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METHOD AND APPARATUS FOR THE CARRYING OUT OF GAS REACTIONS BY MEANS OF AN ELECTRIC ARC.

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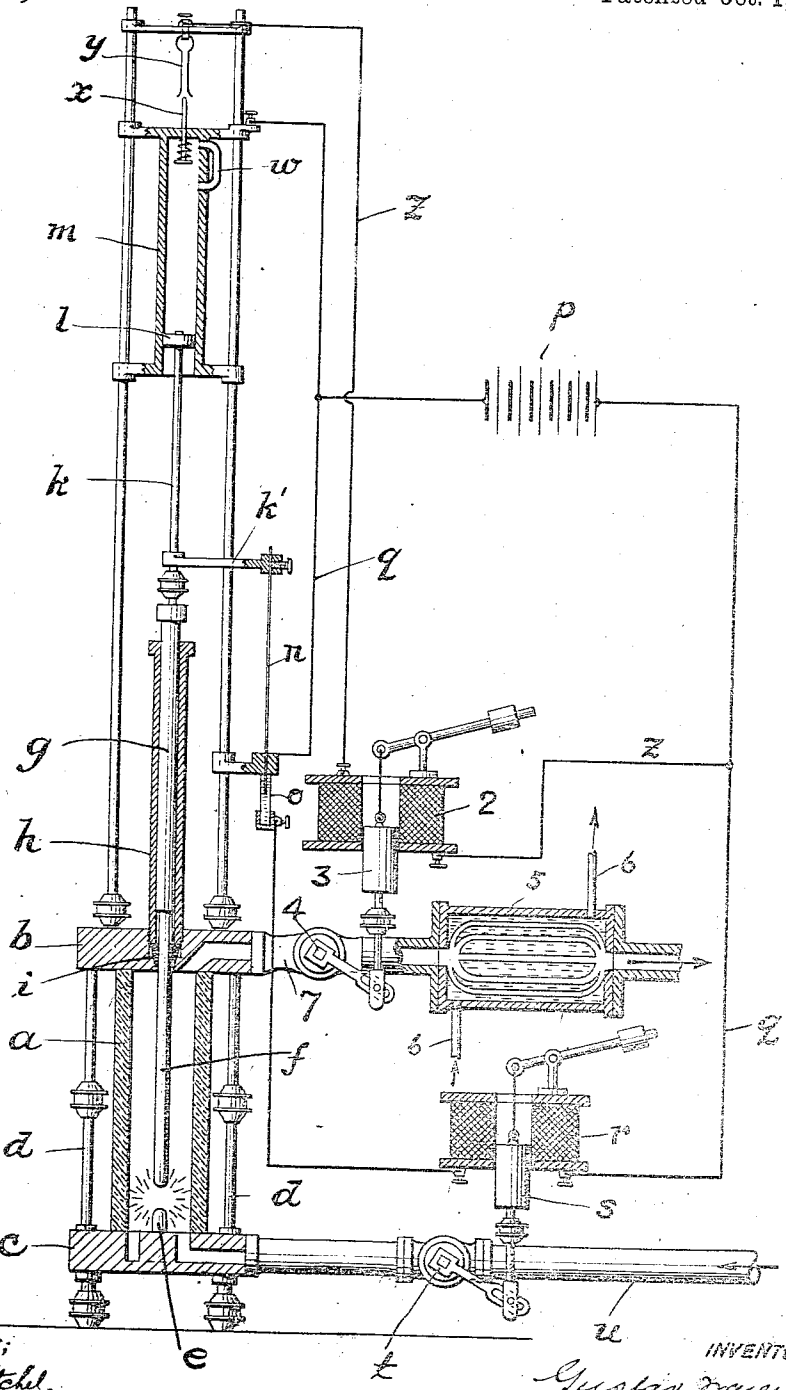

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METHOD AND APPARATUS FOR THE CARRYING OUT OF GAS REACTIONS BY MEANS OF AN ELECTRIC ARC.

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To all whom it may concern:

Be it known that I, GUSTAV WAGENER, a subject of the Emperor of Germany, residing at Schlebusch-Manfort, Germany, have invented a new and useful Improvement in Methods and Apparatus for the Carrying Out of Gas Reactions by Means of an Electric Arc, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, which form a part of this specification.

It has heretofore been tried to carry out gas reactions in the electric arc in such manner that the gases to be treated are continuously introduced under pressure to the steadily burning arc in a closed receptacle and that the reaction mixture produced is continuously passed into a second receptacle in which the gases are permitted to expand. The pressure of the previously compressed gases is still further increased by means of the heating in the electric arc, thus also increasing the speed of the current of the gases. This method, however, is disadvantageous because, owing to the high speed of the current of the reaction gases continuously introduced in the arc and around the same, strong whirls are formed to such an extent that unsatisfactory concentrations are obtained and the yields are relatively low.

It is the purpose of the present invention to overcome these disadvantages.

The new method consists in introducing into an air-tight, sealed, reaction receptacle successive volumes of previously compressed gases and in heating the same by means of an arc drawn out as quickly as possible to its full length each time a certain quantity of the gases are introduced, and, when the maximum pressure is obtained, suddenly expanding the reaction mixture. In this manner a fairly high pressure of the gases contained in the reaction receptacle is obtained, and the gases, suddenly tearing the elongated arc, expand with great violence in an explosive-like manner and immediately cool very effectively. By means of this method and for the reason stated, a considerably higher yield is obtained than heretofore.

The new method is especially suitable for the production of the gases of oxid of nitrogen from compressed air. Experiments have demonstrated that it is advisable, and, to get the best results, necessary that the arc, formed in the air tight closed reaction receptacle, be stretched to its full length as quickly as possible, so as to insure that the entire volume of heat available shall act as quickly as possible. In slowly stretching the arc, a perceptible increase in pressure would not take place, since, as experiments have shown, the increase in pressure is always counteracted by a decrease in pressure in such manner that the heat which is added each time is mostly used to overcome this decrease in pressure. It has been also ascertained, especially after the maximum pressure has been reached, even when the arc over its entire length burns steadily, that a sudden stepwise decrease of the pressure takes place. For this reason precautions must be taken that, when the maximum pressure is reached, the expansion be brought about immediately.

The attached drawing shows a preferred form of apparatus embodying my invention and suitable for carrying out my new method. The same fulfils all requirements referred to above to the greatest extent and works entirely automatically.

The reaction receptacle in this instance is a quartz tube *a* of heavy walls, which is capable of withstanding high pressure and high temperatures and which does not have to be cooled. This tube *a* is at top and bottom sealed airtight by means of two metal plates *b* and *c*, these plates being tightly pressed against the ground cross section surfaces of the tube by means of the insulated rods *d*. In the lower plate *c* the rigid electrode *e* is placed, while the other electrode *f* is arranged in such manner in the plate *b* that the same can slide up and down, while the joint is airtight. The upper electrode *f* is fastened to the lower end of a rod *g*, which slides up and down in the guide tube *h* screwed into the upper plate *b*. The sealing of the electrode *f* in the upper plate *b* is effected by means of a stuffing box *i*.

Insulated from the guide rod *g*, and connected to the upper end of the latter, is the piston rod *k*, the piston *l* of which moves air tight in the cylinder *m*. In the position of the apparatus as shown in the drawing, the electrode *f*, together with the rods *g* and

k, drop down owing to their weight. This downward movement is at first brought about fairly quickly, until the contact rod *n*, fastened to an arm *k'* on the rod *k*, dips into the mercury receptacle *o*, thus closing the circuit *q* through the battery *p* and the magnet coil *r*. The iron core *s* is, therefore, drawn into this coil, thus opening the cock *t* in the pipe *u*, through which the compressed air enters into the reaction receptacle *a*. The entering compressed air delays the downward movement of the electrode *f* in such manner that when the latter comes in contact with the rigid electrode *e*, the flow of compressed air has just ceased. After the receptacle *a* has in the meantime entirely been filled with compressed air, the electrode *f* is slowly moved in an upward direction by means of the pressure of the compressed air. At this stage the arc is formed. During this time the rod *k*, which also participates in the upward movement, has lifted the contact pin *n* out of the mercury receptacle *o*, thereby breaking the circuit *q*. The iron core *s*, therefore, on account of its own gravity, drops from the coil *r*, thus again closing the cock *t*. Due to the fact that the receptacle *a* is now closed airtight, the arc produces a sudden heating and increase in pressure of the inclosed compressed air, so that the electrode *f* which before had moved upward slowly, now moves upward quickly with increasing speed, thus quickly drawing out the arc to its entire length. Shortly before the electrode *f* reaches its highest position, the movement of the same is again delayed, since the piston *l* compresses the air in the cylinder *m* which is closed on top. In this operation the air inclosed in the cylinder *m* does not offer any appreciable resistance to the piston *l* until the latter reaches nearly its highest position, so that the speed of the quickly upward moving electrode *f* is not delayed until it reaches nearly its highest position, thus giving time for the arc to bring the gas mixture to its highest pressure. As soon as the piston *l* passes the lower part of the circulating channel *w* with which the cylinder *m* is provided, the air compressed in the upper part of the cylinder passes, by means of this circulating channel, into the lower part of the cylinder, thereby causing the piston *l* to again move very quickly upward, pressing the pin contact upward between the contact strips *y*. In this manner a current *z* is closed through the battery *p* and coil 2, which latter quickly draws up its iron core 3 thus immediately fully opening the cock 4 in outlet pipe 7 communicating with the upper end of the reaction receptacle *a*. By correctly adjusting the contacts *x y*, the cock 4 will be opened at precisely the time that the maximum obtainable pressure is present in the reaction receptacle. The reaction mixture, therefore, suddenly expands, when the cock 4 is opened, in an explosive like manner, with great violence, and flows into the container 5, which is suitably cooled with water, into which container the cooling liquid is introduced or from which the same is removed by means of the pipes 6, and from which the reaction products are removed by means of suction produced by any desired means. By reason of the explosive-like expansion which succeeds the high pressure, a sudden drop in temperature of the reaction mixture is brought about, and the latter is immediately cooled very intensely in such manner that the greatest possible stability of the endothermic compounds formed in the reaction chamber is obtained. As soon as the expansion takes place, the arc is ruptured, and the electrode *f*, with the rods *g* and *k*, drop in a downward direction. The contact pin *x* is, by means of its spring, drawn from the contact strip *y*, and thus the circuit *z* is broken. The iron core 3, therefore, owing to its own gravity, drops from the coil 2, and the exhaust cock 4 is again closed. During the further dropping of the electrode *f* the contact rod *n* again dips into the mercury receptacle, thus closing the circuit *q*, opening the cock *t* and permitting a fresh charge of compressed air to enter into the reaction receptacle *a*. The operation, as hereinbefore described, is now repeated. The described apparatus, therefore, operates entirely automatically, successive volumes of the gases to be treated being heated by the electric arc until the maximum pressure is obtained, and then suddenly expanded.

By suitably adjusting the corresponding electric contacts, it is readily possible to obtain the maximum pressure with any kind of gases to be treated and to then immediately bring about the expansion. The successful execution of the process is not dependent upon the employment of the particular apparatus described, nor upon the employment of electro-magnetic means for effecting the described operation.

Having now fully described my invention, what I claim and desire to protect by Letters Patent, is:

1. The method of carrying out gas reactions which consists in bringing a definite volume of compressed gas in confinement under the influence of an electric arc, and while shutting off further ingress of gas, maintaining the same under the influence of the arc and thereby continuously heating the same until a maximum pressure is reached, and then permitting the reaction mixtures to suddenly expand and cool.

2. The method of carrying out gas reactions which consists in introducing a volume of compressed gas into a receptacle of substantially unvarying capacity, maintaining the same while confined therein under the

influence of the arc and thereby continuously heating the same until a maximum pressure is reached, and then permitting the reaction mixture to expand and suddenly cool.

3. The method of carrying out gas reactions which consists in bringing a volume of compressed gas in confinement under the influence of an electric arc, and while shutting off further ingress of gas, heating the same until a maximum pressure is obtained, and then releasing the same from confinement to permit sudden expansion and bringing the expanding gases under the influence of a cooling agency.

4. The method of carrying out gas reactions which consists in bringing a volume of compressed gas under the influence of an electric arc, shutting off further ingress of gas, drawing out the arc, and permitting the reaction mixture to suddenly expand.

5. The method of carrying out gas reactions which consists in bringing a volume of compressed gas under the influence of an electric arc, shutting off further ingress of gas, drawing out the arc first slowly and then rapidly, and then permitting the reaction mixture to suddenly expand and cool.

6. The method of carrying out gas reactions which consists in bringing a volume of compressed gas under the influence of an electric arc, shutting off further ingress of gas, causing the gas to draw out the arc, and then permitting the reaction mixture to suddenly expand and cool.

7. The method of carrying out gas reactions which consists in bringing a volume of compressed gas under the influence of an electric arc and causing the gas to act upon an electrode to shut off further ingress of gas and elongate the arc, and then permitting the reaction mixture to suddenly expand and cool.

8. The method of carrying out gas reactions which consists in bringing a volume of compressed gas under the influence of an electric arc, and causing the gas to act upon an electrode to shut off further ingress of gas, elongate the arc with accelerated rapidity, and effect its own egress after a maximum pressure is obtained, thereby permitting the reaction mixture under high pressure to expand, rupture the arc, and suddenly cool.

9. The method of carrying out gas reactions which consists in bringing a volume of compressed gas under the influence of an electric arc, and causing the gas to act upon an electrode to cause the same to form the arc, shut off further ingress of gas, elongate the arc with accelerated rapidity, and then expand, rupture the arc, escape and suddenly cool, and permit a fresh volume of compressed gas to be brought under the influence of the electric arc.

10. The method of carrying out gas reactions which consists in bringing a volume of compressed gas under the influence of an electric arc, and causing the gas to act upon an electrode to cause the same to shut off further ingress of gas, and successively elongate the arc with accelerated rapidity, retard its elongation, and renew its relatively rapid elongation, to then expand, rupture the arc, escape and suddenly cool, and to then permit a fresh volume of compressed gas to be brought under the influence of the electric arc.

11. The method of carrying out gas reactions which consists in bringing a definite quantity of gas to be treated under the influence of an electric arc, permitting said definite quantity of gas to be heated and then the reaction mixture to suddenly expand and cool, and in like manner successively treating separately similar definite quantities of gas.

12. An apparatus for carrying out gas reactions which consists of an air tight reaction receptacle, arc light electrodes therein one of which is movable, and an inlet to and an outlet from said receptacle.

13. An apparatus for carrying out gas reactions which consists of an air tight reaction receptacle, arc light electrodes therein, one of which is movable, and means controlled by the movable electrode to admit gas to be treated to the receptacle, shut off further ingress, allow the reaction mixture to escape, and admit a fresh supply of gas to be treated to the receptacle.

14. An apparatus for carrying out gas reactions which consists of an air tight reaction receptacle, arc light electrodes therein, one of which is movable, and an inlet pipe, an outlet pipe, valves in said pipes, and means controlled by the movable electrode governing the opening and closing of said valves.

15. An apparatus for carrying out gas reactions which consists of a thick quartz tube, air tight closures therefor at the top and bottom thereof, arc light electrodes therein; one of which is movable, an inlet to and an outlet from said receptacle and means controlled by the movable electrode governing said inlet and outlet.

16. An apparatus for carrying out gas reactions which consists of an air tight reaction receptacle, arc light electrodes therein one of which is movable, an inlet to and an outlet from said receptacle, electro-magnets controlling said inlet and outlet, electric circuits including said electro-magnets, and means governed by the movable electrode to open and close said circuits.

17. An apparatus for carrying out gas reactions which consists of an air tight reaction receptacle, arc light electrodes therein, one of which is movable, and a piston connected with the movable electrode, a cylin-

der in which said piston moves having a by-pass therein, whereby the electrode is permitted to move rapidly, then retarded and then again permitted to move rapidly, an inlet to and an outlet from said receptacle, and means controlled by said moving parts governing said inlet and outlet.

In testimony of which invention, I have hereunto set my hand, at Cologne, on this 3d day of November, 1911.

GUSTAV WAGENER.

Witnesses:
ELIZA SCHWARZ,
HANS DUMONT.