# PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

## Improved Metallic Apparatus for Carrying Out Chemical and other Processes.

I, JAMES YATE JOHNSON, a British subject, of 47, Lincoln's Inn Fields, in the County of London, Gentleman, do hereby declare the nature of this invention (which has been communicated to me from abroad by I. G. Farbenindustrie Aktiengesellschaft, of Frankfort-on-Main, Germany, a corporation organised according to German laws) and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

When carrying out chemical and other processes with gases, vapours, liquids and the like, which contain hydrogen, oxygen or sulphur, or several of these elements (for the purpose of the present invention these elements may be referred to as destroying elements) in a free or combined state, in iron apparatus, as for example such as are made of steel, and especially when pressures or high temperatures are employed, a loosening of the structure of the iron, tending to porosity and fracture of the material, occurs after a short period of exposure to such high temperatures or pressures. Consequently the affected parts of the apparatus very soon become unfit for use.

My foreign correspondents have now found that these drawbacks may be overcome by constructing the apparatus of iron which is particularly free from impurities such as oxygen, sulphur, carbon and the like which stands the test hereinafter described. Such iron may be prepared either by direct metallurgical working, or by treating metals of an ordinary type at high temperatures with gases which react with the impurities in the metals or alloys to form volatile compounds, so that the said impurities are eliminated. Hydrogen, or mixtures of reducing and oxidising gases such as gas mixtures containing hydrogen, water vapour, carbon monoxide or carbon dioxide, with or without an admixture of inert gases may be mentioned as examples of gases suitable for this purpose. When mixed gases are used, the relative proportions of the oxidising and reducing gases should be adjusted so that no oxidation of the metal will result.

In order to determine whether the iron is suitable for the purpose required, a sample of the material to be used is treated at high temperatures, and under pressure if necessary, with gases, vapours or liquids which contain free or combined oxygen or sulphur and preferably in the presence of hydrogen. The microscopic examination of the treated sample will reveal whether the material is suitable, because if it is not, the sample will exhibit the effects of corrosion in the boundaries of the grains, whereas when it is suitable, not only no corrosion takes place in the boundaries of the grains but the boundaries of the grains which are usually visible only by means of the microscope disappear almost completely and only a few of such boundaries remain visible not only by means of the microscope but also with a naked eye. It is often advisable, prior to making such microscopic examination, to subject the treated sample to a superficial oxidation, such as is usual in the case of iron by annealing till blue, since under these conditions the interstitial substance between the grains is more clearly visible. The temperatures to be employed in these tests are substantially higher generally speaking than the working temperatures of the apparatus made of the metals or alloys under examination. When the working is to be carried out under pressure in the apparatus, it is also advisable to carry out the tests under pressure. Commercial iron, construction steel for example, becomes corroded by the formation of inclusions at the boundaries of the grains when the working operations are carried on with gases containing hydrogen, in the presence of oxygen or sulphur, free or combined, at raised temperature and under pressure, the iron thereby losing its mechanical strength, which result will in practice become apparent only after it has been in use for some months. If, however, a sample of such iron be treated with a weakly oxidising mixture of hydrogen and water vapour for 144 hours under a pressure of about 150 atmospheres and at a temperature of 550° to 600° Centigrade, the microscopic examination will disclose corrosion round the grains of the metal,

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thereby quickly shewing that the iron under examination is unsuitable for the purpose required. When a sample of commercial iron is treated with a gas at a high temperature, as for example in the manner above described, the microscopic examination will not reveal any such corrosion, and the metal will prove very suitable for the required purpose.

For example iron prepared with the aid of manganese by the Martin smelting process, and which is freed from oxide as completely as possible, forms a very suitable material for the apparatus; or a tube or other article made of ordinary mild steel (ingot steel) may be practically freed from carbon and oxygen by prolonged treatment with hydrogen at a temperature exceeding 900° Centigrade, by the said treatment it acquires the requisite purity for the purpose required and simultaneously undergoes an advantageous change in its structure.

Iron so prepared has not the drawbacks above referred to and the apparatus or parts of apparatus constructed of it have an exceedingly long working life.

For example, when aqueous solutions, such as those of sodium hydroxide, sodium nitrate, ammonium nitrate and the like are concentrated in vessels made of wrought iron or the like, extensive destruction of the vessels occurs after a comparatively short time, whereas when vessels constructed of iron which has to a large extent been freed from impurities, as for example in the manner described, are used, the apparatus may be kept in use for a long time without revealing any substantial corrosion of the material. Again, when working with nitrous gases (i.e. gases containing nitrogen oxides) for example in cast iron or wrought iron apparatus there is soon noticeable an extensive destruction in the shape of cracking or peeling of the material which, however, does not occur when the iron used for making the apparatus has been to a considerable extent freed from impurities. Still further in the heat treatment of coal, tars, mineral oils and other materials contaminated with impurities containing sulphur, and especially when such treatment is carried out with hydrogen under pressure, the apparatus quickly suffers extensive injury, which does not occur when the apparatus is constructed of iron treated in the manner herein described.

It may also be advantageous not only to construct the apparatus of iron which has been largely freed from impurities or in which the impurities have been rendered innocuous, but also to apply to it a coating of resistant material this coating being applied at least to the parts which are most exposed to attack. Chromium, tungsten, uranium, manganese, aluminium, silver, copper, enamel, and the like, may be mentioned as highly resistant materials suitable for such coating. Apparatus of this kind display unusually high resistance and may be kept in use for a long time without showing any corrosion.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that I am aware of Specification No. 275,662 and do not claim anything claimed therein but what I claim is:—

1. Improved iron apparatus for carrying out chemical and other processes with gases, vapours, liquids and the like containing hydrogen, oxygen, or sulphur in a free or combined state, more especially under pressure and at high temperature, which are made of iron particularly free from impurities, so as to stand the test substantially as hereinbefore described.

2. Apparatus in accordance with the preceding claiming clause which are made of iron which has been treated at high temperatures, and under conditions precluding oxidation of the iron, with gases which form gaseous compounds with the impurities in the said iron.

3. A further modification of the apparatus in accordance with the preceding claiming clauses, characterised by being constructed of the said iron and provided, at least in the parts most exposed to attack, with a coating of resistant material.

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Agents.

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