PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1893-4.

Annual Business Meeting.

Province Building, Halifax, 8th November, 1893.

M. Murphy, D. Sc., C. E., *President, in the Chair.*

The minutes of the last annual meeting were read and approved.

The President addressed the Institute, reviewing the progress of the past year.

On motion of Dr. J. Somers and Principal P. O'Hearn a vote of thanks was tendered to Dr. Murphy for his services as President during the last three years.

The Treasurer presented his annual report, shewing the Institute to be in a satisfactory financial condition.

The Curator of the Library presented his annual report, shewing a continuation of the rapid growth of the last few years.

The following were elected office-bearers for the ensuing year :—

President—Professor George Lawson, Ll. D.

Vice-Presidents—H. S. Poole, F. G. S., and A. H. MacKay, Ll. D.

Treasurer—W. C. Silver.

Corresponding Secretary—Professor J. G. MacGregor.

Recording Secretary—A. McKay.

Librarian—Maynard Bowman.

Councillors without office :—M. Murphy, D. Sc., E. Gilpin, Ll. D., A. P. Reid, M. D., J. Somers, M. D., H. Piers, F. W. W. Doane, C. E., and A. Allison.

Auditors—S. A. Morton, M. A., and M. Shine.

FIRST ORDINARY MEETING, Province Building, Halifax, 8th November, 1893.

DR. MACKAY, VICE-PRESIDENT, *in the Chair.*

Inter alia,

Professor J. G. MacGregor read a paper entitled : "On the Isothermal and Adiabatic Expansion of Gases."

SECOND ORDINARY MEETING, Province Building, Halifax, 11th December, 1893.

The PRESIDENT *in the Chair.*

Inter alia,

Dr. J. Somers read a paper entitled : "Notes on Native Forms of Juniperus and Lanius Borealis."

Principal Marshall, of Richmond, N. S., made a statement of facts with regard to what appeared to be a shower of worms. He said :—

In the spring of 1890, while residing in Middleton, Annapolis Co., I observed one morning after a shower of rain with high wind from the south-east, that there were about two dozen earth worms in a molasses cask which was standing so as to catch the water from a spout that was connected with a trough placed under the eaves of the barn. I had been to the cask for water several times the day before and had not noticed them there, and I felt sure that they could not have crawled in over the side of the cask, for it was 3 ft. 8 in. high. I got a ladder and climbed to the roof to see if there was any dirt in the trough in which they might have lived until brought down by the rain. I did not find any earth in which they might have lived, but I found more than a dozen worms sticking to the roof with one end dried fast to the shingles as if they had struck against it with some force and had been partly crushed and killed. When I came down from the roof I examined the wall and found several worms crushed against it. They were on the middle and western part of the wall and roof. I could not discover any on the eastern end, nor on other buildings standing on that side of the barn. There were no buildings at the western end, so I could not determine where, in that direction the limit would have been, if there had been a wall to receive them. As it was they were scattered over a wall about fourteen feet square, and over the side of a roof fourteen feet long and twelve wide. The soil to the south of the barn is sandy and nearly all covered with a grass sod. There were no large trees near the building.

The PRESIDENT, Prof. G. Lawson, read a paper entitled : "Remarks on Some Features of the Kentucky Flora."

On motion of Prof. J. G. MacGregor and Dr. A. H. MacKay the following resolution was passed :—*Resolved,* That the Council be instructed to address a memorial to the Dominion Government setting forth the advantages of low postal rates on natural history specimens, both in facilitating the progress of the various departments of natural history and in making known the natural resources of the country, and praying the said Government to take steps to secure throughout Canada and the postal union the same rate of postage on scientific specimens as is at present provided for in the case of samples of merchandise.

THIRD ORDINARY MEETING, Provincial Museum, Halifax, 8th January, 1894.

The PRESIDENT *in the Chair.*

Inter alia,

Dr. E. Gilpin, Deputy Commissioner of Mines, read a paper entitled: "On the Nictaux Iron Ore Field."

F. W. W. Doane, C. E., read a paper entitled: "On the Operation of the Kennedy Scraper, and the Cause of Recent Failure."

FOURTH ORDINARY MEETING, Provincial Museum, Halifax, 12th February, 1894.

The PRESIDENT *in the Chair.*

Inter alia,

The PRESIDENT, Prof. G. Lawson, read a paper entitled: "On the Botanical and Commercial History of Nova Scotia Foxberries."

A paper by G. H. Cox, B. A., entitled: "List of Plants Collected in and aronnd the Town of Shelburne, 1890-93," was read by the President.

FIFTH ORDINARY MEETING, Province Building, Halifax, 12th March, 1894.

The PRESIDENT *in the Chair.*

Inter alia,

A paper by Principal A. Cameron, of Yarmouth, N. S., entitled: "Notes on Venus,—Morning and Evening Star at the same time," was read by the Secretary.

A paper by Mr. F. J. A. McKittrick, of Kentville, N. S., entitled: "On the Measurement of the Resistance of Electrolytes,"—and containing the results of a series of experimental observations made in the Physical Laboratory of Dalhousie College, was read by the Secretary.

A paper by Mr. D. M. Bliss, Am. Inst. Elec. Eng., entitled: "The Coming Development of Artificial Illumination," was read by the Secretary. The following is an extract from this paper:—

"While a great advance in artificial illumination has been made in the direction of convenience, brilliancy and flexibility, yet it would be hard to find a branch of applied science in which so little improvement in efficiency has been made. And no process is so wasteful of precious energy as this we are now considering.

To the unreflecting mind it would seem that the principle involved in the production of light by the wavering flame of the tallow dip is very different from that brought into action in the electric light, arc or incandescent; but a little thought will serve to convince one that the principles involved in both cases are the same, and indeed the first rays that burst on the astonished gaze of some ancient investigator as he lit the first torch, proceeded from the same source as those in the less unsteady but more expensive illumination of the "fin de siècle age.

In the tallow dip we have a crude retort, producing hydrogen which while burning raises to a white heat, the minute particles of carbon set free in the action of combustion, and by far the greater part of the potential energy present is wasted in producing carbonic acid and water or in the form of heat waves, leaving but a small portion of energy to be converted into light waves. The same action of course takes place in the oil or gas light, the advantage in the latter, from an economic point of view being the production of the carbon-charged Hydrogen at a central point (the gas house) where a given amount of gas can be produced under much better conditions than can be obtained in the numerous and tiny individual gas retorts of the candle or oil lamp.

In an electric light whether arc or incandescent, the principle remains the same and it is not the electric current we see but highly heated carbon, and the energy necessary to heat the carbon points or filament to the proper illuminating point is obtained from the coal under the boilers of the electric light station through the medium of the rapidly revolving wires in the dynamo cutting the unseen but all powerful lines of force of the magnetic field, and not from a direct chemical process as in the other examples of light.

Now the modern dynamo, as a machine for the conversion of mechanical into electrical energy, is a most efficient apparatus, and usually returns in the form of electricity, 90 to 95 per cent. of the mechanical energy put into it, a result we may well be proud of when it is considered that with the most efficient steam plant not more than 5 per cent. of the energy possessed by the burning coal is converted into mechanical energy in the engine ; and as regards the systems of distritribution, the loss is not, or need not be, more than 5 to 10 per cent. in transmitting the electrical energy to the points of conversion.

And so we find that here at the point of conversion into light (or the lamps) the greater part of the waste takes place ; and as there is not the same chemical action in this light as in the oil or gas flame, we do not find this waste in the form of carbonic acid or water, but almost wholly in heat waves or invisible and therefore useless radiation. Now so long as we utilize carbon as the source from which to obtain light so long will we have this waste of energy in heat, as heat alone, whether it be furnished by the gas flame or electricity, will produce (in carbon) the necessary molecular action resulting in light waves. So it seems probable that we shall employ other processes and proceed on new lines before any great advance can be made in illumination.

In the light of the future, energy (probably electrical) will be converted into luminous waves with a loss not exceeding, say, 5 to 10 per cent. in heat ; the light will be practically cold ; and the power now required for one 16 c.p. lamp will give us twenty. In looking for an example of a light of this character we naturally think of the fire-fly and glow-worm, both of which may be said to be good examples of a perfect light, at least as far as efficiency goes. Careful tests have been made on the light emitted by the fire-fly, and the results show that it is practically heatless, less than 2 per cent. of the total radiation being in the form of heat waves. It is true that the secret of its production has not yielded to our tests, but we hope that, like many of nature's formulæ, it will be solved, and the result attained after careful and persistent investigation ; and the fortunate individual who succeeds in penetrating her laboratory and secures the formula for heatless light will win fortune and undying fame.

Another line of investigation which looks inviting is that of phosphorescence and storage of light waves as exhibited by calcium sulphide or luminous paints ; and it is within the range of probability to suppose that a luminous compound will be discovered that will store up the rays of the sun and return them to us when needed at night, not in the feeble glow of the luminous match safe, but with a brilliancy sufficient for all purposes of illumination.

Those who have witnessed Tesla's experiments at the World's Fair will remember the particularly brilliant effect produced when the talented experimenter held in his hand a large glass tube containing but a trace of air and which, though totally disconnected from any visible circuit, glowed with a soft pulsating light of considerable intensity but practically heatless, and we have been told that in the near future we shall light our houses by placing metalic plates on the walls of our rooms and connecting them with a source of a high potential and frequency, and our lamp being simply an exhausted bulb or globe will glow in any part of the room and will need no connection, the light being produced by the rapidly changing electrostatic stress between the walls of the room or plates.

Unfortunately, however, in this method which uses such extremely high potentials and frequencies the ordinary methods of transmission or wiring fail and the effect more nearly approaches the rapidly alternating discharge of lightning in that a metalic circuit is practically opaque, so to speak, to a current of say 1,000,000 volts and the same number of alternations. The self-induction of such a circuit with currents of moderate potential and frequency would be practically nothing, but is something enormous with the above pressure and frequency, and so far as we can see this system if it attains to any degree of perfection will have a very limited field from this effect alone, to say nothing of the severe dielectric stresses.

Whether electricity will play an important part in the light of the future or not is a matter of speculation, and it would not be strange if the coming system were largely a chemical one, though electricity will no doubt be the form of energy used to the points of conversion. However, in any case our present electric light plants will not go out of existance, but will fully occupy the field they are only now entering, for the distribution of power and heat for all purposes.

In conclusion, it may be said that no field is so rich and none so pregnant with good possibilities, but the problem must be worked out on new lines, bearing in mind that any light that depends on carbon as the source of illumination will inevitably consume 90 per cent. of the energy put into the process, in the form of heat, and it matters not whether this energy is supplied by burning gas or the electric current, the results are practically the same, and no great improvement can be obtained till we find out how to separate heat and light, or produce either form of radiation at will."

Mr. John Forbes, of Halifax, addressed the Institute on "Some Modern Methods in Manufacturing with certain Analogies suggested by a Partial Study of the Evolution and Nature of some of the Processes Employed," as follows :—

"The question as to what constitutes raw material is one which has frequently been written about and discussed in its relation to political questions of the day, but our mention of the question at this time is not intended or calculated to excite either sympathy or prejudice in any one on account of its political significance. It is sufficient for us now to suggest that no material used in the arts is qualified to serve any very large useful purpose until it has passed through the hands or machines of some of the numerous classes of manufacture. In this, however, we are met by the reflection that man cannot lay claim to exclusiveness in the manipulation (if the use of the word is permissible) of raw materials in order to fashion them into such shapes and conditions as to subserve his comfort or convenienoe. Perhaps the most that man can claim is the superior ingenuity which enables him to observe the results, defective or otherwise, of past efforts, and improve upon them, or to profit by his observation of results, as the product of what he may thereafter learn to regard as natural laws.

Amongst the first considerations to which we are led by the line of thought now reached is, the great variety of materials which man has thus brought into usefulness, and made available for his comfort and convenience.

Some of these materials he is enabled to use in the state in which nature supplies them to his hand, but far the greater number he has to obtain at the expenditure of a large amount of labor and by the aid of processes, the understanding of which comes very slowly, and to the understanding of which he has to bring large powers of observation, reasoning and experiment.

Several reflections resulting from a desultory consideration of the subject have induced the writer to observe certain seeming analogies between the older and crude methods employed and the refined modern methods now in use, and to regard with interest the seeming inductiveness of the processes and operations which have resulted in our present condition of refinement in some of the branches involved.

I feel, however, that some apology is due to the Institute for trespassing upon its time by presenting a paper which is so retrospective and so historical in its character, but which, if time and opportunity permitted, I have thought might, if the council approved, be with profit divided into several papers, the preparation and presentation of which would probably be both interesting and profitable.

Pre-eminently above all other materials which man has turned to useful account and rendered by his multifarious adaptations, indispensable is the metal iron.

Man's acquaintance, in a measure at least, with some of the uses of this metal may with reasonable assurance be conceded as antedating authentic history, yet its adaptations were unquestionably restricted to articles of small character, consisting very probably of articles of personal adornment and of tools for the working and fashioning of other and softer metals and materials, and weapons of war and of the chase. It is not difficult to frame an interesting and fairly warrantable theory as to the manner of its discovery. The facility with which small masses of iron can be obtained from some of its ores by simply digging a hole in a bank of earth suitably situated, charging the same with ore and fuel and permitting the wind to blow favorably upon the arrangement so as to fan the fuel to the requisite heat, suggests the accidental production of the metal as the result of forest fires ; and the discovery of small lumps which might be found upon the ground,—after the conflagration—would naturally suggest the inference that the metal was the product of the action of the fire upon certain masses of brown earth or ore which might be found upon the ground in the vicinity.

Job 28th and 2nd : "Iron is taken out of the earth, and brass is melted out of the stone."

Deuteronomy 8th and 9th : "A land whose stones are iron, and out of whose hills thou mayest dig brass."

The iron rocks of Elba, Styria and Spain, and the processes employed for the reduction of the metal, are described by writers before the Christian era, the product being exported to other countries, notably to Italy, to be used in the production of tools ; but the methods employed were evidently not very reliable and the product not uniform, as historians of the second century complained that the knives, although very hard, were so brittle that the cutting edge splintered off, which was probably due to the inferior quality of the steel of which they were made and imperfect knowledge as to the working of it. I should remark that I can not claim any originality in this paper, not even to researches at first hand from the old writers themselves, but am indebted to well known treatises upon the subject by able writers and investigators.

It seems probable that the grade of the metal, which we know as steel, was known and utilized by the ancients about as early as the purer metal ; in fact, we think it not improbable that the different qualities of the ore obtained from different localities governed the uses which were made of the several products. It would seem also that the rude processes employed for the extraction of the metal rendered the resulting material a somewhat uncertain matter, a large part of the metal in the shape of pig metal or cast iron being thrown away with the slag as a product for which, for a very long period, and in fact up to a comparatively recent era, no use was found. Egyptians sculptures antedating the christian era by 1500 years or more, represent workmen or smiths, operating bellows for blowing the fire used in the production of the metal from the ore, or in the subsequent operations of fashioning it into the articles for which it was found to be adapted, and we think it very reasonable to conceive that this recognized means of urging the fire by a forced blast of atmospheric air, directed upon and amongst the molten mass was the initial discovery which might be established as the link, which has connected the crude processes of the ancients with the magnificent achievements of chemistry in its application to modern metallurgy, the analogy being found in the different effects, which were evidently known to the ancients, of so manipulating the tuyeres and blasts of air, at certain stages of the operation as to produce the desired result, at times intensifying the heat and reducing the metal and then if metal of a steely character were wanted enabling the metal, after its extraction from its earthy oxides, to become impreguated with carbon from the fuel.

The processes were without doubt only experimental, and not understood, some workmen probably operating successfully with some ores and other workmen realizing success from other ores, as their experience had taught them. But in modern times the Bessemer and the Siemens-Martin processes bring about the desired results in a similar although in a more refined manner and with a know ledge of the rationale of the processes involved. It seems rather surprising that the extraction and use of the metal in its malleable character was known for so long a period before its usefulness in the molten and fluid state were recoguized. It would seem from the records that among the first uses for which cast iron was found suitable was in the production of cannons, which is stated to have been accomplished in the thirteenth century.

But it seems to have been much later than this before it was learned that the best way to obtain the metal in its malleable condition was to first arrange for its combination with carbon and run it out of the furnace in the shape of pig or cast iron, and then get the purer metal by burning off the carbon by a plentiful supply of oxygen under a forced blast of atmospheric air, and it is, we think, an interesting reflection that for probably thousands of years those engaged in the operations of iron extraction had been frustrated in their efforts by the accidental conversion of the metal into a state which was useless to them, but which really formed part of the correct process for its economic recovery.

Perhaps it may be well quite briefly to re-state some facts in connection with the matter, viz. : There are two general processes by which the metal may be revived from its ores; one is called the direct process, and consists in subjecting the ore to the action of incandescent fuel in connection with a free supply of air, the air being forced in and among the mass by some means for maintaining a continued blast under pressure. This direct process requires that it is shall be discontinued as soon as the ore has given up its oxygen to the carbon of the fuel, at which stage the particles of the metal cohere in a pasty mass of malleable iron.

If now, instead of stopping the operation at this stage, the process is continued, a result will follow which constitutes the first stage in what may be termed the second or indirect process. This result is, that the metal takes up a portion of carbon from the fuel and becomes more easily fusible and thus passes to a molten state, and becomes what is known as pig iron.

If now, a further continuation of the process is maintained, and a constant stream of air is forced over and amongst the mass of molten metal, the oxygen from the air will combine with the carbon in the iron and the metal will again assume the plastic condition of a highly heated mass of malleable or decarbonized iron. The ancients, as before stated, were only acquainted with the uses of the metal in its malleable condition and so of course aimed at its production by the direct process, but, doubtless accidents at times occurred when their aims were frustrated either by too much fuel or too prolonged a continuance of the operation, and so cast or pig metal was the result; but, although probably things were taken for granted with greater readiness than now, yet it is not, we think, attributing too much intelligence to the smiths and metallurgists of old to imagine them as asking themselves how such and such a result could come about, and when, as probably occurred, it was found that the fuel becoming exhausted and the supply of air being kept up the pasty condition of the metal again ensued, we think it not too much to assume that the chemistry of the subject became a matter of consideration and study. It will of course be borne in mind that many impurities exist in the ore, and are to be got rid of besides the oxygen which seems to be its most intimate friend, but it was not our wish to take the chemistry of the process into consideration, and we propose only to speak of the principal causes of the difference in the constitution of the metal in the three principal characters under which it is known, viz.: as wrought iron, cast iron, and steel. Now, barring the different qualities of ore—that is, the different combinations of the metal with other matters than oxygen as found in different ores—and hence the different qualities of metal obtainable; the only difference in the three phases of the metal named consists in the different proportions of carbon with which it becomes impregnated either designedly or by accident. It is proper to remark that the fuel used by the ancients, and indeed down to the close of the 16th or commencement of the 17th century was wood charcoal. This gave the early producers a great advantage, as the use of so pure a carbon prevented in a great measure the introduction of other impurities, except as they might exist in the ore itself, to some of which, notably sulphur and phosphorous, the metal exhibits great affinity and great reluctance to separate from. We are here met by the reflection that if no other means of obtaining iron had been discovered except the old method, and the employment exclusively of wood charcoal as fuel, the advance of the world in the magnificent strides of the present century would have been simply impossible, for the forests would not have sufficed to supply the amount of charcoal needed for the purpose.

In consequence of the lack of knowledge of the uses of mineral coal the demand upon the forests of England for the supply of wood charcoal for iron making was so great that in Queen Elizabeth's reign a law was passed prohibiting the extension of the iron manufacture in certain districts.

In consequence of which law efforts were made to use the mine coal, which was then coming into use as a fuel. These efforts were however strenuously resisted by the manufacturers operating with the wood charcoal, and it was only in the early part of the 18th century that full success in the use of mineral fuel in the production of iron was realized.

We must now again revert to the statement already made that the ancients only practised the production of iron by the direct process, but they also at a very early period learned to produce steel, as Aristotle is said to have described the process of making steel in India, and it was without doubt known that ores found in certain localities were adapted to the more ductile requirements of the producers, and other ores to the requirements of the steel makers. However, from the very long time which seems to have elapsed before the production of steel from iron itself, after its reduction from the ore, it would seem to be a fair inference that the rationale of the process was not at all comprehended. The production of steel by the process known as cementation is based upon the readiness with which the metal in a heated state combines with carbon. Now, while it would have been known that certain different conditions of the metal were produced by different manipulations of the fire in which it was produced, yet ignorance of the chemical constituents of fuel and air prevented the comprehension of the processes. But we think the process of cementation for converting the soft iron into steel was not very difficult to evolve. The reasoning was comparatively easy, that the iron was in some way affected by the presence of the charcoal when both iron and charcoal were red hot, and the experiment would, we think, be naturally suggested, to try the effect of the combination after the iron had been obtained, had become cold and had again been heated. The process of cementation for producing steel consists in placing bars of soft iron in contact with charcoal in a suitable vessel and luting the joints of the vessel well with a suitable clay to prevent the access of air, the wasting effect of the action of the air upon the metallic iron when red hot, being known by those who were engaged in such occupations as to afford them the opportunity for observation, the effect of air combining with the heated charcoal and thus preventing the carbon from combining with the iron, by its greater preference for combination with the carbon, would have been a lesson upon which a long previous experience would have afforded unquestionable instruction.

After being thus properly luted and prepared, the pots or chests containing the alternating layers of iron and charcoal are subjected to a strong heat from furnaces suitably arranged, and the heat being kept up for a sufficient length of time (some four to eight days) the whole is then allowed to cool, and after being taken out of the pots or boxes, the carbon (from the charcoal and other carbonizing materials) is found to have entered in combination with the iron, which is also found to be covered with small blisters resulting from the expanding effects of the gases evolved in the process of combination.

The iron which has been thus treated is now known as blistered (or blister) steel, and for a long time (or until the middle of the 18th century) this material made from different qualities of bar iron was used for various purposes in which steel was required. It was also learned that steel thus made could be welded to its more ductile cousin, decarbonized iron, and thus tools could be prepared which, in consequence of their combined qualities, could be made hard by tempering the steel part, while the softer backing afforded by the iron to which it was thus united permitted the cutting part to be made harder with less tendency to break or twist out of shape in the process of hardening. Also, as the steel part was more expensive than the iron part, economy was effected in thus not having to make the entire article of the more expensive material.

But as time passed on and the required uses for steel became more numerous, and more exacting as to the character of the steel required, it was found that a more uniform and stronger steel was needed, and as the reasoning powers of man acquired a greater strength for wrestling with the problems afforded by the necessities of the case, and the artizan and the investigator realized that we are "the heirs of all the ages in the foremost files of time," so we think the reasoning became not so very profound which enabled Huntsman to conclude that as iron when combined with carbon fuses at a much lower heat than the purer iron, and, as might be easily reasoned, the blister steel could thus be melted, (an experiment would demonstrate the fact), and as it had been required to exclude the air while making the blister steel, so also it would be needed to exclude, at any rate in a measure, the air from the blister steel when so fused, and also that this fusing and blending, so to speak, of the mass by mixing it well while in a state of fusion would materially assist in rendering the metal much more uniform. This seems to have been the way in which the change from blistered steel to its more uniform and denser relative cast steel was effected. This improvement is said to have been effected by Benjamin Huntsman about 1740 in a little town near Sheffield. It is said that Huntsman and his family enjoyed an enviable success as steel makers, and as the process employed by them was kept a profound secret their success naturally aroused the cupidity of his less fortunate competitors who were engaged in the productions of those articles, for which this improved steel was especially adapted, and, as the story goes, on a very stormy night when Huntsman and his workmen in an apartment brightly lighted by the fires were employed in these metallurgical operations, a traveller besought permission to enter and escape for a while the inclemency of the weather, and admission having been obtained the stranger lay down upon the floor and soon feigned sleep, but during the operation of melting and pouring the molten steel he "kept his weather eye open" and became acquainted with the secrets of the process.

It is reasonable to assume that a part of the secret lay in mixing with the molten steel fragments of a more highly carbonized metal, such as had been produced by the direct process, and so, from that time on, various improvements were from time to time effected in the composition, adapting it ultimately for the great variety of purposes for which this most indispensable combination of iron and carbon is so eminently useful.

But while these several processes were being developed for the productien of steel, and of different kinds or qualities of steel, adapted to the various purposes for which steel was necessary, the demands for malleable iron in much greater quantities than previously, stimulated continued efforts to cheapen *its* production and improve its quality. One of the most important advances in this direction was made towards the latter part of the 18th century when it was learned that more energetic mechanical agitation of the metal while in a molten state, in the presence of a blast of air, facilitated the decarbonizing process from the condition of cast iron to that of malleable iron, and the operation of puddling was perfected. In this process the molten metal is continually stirred and agitated by the workmen with the aid of a kind of hook or "rabble" so called, and by this means new surfaces and portions of the molten iron are successively exposed to the decarbonizing effects of the stream of air thrown into the furnace while the process goes on. After a while the refined portions of the metal begin to stick together and the workman, with the aid of his rabble, collects together enough to constitute a ball which he pushes to one part of the furnace while he continues the process and gathers together successively ball after ball until as much as possible of the metal has been recovered from the mass of molten slag and scoria which remains in the furnace, this is then drawn off at suitably prepared orifices and the furnace prepared for another charge. These balls or spongy masses of malleable or decarbonized iron, glowing with a brilliant white heat, and dripping with fluid slag or scoria which is contained in their numerous cracks and fissures, are then taken and subjected to the action of powerful squeezers, or sometimes steam hammers, which acting upon the balls while in the soft and plastic state in which they are taken from the furnace, squeeze out as much as possible of the impurities which are contained in their mass, and they are then passed through heavy roughing rollers and reduced to the shape of a rude bar of a flattened form, say from 6 to 10 inches wide by some 1 inch to 1½ inches thick, called muck bars. These bars, after being allowed to cool, are then cut up into pieces some two feet long and piled one upon another forming a pile some 8 inches deep. A number of these piles are then taken and placed in a furnace where they are again heated to a welding heat, and are then again passed successively through a number of suitably shaped rolls, and so fashioned into bars and adapted for sundry purposes. It must now be noticed that the operation just described and the forming of the mass into bars depended entirely for its success upon the quality possessed by iron, of being plastic at a certain high temperature, and also that at this temperature, called a welding heat, its particles when brought together will cohere, and may, by being pressed forcibly together while at this heat, be formed into a solid mass, but there are sundry exceptions to this result, for instance if some of the liquid slag or other impurities remains between the particles of the metal, or between the surfaces to be united, then the union will not be a perfect one, and a condition of the metal known as "seamy" will result. This seamy condition rendered the metal quite unfit for many purposes, and although very fine results were obtained in course of time by careful management and by refining, as well as by compacting the mass by very powerful mechanical appliance, yet there were some features in the structure of the material which suggested the need of efforts to obtain a metal possessing greater homogeneity.

The constantly increasing demands made upon the metal by very numerous new uses which were found for it also stimulated the thoughts and investigations of the ablest minds. Physics and chemistry joined hands in endeavouring to realize what seemed within the bounds of practicability, viz., to evolve some means of producing an iron which should meet the exacting demands of new inventions, and their application in enterprises of an importance and magnitude theretofore almost undreamed of.

We have noted the difficulty which occurs when impurities, such as are always present in some degree with malleable iron, are contained between the numerous fissures in the spongy mass. It is almost impossible to get rid of them, and the result is they get rolled or hammered into the mass of the metal in the succeeding processes to which it is subjected in the course of its preparation for the market.

In the process of rolling, these impurities become drawn out into fine longitudinal defects, sometimes involving an entire lamina, and sometimes in defects of less extent. As the masses of metal turned out from the furnaces increased in size, so the hammers and rolls required to deal with these masses had to be also increased in size and power, but yet these improvements did not meet the case in furnishing a metal free from the troubles named. Very much ingenuity however was displayed in efforts to improve these tools so as to give a greater economy in the production and also greater freedom from the imperfections complained of.

As it is but a few years, not more than from 30 to 50 years, or less, since some of the more important of these inventions came into usefulness, it is difficult for us to realize how much they have contributed to possibilities that now seem to be so easy of accomplishment.

For a number of years after the art of rolling became known, only two rolls arranged one above the other were used, and in consequence the bar or sheet of metal, after passing through the rolls in one direction, had to be transferred again to the side from which it had passed through, in order to make another pass. This objectionable loss of time was overcome by arranging three rolls superposed, one above another, called three high rolls, and this permitted the passage of the bar or sheet of metal from either side between one pair of the three, no matter on which side the sheet or bar might happen to be. This arrangement not only saved time but caused the metal acted upon to be elongated alternately from each end instead of being acted upon always in one direction.

Another improvement was also made upon the rolls by which while the metal was receiving the effect of one pair of rolls in one direction another pair of rolls was at the same time acting upon it in a direction perpendicular to the plane of action of the initial pair. This principle was only applicable to the rolling of quarilateral or rectangular forms of cross section.

But there was one serious defect which existed in and was absolutely inseparable from all malleable iron which was fashioned into merchantable shapes by the rolling process, and that was the effect produced by the process of rolling upon iron which had been welded up in its mass in the process of production. The effect was, that there was organized and maintained by the rolling process a well defined fibrous structure of the metal, which, while it did not diminish its resistance in a direction parallel to the fibre, yet it very materially interfered with its strength in a direction at right angles to the fibre, and although for many purposes this did not so much matter, yet there were other uses in which this feature was a serious difficulty. This led to investigations with a view to obtain a homogenous metal, and it was easily comprehended, at this stage in the metal's history, that this condition required that such a metal should be produced by a process of fusion and pouring instead of by the method of welding theretofore practised. Several processes were devised with a view to obtain this much desired homogeneity: some proposed to decarbonize the molten pig iron by mixing with it as it poured from the furnace, powdered and highly oxidized ore, to operate in reducing the portion of carbon to such a small degree that its presence would not be objectionable, a proportion of one quarter of one per cent. having been found to be no serious objection unless the iron is required for smithing or welding purposes.

At this stage it was proposed by Mr. Bessemer to put the molten metal into a suitable vessel and blow air under pressure through the mass in order to burn up the carbon by admixture with oxygen; other processes were made passible by the discovery by Mr. afterwards Sir Wm. Siemens, of a means of obtaining much more intense heat in furnaces by using the waste heat of a present conduct of operations to heat up a nest of refractory brickwork, through which in turn the air for a continuation of the processes of the furnace is in succession drawn. The intense heat thus obtainable would have rendered possible the fusion of even the malleable iron, but in the progress of experimenting it was found that with this furnace a charge of metal could be kept in a state of fusion while tests of the constitution of its charge were being made, and the correct or desired result having been thus reached, the whole charge could then be drawn off into ingots to be shaped into the desired shapes as required. This, with the further improvements in the method of Bessemer, principally the invention of Mr. Mushet, whereby the charge was suitably mixed with a certain kind of steely ore, very soon solved the problem of how to produce a homogenous iron, and the result is that today metal of the iron family can be obtained of every conceivable quality and capable of supplying the needs of the most exacting purposes.

The value of this feature of homogeneity is one which it is scarcely possible to over estimate, and, having arrived at this most satisfactory stage of the history of the iron manufacture, we are now enabled to solve problems in the application of the metal to various uses, and the production of articles from it in ways that up to a comparatively recent period, would have been simply impossible."

SIXTH ORDINARY MEETING, Church of England Institute, Halifax, 9th April, 1894.

The PRESIDENT *in the Chair.*

Inter alia,

A paper was read by Dr. D. A. Campbell, entitled : "General Considerations concerning Bacteria, with Notes on the Bacteriological Analysis of Water."

SEVENTH ORDINARY MEETING, Province Building, Halifax, 14th May, 1894.

The PRESIDENT *in the Chair.*

Inter alia,

The following papers were read :—

"Notice of a New Test for Antipyrine," by the President, Professor G. Lawson, LL. D.

"Phenological Observations made at several Stations in Nova Scotia and New Brunswick during the year 1893," compiled by A. H. McKay, LL. D., Halifax.

"Note on a Sponge from Herring Cove," by J. Somers, M. D.

"Notes on Nova Scotia Zoology, No. 3," by Harry Piers.

The following papers were read by title :—

"Notes on a Collection of Silurian Fossils from Cape George, Antigonish Co., N. S., with descriptions of three new species," by Henry M. Ami, D. Sc., F. G. S.

"Notes on Sedimentary Formations on the Bay of Fundy Coast," by R. W. Ells, LL. D., &c.

"Additions to the Flora of Truro," by Percy J. Smith.

"Deep Mining in Nova Scotia," by W. H. Prest.

A. McKAY, *Recording Secretary.*

Halifax, 19th May, 1894.