infancy. Thus the well-known donkey at Carisbrooke Castle drew water from a deep well by a treadmill arrangement just as well as a man could do it. He had seen a canary gradually lift from a little well, situated a foot below its perch, a thimbleful of water by pulling up with its beak, bit by bit, a little chain attached to it, and securing each length lifted with its foot till it could take another pull. When the thimble reached its perch level the bird took a drink, and then let it fall back into the well. Mr. C. Wood, of Middlesbrough, informed him that certain crows which frequented oyster-beds on the coast of India waited until the receding tide uncovered the oysters, which still remained open for a time. A crow would then put a pebble inside one, and, having thus gagged it and secured his own safety, would proceed to pick it out and eat it at leisure. A monkey would crack a nut between two stones, and would hurl missiles at his enemies. But in some countries he was systematically entrapped by tying to a tree a hollow gourd containing rice, and having a hole large enough for his hand, but too small for his clenched fist, to pass through. He climbed the tree and grasped the rice, and remained there till taken, being too greedy and not having sufficient sense to let go the rice and withdraw his hand. All animals were in their bodily frames, and in the intricate processes and functions which went on continuously therein, mechanisms of so elaborate a kind that we could only look and wonder and strive to imitate them a little here and there. The mechanical nomenclature of all languages was largely derived from the bodies of men and other animals. Many of our principal mechanical devices had pre-existed in them. Mr. Head proceeded to consider how far man was in his natural condition, and had become by aid of mechanical science, able to compete successfully with other and specially endowed animals, each in his own sphere of action. The bodily frame of man was adapted for life and movement only on or near to the surface of the earth. Without mechanical aids he could walk for several hours at a speed which was ordinarily from 3 to 4 miles per hour. Under exceptional circumstances he had accomplished over 8 miles in one hour and an average of 2¾ miles per hour for 141 hours. In running he had covered about 11¼ miles in an hour. The power of the living human mechanism to withstand widely diverse and excessive strains was altogether unapproachable in artificial constructions. Thus, although fitted for an external atmospheric pressure of about 15 lbs. per square inch, he had been able, as exemplified by Messrs. Glaisher and Coxwell in 1862, to ascend to a height of 7 miles and breathe air at a pressure of only 3¼ lbs. per square inch, and still live. And, on the other hand, divers had been down into water 80 ft. deep, entailing an extra pressure of about 36 lbs. per square inch, and had returned safely. One had even been to a depth of 150 ft., but the resulting pressure of 67 lbs. per square inch cost him his life. No animal burrowed downward into the earth to a greater depth than 8 ft., and then only in dry ground. The horse, though he could not walk faster than man, nor exceed him in jumping heights or distances, could certainly beat him altogether when galloping or trotting. A mile had been galloped in 103 seconds, equal to 35 miles per hour, and had been trotted in 124 seconds, equal to 29 miles per hour. How man's position as a competitor with other animals in speed was affected by his use of mechanical aids, but without any extraneous motive-power, was considered in reference to locomotion on land, in water, and in air. But the most wonderful increase to the locomotive power of man on land was obtained by the use of the modern cycle. One mile had been cycled at the rate of 27.1 miles per hour, 50 at 20, 100 at 16 6, 388 at 12.5, and 900 at 12.43 miles per hour. Unaided by mechanism man had shown himself able to swim for short distances at the rate of three, and long distances (22 miles) at the rate of 1 mile per hour. He had also given instances of being able to remain under water for 4¼ minutes. Credible eye-witnesses stated that porpoises easily overtook and kept pace with a steamer going 12¼ knots, or, say, over 14 miles per hour, for an indefinite length of time. This was five and 15 times the *maximum* swimming speed of a man for short and long distances respectively. The fastest mechanism of any size, animal or man-made, which had ever cut its way through the waters for any considerable distance, was the torpedo-boat *Ariete*, made by Messrs. Thornycroft & Son, of London, in 1887. By inventing and utilizing mechanical contrivances, entirely independent of his own bodily strength, man could now pass over the surface of the waters at the rate of over 500 knots per day, and at the same time retain the comforts and conveniences of life as though he were on shore. He had in this way beaten the natural and specially fitted denizens of the deep in their own element, as regarded speed and continuity of effort. But he was still behind them as to safety. We did not find that fishes or aquatic mammals often perished in numbers as man did by collisions in fogs, or by being cast on lee shores and rocks by stress of weather. Should we ever arrive at the point of making ocean traveling absolutely safe? In one way the chances of serious disaster had been of late largely diminished, and here, again, nature had been our teacher. The bodies of all animals except the very lowest were symmetrically formed on either side of a central longitudinal plane. Each important limb was in duplicate, and if one side was wounded the other could still act. The serpent, having no limbs whatever, would seem at first sight to be terribly handicapped; yet, in the language of the late Professor Owen, "it can out-climb the monkey, out-swim the fish, out-leap the jerboa, and, suddenly loosing the close coils of its crouching spiral, it can spring into the air and seize the bird on the wing." Here we had the spiral spring in nature before it was devised by man.

The decisive victories which in modern times man had gained over matter and over other animals had been due to his use of power derived from other than animal sources. That power had invariably proceeded from the combustion and the destruction of fuel, the accumulations of which in the earth were necessarily limited. Mechanical appliances, involving the consumption of fuel, had for a century at least been multiplying with alarming rapidity. Our minds had been set mainly on enlarging the uses and conveniences of man, and scarcely at all on economizing the great sources of power in nature, which were now for the most part its fuels. Terrible waste of these valuable stores was daily going on in almost every department of use. Once exhausted they could never be replaced. They had been drawn upon to some extent for 1,000 years, and extensively for more than 100. Authorities said that another 1,000 years would exhaust all the more accessible supplies. But suppose they last 5,000 years, what then? Why, then, as far as we could at present see, our only motive powers would be wind and water and animals, and our only mode of transit, sailing and rowing, driving, cycling, riding, and walking. Sir Robert Ball had estimated that in not less than 5,000,000 and not more than 10,000,000 years the sun would have become too cold to support life of any kind on this planet. Between the 5,000 years when fuel would certainly be exhausted and the 5,000,000 years when all life might be extinguished, there would still be 4,995,000 years when, according to present appearances, man would have to give up his hardly earned victories over matter and other animals, and the latter would again surpass him, each in its own element, because he had no fuel.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

V.—METHOD OF DETERMINING SULPHUR IN PIG AND WROUGHT IRON.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

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(*Continued from page 445, Volume LXVII.*)

OPERATION.

Put 5 grams of the borings into a beaker whose bottom is about 3 in. in diameter, add 40 c.c. of concentrated C. P. nitric acid, and cover with a watch glass. If action takes place immediately with foaming, put the beaker in cold water until the action is modified somewhat. If action does not start at once after addition of acid, warm to start the action, and then, if necessary, put the beaker in cold water until the violence of the action has passed. As soon as quiet action is obtained, add about half a gram of pulverized chlorate of potash, keeping the beaker still covered, and put on the steam table. After all effervescence has ceased, set the cover up on a glass triangle and evaporate to remove free nitric acid until the material in the beaker will no longer adhere to a glass rod. Remove now from the steam table, allow to cool, and add 30 c.c. of concentrated C. P. hydrochloric acid, cover the beaker with a watch

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glass, and heat until solution is complete, and then set the cover up as before and evaporate to dryness to render silica insoluble. A temperature not below 250° F. should be used, and the drying should be continued until only faint odor of HCl. is perceptible. Allow to cool and then add 20 c.c. concentrated C. P. hydrochloric acid, heat covered until solution is complete, and then evaporate the free acid until a skin begins to form over the top of the material in the beaker. As soon as this skin appears, add 5 c.c. concentrated C. P. hydrochloric acid and 25 c.c. of water, heat to boiling to insure solution, filter, and wash with water until the filtrate and washings amount to 100 c.c. Add now to the filtrate 10 c.c. barium chloride solution, heat to boiling to granulate the precipitate, then remove from the heat, allow to cool slightly, and add 100 c.c. of 95 per cent. alcohol. Stir thoroughly, cover with a watch glass and allow to settle until the solution is clear. Filter through a 7 centimeter filter, wash with hot water until the washings no longer react for chlorine with silver nitrate, transfer the wet filter with the barium sulphate on it to a weighed half-ounce platinum crucible, "smoke off" the filter, ignite and weigh. Add now to the crucible about half a gram of C. P. carbonate of soda and a crumb of C. P. nitrate of potash about the size of half a kernel of wheat, and fuse with the cover on until the material in the crucible is quiet. Treat the material in the crucible with hot water and wash out into a small beaker, taking pains also to detach anything adhering to the cover. Warm or boil the liquid in the beaker to insure complete solution of the sulphate of soda, filter through a small filter, wash with hot water until a drop of the filtrate shows no reaction with turmeric paper, and then two or three filtersful more. Now cover the beaker with a watch glass, add by means of a pipette through the nose of the beaker concentrated C. P. hydrochloric acid until the liquid is just acid to litmus paper; then add three drops more of acid and 5 c.c. of barium chloride solution and bring to boiling, keeping covered to avoid loss by effervescence. Remove from the heat, allow to settle, filter, wash, ignite wet, and weigh as before described.

APPARATUS AND REAGENTS.

The apparatus required by this method presents no peculiarities and requires no especial description. Since one of the directions requires that the material shall be evaporated until a skin begins to form, it is probable that more uniform results will be obtained by different operators and in different tests if the evaporation is done with the same surface exposed in all cases. It is accordingly specified that this evaporation shall be done in a beaker whose bottom is about 3 in. in diameter.

The nitric, and hydrochloric acids, the chlorate of potash, and the carbonate, and nitrate of soda are the C. P. materials such as are obtained in the market.

The chloride of barium solution is made by adding 100 grams of the C. P. salt to 1 liter of distilled water, allowing to dissolve and filtering before use.

The alcohol is the ordinary commercial 95 per cent. material of the market.

CALCULATIONS.

Since the sulphur is 13.73 per cent. of the weight of the barium sulphate, if the weight obtained expressed in grams is multiplied by 13.73 and the product divided by 100, the quotient will be the sulphur expressed in grams. Then, since the estimation is made on 5 grams, the percentage of sulphur in the steel will be shown by removing the gram decimal point two places to the right and dividing by 5, thus:

If the weight of barium sulphate found is 0.0259 gram, the sulphur is $\frac{0.0259 \times 13.73}{100} = 0.00355$ gram, and the percentage of sulphur in the steel $\frac{0.355}{5} = 0.071$ per cent.

NOTES AND PRECAUTIONS.

This method, as will be observed, oxidizes the sulphur in the iron principally, and perhaps wholly, by means of nitric acid, converts the nitrate of iron formed into chloride by means of hydrochloric acid, separates silica by evaporation to dryness after the material is converted into chlorides, and precipitates the sulphuric acid in presence of the chloride of iron by means of barium chloride, using alcohol to effect the separation of the last traces of barium sulphate from the solution. It seems probable that the chlorate of potash, which is added principally in order to have a little alkaline base for the sulphuric acid to combine with and thus prevent possibility of loss during the evaporation to dryness, may possibly assist the oxidation of the sulphur. Furthermore, the first evaporation to expel the excess of nitric acid rarely removes it all, and the subsequent addition of hydrochloric acid to expel the nitric forms with this remnant of the nitric a little aqua regia, which may still further render the oxidation of the sulphur secure.

It is essential before making a determination that not less than two blanks should be made, using all the chemicals in the prescribed amounts and conducting the whole operation just as for a regular analysis, except that no iron is present. The weight of barium sulphate obtained as the result of these two determinations, which should not differ more than half a milligram, must be deducted from the weight of the barium sulphate obtained in the regular analysis of a wrought or pig iron. It is recommended to set aside, for use in sulphur determinations only, a bottle of each of the chemicals used in making the blanks. Of course the figures obtained will be available as long as these bottles last.

It is obvious that if the air of the laboratory is contaminated with H_2S or SO_2, or even sulphuric acid fumes from ignitions and evaporations, there will be danger of too high results from contamination of the liquid in the beaker from the two gases while the evaporations to dryness are going on, and at all times during the manipulation of the material in the open beaker from the sulphuric acid fumes. We have never proven how great this danger is, but it may possibly help to explain some anomalous results.

It will be observed that after the evaporation to dryness to render silica insoluble, it is directed to add 20 c.c. of concentrated C. P. hydrochloric acid; then this acid is evaporated until a skin forms and then 5 c.c. of concentrated C. P. hydrochloric acid is again added. This looks like unnecessary complication. The reason for this manipulation is that 20 c.c. of concentrated C. P. hydrochloric acid is about the least amount that will take up the soluble material in the beaker after evaporation to dryness. But this is too much free acid to be present when precipitating with chloride of barium; also, in order to secure uniform results, the precipitation must be done in presence of a moderately definite amount of free acid. The removal of the excess and the securing of the definite amount of free acid are believed to be more certainly accomplished by the method described than by the attempt to evaporate in a beaker to a definite volume. Moreover, in attempting to evaporate to a definite volume it not infrequently happens from local overheating, since the bottoms of all beakers are not flat, that basic or semi-basic salts are formed that will not dissolve in water. Only careless manipulation will lead to this result with the method described.

It sometimes happens that 20 c.c. of concentrated C. P. hydrochloric acid is not enough to take up everything soluble after the evaporation to dryness. In this case more acid and longer continued heating must be employed. This excess of added acid must of course be evaporated until the skin appears, as already described.

It is well known that sulphates are insoluble in alcohol, and accordingly an equal volume of alcohol is added to the chloride of iron solution to secure, if possible, a complete separation of the barium sulphate. Direct experiments show that with this manipulation about 2 milligrams more barium sulphate are obtained than if the alcohol is omitted. This is equivalent to a difference of a little over half a hundredth per cent. (0.005 per cent.). Practically the same results were obtained when one-third, one-half and two-thirds of the bulk of the solution was alcohol.

Barium sulphate is liable to be reduced during the ignition of the filter, and thus lead to slightly low results. To obviate this difficulty the filter and precipitate are put into the crucible wet, and the filter "smoked off" and then burned. The "smoking off" consists in applying the heat to the wet material in the crucible so slowly that the volatile matter of the filter passes off without ignition, free access of air being maintained at the same time. To accomplish this, fold up the wet filter and place it in the crucible. Put the crucible on the triangle, as in ordinary ignitions, and leave the cover off. Then heat the open end of the crucible slowly. The filter and precipitate gradually dry, and soon the parts of the filter in contact with the crucible begin to distill off the volatile matter at low heat, even before the whole is dry. This process goes on if the flame is properly adjusted, until in a little while everything that is volatile at a low temperature has passed away, and the precipitate, with a black envelope of carbonaceous matter, is left. When this is the case the temperature can be raised, the lamp moved back to heat the bottom of the crucible, and the carbon burned off completely. Usually when the temperature is raised the black envelope of carbonaceous matter falls away from the precipitate and is rapidly consumed. By this method of ignition the material is a little longer time in the crucible than with the old method of previ-

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ously dried precipitates, but the danger of reducing the precipitate is believed to be very much diminished.

It will be observed that directions are given to weigh before the barium sulphate is purified by fusion with carbonate of soda. This may seem unnecessary manipulation, but it is believed that this check on serious error arising during the fusion and subsequent operations is worth all it costs. If the manipulation as described is carefully followed, if the amount of barium sulphate is not large, and especially if it shows no tinge of color after the first ignition, the amount of barium sulphate obtained after the fusion differs so little from the first weight that the error can be ignored, and the question fairly arises whether the fusion may not in general be omitted. On the other hand, if the ignited barium sulphate is colored, showing presence of iron, or if the "smoking off" of the filter is carelessly managed, resulting in reduction of some of the barium sulphate, quite serious errors may result from omitting the fusion. Also if the silica is not all rendered insoluble by the evaporation to dryness, some of it may appear with the barium sulphate on the first weight. By far the largest portion of this is removed by the fusion, so that when the highest accuracy is required the fusion should not be omitted. The addition of the little crumb of potassium nitrate to the fusion is to ensure the oxidation of any reduced barium sulphate which may have been formed while "smoking off" the filter.

The examination of a number of samples of the graphitic residue and silica obtained as the result of the first filtration shows only traces of sulphur in this residue, and it is questionable whether even these traces did not come from the gas flame used in burning off the graphite.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 535.*)

The Conference on Aerial Navigation in Chicago in August, 1893, brought out a number of experimenters whose ventures had theretofore been unpublished.

One of these, Mr. *E. C. Huffaker*, of Tennessee, had been experimenting with a model somewhat resembling the "effigy" of Mr. *Lancaster*. It consisted in a rectangular surface of fabric made concavo-convex by a rigid front spar with curved ribs at right angles thereto, so as to resemble the cross section of a soaring bird's wing. A cross stick attached thereto carried a balancing horizontal tail, the center of gravity being determined at the front by loading with lead. The area of sustaining surface was 2 sq. ft., and when held by the cross stick at arm's length overhead, vibrating between two fingers and facing a wind of 35 miles per hour (6 lbs. pressure at right angles), the weight sustained (or lift) was estimated at 2 lbs. to the square foot, or that corresponding to an angle of 10° upon a flat plane, while in point of fact the model seemed to be horizontal, and the force required to hold it in the wind was very small.

When the model was let go in a steady breeze it would rise to a height of 12 or 15 ft., slowly retreating from the wind, but always facing it; then, tipping slightly forward, it would descend into the face of the wind; all these effects being easily explained in a horizontal current.

When projected forward by hand, the model would sail away in steady flight with a velocity of about 17 miles per hour, and then descend on a gradient of about 1 in 15. If thrust rapidly forward it would rise some 8 or 10 ft., and then, hanging suspended for a moment, it sailed forward to the ground.

These experiments are interesting as confirming what has hitherto been said concerning the greater lift appertaining to concavo-convex surfaces, and it is to be hoped that they will be continued.

The other experimenter was Mr. *J. J. Montgomery*, of California. He had, some years previously, constructed a soaring apparatus, consisting of two wings, each 10 ft. long by an average width of 4½ ft., united together by a framework to which a seat was suspended, and provided with a horizontal tail which could be elevated or depressed by pulleys. The wings were arched beneath, like those of a gull, and afforded a sustaining area of about 90 sq. ft. The weight of the apparatus was 40 lbs., and that of the experimenter some 130 lbs. more.

Mr. *Montgomery* took this apparatus to the top of a hill nearly a mile long, which gradually sloped at an angle of about 10°, and placing himself within the central framework, the rods of which he grasped with each hand, ready to sit down, he faced a sea breeze steadily blowing from 8 to 12 miles an hour, and gave a jump into the air without previous running.

He found himself at once launched upon the wind, and glided gently forward, almost horizontally at first, and then descended to the ground, finding that he could meanwhile direct his course by leaning to one side or the other. The total distance glided was about 100 ft., and the sensation was that of firm yet yielding and soft support, being quite similar to the experience of M. *Mouillard*, as already described, except that there was no apprehension of disaster.

Mr. *Montgomery* carried his machine back to the top of the hill and prepared to repeat the experiment, but as soon as he got into position the apparatus began to sway and to twist about in the wind; one side dipped downward, caught on a small shrub, and, as quick as a flash, the operator was tossed some 8 or 10 ft. into the air, overturned, and thrown down headlong. He fortunately fell without serious injury, and found, as soon as he recovered himself, that one side of his machine was smashed past mending.

This experience led him to design and build a second soaring apparatus, in which he endeavored to relieve undue pressure upon either side by providing a diagonal hinge in each wing, along which the rear triangle might fold back (it was restrained by a spring) and yield to a wind gust. This apparatus measured some 132 sq. ft. of sustaining surface, and weighed 45 lbs. It was not successful; several trials were made, but no effective lift could be obtained with it. This was attributed to the fact that the wings had been made true planes (flat) instead of being arched underneath as in the first machine.

So a third apparatus was designed and built. The wings were each 12 ft. long by an average width of 6 ft., and were given the cross section and front sinuosity of those of a soaring vulture. They were so built and braced as to allow rotation in a socket at the front of the frame which supported the seat. A hinged tail was added, as in the two previous trials, and the machine weighed 50 lbs.

This last apparatus proved an entire failure, as no lifting effect could be obtained from the wind, sufficient to carry the 180 lbs. it was designed to bear. Mr. *Montgomery* then turned his attention to other matters, but he has since made a more careful and complete study of the principles involved, and he expects to resume his experiments.

The foregoing pages comprise all the experiments, the result of which has been published, which the writer has been able to collate, and which he has considered of sufficient importance to be described in this account of "Progress in Flying Machines." Other important experiments are pending or in partial progress; but the designers of these have as yet given out no information for publication, and indeed could scarcely do so concerning tentative plans, subject to constant modifications.

The writer has gathered from the newspapers, accounts of some other experiments, but these seem to be so erroneously or vaguely described that no instruction could be obtained by republishing them. It has been the aim of the writer throughout to gather all the information possible, but only to publish that which was reliable and instructive.

CONCLUSION.

Having thus passed in review the various attempts which have hitherto been made to compass artificial flight, there remains the task of pointing out as briefly as possible whether and how the information gathered may be made to conduce to a possible solution of the problem of aviation.

It was thought more effective to bring out the various theories of flight, and my own views, while describing the experiments, rather than to present them in a series of abstract statements and propositions, the immediate bearing of which might not be so evident. The reader has probably reached deductions of his own; but he may also wish to know my own general conclusions, and in what manner if any the many failures which I have described can be made to subserve eventual success.

These failures have resulted from so many different causes that it is evident that many conditions must be observed. These conditions virtually each constitute a separate problem, which can probably be solved in more ways than one, and these various solutions must then be harmoniously combined in a design which shall deal with the general problem as a whole. These various conditions, or problems, as I prefer to call them, may be enumerated as follows:

1. The resistance and supporting power of air.
2. The motor, its character and its energy.

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