from gas, tar, oil, glue, gelatine, and size works; from



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tanners', skimmers', and curriers' yards; and from works, manufactories, or other situations generally from which there is an efflux of impure water or other liquid; and to recovering, treating, and utilizing the matters or "sludge," whether animal, vegetable, or mineral, contained in such water or other liquids. 5

The Invention relates in the second place to obtaining or preparing the chemical or other agents employed in such purification of the liquids and recovery of the matters or "sludge" contained therein; and also to the recovery, treatment, and utilization of the waste or bye-products of manufacture in obtaining or preparing such agents, or for other 10 purposes.

In purifying water or other liquids in accordance with the first part of my said Invention an admixture in equal or other suitable proportions of per-chloride of iron, commonly called sesqui-chloride or per-muriate, with per-sulphate or other suitable per-salt of iron is employed. The 15 said admixture need not be chemically or commercially pure, and it may or may not be further admixed or combined with any suitable sub-salt of iron, the sub-salts obtained from alum, alkali, and galvanizing works being preferably employed. The water or other liquid to be treated is placed in a tank or receptacle and the salt solution added 20 thereto, and agitated or stirred with the liquid for such length of time as is requisite to effect combination of the solution with the vegetable, animal, or mineral matters or "sludge" contained in the liquid. The duration of agitation in a great measure depends on the amount of impurities or matters present as well as on the nature of the liquid 25 itself. When the combination of the salts with the matters has been effected a quantity of alkali or alkaline earth (lime being preferably used) is added, and the stirring or agitating continued until combination or chemical union of the alkali or alkaline earth with the salts is effected. The liquid is then allowed to settle, when the matters or "sludge" 30 held in suspension are precipitated and may thereafter be removed from the tank or receptacle as desired, or the supernatant and purified liquid may be decanted, and the precipitate or "sludge" allowed to remain in the receptacle.

The proportion of the iron-salt solution relatively with the impure 35 liquid may be from 1 to 10 parts of the solution to 10,000 (ten thousand) parts of the liquid operated on, and a similar or other proportion of



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alkali or alkaline earth may be used, the total amount of such alkali or alkaline earth being sufficient to decompose all the free chloride and other salts of iron used. It is to be here understood that although I have obtained good results with the proportions herein-before stated the

5 Invention is not limited to such proportions.

The greater number of precipitates obtained by the process herein-before described lose their affinity for water, and are thus easily dried by any ordinary means and rendered capable of being reutilized. This is especially the case with the precipitate or "sludge" obtained from  
10 the effluent water of paper pulp and fibre mills, and to the utilization of such "sludge" this Invention is particularly applicable.

The said precipitate when obtained is dried in a centrifugal machine in a vacuum apparatus, or in any equivalent arrangement of pressing or drying machine, and it may thereafter be returned into the paper engine  
15 either alone or in combination with fresh pulp or "strong stuff," such as old canvas, ropes, jute, jute waste, esparto grass, straw, or other paper making material, and converted into paper, millboard, pasteboard, or cardboard, or it may be employed as a size in substitution for china clay in paper making, or for other purposes such as manure or artificial  
20 fuel.

The deposit or "sludge" obtained by natural gravitation, that is to say, the matter which is precipitated from the water whilst flowing through a course or channel may be reutilized either by adding sufficient water to enable it to be agitated with the combined or admixed per-salts  
25 of iron, or a per-oxide of iron may be intimately blended with the said matter in the proportion of from 2 to 10 parts of the per-oxide to 100 (one hundred) parts of the matter or "sludge," or in other suitable proportion when the admixture, either dried or not, may be utilized as previously described.

30 The per-chloride of iron employed in purifying the liquids may be obtained in any of the customary modes, or in accordance with the second part of my said Invention it may be obtained by digesting from 3 to 5 parts of that form of the hydrated per-oxide of iron known as bog ore or ochre, with 1 to 2 parts of muriatic or hydrochloric acid and  
35 with or without the aid of heat. The digestion is continued for 48 hours, or until a saturated solution is obtained, which solution may be concentrated to any desired degree by placing it in a suitable vessel provided



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with condensing apparatus and applying heat thereto, when the free hydrochloric acid and water pass off and are condensed for further use leaving a concentrated solution of per-chloride of iron in the vessel.

Another deposit or bye-product in connection with paper mills and other works is waste lime, variously called spent bleach, soda lime, gas 5 lime, tanner's lime, soap lime, according to the nature of the work at which it is produced.

The second part of this Invention further relates to the recovery and utilization of such lime which has a great affinity for water. To deprive it of its affinity and to render it available as a cement for building, for 10 employment in the purification of gas, for glass making, and for agricultural and other similar purposes the refuse lime is mixed with from 10 to 20 parts of coal dust or other slack to 100 (one hundred) parts of lime, and with a similar amount of soda liquor derived from the boiling of esparto grass or rags in the manufacture of paper, or other suitable 15 spent alkaline liquor may be used in lieu thereof. The mixture is effected by any suitable mechanical means and allowed to stand until of such consistency that when pierced with a rod the aperture remains after the rod is withdrawn. The mixture is then placed in a calcining kiln of suitable construction, preferably consisting of a cone whose height is about 20 double the base. The cone rests on or is provided with a fire-grate under which an ash-pit is situated. A fire is first kindled on the grate and the lime mixture laid thereon and pierced with numerous apertures over its surface down to the live coal. A powerful draught is thereby created in the kiln, whilst at the same time the products of combustion 25 are allowed to pass upwards, and these are followed by the flame which first dries the lime mixture and then consumes the coal dust or slack, the heat produced by the combustion of which converts the lime from carbonate of lime into caustic lime which gradually falls through the grate bars into the ash pit, and is from thence removed. 30

The kiln may be provided with a pipe at its upper end through which the waste heat may be conducted and utilized, or the pipe may be connected to a chimney. The kiln may or may not also be formed with holes around its base for the purpose of stoking.

As the combustion proceeds fresh quantities of the lime mixture are 35 added, so that the process is continuous.



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The addition of soda liquor or "ley" to the lime compound, as herein-before described, may in some cases be dispensed with, and sawdust, spent bark, or other refuse may be used instead of coal dust.

The waste bleach lime, either before or after being calcined, as herein-  
5 before described, may, in addition to being employed for the various purposes herein-before set forth, also be used as a substitute for alum in the manufacture of paper, in the method of sizing known as engine sizing or sizing in the pulp. For this purpose the lime is mixed in any suitable vessel with twice or three times its weight of water, so as to  
10 obtain a smooth and uniform cream of lime, which is then strained through a wire sieve. After standing for one or two hours any clear water which may rise to the surface is decanted or drawn off, and the lime deposit is then agitated with commercial, muriatic, or hydrochloric acid. The agitation is continued until effervescence ceases, and the liquid  
15 shews neutral to test paper. The liquid is then left at rest until it is perfectly clear, or in lieu of leaving it at rest it may be filtered through flannel or other suitable cloth. The liquid obtained by this means gives on an average a strength of 34 degrees of Twaddle's hydrometer, which is the strength preferred. If, however, the liquid is required to be  
20 transported to a distance it may be boiled down to any desired strength, or even to a solid or comparatively solid condition, and when required for use reduced to the necessary strength by the addition of water.

It is to be understood that I have adopted 34 degrees of Twaddle's hydrometer as a standard strength, not on account of any peculiar action  
25 or virtue pertaining to the liquor at such strength, but because it is found in practice to be the most concentrated solution which will readily clear without filtration, and still sufficiently dilute to mix with a rosin soap, as herein-after more particularly referred to.

The liquor having been prepared, as herein-before set forth, a quantity  
30 thereof is added to each engine of pulp in a similar manner to that in which a solution of alum has been hitherto added, but in a lesser quantity. There being great diversity in the strength of rosin size employed by paper makers under different circumstances, it is difficult to accurately define a suitable proportion of admixture of the lime liquor  
35 with a given quantity of the solution of rosin soap. I will therefore take dry rosin as the unit of comparative proportion, and without reference to the quantity of water or soda with which the rosin is



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admixed to form the solution. Under these circumstances it is found that the addition of from 8 to 10 ounces, imperial measure, of the lime liquor at 34 degrees of Twaddle's hydrometer to each imperial pound of dry rosin is a good proportion of admixture. If the liquor is weaker or stronger the quantity is increased or diminished according to its strength, 5 and the quantity of lime liquor is also increased when the water with which the dry rosin is admixed to form the size is hard or contains much matter in solution, such additional quantity of the lime liquor being determined by experiment with the different waters used.

When it is desired to produce a hard or crackling paper a proportion 10 of alum is or may be added to the materials contained in the pulp engine after the rosin, size, and lime liquor have been mixed with the said materials, such quantity of alum depending on the stiffness of paper required.

In the manufacture of coloured or inferior qualities of paper the solid 15 matter deposited during the filtration of the lime liquor, as aforesaid, may be used in lieu of the said clear liquor, and in the proportions herein-before given, on in other suitable proportions.

By the employment of lime liquor, or the solid matter deposited during the filtration of the said liquor in lieu of alum, the cost of 20 making paper is diminished, the said liquor or solid matter being cheaper than alum, and at the same time a paper more smooth and pliable for printing purposes is produced than when alum is used, which latter substance is injurious to the type and other printing machinery. In addition to these advantages the paper thus made takes on the ink 25 quicker and in a more uniform manner without blotting or blurring, and without requiring to be damped.

Having now described and particularly ascertained the nature of my said Invention, and the system, mode, or manner in or under which the same is or may be used or practically carried into effect, I would observe 30 in conclusion that what I consider to be novel and original, and therefore claim as the Invention secured to me by the herein-before in part recited Letters Patent is,—

First. The purification of water, sewage, and other liquids effluent from works, manufactories, towns, and other situations generally by 35 treating the same, first, with an admixture in equal or other suitable proportions of per-chloride of iron, and per-sulphate or other suitable



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per-salt of iron, with which admixture any suitable sub-salt of iron may be combined; and second, with a quantity of alkali or alkaline earth, substantially as herein-before described.

Second. Obtaining per-chloride of iron by digesting from 3 to 5 parts  
5 of hydrated per-oxide of iron, otherwise known as bog ore or ochre, with 1 or 2 parts of muriatic or hydrochloric acid and with or without the aid of heat, substantially as herein-before described.

Third. Recovering, treating, and utilizing the matters or "sludge," whether animal, vegetable, or mineral contained in impure water or  
10 other liquids by treating the said water or liquids with per-salts of iron (combined or not with sub-salts) and with alkali or alkaline earth, substantially as herein-before described.

Fourth. The recovery and utilization of the matters or "sludge" deposited from impure liquids by natural gravitation by admixing the  
15 said matters with a sufficient quantity of water to enable them to be agitated with the combined or admixed per-salts of iron, or by blending the said matters or "sludge" without admixture of water with a per-oxide of iron, substantially as herein-before described.

Fifth. The recovery and utilization of the waste lime from paper mills  
20 and other works by admixing it with a proportion of coal dust, sawdust, spent bark, or other suitable refuse, to which a proportion of soda liquor or "ley" is or may be added, and the arrangement or construction of kiln wherein the waste lime so admixed is calcined or burned and converted from carbonate of lime into caustic lime, substantially as herein-  
25 before described.

Sixth. Utilizing the waste bleach lime, either before or after being burned, as a substitute for or in conjunction with alum in the manufacture of paper by treating the said lime in the manner herein-before described.

30 In witness whereof, I, the said George Mackay, have hereunto set my hand and seal, this Ninth day of July, One thousand eight hundred and seventy-five.

GEORGE MACKAY. (L.S.)

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LONDON :

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Printers to the Queen's most Excellent Majesty. 1875.



It is to be understood that the following is a description of the invention.

First. The process consists in the treatment of the waste water of a paper mill with a quantity of alkali or alkaline earth, substantially as herein-before described.

Second. Obtaining peroxide of iron by digesting from 2 to 3 parts of hydrated peroxide of iron, otherwise known as bog iron or bog ore, with 1 or 2 parts of nitric or hydrochloric acid and with or without the aid of heat substantially as herein-before described.

Third. Recovering, treating, and utilizing the matter or "sludge" whether animal, vegetable, or mineral contained in sewage water or other fluids by treating the said water or fluids with peroxide of iron (combined or not with sulphate) and with alkali or alkaline earth, substantially as herein-before described.

Fourth. The recovery and utilization of the matter or "sludge" deposited from sewage fluids by natural gravitation by adding the said matter with a sufficient quantity of water to enable them to be agitated with the combined or admixed peroxide of iron, or by blending the said matter or "sludge" without admixture of water with a peroxide of iron, substantially as herein-before described.

Fifth. The recovery and utilization of the waste lime from paper mills and other works by adding to it with a proportion of acid first, sulphuric acid or other suitable reagent, to which a proportion of soda liquor or "lye" is then added, and the arrangement or construction of the works in the waste line so adjusted is obtained or turned and run, and the waste water of the said works is then substantially as herein-before described.

Sixth. Utilizing the waste lime from the said works or other being burned as a substitute for or in conjunction with lime in the manufacture of paper by treating the said lime in the manner herein-before described.

In witness whereof, I, the said George Mackay, have hereunto set my hand and seal, this 20th day of July, One thousand eight hundred and forty-five.

GEORGE MACKAY. (Sd.)