

FILTRATION WITH FILTERS OF METALLIC FELT.

By CHARLES E. MUNROE.

To produce this filter I precipitated platinum chloride with ammonium chloride, using a slight excess of the reagent, and washed the salt thoroughly, first with water and then with alcohol. Then taking a Gooch filtering crucible of platinum, I placed it on a thick piece of bibulous paper and poured in the moist salt. The alcohol ran through the perforations in the crucible and was absorbed by the bibulous paper, while the salt remained behind, the filtering crucible being filled in this way to a height of about 5 mm. The crucible was then carefully cleaned and dried, the cap and cover put on, and the whole ignited, thus driving off the volatile constituents and leaving a spongy, coherent residue of metallic platinum well distributed over the perforated bottom of the crucible.

In order to prevent the sponge from cracking and curling, it was found essential to dry and ignite the salt quite cautiously, but in some instances where cracks did appear they were easily and effectually closed by gently rubbing with a glass rod, while in other cases the crevices were filled with a fresh portion of the ammonium platinum chloride and the drying and igniting repeated. The latter method was also employed when it was thought desirable to increase the thickness of the felt. After a short trial the preparation of the felt became quite easily and readily accomplished. The prepared filters are used in the same way as Gooch's asbestos filters are, the caoutchouc gasket described in my paper on the "Use of Porous Cones in Filtration" being employed to secure an air tight joint. The platinum felt may be easily removed, when desired, by means of a spatula, the small portions remaining in the perforations being pushed out with the point of a needle.

I have repeatedly prepared these filters in the manner above described, and have filtered with them such preparations as freshly precipitated barium sulphate to my entire satisfaction. Not only that, but by treating the precipitates with their proper solvents I have been able to clean the felt so that the same filter could be used repeatedly. The following data illustrates such use of this filter:

	Grms.
Weight of crucible and felt after first ignition	31.0612
Weight of crucible and felt after second ignition	31.0607
Weight of crucible and felt after rubbing with glass rod to remove thin spots	31.0607
Weight of crucible and felt after third ignition	31.0607
Weight of ditto after 250 cm. of water have been passed through ten times	31.0607
Weight of ditto after freshly precipitated CaC_2O_4 has been filtered upon it and ignited	31.5355
Weight of ditto after treatment with HCl, washing, and igniting	31.0634
Weight of ditto after same operation repeated	31.0609
Weight of ditto after same operation repeated	31.0608
Weight of ditto after BaSO_4 has been filtered upon it and ignited	31.4403
Weight of ditto after dissolving the BaSO_4 in hot concentrated H_2SO_4	31.0640
Weight of ditto after second treatment with H_2SO_4	31.0609
Weight of crucible complete	30.6744
Weight of felt	0.3863

Felts of this character may of course be obtained by similar means from easily decomposable salts of other metals than platinum, and such felts may be found to have useful applications.

It is probable that this method of producing a platinum sponge within a platinum tube may find useful applications in organic chemistry in addition to its use as a filter.—*Journal of Analytical Chemistry*, vol. ii., Part 3.

THE HISTORY OF A SCIENTIFIC DOCTRINE.

By S. P. LANGLEY.

"MAN, being the servant and interpreter of nature, can do and understand so much, and so much only, as he has observed, in fact or in thought, of the course of nature. Beyond this he neither knows anything nor can do anything."—BACON'S *Novum Organum*, aphorism 1.

In these days, when a man can take but a very little portion of knowledge to be his province, it has become customary that your president's address shall deal with some limited topic, with which his own labors have made him familiar, and accordingly I have selected as my theme the history of our present views about radiant energy, not only because of the intrinsic importance of the subject, but because the study of this energy in the form of radiant heat is one to which I have given special attention.

Just as the observing youth, who leaves his own household to look abroad for himself, comes back with the report that the world, after all, is very like his own family, so may the specialist, when he looks out from his own department, be surprised to find that, after all, the history of the narrowest specialty is amazingly like that of scientific doctrine in general, and contains the same lessons for us. To find some of the most useful ones, it is important, however, to look with our own eyes at the very words of the masters themselves, and to take down the dusty copy of Newton or Boyle or Leslie, instead of a modern abstract; for, strange as it may seem, there is something of great moment in the original that has never yet been incorporated into any encyclopedia, something really essential in the words of the man himself which has not been indexed in any text book, and never will be.

It is not for us, then, here to-day, to try

"How index learning turns no student pale,
Yet holds the eel of science by the tail,"

but, on the contrary, to remark that from this index learning, from these histories of science and summaries of its progress, we are apt to get wrong ideas of the very conditions on which this progress depends. We often hear it, for instance, likened to the march of an army toward some definite end; but this, it has seemed to me, is not the way science usually does move, but only the way it seems to move in the retrospective view of the compiler, who probably knows almost nothing of the real confusion, diversity, and retrograde motion of the individuals comprising the body, and only shows us such parts of it as he, looking backward from his present standpoint, now sees to have been in the right direction.

I believe this comparison of the progress of science to that of the army which obeys an impulse from one head has more error than truth in it; and though all similes are more or less misleading, I would almost prefer to ask you to think rather of a moving crowd, where the direction of the whole comes somehow from the independent impulses of its individual members, not wholly unlike a pack of hounds, which, in the long run, perhaps catches its game, but where nevertheless, when at fault, each individual goes his own way by scent, not by sight, some running back and some forward; where the louder voiced bring many to follow them, nearly as often in a wrong path as in a right one, where the entire pack even has been known to move off bodily on a false scent; for this, if a less dignified illustration, would be one which had the merit of having a considerable truth in it, but one left out of sight by the writers of books.

At any rate, the actual movement has been tortuous, or often even retrograde, to a degree of which you will get no idea from the account in the text book or encyclopedia, where, in the main, only the resultant of all these vacillating motions is given. With rare exceptions, the backward steps—that is, the errors and mistakes, which count in reality for nearly half, and sometimes for more than half, the whole—are left out of scientific history, and the reader, while he knows that mistakes have been made, has no just idea how intimately error and truth are mingled in a sort of chemical union, even in the work of the great discoverers, and how it is the test of time chiefly which enables us to say which is progress when the man himself could not. If this be a truism, it is one which is often forgotten, and which we shall do well to here keep before us.

This is not the occasion to review the vague speculations of the ancient natural philosophers from Aristotle to Zeno, or to give the opinion of the schoolmen on our subject. We take it up with the immediate predecessors of Newton, among whom we may have been prepared to expect some obscure recognition of heat as a mode of motion, but where it has been, to me at least, surprising, on consulting their original works, to find how general and how clear an anticipation of our modern doctrine may be fairly said to exist. Whether this early recognition of the atomic and vibratory theories be a legacy from the Lucretian philosophy, it is not necessary to here consider. The interesting fact, however it came about, is the extent to which seventeenth century thought is found to be occupied with views which we are apt to think very recent.

Descartes, in 1664, commences his "Le Monde" by a treatise on the propagation of light, and what we should now call radiant heat, by vibrations, and further associates this view of heat as motion with the distinct additional conception that in the cause of light and radiant heat we may expect to find something quite different from the sense of vision or of warmth; and he expresses himself with the aid of the same simile of sound employed by Draper over two hundred years later. The writings of Boyle on the mechanical production of heat contain illustrations (like that of the hammer driving the nail, which grows hot in proportion as its bodily motion is arrested) which show a singularly complete apprehension of views we are apt to think we have made our own; and it seems to me that any one who consults the originals will admit that, though its full consequences have not been wrought out till our own time, yet the fundamental idea of heat as a mode of motion is so far from being a modern one, that it was announced in varying forms by Newton's immediate predecessors, by Descartes, by Bacon, by Hobbes, and in particular by Boyle, while Hooke and Huyghens merely continue their work, as at first does Newton himself.

If, however, Newton found the doctrine of vibrations already, so to speak, "in the air," we must, while recognizing that in the history of thought the new always has its root in the old, and that it is not given even to a Newton to create an absolutely new light, still admit that the full dawn of our subject properly begins with him, and admit, too, that it is a bright one, when we read in the "Optics" such passages as these:

"Do not all fixed bodies, when heated beyond a certain degree, emit light and shine, and is not this emission performed by the vibrating motions of their parts?" And again: "Do not several sorts of rays make vibrations of several bignesses?" And still again: "Is not the heat conveyed by the vibrations of a much subtler medium than air?"

Here is the undulatory theory; here is the connection of the ethereal vibrations with those of the material solid; here is "heat as a mode of motion;" here is the identity of radiant heat and light; here is the idea of wave lengths. What a step forward this first one is! And the second?

The second is, as we know, backward. The second is the rejection of this, and the adoption of the corpuscular hypothesis, with which alone the name of Newton (a father of the undulatory theory) is, in the minds of most, associated to-day.

Do not let us forget, however, that it was on the balancing of arguments from the facts then known that he decided, and that perhaps it was rather an evidence of his superiority to Huyghens that, apprehending before the latter, and equally clearly, the undulatory theory, he recognized also more clearly that this theory as then understood failed utterly to account for several of the most important phenomena.

With an equally judicial mind, Huyghens would perhaps have decided so too, in the face of difficulties, all of which have not been cleared up even to-day.

These two great men, then, each looked around in the then darkness as far as his light carried him. All beyond that was chance to each; and fate willed that Newton, whose light shone farther than his rival's,

found it extend just far enough to show the entrance to the wrong way. He reaches the conclusion that we all know; and with the result on other men's thought that, light being conceded to be material, heat, if affiliated to light, must be regarded as material too, for we may see this strange conclusion drawn from experiments of Herschel a century later.

It would seem that the result of this unhappy corpuscular theory was more far-reaching than we commonly suppose, and that it is hardly too much to say that the whole promising movement of that age toward the true doctrine of radiant energy is not only arrested by it, but turned the other way; so that in this respect the philosophy of fifty years later is actually farther from the truth than that of Newton's predecessors.

The immense repute of Newton as a leader, on the whole so rightly earned, here leads astray others than his conscious disciples, and, it seems to me, affects men's opinions on topics which appear at first far removed from those he discussed. The adoption of phlogiston was, as we may reasonably infer, facilitated by it, and remotely Newton is perhaps also responsible in part for the doctrine of caloric a hundred years later. After him, at any rate, there is a great backward movement. We have a distinct retrogression from the ideas of Bacon and Hobbes and Boyle. Night settles in again on our subject almost as thick as in the days of the schoolmen, and there seems to be hardly an important contribution to our knowledge, in the first part of the eighteenth century, due to a physicist.

"Physics, beware of metaphysics," said Newton—words which physicists are apt so exclusively to quote, that it seems only due to candor to observe that the most important step, perhaps, in the fifty years which followed the "Optics" came from Berkeley, who, reasoning as a metaphysician, gave us during Newton's lifetime a conception wonderfully in advance of his age. Yet the "New Theory of Vision" was generally viewed by contemporary philosophers as only an amusing paradox, while "coxcombs vanquished Berkeley with a grin;" and this contribution to science—an exceptional if not a unique instance of a great physical generalization reached by *a priori* reasoning—though published in 1709, remains in advance of the popular knowledge even in these closing years of the nineteenth century.

In the meantime a new error had risen among men—a new truth, as it seemed to them, and a thing destined to have a strong reflex action on the doctrine of radiant energy. It began with the generalization of a large class of phenomena (which we now associate with the action of oxygen, then of course unknown)—a generalization useful in itself, and accompanied by an explanation which was not in its origin objectionable. Let us consider, in illustration, any familiar instance of oxidation, and try to look first for what was reasonable in the eighteenth-century views of the cause of such phenomena.

A piece of dry wood has in it the power of giving out heat and light when set on fire; but after it is consumed there is left of it only inert ashes, which can give neither. Something, then, has left the wood in the process of becoming ashes; virtue has gone out of it, or, as we should say, its potential energy has gone.

This is so far an important observation, extending over a wide range of phenomena, and, if it had presented itself to the predecessors of Newton, it would probably have been allied to the vibratory theories, and become proportionately fruitful. But to his disciples, and to chemists and others, who, without being perhaps disciples, were like all then, more or less consciously influenced by the materiality of the corpuscular theory, it appeared that this also was a material emanation, that this energy was an actual ingredient of the wood—a crudeness of conception which seems most strange to us, but it is not perhaps unaccountable in view of the then current thought.

I have said that the progress of science is not so much that of an army as of a crowd of searchers, and that a call in a false direction may be responded to, not by one only, but by the whole body. In illustration, observe that during the greater part of the entire eighteenth century this doctrine was adopted by almost every chemist and by most physicists. It had quite as general an acceptance among scientific men then as the kinetic theory of gases, for instance, has now, and so far as time is any test of truth, it was tested more severely than the kinetic theory has yet been; for it was not only the lamp and guide of chemists, and to a great extent of physicists also, but it remained the time-honored and highest generalization of chemico-physical science for over half a century, and it was accepted not so much as a conditional hypothesis as a final guide and a conquest for truth which should endure always. And now where is it? Dissipated so utterly from men's minds that, to the unprofessional part of even an educated audience like this, "phlogiston," once a name to conjure with, has become an unmeaning sound. There is no need to insist on the application of the obvious moral to hypotheses of our own day. I have tried to recall for a moment all that "phlogiston" meant a little more than a hundred years ago, partly because it seems to me that, though a chemical conception, physics is not wholly blameless for it, but chiefly because before it quitted the world it appears to have returned to physics the wrong in a multiplied form by generating an offspring specially inimical to true ideas about radiant heat, and which is represented by a yet familiar term. I mean "caloric."

This word is still used loosely as a synonym for heat, but has quite ceased to be the very definite and technical term it once was. To me it has been new to find that this so familiar word "caloric," so far as my limited search has gone, was apparently coined only toward the last quarter of the last century. It is not to be found in the earliest edition of Johnson's Dictionary, and, as far as I can learn, appears first in the corresponding French form in the works of Fourcroy. It expressed an idea which was the natural sequence of the phlogiston theory, and which is another illustration that the evil which such theories do lives after them.

"Caloric" first seemingly appears, then, as a new word coined by the French chemists, and meant originally to signify the unknown cause of the sensation heat, without any implication as to its nature. But words, we know, though but wise men's counters, are the money of fools; and this one very soon came to commit its users to an idea which was more likely to have had its origin in the mind of a chemist at that time than of any other—the idea of the cause of heat

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