THE JOURNAL
OF THE
Board of Arts and Manufactures
FOR UPPER CANADA.

FEBRUARY, 1864.

MECHANICS' INSTITUTES,

AS EDUCATIONAL INSTITUTIONS FOR THE ADULT INDUSTRIAL CLASSES.

In the year 1838 we first became connected with the Mechanics' Institute of this city—a society which then comprised about 90 members, and occupied, as library and lecture hall, a large room of very unattractive appearance, up-stairs, in the old Market Buildings. The library then contained some five or six hundred volumes of books, and was open to the members on one evening only in each week. Weekly lectures were usually delivered during the winter season by gentlemen of the city and neighborhood, to perhaps a dozen or so of individuals; or if the subject was a very popular one, say on Laughing Gas, with illustrations, or some kindred subject, the audience would be considerably larger. These were times of hard struggling; the treasury was generally very low and often overdrawn; occasionally the directors would have to put their hands in their pockets and contribute of their own means to secure the continued existence of the Institute. Efforts were usually made as each season came round to establish classes in architectural and free hand drawing, or chemistry, or some other useful subject, but as a general thing with very limited success. These efforts were often entirely discontinued for a time, the discouragement was so great.

The foregoing is, no doubt, very nearly the history of many of the Mechanics' Institutes in the villages and smaller towns at the present day. We send a free copy of this Journal to each Institute, the existence of which we have any knowledge. Now and again we have a number returned, marked by the local postmaster, "Not taken out—Institute broken up." We wonder at the cause, and often ask ourselves the question—"Are these institutions not required by the youth of Canada? or have they a place to fill, and fail to use the proper appliances to ensure success?" We answer, such institutions are eminently fitted to benefit a community; but the men to take hold of them, to throw their energies into them for the benefit of the industrial classes, and induce them to avail themselves of the privileges afforded for self-culture, are in most cases wanting.

No doubt the withholding of the usual Legislative grant of $200 to each properly organized mechanics' institute some five years since, has had much to do with the failure of some of them; and while our agricultural societies, universities, colleges and common schools continue to be so liberally supported by the Legislature, we do not see the justice of withdrawing this trifling support, which amounted for the whole United Province to the small sum of $10,000 a year; but, thrown upon their own resources alone, if the managers of these institutions continue their self-denying efforts, success will at last amply repay those so engaged.

With several other active co-laborers, we have continued to devote a large portion of our time for the last twenty-six years to the Toronto Institute, and now have the satisfaction of looking upon it as perhaps the most extensive institution of its kind upon this continent, and occupying a building of its own we believe superior to that owned by any mechanics' institute in Great Britain. It has a library of over six thousand volumes of books, and a reading and news room well supplied and fitted up; and these are open on all week days from 8½ a.m. to 10 o'clock p.m. It has also a well organized system of evening classes for the instruction of such youths as are engaged in regular daily occupations, as well as numerous other appliances for the instruction and recreation of its members and subscribers. Of course we cannot look for all these results in localities containing small populations; but we do believe that if suitable rooms are secured and comfortably fitted up—a few of the daily papers and choice periodicals subscribed for and kept on the table—a well-selected though it may be small library formed, and kept open three, or, if possible, every night in the week—and, above all, the services of some one engaged as secretary and librarian, who has not only the ability but the enthusiasm necessary, success will be almost certain.

One satisfaction the directors of such institutions will always have, where they are successful, that by their efforts many young men are saved from the drinking and gambling saloons, from loitering at street corners, or spending their time in idleness, during the most dangerous period of life, and induced to habits of sobriety and study. In the course of our experience we have known hundreds such, many of whom are now filling responsible positions in society, resulting in part from their connection with these institutions. In every city and town how many youths are there away from parents and home, learning their various trades and callings, or who have homes entirely wanting in everything that could conduce to their mental or moral improvement; and how large a proportion there are, also, who are scarcely acquainted with the ordinary rudiments of a common education, much less with the more intricate studies that would be found so useful to them in their several occupations. To all such, well appointed mechanics' institutes offer the peculiar advantages they require.

There are also large numbers of our youth who have received a fair amount of rudimentary training, but who left school at an early age to engage in the more active duties of life, and are thus apt to forget in those engagements what they had previously learned. To such the evening classes furnish the means for exercising and further improving their minds.

The author* of *Handbook of Mechanics' Institutions* on this subject, remarks:

"The interval between the period at which children usually leave school, and that in which, as youths and men, they become fully occupied with the duties and responsibilities of providing for themselves and families, and taking a recognised position in society, is peculiarly fitted for the acquisition of those branches of knowledge which have been imperfectly learned or wholly neglected at school, or to make further progress in studies already commenced, combining the daily maturing power of the understanding and reason with the exercise of the memory."

As to what may be done to supply early deficiencies of youth, and the importance of elementary acquirements to success in life, the author says:

"If the intervals of leisure which fall to the lot of most youths and young men be improved, even by those who have not received the blessings of early instruction, it is quite inconceivable to those who have not had the opportunity of witnessing it, what earnest application, under wise directions, can accomplish. Thus, in the most mechanical, yet, perhaps, most decisive, of a young man's attainments in relation to advancement in position —penmanship, it is curious to notice the progress from the uncouth scrawl, produced with painful distortion of limb and feature, which perplexes and baffles the reader; the helpless efforts at orthography, and the oblivious disregard of the simplest rules of grammar, so common among young men who have had a very scanty measure of early schooling, or who have neglected for a few years to apply such knowledge as they have acquired at school, and to compare these uncouth efforts with the results of a few lessons of an hour each, when the system is good. The defects and deformities disappear, the crooked and cramped characters become symmetrical, parallelism takes the place of the vagaries of zigzag, angles and most irregular polygons settle into curves, and almost imperceptibly a plain and frequently a very good style of writing is attained.

"If the very large number of young men whose prospects of advancement in life are blighted from their inability to write a fair hand, had any idea of what a simple matter this accomplishment is, with a little application under a good teacher, they would subdue the silly bashfulness which too often keeps them aloof from the class-rooms of a Mechanics' Institution, and sweep away so insignificant an obstacle to success in life. Spelling, if wholly neglected, is a much more serious affair; but if the pupil be sufficiently impressed with its importance, and with the necessity of becoming his own vigilant monitor, every scrap of matter carefully committed to paper strengthens the habit of accuracy, and increases the knowledge of orthography. Grammar is generally a most interesting study, and affords an excellent exercise for the memory and the reason.

"Again, Arithmetic, if accompanied, as soon as the rudiments are mastered, by a gradual exposition of the *rationale* of the processes, besides being of eminent practical value, is an admirable mental discipline, and one upon which young people generally will enter with as much gratification as profit. Steadily conducting the mind onward in the acquisition of knowledge, which, valuable in itself, has a further and, perhaps, higher value, as preparatory to a wider range of study, it is most desirable to make Geometry a subject of attainment, —the teacher giving the pupil, by the way, glimpses of those sciences whose phenomena only admit of a mathematical explanation, as Astronomy, Mechanics, and Optics. But such pursuits are apt, if followed too exclusively, to beget a neglect of, and sometimes a contempt for, other important and interesting classes of inquiry,—those which keep alive the intelligent sympathy with human concerns, and which subdue prejudices and foster circumspection in the formation of opinion. Hence we would encourage those studies which bring the light of history to bear on our views of the age in which we live, acquaint us with the results of the enterprise and observation of travellers in other climes, amongst other races of mankind, and under widely different forms of government, and thus enable the student to obtain a clearer and juster idea of the religious, moral, social and political circumstances amid which his lot is cast. In short, a comprehensive course of elementary instruction should be given, such as every man ought to go through, to prepare him to fulfil his duties satisfactorily, to fit his mind to comprehend at least, if not to improve upon, the mode of conducting any operations he is employed in; to habituate him to derive a considerable degree of pleasure from intellectual pursuits, and to endow him with the power to read such books as he may have access to, and the current literature of the day, with a deeper and truer insight, and, therefore, a greater interest and profit, than the uncultivated mind can enjoy.

"Hence we do not hesitate to say, with regard to persons not arrived at maturity, means should be provided in all educational institutions which receive them, to give them this elementary course of instruction and discipline.

"Among the number of those who have had no opportunity of procuring this preparatory training, we have frequently noted with pity the chagrin and disappointment, the wounded self-esteem, and conscious incapacity of young men anxious to make their way in the world, and thoroughly sensible of

* W. H. J. Traice, Secretary to the Leeds Mechanics' Institute and Literary Society, 1856.

the importance of applying science to practical uses. If they could only supplement the fragments of higher knowledge they have often obtained by herculean efforts, with the elementary instruction that may be procured in a common day school, they might rank with that intellectual class with whom systematic knowledge enters as a vital element into all operations under their care."

If in past years it was important that the various classes of operatives should be well informed on subjects connected with their several employments in life, how much more important is it in this age of the world's progress? Our country is covered with educational institutions of every order, from the common school to the university, and the rising generation have every opportunity that can possibly be afforded them for the attainment of all the ordinary as well as the higher branches of education; but if our mechanics and artizans are not supplied with that scientific and mechanical knowledge so necessary to practical men, and of which as a general thing they are now so lamentably deficient, they will lag behind in the world's history, and, as a people, we shall make no rapid or even creditable progress in the race of competition with the more intelligent and better educated industrial classes of other countries.

We close by quoting Sir Isaac Newton on the value of scientific knowledge in its relation to seamanship, but which is just as applicable to every one engaged in any kind of mechanical pursuits:—

"Without the learning in this article (Mechanics) a man cannot be an able and judicious mechanic, and yet the contrivance and management of ships is almost wholly mechanical. 'Tis true that by good natural parts some men have a much better knack at mechanical things than others, and on that account are sometimes reputed good mechanics; but yet, without the learning of this article, they are so far from being so, as a man of a good geometrical head who never learnt the principles of Geometry, is from being a good geometer. For whilst Mechanics consist in the doctrine of force and motion, and Geometry in that of magnitude and figure, he that can't reason about force and motion is as far from being a true mechanic, as he that can't reason about magnitude and figure from being a geometer. A vulgar mechanic can practise what he has been taught or seen done, but if he is in error he knows not how to find it out and correct it, and if you put him out of his road he is at a stand; whereas he that is able to reason nimbly and judiciously about figure, force and motion is never at rest till he gets over every rub. Experience is necessary, but yet there is the same difference between a mere practical Surveyor or Guager and a good Geometer, as between an Empyric in Physic and a learned and a rational Physician." *

* Appendix to the "Correspondence of Newton and Cotes," p. 283.

OUTLET DOORS AND ROOFS OF PUBLIC BUILDINGS.

The fatal catastrophe of which we have just been informed as having occurred at Santiago, in South America, in the burning of a Catholic Cathedral, and the loss of upwards of two thousand lives, occasioned to a considerable extent by the insufficiency in number of outlet doors, and the blocking up of those that were provided as soon as the alarm was given, reminds us of the wrong construction, and insufficiency in number of outlet doors to most of our public buildings. From observation we are led to believe, that the doors of such buildings are generally hung to open inwards, so that if fire or any other cause of alarm occurs in the audience, a hundred chances to one but the ordinary doorways would at once become so blocked on the inside that they could not be opened, and a large number of persons would perish ere relief could be afforded.

This is really an unpardonable oversight on the part of the architects and others connected with the erection of public buildings; and wherever loss of life does occur from these causes, as was the case in a theatre in the City of Quebec a few years since, on the heads of such parties rests the responsibility. Persons attending at large assemblies in the Music Hall of the Toronto Mechanics' Institute may have the comfort of knowing that one of the large pairs of doors entering that Hall swing clear both outwards and inwards (and the sooner the other pair is altered to do so the better), and that the two pairs of outlet doors on the main front both open outwards, so that a jam or blocking up on the inside can never take place. How much more satisfactory would it be if the doorways of all our public halls, theatres and churches were constructed on the same principle.

While on this subject, we would suggest to architects and others engaged in their planning, that some great improvement is necessary on the general mode of constructing the roofs of large buildings. We can point to public buildings in this city that are seriously damaged every spring from the melting of the snow on the roof, followed by a freezing up of the gutters, and the consequent backing of the water resulting from the next thaw over the wall plates into the building, destroying the plaster ceilings and the paper or other finishing on the walls. We do not here offer any suggestions as to how this may be prevented, but have no doubt whatever in our mind that an efficient remedy can be found, if proper consideration is given to the subject by those whose business it is, more especially, to make it their study. Our pages are open to the discussion of this as well as all other improvements of a practical character.

MERRYWEATHER'S STEAM FIRE ENGINE "SUTHERLAND."

This Engine, which was awarded the first prize at the International contest, has been purchased by the Lords of the Admiralty for the Royal Dockyard, Devonport. At a recent testing of the engine before the authorities at the Dockyard, 60 lbs. of steam pressure was raised in eight minutes from the time of lighting the fire, the water in the boiler being perfectly cold at starting. The weather during the trial was unfavorable, being boisterous and wet. Four jets of 1 inch diameter, and six jets each of ¾ inch diameter, were attached to the hose from the engine at one time. The quantity of water discharged from each of these ¾ jets being from 150 to 160 gallons per minute, and through each of the four 1 inch jets 220 gallons per minute. The engine had to lift water from 12 to 14 feet, and then discharge it through two lines of leather hose, each 1000 feet long. The engine was run about the Dockyard by a few of the Metropolitan Police. On one occasion they ran the engine a distance of a quarter of a mile from the station, and had a large quantity of hose attached; and four fine streams, each from 1 inch nozzles, were playing in twenty minutes from the time of the alarm, the fire not being lit until the time of its arrival.

We notice also that Messrs. Shand and Mason have recently completed a light steam fire-engine, for the Dublin Fire Brigade. It weighs in working order only 27 cwt. A trial of this engine took place yesterday, at the London Docks, with the following results:—Steam got up at 50 lbs. from cold water in 8 min. 5 sec.; started at that pressure with ¾ jet, steam 50 lbs.; water 40 lbs.; changed to 7-8ths jet, steam 90lbs; water 60 lbs.; changed to 15-16ths jet, steam 85 lbs., water 80 lbs.; changed to 1 in. jet, steam 100 lbs., water 60 lbs.; changed to two jets at one time ⅝ and ¾, steam 10 lbs. water 60 lbs.; all these changes made without stopping engine. It was then worked through three jets, being two ½ in. and one ⅝ in., steam 80 lbs., water 60 lbs.; and changed to one 15-16ths jet, steam 100 lbs., water 90 lbs.; throwing over a shed 80 ft. distance, through 120 ft. of hose.

The jet third on the list was thrown 40 ft. above one of the large warehouses, which is 68 ft. from the parapet to the ground, through 160 ft. of hose. In all these experiments the engine was placed upon the quay, and drew at once from a depth of 20 ft. from the suction outlet of the engine to the surface of the water.

Messrs. Shand and Mason have recently simplified their machinery very considerably, thereby reducing the weight of their engines and adding to their efficiency.

Board of Arts and Manufactures for Upper Canada.

THE JOURNAL.

Secretaries of Mechanics' Institutes, and Agricultural and Horticultural Societies, are requested to send in their lists of subscribers to the *Journal* for 1864 as early as convenient; and all subscribers in arrears for the past are particularly requested to remit the amount due, in postage stamps or otherwise, as promptly as possible, as the amounts are too small to send an agent to collect.

The subscription price of the *Journal* for this year is 75 cents, and to members of Societies, when paid through their respective Secretaries, only 50 cents. A few copies of Vols. I., II. and III., half bound and lettered, are for sale at $1 per volume.

The covers of each monthly issue are available for advertisements, at moderate charges.

W. Edwards, *Secretary.*

BOOKS ADDED TO THE FREE LIBRARY OF REFERENCE.

Shelf No.

A. 9—Architectural and Decorative Interiors and Exteriors in Venice; 1 Vol., folio, 1848..... *Lake Price.*
A. 10—Architectural, Sculptural and Picturesque Studies in Burgos and its Neighborhood; 1 Vol., folio, 1852 .... *J. B. Waring.*
D. 7—Scroll Ornaments for the use of Silversmiths, Chasers, Die-Sinkers, Modellers, &c. &c. 1 Vol., 4to. .... *F. Knight.*
E. 91—Monumental Remains of Royal and Eminent Persons, from Churches and Cathedrals of Great Britain; 1 Vol., 4to. .... *Edw. Blore.*
G. 58—Gems, a Device Book, containing many hundred Devices for Seal Engravers, Painters, Carvers, Cabinet Makers, &c. &c.; 1 Vol., 8vo........ *F. Knight.*
Legislative Council Journal for 1863.
" Assembly Journal for 1863.
" " Sessional Papers for 1863.

BOOKS RECENTLY PUBLISHED IN GREAT BRITAIN.

Adcock's Engineers' Pocket-Book for 1864, 12mo	£0	6	0	*Simpkin.*
Aitken (William) Science and Practice of Medicine, 2 vols., 2nd ed. revised, 8vo	1	8	0	*Griffin.*
Alford (Henry) Queen's English: Stray Notes on Speaking and Spelling, fcp. 8vo	0	5	0	*Strahan.*
Art Journal Illustrated Catalogue of the International Exhibition, 1862, roy. 4to	1	1	0	*Virtue.*
Builder's (The) and Contractor's Price Book for 1864, rev. by G. R. Burnell, 12mo.	0	5	0	*Lockwood.*
Culloy (R. S.) Handbook of Practical Telegraphy, 8vo.	0	7	6	*Longman.*
Delamotte (F.) Book of Ornamental Alphabets, Ancient and Mediæval, 5th ed obl.	0	4	0	*Lockwood.*
Elements of Designing on the Developing System. No. 1, sm. 4to	0	1	0	*Simpkin.*
Engineer's (The) Architect's and Contractor's Pocket-Book for 1864, 12mo	0	6	0	*Lockwood.*
England's Workshops, by Strauss, Quin, Brough, &c. &., sm. post 8vo	0	5	0	*Groombridge.*
Hardwich (T.F.) Manual of Photog. Chemistry, 7 ed., by Dawson & Hadow, fcap.8vo.	0	7	6	*Churchill.*
Jeanes (William) Modern Confectioner, 2nd edit., post 8vo	0	6	6	*Hotten.*
Martin (L. C.) and Trübner (C.) Gold and Silver Coins of all Countries, roy. 8vo	2	2	0	*Trübner.*
Mining and Smelting Magazine (The), edited by H. C. Salmon, Vol. IV., 8vo.	0	7	6	*Office.*
Nightingale (Florence) Notes on Hospitals, 3rd edit., enlarged, post 4to	0	18	0	*Longman.*
Nystrom (J. W.) Pocket-Book of Mechanics and Engineering for 1864, 12mo	0	7	6	*Trübner.*
Quarterly Journal of Science (The), No. 1, January, 1864, 8vo	0	5	0	*Churchill.*
Thompson (Jno.) Manual of Phonography: Short-hand Swift as Speech, &c., 8vo	0	2	6	*Phonog. Depart.*

Proceedings of Societies.

CANADIAN INSTITUTE.

At a recent meeting of the Canadian Institute, Dr. A. M. Rosebrugh, oculist, of this city, submitted a new instrument invented by him, by which he is enabled to photograph the deep structure of the living eye.

The Doctor, in introducing his Opthalmoscope to the meeting, explained its object and gave a very clear explanation of its working. The scientific gentlemen present highly complimented the Doctor on his valuable discovery, and his success, by the aid of diagrams, in explaining in so satisfactory a manner the mode of using the instrument.

We purpose giving a full description of the Opthalmoscope, with wood-cut illustrations, in our next issue.

TORONTO ELECTORAL DIVISION SOCIETY.

The annual meeting of this Society was held on the 21st of January. The Directors, in their report of the results of the Union Exhibition held last autumn, stated that the total number of exhibitors was 568; number of entries, 1,928; amount of prizes awarded, $1,494 25—in addition to about 75 diplomas. The total amount of prizes offered in the prize list was $2,100. The number of persons who visited the exhibition by tickets, other than members of the societies in union, was 3,953, and had the weather not been unfavorable there would no doubt have been double that number. The show of live stock is reported as very large and of superior quality; in vegetables equal, and in fruits superior, to any exhibition before held in the Province. In fine and decorative arts the show was very fair: but in manufactures singularly deficient, reflecting no credit upon the manufacturers of this city. The report stated that the aim of the Directors had been to obtain a union of all the societies in the city and county in holding this exhibition, and expressed a hope that their successors would accomplish that result for the ensuing season.

The several office-bearers and Directors elected for the ensuing year were:—

President—Mr. F. W. Jarvis.

1st Vice-President—Mr. James Fleming.

2nd Vice-President—Mr. R. L. Denison.

Secretary-Treasurer—Mr. Wm. Edwards.

Auditors—Messrs. F. W. Coate and Hugh C. Thomson.

Directors—Messrs. Alex. Shaw, John Gray, Philip Armstrong, W. H. Sheppard, Geo. Lesslie, J. G. Bowes, and W. Sharpe.

The meeting nominated as members of the Board of Agriculture, in place of the four retiring members, R. L. Denison, Esq., Col. E. W. Thompson, Hon. Geo. Alexander, and Hon. G. W. Allan.

At a meeting of the new Board of Directors, subsequently held, it was

Resolved—"That in accordance with the resolution of the annual meeting, now submitted, the Secretary be instructed to invite all the agricultural societes in this and adjoining counties, and the City of Toronto Horticultural Society, to unite with this society in holding a Grand Union Exhibition in this city during the ensuing autumn."

It was also

Resolved—"That all members of the society subscribing not later than the 1st of May next, a sum of not less than one dollar, shall be entitled to a copy of the *Journal of the Board of Arts and Manufactures* for the year; and all subscribing not less than one dollar and twenty-five cents, shall be entitled to a copy of the *Canada Farmer* for the year."

We trust that persons intending to avail themselves of the proposals contained in the last resolution will do so at once, that they may be sure of obtaining either of the journals referred to from the commencement of the year.

Selected Articles.

ON THE ECONOMIC VALUE OF FOOD.

(*From a paper read before the Society of Arts, December, 1863, by Dr. Edward Smith, F.R.S., of the Brampton Hospital for Consumption.*)

The amount of nutriment which can be obtained from any given food, depends upon the nutritive elements of which it is composed, and on the use which the body can make of them. Thus, the bark of trees and sawdust in chemical composition, contain much of the elements of nutrition, but as the stomach cannot digest much of them, they would not be an advantageous food at any price. It is at this point that deductions from chemical knowledge alone have led, and I must add, are still leading to error. Nearly all the generalisations of Liebig on the nutritive value of food, were based simply upon their chemical constituents, assuming in a general manner that they would all be equally well digested and appropriated by the system. That this too hasty generalisation should have been made many years ago, cannot be wondered at, seeing that both chemical and physiological knowledge was then most imperfect, and that the authorities were chemists only; but that men of repute should, even to the present week, publish knowledge of this kind, and even take credit for it, is much to be regretted. So strong a hold do the impressions of our earlier years take upon our minds, whether they have been derived from our own observation or from the books by which we were educated. It is still not at all generally apprehended, even by good chemists, that on questions of food we must ascertain in what degree the system can appropriate foods, before we can venture to affirm their relative nutritive qualities from their relative chemical composition. As I attach great significance to this fact, and shall have to apply it as we proceed, I am particularly desirous that it should not be forgotten. The question is not what nutritive elements food possesses, but how much nutritive matter the body can obtain from it. Hence, a food is economical as the body can obtain from it the largest amount of nutriment at the least cost. In proceeding to apply these general principles to the individual articles of food, I must select those elements essential to nutrition, and also name some price which shall be regarded as a standard of cost.

Nutritive Elements Selected.

As to the elements of food, I propose to select the carbon and nitrogen only, since they alone can be collected as they leave the body. If I were treating of the nutritive value of food in a chemical aspect only, apart from any daily measure of the amount required by the body, I should add the free hydrogen also, since with its combination to form water within the body it must generate heat; but we have no means of ascertaining how much heat is produced and required by the body; neither can we ascertain how much of the water which leaves the body is generated in this manner, and how much is due to that which was taken as food. Hence, in seeking to ascertain how much nutriment is required by the body, we must altogether omit any reference to this element, and must restrict ourselves to the carbon and nitrogen, for as the latter in leaving the body can be measured, they give the best indication as to how much is required to supply their place. This is the only practicable basis for dietary in a physiological point of view, and hence my object is to show in what way the largest amount of carbon and nitrogen can be obtained at the least cost.

I wish I could select terms which would be less technical, and yet be at the same time exact, but I cannot. An attempt to do this has been long made, and this also on purely chemical grounds, by calling some elements heat-givers, and others flesh-formers, as though the two had quite distinct actions; but it should be understood that in all the important foods, excepting fat and sugar, both these classes are always found in the same food, so that bread and meat are heat-givers and flesh-formers; and it has been also proved, by the experiments of Messrs. Lawes and Gilbert, myself, and others, that nitrogen—the flesh-former—passes through the body every moment without forming flesh, and therefore cannot always be a flesh-former, and that, whilst in the body, it stimulates vital action, and promotes the change of the heat-givers, and is therefore indirectly a heat-generator. Hence physiology has again shown that the clear lines of distinction drawn by chemists and chemistry are incorrect, and lead to error. It is probable that in every case the one kind of food assists the digestion of the other, and it is certain that no such division as heat-giver, and flesh-former can now be tolerated, except in a general and popular sense. It is also necessary to add that I cannot treat of them collectively, or say that a food offers so much nutriment, for these two elements are required by the body in different proportions, and foods differ in the relative quantity of each which they contain.

Hence I must speak of the two elements simply as carbon (the so-called heat-giver) and nitrogen (the so-called flesh-former), and it will not be difficult to follow all that is to be said respecting them without any chemical knowledge whatever.

Separate Foods.

BREAD.—I purpose to consider bread as the first and basal element of dietary, both from its extreme importance in relation to the whole dietary, and from its universal use in this country. This may be made of white wheaten flour, brown wheaten flour, rye or barley, or an admixture of these substances. 1 lb. of white wheaten bread, made of household or seconds flour, is worth from a 1¼d. to 1½d. in different parts of the country, and most frequently 1⅜d. or 5½d. per 4 lb. loaf. 1 lb. of bread contains 1,994 grains of carbon, and 89 grains of nitrogen, or, in round numbers 2,000 grains and 90 grains, and as the cost is 1¼d., 1⅜d., and 1½d., the quantity for each 1d. will be as follows:—

	Carbon Grains.	Nitrogen Grains.
At 1¼d.	1,600	71
1⅜d.	1,450	66
1½d.	1,308	60

I will take the middle quantities as my standard, since it will apply more largely to the country than any other, and will consider that 1,450 grains of carbon and 66 grains of nitrogen are obtained generally for 1d. spent in white bread.

The above has reference to the quality known as households. When a whiter flour is used, if there be no adulteration, the cost is increased, not only because the manufacture of the flour is more costly, but because fine white English or Genesee wheat is used, which is dearer than red wheat; but there is no evidence to show that the nutritive value is increased, except in the case of wheat selected which is grown in hot climates, and which contains somewhat more nitrogen. Taking the increased price of 2d. to 4d. a peck of flour into account, this flour is the dearer food. But it is largely the practice, and particularly in the French flour, to add rice to the very white flour in order to improve the colour, and in so doing a reprehensible adulteration of the flour occurs; for, taking the price of fine flour and rice at 2d. per lb. each, the amount of carbon and nitrogen for 1d. would be:—

	Grains.		Grains.
Flour, carbon......	1,330	Nitrogen	60
Rice, "	1,380	"	35

so that with a trifling increase in carbon the amount of nitrogen has been reduced nearly half. But in in truth the loss is greater, for the value of the rice does not exceed 1d. to 1¼d. per lb., and the difference between that and the selling price of the flour is to the gain of the miller and the loss of the consumer. There cannot be a doubt that it ought to be as penal to adulterate flour with rice as to mix chicory with coffee, and the law ought to require from the seller the same affirmation of the admixture in both cases.

Now to turn to the other aspect of the question. What is the effect of retaining in or of adding to the flour the bran as a whole or in part. In this matter there is a fallacy which was originated by chemists; and now that bread companies are doing a large trade, and have medical men upon their direction, who quote and scatter medical opinions, the fallacy is revived, but there is no fallacy on the part of the masses of the people. The use of white wheaten flour is extending as rapidly as possibly in the western world of America (the home of the Maize), and even in the poorer districts of the world the dark-coloured bread is not the brown bread of this country, but barley or rye bread in whole or in part. The millions of this country cast aside the bran, and in doing so follow the dictates of experience, of far greater value than theoretical reasons derived from a single scientific fact, and such assertions as that of Dr. F. W. Headland, in his Medical Handbook: "This is one of the matters in which the world has gone grievously wrong;" and also that of Dr. Mapother, who, in an interesting paper lately read in Dublin, remarked: "We are receding in the art of dietetics in regard to whole-meal bread, for up to some forty years ago it was most generally used in these countries." In these assertions the terms have been inverted, and instead of testing the truth of scientific statements by universal practice they presume to set universal practice at nought, when compared with inductions which themselves can only properly flow from practical experience.

The question then is—Is brown bread cheaper than white bread in the nutrition of the body? By brown bread is universally understood the admixture of the bran, in its entire composition, with the farina of the flour, and not the exclusion of the outer husk of the bran and the retention of the inner layer. This must be understood, or the the statements of persons cannot be compared, neither shall we treat of bread in actual use.

Dr. Dundas Thompson was one of the earliest authorities on this subject, and in lectures now publishing he writes as follows:—

"It is important that we should be able to analyse bran in order to be capable of appreciating the ground upon which it has been long known that this substance is alimentary, and that to remove it from flour is to deprive flour of a large amount not only of nutriment, but of meat-producing principles. It is well known, both by physiological and chemical research, that oatmeal contains more nutritive matter than any other of the cerealia. This may no doubt be in some measure due to the imperfect manner in which the bran is separated from the flour. We may truly consider these infallible physiological results which are obtained in the history of such people as enjoy robust health and longevity with oatmeal as their staple article of food; and when chemical analysis confirms these experiments, our conclusions seem to be deduced from a powerful species of induction."

Again, he writes, "I am not aware that the nutritive superiority of brown to white bread was known upon scientific data prior to the year 1843, when the writer showed that the per-centage of nitrogen in white bread (freed from water) was 2·27=14·8 nitrogenous principle, while that of brown bread containing bran was 2·63=16·43 nitrogenous principle."

Thus because bran contains more gluten and less starch than the inner portion of the wheat, it was assumed that it was more nutritious. This statement has been handed down and copied from book to book up to this day, so that in the book of Dr. Headland just quoted we find:—

"This husk contains more gluten, more nutritious matter, than the whole interior, the proportion being in the husk about 17, in the seed about 12 in 100 parts. White bread is not only more expensive, but is far less nutritious than flour in which the bran is ground. Yet the poor as well as the rich prefer white bread. The former even consider the recommendation to eat brown bread as a sort of insult. This is one of the matters in which the world has gone grievously wrong." Dr. Guy, who quotes this passage, remarks in the text of his paper on dietaries, read before the Statistical Society, "that we can make a considerable addition to the gluten and the oil by adding the bran to the flour; or making the bread of whole meal obtained from the grain either before or after the modern process of decortication." He also adds a table, to show that bran contains 8 per cent. more gluten (which is about 1½ per cent. of nitrogen), and 9 per cent. less starch, &c.

Dr. Johnston, in his "Chemistry of Common Life," also writes, "Bread made from the whole meal is therefore more nutritive;" but he adds another chemical statement to that already mentioned, viz., that "the bran of wheat possesses also the property of dissolving the flour or bread with which it is mixed, and of rendering it more easily digestible in the stomach." He seems to regard this as an advantage, and a more recent authority makes the following remarks:—

"The conversion of the starch into dextrin and sugar likewise renders the bread darker in colour. In fact, the brown colour of wheaten bread made from flour containing fine bran, is due, not to admixture of particles of bran, but in great part at least to a conversion of the starch into dextrin and sugar by the action of the altered albuminous matter in the bran. According to Mège-Mouriès, bran contains a peculiar nitrogenous body called *cerealin*, which is specially active in inducing this conversion: it appears, however, to be identical or nearly identical, with ordinary diastase. Be this as it may, it is certain that the finest wheat flour obtained from the central portion of the grain, which contains but little nitrogenous matter, has very little tendency to undergo the change under consideration; but coarse flour obtained from the exterior of the grain is rich in azotised substances, and more ready to undergo the glucosic deterioration. In white bread of good quality, the starch has undergone very little alteration. A small portion of it is rendered soluble in water, but the greater number of the granules are simply swollen, not burst, and may be washed out of the bread, collected and weighed."—*Watts' Dictionary of Chemistry.*

Hence, the arguments on this side of the question are, that as the bran contains more nitrogen than the farina, and as there is a principle in bran which, acting as a ferment, aids in the conversion of starch into dextrin and sugar, brown bread is more nutritious than white bread.

Now, what does the fact amount to? An average sample of wheat will yield one-fourth to one-fifth of its weight of bran, and so far whole meal, or brown flour, will contain more nitrogen and less carbon than white flour. The estimate of the contained nitrogen in bread, as made by Dr. Thompson twenty years ago, on Prussian bread, is higher than is applicable to the bread of this day, for instead of being 2·27 per cent. dry. or 1·59 per cent. fresh, it is now only 1·3 per cent. fresh. But if we accept the relative statement as to the respective quantities of nitrogen in the white and brown bread, we shall find that the increase in 1 lb. brown bread is about 20 grs., whilst the carbon is reduced. As to the latter assertion, viz., that the cerealin of the bran aids the conversion of the carbonaceous elements, as the action is deteriorating, it can be useful only as it is necessary. But both statements alike ignore the action of the living body, and assume that the nitrogenous fluids of the body are insufficient to provide the starchy and saccharine transformation, and also that the nitrogen in the bran will be appropriated as freely as that of the farina, and thus, upon an assumption of these, which are the essential facts, the inference that brown bread will be more nutritious, is drawn. That is "begging the question." Moreover, it is well known that the body itself furnishes a substance which, acting like a ferment, procures the conversion of the starch into sugar, and there is no evidence to show that the converting property of the cerealin is as necessary to digestion as it is deteriorating in the destruction of nutritive matter.

Let us now see what can be said on the other side. Dr. Prout is quoted by Dr. Guy in support of this brown bread nutriment theory, but with singular infelicity, for Dr. Prout, instead of regarding bran as nutritious, terms its excrementitious. Thus he is quoted by Dr. Guy:—"Bread, therefore, made with undressed flour, or even with an extra quantity of bran, is the best form in which farinaceous and excremental matter can be usually taken, not only in diabetes, but in most of the other varieties of dyspepsia, accompanied by obstinate constipation. This is a remedy, the efficacy of which has been long known and admitted." Hence, he regards bran as a remedy for constipation, which nature has conjoined with food, and therefore denies that it is food, or directly adds to the nutriment of the bread; and in this view of the action of bran he is joined by the medical profession generally—by the poor, who have used it and ceased to use it—and by the rich, who need a remedy for constipation. This question is now of the greatest interest (otherwise than as a commercial one) in reference to prison dietaries, and, when under examination before the Committee of the House of Lords, this year, in answer to the question (No. 988), "Will you state what sort of bread you would recommend?" I replied, I think it essential, for prison diet that it should be white bread, or if not white bread it should have the bran ground finely. My reason for this is, that I and others have shown that the bran of brown bread—as the husk of oatmeal and the shells of peas—hastens the nutritious material through the bowels. We therefore have a larger waste of food if we give the bran with the bread, and the husk with the oatmeal, and the shells with the peas, than we should without them." When these words were read to Dr. Guy, the other scientific witness, at his examination before the same Committee, and question put by the Chairman (No. 3,796), "Would your experience enable you to confirm that statement?" the reply is, "Yes; I should agree with that statement. If whole meal bread were found to produce diarrhœa, I should expect it to prove less nutritious." In answer to a former question (No. 3,789), "Is there any objection to using all that there is in wheat?" the same authority replied, "I think not; but that must be a matter of experiment. If it were found that by continuing brown bread for a long time, diarrhœa was occasioned, it might become necessary to substitute white bread on certain days of the week, but brown bread should be used as much as possible."

Thus the excremental quality of the bran is, I may say universally admitted, and if in its full action it will purge, in its less and more constant action it will tend in the same direction, and cause more frequent and free removal of material from the body than occurs with white bread. But this latter action, which had not been estimated, has been established by the experiments of Mr. Milner and myself, as a Committee of the British Association appointed to make inquiries into the influence of prison punishment and dietary over the bodily functions of prisoners, which are very extended, and as they are the only similar ones on record, I must refer to them to prove that under the influence of the brown bread dietary, the waste by the prisoners was more than twice as much as that occurring in ordinary life. Hence here is a food inducing an action which, in its full effect, is one of disease, and is to be restrained, and, in its less effect, causes the removal of double the amount of nutritive elements from the body which occurs without it, which is recommended by medical men, and taken by the richer classes as a remedial agent to remove constipation, and hence, of necessity, must increase the waste of food, but still it is affirmed to be more nutritive, because it is ascertained out of the body to contain a larger quantity of a chemical element, which, if used by the body would afford nutriment. Such are the hasty deductions upon which this theory has been based; and Dr. Guy, in his evidence just quoted, and in answer to the question No. 3788, "Why would you prefer brown bread?" replied, "the only bread used in prisons should, I think, be brown bread, partly because it is more nutritious and contains more of the muscle-making element in it (the nitrogen which has been spoken of) than white bread does." But how much further, let us ask, can this *non sequitur* be carried when it is known that the bran itself passes out of the body unchanged as may be ascertained by any observer, and as was proved by us in our analyses daily for two months in prisons—this wonderfully nutritive material, which contains so much of the muscle making element, and which must, besides, have the faculty of being in two places at the same time!

The proper place in which the action of bran should be arranged is manifestly that of a medicine (and it would be easy to show that it is a bad one), as stated by Dr Prout, and as practised by mankind, and therefore to be used when constipation occurs, or when, as is commonly the case, this is accompanied with the excess of food to which the well-fed and under-worked classes are accustomed. Hence, when I was asked by the Committee before-mentioned, No.987, "Then the general prejudice which prevails amongst the agricultural community that the finest white bread is the best for them, and the most nutritious, is correct." I replied in language not my own, "Certainly, it is correct. Brown bread is the rich man's and not the poor man's diet." I thought this necessarily followed from the statement of the action of the brown bread, which had been given in answer to No. 988, and assented to by Dr. Guy, in answer to No. 3,796 already quoted; but when my answer was read to Dr. Guy, No. 3,797, he replied, "I do not agree with that view of it; I think brown bread is especially the poor man's dietary, not the rich man's. I should reverse that answer." So that the poor man who can scarcely obtain food enough to keep body and soul together, must for his own good take that kind of bread which is less agreeable, and will cause more waste of his food in order to be consistent with a single fact in science. It is clear that science and bran together would be the death of him, only that his own experience had taught him to cast both aside, to leave the physic to them who can afford to take it.

It is, perhaps unnecessary to proceed further in the matter, or I might adduce the experience of persons in feeding horses and pigs with the bran and the inner husk of wheat or sharps. When a bran mash is given to a horse it is given as a medicine, and no one who has had the least experience in feeding pigs would give sharps—the highly nutritious inner husk of wheat!—instead of barley meal, which contains so much less nitrogen. Moreover, the price of the bran and sharps indicates the estimate which is formed of their nutritive values. Thus:—

1 bushel of	seconds flour,	weighing	56 lbs.	costs	7s. 9d.
"	bran	"	12	"	9d.
"	coarse pollard	"	14	"	10d.
"	fine pollard	"	18	"	1s. 0d.
"	sharps	"	26	"	2s. 0d.

I have entered at length into this question on the ground of its importance, both in a scientific and social point of view, and I trust that we shall assent to this conclusion, that at equal cost, brown bread is dearer than white bread, and from its medicinal action should be used intermittingly and not continuously (if used at all), and should not be used by the poor man. The relative values when differences of cost occurs must depend upon the amount of difference. Years ago white flour was from 2d. to 4d. a peck dearer than brown flour, but the quantity of the latter which is now made is so much reduced, that when wheat of equal quality is used there is no difference in price in some localities, as in London, and but little difference in country places. Hence there is now nothing in favour of its use by the working classes, but if a large sale of it at the present high prices could be effected, the bakers, buying it in large quantities at a cheaper rate, would make larger profits by it.

Barley bread is much inferior to wheaten bread in the amount of nitrogen which it contains, but it is so much cheaper that, where the flavor and dark color are not objected to, its use is economical. The meal is sold at 1s. and 1s. 2d. the 14 lbs., and if we take the higher sum, we shall find that 2,500 grains of carbon and 93 grains of nitrogen will be obtained for 1d.

Rye alone is not made into bread at the present day, but it is mixed with wheaten flour to make brown bread. It contains more nitrogen than barley and less than wheat, but both are remarkable for the large amount of indigestible husk which is found in the bread.

As the bread in use in this country is derived from the grains already referred to, it will be convenient to consider here the economy of baking the bread at home. The discussions which have recently taken place in the *Times* have shown that not less than 94 loaves of 4 lbs. each, and one baker admitted that 95 loaves of 4 lbs. could be made from 280 lbs. of flour, not necessarily so that every loaf could be sold at the highest price. The quantity varies with the soundness and highly nitrogenised qualities of the flour and the skill of the baker, so that in numerous experiments made at home, I found that the quantity of bread varied from 19 lbs. to 20½ lbs. from the peck of 14 lbs. of flour. 95 loaves to the sack, and 19½ lbs. to the stone, are equal to the quantity of flour multiplied by 1·4, and whilst the quantity of bread should be somewhat greater, it ought not to be less. Where the 4 lb. loaf may be purchased for 5½d., the flour may be bought retail at from 1s. 10d. to 2s. the peck. If we select the former price we shall obtain 16 lbs. of bread for the same price as 14 lbs. of flour, so that the value of 3½ lbs. of bread (the extra quantity which should be produced from the peck of flour), represents the cost of baking and gain if any. The cost will include yeast, which will vary from 1d. to 1½d., salt and the cost of the firing, which would not be so much as the balance, 3d. or 3½d. The labour of the housewife need not be taken into the account, and where there is convenience for baking, it is probable that 2d. to 3d. per peck will be saved where fuel is cheap. In London the cost of bakers' bread and flour is nearly the same.

Oatmeal and Indian corn are not baked into loaves, and wherever they are eaten it is most usual to eat them in a moist state. Oatmeal is richer in nitrogen than wheaten flour, but this is owing very much to the husk, which is not thoroughly removed, and which when taken into the body is not digested. The price of oatmeal is now universally 2d. to 4d. per peck of 14 lbs. higher than that of household flour, so that the gain in the use of oatmeal is lessened. The amount of carbon and nitrogen to be obtained for 1d. when oatmeal costs 2s. 2d. the 14 lbs., is 1513 grains of the former and 75 grains of the latter.

Indian corn, or maize, may be purchased here at the price of barley, and as it contains much more nitrogen and carbon than the latter, it is by far the cheapest food hitherto mentioned. Thus at 1s. 2d. per stone of 14 lbs. there will be no less than 2,800 grains of carbon and 121 grains of nitrogen obtained for 1d.

Rice and Peas.—Rice has already been mentioned, and it remains to speak of peas and beans in connection with this part of the subject, since whilst peas are usually eaten after boiling, there are parts of the country where they are added to other foods in making bread. Split peas may be purchased at 1½d. per lb. retail, and at that price will yield 1820 grains of carbon and 170 grains of nitrogen for 1d. Hence in the latter particular, they far exceed in economy all the foods already mentioned. It must, however, be stated that this analysis refers to whole peas, and assumes that the whole will be ground into meal, but when they are boiled the shells are indigestible, as has been already pointed out, and lead to waste of food. Hence, although split peas are somewhat dearer, it is probable they are more economical.

The foods which are thus associated offer a wide range in their relative economy, so that some have twice as much carbon and others twice as much nitrogen as the standard quantity found in bread, and in relation to the same monetary value and in their effect upon the system would probably differ but little from that proportion. Hence it may be asked, "Why is it that the cheaper foods are not universally selected." The answer must have reference to the income and the tastes of the people. So long as good wheaten bread can be obtained its approved flavour will commend it, whilst other and cheaper foods will only be used as adjuncts. It is only as the real wants of the system are greater than the income spent on bread will supply, that unusual and less agreeable foods, as peas and beans, barley, rye and maize, will be accepted. In all these discussions a practical as well as scientific view must be taken, and to the destitute class only can we commend the use of such foods with success (and only then as a temporary expedient), whilst any general attempt to enlist the sympathies of those who can purchase white bread will certainly fail.

Fresh Vegetables.—Potatoes will be dear or cheap as they are purchased or grown, and therefore their value will be differently estimated by persons occupying the two positions. Moreover, when they are purchased their cost varies much at different seasons and in different parts of the country so that it will not be easy to obtain an approved standard for our calculations. I propose to select ½d. per lb. as a medium cost, and at that price 1540 grains of carbon and 49 grains of nitrogen, would be obtained for 1d., but as the price is often 1d. per lb. in London and other large towns, only one half of that quantity would be then purchased for 1d.; hence their inferiority to the standard quantity in reference to nitrogen is very striking, and at either price they are dear food.

Other fresh vegetables may be classed together, and if we consider that 2 lbs. in weight could be purchased in London and large towns for 1d., and 4 lbs. in country villages for the same sum, we shall find that the carbon and nitrogen obtained would be respectively 820 grains, and 1640 grains of the former and 28 grains or 56 grains of the latter, and hence would closely correspond with the nutritive value of potatoes when purchased at ½d. per lb.

When potatoes and green vegetables are grown by the consumer, their cost is represented only by the rent of the land and the manure, and often by the former only, for manure is often collected, and the planting and gathering of the crops effected by the labour of the family, and as that labour could not be otherwise profitably employed, the potatoes add to the wages of the family, or are obtained almost without cost, as the question may be regarded. Such persons have great advantages over those who must buy their food, and exhibit a real economy in extending the use of fresh vegetables as far their appetite and health or their means of production will allow.

Fats are allied to the class of foods now discussed in that both constitute the chief supply of carbon to the system, but they differ in offering no nitrogen. They also contain much free hydrogen, which is useful to the system, but for the reason already given I shall refer only to the carbon. Those fats which are in common use, when separated from other foods, are butter, lard, dripping, and suet. The prices differ greatly, and particularly that of butter, so that I must take a medium, and shall select 1s. 2d. per lb. for butter, 9d. per lb. for lard 6d. per lb. for dripping, and 7d. per lb. for suet. At these prices the following are the quantities of carbon which can be obtained for 1d.:—Butter, 327 grains; lard, 591 grains; dripping 886 grains; and suet, 657 grains. Hence butter is by far the dearest of the fats, and dripping the cheapest, whilst the average of the whole is not nearly half of the standard quantity of carbon, omitting any reference to nitrogen.

Sugars, like fats, yield no nitrogen, but supply carbon largely. The two kinds are sugar and treacle, each having much variation in price, but little in nutritive value. I propose to consider sugar to be worth 4½d. per lb., and treacle 3d. per lb., and at these prices the quantity of carbon afforded by them at the cost of 1d. is, sugar, 622 grains, and treacle, 746 grains. Treacle is thus the cheaper but its use is more limited than sugar, and could not supplant the latter. The relation of the nutritive value to the standard in bread is almost the same as that of fats, and both are dear foods as compared with the standard. It is also seriously doubted whether the elements of which sugar is composed can be rendered equal in nutritive value to the same elements in fat; and, although this cannot be determined at present, it seems probable that the absence of sugar in a dietary would be less important than the loss of an equivalent value in fat.

Meats.–The determination of the exact economic value of meats is a work of great complexity owing to the different kinds and joints of meat which are used, containing very different relative quantities of fat and lean, and the valuable flavoured juices of the meat. All contain both carbon and nitrogen, and these will vary as the fat and lean vary. As a general expression, it may be stated that in point of cost, beef and English bacon are the dearest, whilst American bacon, mutton, and pork are the cheapest. In reference to the nutritive elements, bacon, pork, mutton and beef have the greatest quantity of fat, beginning from the first, and will therefore be richer in carbon than beef, whilst the latter will exceed the others in nitrogen. If we consider that the average price of beef is 7½d., of mutton and pork 7d., of English bacon 8½d. and of American bacon 4½d., we shall find the following quantities of each to be procured for 1d.:—

	Carbon.	Nitrogen.
Beef	320 grains	23 grains.
Mutton	415 "	20 "
Pork	483 "	18 "
Dried English bacon	510 "	12 "
Wet American bacon	918 "	17 "

Hence the quantities of carbon vary from 320 grains to 918 grains, and of nitrogen from 12 to 23 grains, so that when compared with the standard they are deficient by two-thirds.

A communication addressed to me by the Consul of Uruguay led me to expect the receipt of specimens of dried meat from South America, which after examination and consideration, I might have included in my list of foods, but the parcel has not yet arrived.

Time does not permit me to consider the propriety of admitting or rejecting the flesh of animals which have died from accident or disease (thence often misnamed diseased meat), and which is sold cheaply. There is a natural repugnance to the use of this food, and yet it has been eaten in various parts of the country in all ages, as for example the braxy mutton of Scotland, and veal from calves dying natural deaths in Wales, and no evil has been traced to it. So also with animals dying from accident, such as suffocation on board ships in a storm, or by acute inflamations, it has not been shewn that any change has taken place in the flesh which, when eaten would produce unhealthy nutrition. The case is far different when the animals have been long ill, or when the disease has been a specific one, which could in other ways have been transmitted. As there is not time to discuss this important question properly, I should regret saying anything which might lessen our repugnance to the use of the flesh of animals dying from any disease, but I am of opinion that some of the denunciations which have recently been hurled against them are not supported by known facts, and that in the interests of science as well as of justice nothing should be asserted which cannot be supported by proof. As there could not be any means of distinguishing the meat of animals dying of different diseases (except in a few cases), it is only at present practicable to wholly admit or wholly exclude it, and the latter is doubtless the safer plan.

There are two substances in reference to meat to which I must further refer, viz., liver and bones. There is a scientific prejudice against the use of liver on account of the frequency with which it is diseased, but when it is cut into thin slices and no disease is evident to the eye, it is only necessary that it be well cooked. It is an economical food, for if it cost 3d. per lb. it will yield 410 grains of carbon and 70 grains of nitrogen for 1d.

Bones are used by every housewife, if she have them, when she makes soup or broth, and yet there is a scientific prejudice against them because an inquiry made by "The Gelatin Commission" in France many years ago, proved that animals could not live on bones alone. Here again we have a hasty generalization, for whilst the conclusion just mentioned was proved, it was not shown that bones may not be advantageously used as a part of the dietary—yet from that conclusion and the further fact that the residue of digested (or boiled) bones consists largely of gelatin, arose assumption that gelatin was not nutriment, yet medical men order jelly for sick diets, and everybody who can obtain a jelly, if it is nicely flavoured, enjoys it, and all have the impression that it nourishes. Moreover, in my experiments I proved that when jelly had been eaten the emission of nitrogen was increased—thus showing that the jelly had been absorbed and converted into other substances; yet, with the habit of writers to hand down that which has been written, the writers on diet of to-day deny the nutritive value of Gelatin. As bones cost about 1d. per lb., and when cooked may be sold again for a ½d. per lb., the analysis which I made for the Government proved that 1d. worth of bones well digested gave 1566 grains of carbon and 48 grains of nitrogen, so that I trust science will not prevent your using them.

Fish.—Of fish I shall refer only to herrings, since it is impossible to fix a uniform price to that article of diet. If we take a dried herring of the size sold at three-farthings each, and a fresh one sold at one half-penny each, the following will be the amount of carbon and nitrogen per 1d.

	Carbon.	Nitrogen.
Dry	352 grains	54 grains.
Fresh	480 "	72 "

The size will vary with the state of the market, but fresh herrings are more economical than dried herrings at the price named, and, whilst greatly below our standard in carbon, approach it very nearly in hydrogen.

Milk.—Milk is used as new milk, skimmed milk and butter-milk. These differ extremely in the price paid for them, but they approximate closely in the nutritive elements which they contain, for skimmed milk differs from new milk only in having lost the butter, and butter-milk from skimmed milk only in having lost a portion of its sugar and gained a portion of acid. Hence, skimmed milk and butter-milk may be rendered nearly equal to new milk by adding a proper quantity of fat to them.

I do not think that a medium price can be selected for each of these kinds of foods, since they are purchased at the different places at different and yet fixed prices, over large areas of the country, but I will name the following:—New milk, 1d. and 2d. per pint; skimmed milk, ¼d., ½d. and 1d. per pint; and butter-milk, ⅙d. and ½d. per pint. At these prices the following quantities of the elements may be obtained for 1d.

			Carbon.		Nitrogen.	
New milk......	1d.	per pint	546	grains......	44	grains.
"	2d.	"	273	"	22	"
Skimm'd milk.	¼d.	"	1,748	"	174	"
"	½d.	"	874	"	87	"
"	1d.	"	437	"	44	"
Butter-milk...	⅙d.	"	2,514	"	262	"
" ...	½d.	"	838	"	88	"

If we select skimmed milk and butter milk at their lowest price, we find that they exceed the standard in carbon, and are very much richer in nitrogen. Even butter-milk at the highest price, and skimmed milk at its medium price, are higher than the standard in nitrogen but deficient in carbon, whilst new milk at the highest price is somewhat dearer than beef, and incomparably dearer than the standard. As the cost of milk cannot be varied by the purchaser, but each person must in his own locality pay the price demanded, it is easy to perceive how much more highly-favoured some portions of the community are than others, and how unfavourably the inhabitants of this metropolis compare with those of small towns and villages. How absurd also is the frequent habit, even among the poor, of regarding butter-milk as a food for pigs and not for man.

Whey.—Whey is nowhere sold by farmers I believe, and in but few places is it regarded as a food worthy of man. It is not a rich food, for nearly all the cheese and butter have been extracted in its production, but yet each pint contains nearly 200 grains of carbon and 15 grains of nitrogen, so that it is much more economical to drink whey than water.

Cheese.—Cheese is a substance particularly rich in nitrogen, and the poorest kinds of it, namely, those made from skimmed milk, contain the greatest amount of this element. It is very probable that the only real difference between skimmed milk cheese and new milk cheese, is in the absence of butter in the former, and its presence in greater or less quantity in the latter. Hence the latter will be richer in carbon, besides being more agreeable to the palate. There is a great difference in the value of these kinds of cheese, so that whilst skimmed-milk cheese is obtained at 3d. per lb., it is needful to give 8d. for a fair sample of new milk cheese; and accepting those prices we shall find the amount of carbon and nitrogen which can be obtained for 1d. as follows:—

	Carbon.	Nitrogen.
Skimmed-milk cheese ...	782	122
New milk cheese..........	333	40

The difference in the economic value of the two kinds is exceedingly great, but it is not known whether both are equally digestible and appropriated by the system. It is highly probable that when more than half an ounce of cheese is eaten at a meal a considerable portion passes off unused, for in my experiments the amount of nitrogen which enters the blood when two ounces of cheese had been eaten was far less than was contained in the cheese. Admitting, then, that there is a waste of material whenever cheese of any kind is eaten in large quantities, I doubt if there is any ground for the belief that the cheaper kinds of cheese are less digested than the other, provided the following conditions be fulfilled in both cases, viz., that the cheese be neither new nor old, but the skimmed milk cheese about 6 months, and the new milk cheese from 6 to 12 months old. If too new, the skimmed milk cheese is tough, and if too old, it is hard, and therefore in both cases it will be imperfectly masticated.

When compared with our standard, skimmed milk cheese far exceeds it in nitrogen, whilst both kinds are greatly deficient in carbon, and from this must also be taken an unknown quantity for the supposed loss in digestion. It is a great mistake in the poor to buy high priced cheese, and cheese at whatever price which is strong to the taste.

Tea.—Tea was largely considered by me in the paper* which I had the pleasure of reading before this Society two years ago, and which the council honoured with a medal. It is by far the least economical of all the substances used as food, since if valued at 3d. per oz. it would not give more than 4 grains of nitrogen and an infinitesimal quantity of carbon for 1d. Hence, as affording nutriment, its purchase is most wasteful; and although it is useful by enabling the poor to drink hot water in an agreeable form, it is most desirable that its cost should be reduced to the least possible amount.

Alcohols.—I do not propose to discuss the value of alcohols in this paper, since regarded as food they offer extremely little nutriment in proportion to their cost, and regarded as medicinal agents their worth cannot be measured by the nutritive material which they contain.

Summary.

I have now completed the details which I proposed to lay before you, and, in conclusion, have only to sum up the subject by showing at what cost the standard quantity of carbon and nitrogen may be obtained from the various foods which have now been considered. The standard quantity required is 1450 grains of carbon and 66 grains of nitrogen, at a cost of 1d.

As to the Carbon.

Maize will yield the standard quantity at a cos of ½d. Buttermilk (bought at 6 pints for a penny) and barley meal at a little more than ½d.; peas, green vegetables (costing ¼d. per lb.), potatoes (costing ½d. per lb.) and oatmeal and bones, at from ½d. to 1d. Fine flour, rice, butter-milk (costing ½d. per pint) at from 1d. to 1½d.; green bacon, skimmed milk (costing ½d. per pint); dripping, green vegetables (costing ½d. per lb.); treacle and skimmed milk cheese, at from 1½d. to 2d.; suet, sugar and lard, at from 2d. to 2½d.; new milk (costing 1d. per pint); fresh herrings and pork, at from 2½d. to 3d.; mutton and skimmed milk (cost-

* Vol. IX., p. 185.

ing 1d. per pint), at from 3d. to 3½d.; dried herrings, butter, new milk, cheese and beef, at from 4d. to 4½d.

As to the Nitrogen.

As the relative quantity of nitrogen to carbon is not high in bread, we shall find that numerous articles of food offer the nitrogen at less cost than bread, whilst at the same time the extreme variation from bread is in reference to the nitrogen. Thus, butter milk (costing ⅙d. per pint) will give the standard quantity of nitrogen for ¼d.; skimmed milk (costing ¼d. per pint), peas, and South American beef, at from ⅓d. to ½d.; skimmed milk, cheese and maize, at about ½d.; butter milk and skimmed milk, each costing ½d. per pint, and barley meal, at ¾d.; oatmeal, fresh herrings and liver, at from ⅞d. to 1d; fine flour, green vegetables (costing ¼d. per lb.); dried herrings, new milk, and skimmed milk (each costing 1d. per pint), and bones at from 1d. to 1½d.; new milk cheese, at a little more than 1½d.; green vegetables (costing ½d. per lb.); potatoes costing 1d. per lb.; beef and new milk costing 2d. per pint, at from 2d. to 3d.; mutton, pork and green bacon, at from 3d. to 4d., dried bacon, 5½d., and tea at 20d.

These with other facts are contained in the following table:—

TABLE, showing the quantity of Carbon and Nitrogen contained in 1d. worth of various foods at the prices annexed, and also the variation from the pennyworth of various foods to supply as much Carbon and Nitrogen as are contained in one pennyworth of bread (the standard quantity).

Food.	Costing.	Carbon for 1d.	Nitrogen for 1d.	Variat'n from cost of 1d. to supply the stand'd quantity of 1450 grains of carbon and 66 grs. of nitrogen. Carbon.	Nitrog'n
	d.	Grains	Grains	d.	d.
Bread	1⅝ per lb.	1,450	66	......	......
Fine Flour	2 "	1,330	60	1·09	1·1
Barley	1 "	2,600	93	·58	·7
Rice	2 "	1,380	35	1·05	1·88
Oatmeal	1⅘ "	1,618	75	·957	·88
Maize	1 "	2,800	121	·51	·545
Peas	1½ "	1,820	170	·796	·388
Potatoes	½ "	1,540	49	·94	1·34
Potatoes	1 "	770	24½	1·88	2·69
Green Vegetables	¼ "	1,640	56	·88	1·18
Green Vegetables	½ "	820	28	1·76	2·36
Butter	14 "	327	...	4·43	......
Lard	9 "	591	...	2·45	......
Dripping	6 "	886	...	1·63	......
Suet	7 "	651	...	2·22	......
Sugar	4½ "	622	...	2·34	......
Treacle	3 "	746	....	1·94	......
Beef	7½ "	320	23	4·53	2·87
Mutton	7 "	415	20	3·49	3·3
Pork	7 "	483	18	3·0	3·66
Liver	3 "	410	70	3·53	·94
Bones	½ "	1,566	48	·92	1·46
Dried Engl'h bacon	8½ "	510	12	2·84	5·5
Green Amer. bacon	4½ "	918	17	1·58	3·88
Dried herrings	¾ each.	352	54	4·1	1·22
Fresh herrings	½ "	480	72	3·0	·01
New milk	1 per pint	546	44	2·66	1·5
New milk	2 "	273	22	5·32	3·0
Skimmed milk	¼ "	1,748	174	·82	·38
Skimmed milk	½ "	873	87	1·64	·76
Skimmed milk	1 "	437	44	3·28	1·52
Butter milk	⅙ "	2,614	262	·576	·25
Butter milk	½ "	838	88	1·15	·75
Whey	....	...	...	......	......
Skim'd milk cheese	3 "	782	122	1·98	·54
New milk cheese	8 "	333	40	4·33	1·65
Tea	3 per oz.	...	3·3	......	20·0

I have only now to offer an apology for the length of this communication, and to state that with the information obtained I shall be prepared to consider the combinations of foods in private and public dietaries, should an opportunity be offered to me.

Discussion.

Dr. Lankester (responding to the invitation of the chairman) said they must all feel the importance of this subject, and they were much indebted to Dr. Edward Smith for bringing it before the Society. At the same time he felt that the great food question could not be decided merely by a few experiments. This was a subject to be treated with the greatest caution, and all that had been done hitherto, only served to indicate the direction in which further inquiry must go. Our government had been lately paying attention to this question, especially by means of that Committee before which Dr. Edward Smith himself had given evidence, but he (Dr. Lankester) must say that, in certain practical departments, the Government had paid little or no attention to this matter. He formerly held the office of Superintendent of the Food Museum at South Kensington, but he felt bound to say no encouragement was given him or the other officers of that department in the proper development of it. Enormous sums had been expended in the purchase of works of art which, in his opinion, were of little value as compared with the more important matter of the food of the people: and every effort appeared to be made to suppress the development of that department of the museum. Dr. Edward Smith had rather disparaged the experiments of Liebig and his school, but he (Dr. Lankester) must say they were deeply indebted to that great chemist for the light he had thrown upon the subject of chemical physiology; and though Dr. Smith was inclined to disregard the distinction drawn by Liebig between heat-givers and flesh-formers, yet he (Dr. Lankester) thought there was no better mode of describing those articles of food which supplied carbon and those which supplied nitrogen. Dr. Smith appears to have ignored hydrogen, which was a powerful heat-giving agent as well as carbon; consequently when the hydrogen derived from such food as fat and butter was disregarded, a false view of the value of those articles of diet was arrived at. The fact was Liebig was correct when he stated that the value of butter and fats in relation to sugar and starch as heat-givers was as 2½ to 1. Our knowledge of the action of various foods was one to which further contributions were constantly being made. With regard to the influence of alcohol, a subject treated by Dr. Smith before this Society two years ago, the experiments of M. Baudot had materially modified the conclusions arrived at by Messrs. Lallemand and Perrin, and this showed how carefully this subject of food should be approached. He had been at some pains to consider some of the practical questions with which Dr. Smith had more particularly dealt. With regard to the question of brown bread, he could say he had eaten it himself regularly for the last 20 years, with considerable advantage; at the same time, he was free to confess that upon its introduction into families there was a distaste manifested towards it by children, which he was at a loss to account for. With reference to the point urged by Dr. Smith, that brown bread was of an excrementitious character, he thought the experiments on which that conclusion had been arrived at were limited and vague. He (Dr. Lankester) thought that Dr. Smith had been led into error from having found in his microscopic examinations of excrement the cellulose of the bran which was not capable of assimilation, or at least only so to a partial extent. The substances which were passed off when brown bread was eaten, were those which were not digestible, and which he (Dr. Lankester) had characterised, in his analyses at the South Kensington Museum, as substances accessory to food, and not really food, but which he allowed had been estimated by the school of Liebig as heat-givers, but which should properly be regarded as accessory or excrementitious matters. It seemed to be quite necessary along with the food to take a certain quantity of indigestible matter. He therefore thought Dr. Smith had not quite proved that throwing away the bran was not injurious to the community by whom it was practised. Then there was another element in the consideration of this question, namely,—that the value of foods was not to be estimated solely by the amount of carbon and nitrogen which they contained, but their mineral elements must be taken into consideration. Many of the substances mentioned contained mineral constituents, but Dr. Smith had not alluded to these. The potatoe might be an expensive thing with regard to carbon and nitrogen, but it might turn out to be a cheap thing with regard to its mineral constituents. Words could hardly exaggerate the importance of that vegetable as a food. They found as it increased in price so disease increased. It was an articl of so much importance, that the Registrar-General published the prices of it, and in proportion as these rose, marriages and births decreased and deaths increased. What did that depend upon? Not on the carbon and nitrogen, but probably on the mineral elements. Milk and cheese respectively contained these mineral constituents in a large degree. The latter was not only valuable on account of the caseine and butter it contained, but also on account of its mineral constituents, and he thought Dr. Smith should not have left them out of consideration. The relative digestibility of the various kinds of food was also most important. He had shown that split peas and maize bread were the most perfect kind of food they could use, considered in the relation of their chemical constituents to their price. Why then should anything else be eaten? Simply because the nitrogen so essential to the body was not taken so readily from bread as from meat, so it was better to pay twice the amount for it in the form of fresh meat than in bread; it was the ready appropriation of animal food which made it so important as compared with the various forms of vegetable food. If they fed soldiers and sailors, paupers, and prisoners, on such principles as Dr. Smith had advocated, they would feed them to their injury. They could, however, hardly have fed soldiers worse than they did up to the last few years. It was indeed folly to feed men with boiled beef, throwing away the water in which it was boiled and giving merely the fibrous matter of the meat, from which all the nutritious juices had been extracted. He should be glad to see the time when men like Dr. Smith, Mr. Lawes, Dr. Gilbert, and others, who had worked with so much earnestness and care on this subject, were consulted by the Government, and a proper dietary laid down for our public establishments.

Dr. Gilbert thought all recent investigation tended to show that the relative values of different food-stuffs could not be so directly estimated by their proportions of nitrogenous or so-called flesh-forming substances as had been generally supposed. It was maintained that bread containing the bran of the wheat was better food for the labouring classes than white bread, because it contained more nitrogen. He quite agreed with Dr. Smith, however, that whole-meal bread was the rich man's, not the poor man's food. It would hardly be doubted that the man who was rather under than over fed would improve his white bread diet much more by the addition of fat bacon than by the retention of the bran in the flour. Yet, by the use of the bacon, the labouring man diminished considerably the proportion of the nitrogenous to the non-nitrogenous constituents in his food. Even the classes who used the leaner meats undoubtedly reduced the proportion of the so-called flesh-forming to the so-called heat-producing constituents, by the admixture of animal with vegetable diet, owing to the large quantity, and high equivalent of the fat which the former introduces into their diet. It was probable, however, that those who are well-fed on a mixed animal and vegetable diet, do take a larger actual quantity of nitrogen into the system than those exclusively fed on vegetable food. A certain quantity and proportion of nitrogen were of course essential, but as our current food-stuffs go, the under fed seemed generally first to feel the want of more of the non-nitrogenous matters. In settling dietaries on chemical principles, he (Dr. Gilbert) thought it important to take into the calculation what was called the free hydrogen; a point which he illustrated by reference to figures, showing that in the case of the animal aliments, it made a considerable difference whether the free hydrogen were estimated or not. Independently of ultimate composition, digestibility and assimilability were, of course, important points to consider; and here came in observation and experience to modify the conclusions deduced from purely chemical data. It had been remarked that hence error arose, in not eliminating the cellulose in estimating the nutritive values of foods. Undoubtedly a large quantity of cellulose passed from the body undigested; but recent investigations of Mr. Lawes, himself, and others, had shown that ruminant animals digested a good deal of the cellulose they took into their stomachs. There was not, as far as he was aware, any facts showing whether or not the human economy appropriated any considerable quantity of cellulose. It might, however, safely be concluded that the indulated cellulose of bran would be little, if at all, amenable to the digestive process, and there was no doubt that the branny particles did keep up an active condition of the bowels, and tended to aid the passage from the system of undigested or unassimilated, but digestible or assimilable material.

Dr. Wyld remarked that Dr. Lankester had made an eloquent appeal on behalf of bran, but at the same time he (Dr. Wyld) declared himself a convert to Dr. Smith's view on that subject. The various national predilections for certain descriptions of food were remarkable. On the part of the Scotch there was a national preference for oatmeal, an article of food which was adapted to the peculiarities of the climate. The almost universal dislike of children to brown bread he attributed to an instinctive desire for that food which most promoted the physical development of the body and which contained the smallest amount of *débris*. When the Government attempted to force brown bread upon criminals it occasioned insurrection amongst them, which seemed to show that they instinctively knew better than Government what was good for them. * * Dr. Wyld proceeded to express an opinion unfavorable to pork as an article of food, and remarked that it was prohibited as unclean by Moses, whose hygienic regulations had never been surpassed. One remarkable result incidental to eating raw pork, which was often in a diseased state, was the production of the tape worm in the human stomach. He also condemned all young meats, such as veal and lamb, as objectionable articles of food. He advocated animal food in the form of sausages as a nutritious form of diet, particularly for the labouring classes, the skin in which it was enclosed retaining all the essential juices.

Dr. Robert Dickson, responding to the call of the chairman, said he had paid a great deal of attention to this subject, both theoretically and practically, and he was happy to say he had learnt a great deal from the paper read this evening. Of the relative value of white and brown bread opinions would differ, which was in a great degree owing to the diversity of tastes among mankind, which prevented an undue "run" upon any particular article of food. If the object was to afford nutriment to the system, he believed brown bread was inferior to white; if the object was to obviate a tendency to constipation, induced by a too sedentary habit, its use was essential. Dr. Lankester had very properly remarked that too little value had been attached to hydrogen in articles of food—whether animal or vegetable. There could be no doubt of the great utility of hydrogen as well as oxygen, to which scarcely any attention had been given in the paper. The hydrogen which existed in vegetable matters in the form of various hydro-carbons was of immense value. There were also other constituents in food of great importance. Nothing had been said of the great value of phosphorus, yet they all knew how essential that was to the animal system. It was alike important in health and in disease, and was an essential element to be taken into consideration in estimating the relative values of foods. Hence fish, which contained phosphorus, was a most excellent article of food, and if it were cheaper no doubt it would be more largely used by the lower classes.

Mr. Frank Buckland said, having had the medical charge of a regiment of the Guards for some years, he had made it part of his duty to observe the effect of diet upon those fine specimens of Englishmen. He found young recruits from Ireland who had lived chiefly on potatoes all their lives, and were apparently strong, muscular men, after being put upon the ordinary diet of the English regiments, altered very much in appearance, and though they made flesh very considerably, they frequently broke down physically in going through their duties. The biggest boned men in the regiment were north country men and Scotchmen. That might be attributed to the oatmeal and also to the coldness of the climate. People from cold countries were invariably strong.

The Chairman* said they would all agree that the inquiry which had been instituted by the Privy Council was of the highest public as well as private importance, and, so far as it had been carried out, it appeared to him to have been very ably executed. Hitherto Dr. Edward Smith had been confined in his researches to the dietaries in use amongst the poor of the northern districts of England, of Scotland, and of some parts of Ireland. The observations he had made there were highly valuable. They indicated the superior efficacy of the simpler diets, those of oatmeal porridge and milk in Scotland, and of potatoes and butter-milk in Ireland. He had ascertained that in Scotland the country bred people, when they went into towns and obtained higher wages, and substituted tea and bread and butter for oatmeal porridge and milk, did not thrive so well upon this more expensive and stimulating diet. Public warning should be given of these results. It was highly important that these observations should be extended to the examination of the effects of the large variety of high and low dietaries in use in public institutions. There was great advantage in the observation of the effects produced on persons of similar ages and conditions, who might be weighed and examined. A German prince had lent to Liebig a body of soldiers to make experiments upon. He (the chairman) had promoted trials of different sorts of dietaries in prisons, and those trials might well be repeated under such scientific observations as Dr. Edward Smith was pre eminently qualified to make. If the examination of the effects of the brown bread, as compared with the white wheaten bread, made by Dr. Edward Smith, were deemed conclusive, let the trials be repeated on other classes of persons. Each chief article of food ought to be separately tried. The late Mr. Aubin, the manager of the Central District School of London, who had had 30,000 children under his care, and was a good observer of foods, had found that there were great variations in the effects of various conditions of the same food; for example, oatmeal of inferior growth or condition produced eruptions on the skin and functional disturbance, whilst a good quality of growth was productive of good effects. It had fallen to him (the Chairman) to collect and compare, rudely as it might be, the effects of different public dietaries before chemical analysis had been brought to bear on foods. The dietaries collected from different parts of England, he found, when reduced to comparative weights, fell in the following scale, that was, the aggregate amount of solid food. The average that each class got was as follows:—

As agricultural labourers	122
As artizans of the highest wages	140
As paupers	150
As soldiers	168
As prisoners in goal	217
As convicts on board the hulks, or as transported felons	237

To an allowance of ten pounds of meat a week in

* Edwin Chadwick, Esq., C. B.

the stimulating climate of Australia was added half-an-ounce of tobacco daily for the use of the convicts in Western Australia. It was at that time urged by medical authorities, and indeed was so still by many, that dietaries containing high stimuli beyond those got by the hard working honest population were necessary to sustain the health of the prisoners. He found that the quality of the diets, as containing more or less of animal food, was very much represented by the cost, and this varied from 1s. 2d. to 5s. and even 7s. per head per week. Now, it should follow, from the medical recommendations, that the health of the prisoners would rise in proportion. To determine this question he resorted to statistics. Taking 104 prison returns—which enabled a comparison of the twenty gaols where the expense and the quantity of the diet were the lowest; the twenty where the expense and the quantity of the diet were the highest, and the twenty where they were intermediate between the highest and the lowest—the results came out as follows:—

	Ounces of solid food per week.	Cost per head per week.	Sick per cent.	Deaths per 1,000
Twenty Lowest Prison Diets	188	1s. 10½d.	3	1½
Twenty Intermediate Diets	213	2s. 4½d.	18	3
Twenty Highest	228	3s. 2d.	23½	4

The results were objected to on the grounds that in some of the larger prisons, where the lower dietaries were adopted, the terms of imprisonment were shorter than in others. But those objections were met by the trial of the simpler dietaries in the same prisons, with the same classes of prisoners, with labour and without labour, for the like periods, where the like results appeared. * * The meeting would, he was sure, give a unanimous vote of thanks to Dr. Edward Smith for his able paper on this nationally most important subject.

The vote of thanks having been passed,

Dr. Edward Smith, in acknowledging the compliment, said he thought that some of the remarks of Dr. Lankester had been made without due deliberation. He had characterised the experiments he (Dr. Smith) had made as limited and vague. He could say, having been appointed upon the committee of the British Association, that the experiments were made continuously for a month upon four persons in Coldbath Fields Prison, and likewise upon the same number of persons in Wakefield Gaol, the examination of what passed from the body being chemical, and not merely microscopical, as Dr. Lankester had assumed. He therefore thought those experiments were not open to the objection that they were either limited or vague. With regard to the constituent of hydrogen in food, he had not undervalued this element, but had said that if he were treating of the nutritive value of food in a chemical aspect only, apart from any daily measure of the amount required by the body, he should add the free hydrogen also, since by its combination to form water within the body it must generate heat; but we had no means of ascertaining how much heat is produced and required by the body; neither could we ascertain how much of the water which leaves the body is generated in this manner, and how much is due to that which was taken as food. No doubt the mineral matters contained in the food were of the highest importance, and in mixed diets these were found. With reference to the remarks of Mr. Frank Buckland as to the physical condition of the Irish recruits, he would say he was now engaged in a large enquiry, on behalf of the Government, to ascertain the exact amount of food taken by the different classes of the community in England, Ireland, and Scotland. At present he could not give the results of that inquiry, but in due time they would be published. The important question as regarded the Irish recruits was—not the potatoes, but the milk. The amount of milk taken by that class was generally large, and the great advantage to the muscular system was derived from this source, and not from the potatoes.

PROGRESS OF ENGINEERING SCIENCE.*

Water-Pressure Engines. — Recently a new application of water power has been effected by the inventive genius of Sir W. Armstrong. He first applied it at Newcastle, where the general level of the town is very much above that of the wharves of the harbor, and the water works in consequence provided a very tall column of water at the lower levels. Of this he availed himself by applying the pressure so obtained to force a piston along a water-tight cylinder, and with a simple multiplying gear the cranes on the quays were made, by the mere turning of a cock, to raise any weight their construction could support. By applying the water power alternately on both sides of the piston, and acting on a cranked axle—as done in the steam engine—a water engine was next invented, capable of exerting any amount of power that could be obtained from the height of the column of water and the amount of supply. When a sufficient head of water is available, or where the work is intermittent, this is certainly one of the most successful applications of water power yet invented. At Great Grimsby Dock, and at Birkenhead, pipes are laid under the pavement from a reservoir at the top of a tall tower, to every part of the Dock premises. At the foot of every crane, under the piston of every hoist, at every dock gate, unseen and noiseless, the power lies dormant; but a woman's hand, applied to a small handle, will set in motion a force sufficient to raise a mass weighing fifty or one hundred tons, either to place it in the hold of a ship, or deposit it in any spot within reach of the arms of the crane. With equal ease the gates of locks 100 feet in width are opened or shut, and the smallest as well as the heaviest works of the dockyard done, without a stranger being able to perceive what it is that sets everything in motion.

As an accumulator of power, Bramah's hydraulic press surpasses anything that has yet been invented, and may be carried to any extent that the strength of the metal will stand. The presses which were used to raise the tubes of the Menai Bridge, when worked by a forty-horse power engine, were capable of exerting a power equal to that of 14,200 horses, and raised one-half the tube, or 900 tuns, slowly but steadily, through the 100 feet at which they were to be placed above the level of the water.

Air-Pressure Engines.—The tunnel under Mont Cenis is to be rather more than seven miles and

* Extracts from an article in the *Quarterly Review*.

a half in length, and as it is one English mile below the summit of the mountain, no air-shafts could be sunk from above; and the first difficulty was to ventilate a *cul-de-sac*, that at one time at least must be nearly four miles in length. This has been accomplished most successfully by M. Someiller, the engineer, availing himself, on the Italian side, of a stream of water eighty feet above the mouth of the tunnel. This is used to force air into a chamber, where it is kept at a constant pressure of six atmospheres, by a stand pipe 165 feet (50 metres) in height. From this it is conveyed in pipes to the innermost end of the excavation, where it is set to work to bore holes in the face of the rock for blasting purposes. There are eight perforators, each of which sinks ten holes three feet deep in the face of the rock in six hours. It takes some time to dry each of these, and to charge it with gunpowder; and it takes four hours to clear away the *debris*, and to make all ready for commencing another set of perforations; so that practically only two sets are bored in twenty-four hours, and the progress is consequently six feet per day. At each blow on the head of the jumper, a portion of the compressed air escapes, as steam does in a high-pressure engine. Its expansion is sufficient to cause a draft outwards, and keep the place perfectly ventilated; and even immediately after a blast, the tunnel is freed from the effects of the explosion very rapidly, and no inconvenience felt. By improvements in the machinery, the engineer hopes to bore one set of holes in eight hours; and as the more work it does the more air it blows off, not only will the work be expedited, but the ventilation improved by the more rapid working.

The Steam Engine.—Without doubt the invention of the steam engine is the greatest mechanical triumph which man has yet achieved. Although the invention of a practical engine is hardly more than eighty years old, and it is little more than half that time since its real value came to be appreciated, the mode in which engines have been multiplied and improved during the last forty years, and the thousand new purposes to which they have been and are daily being applied, is perhaps the most extraordinary fact in the industrial history of the world. It certainly is the one, the magnitude of whose results we are the least able to grasp. One of the greatest advantages of the steam engine, besides the power of placing it anywhere, is the wonderful flexibility with which it can adapt itself to almost any work it is set to perform. The difference between an elephant and a race-horse is not greater than between a Cornish pumping engine and an express locomotive. The perfection of the former arose from the necessity of importing every ounce of fuel to be used in Cornwall, and frequently of carrying it for miles over bad roads. This set engineers calculating how fuel could be saved, and with such success, that at one time a pound of coals did twice the quantity of work that it did elsewhere, though this difference is fast vanishing now. To any one accustomed to the noisy activity of most marine or manufacturing engines, nothing can be more remarkable than the sleepy quiet of Cornwall. The fire-bar area is so great, and the boiler arrangements so roomy and so carefully appropriate, that all the fuel and all the smoke are consumed, and none issues from the chimney. In the engine room nothing is seen but one great cylinder, hooped with wood, and looking more like a beer-vat than a part of an engine, and almost as cool to the touch. A few slender bright rods extend from the roof through the floor, and to these are attached some delicate bright handles, of rather fanciful forms, but these suffice to open and shut its valves and to regulate its expansion. As the stranger enters, all is quiet and at rest; no burst of smoke, no smell of oil, no escape of steam, and no noise. Presently there is a click-click among the handles; the great beam lazily raises itself, and lifts 100 or 200 fathoms of heavy pit work some ten feet upward, and then as quietly drops it again into its place. Having done this giant's work, it goes to sleep again for ten or twenty seconds, as the case may be, till called upon to make another effort. This it repeats at stated intervals during the whole twenty-four hours, week after week, or for months together, without rest or intermission.

Contrast this with the express engine, rushing past at a speed of fifty or sixty miles an hour, making 1,000 or 1,200 pulsations in a minute, consuming coals with reckless wastefulness, and casting its vital heat and life's blood to the four winds at each beat of its valves. Nothing that man has done comes so near to the creation of an animal as this—even the most unimaginative can hardly help drawing comparisons between the steam-horse and his quadrupedal competitor. There is indeed more in the comparison than appears at first; especially when we see the monster fed with great spoonsful of cooked black vegetable food, from which it evolves its vital heat in its capacious lungs, which, after circulating through its tubular veins, is launched into the air with the waste products of combustion.

In this, as in most things, the steam engine is strictly original, and, strange to say, no new principle has been invented since Watt left it, and no new form added which he did not at least foresee. The immense progress that has been made since his day has been due to the daily growing perfection of workmanship, and more perhaps to the careful adjustment of every part, and of every engine to the exact special work it has to perform. The progress is practically due to the knowledge which is obtained by the daily experience of those who watch the working of all these engines, from those which make three strokes in one minute, to those that make 1,000 in the same time, as well as all the intermediate grades between these two extremes, which are hourly performing every class of work under the most completely various circumstances.

There does not seem to be any theoretical limit to the size of a cylinder of a steam engine, or consequently to the power that may be given to it; but, practically, it is generally found more expedient to use two or more engines to do a given amount of work, than to increase to any very great extent the power of one. Pumping engines with cylinders 100 inches in diameter and with ten feet stroke, are common in Cornwall, and those used to drain the Haarlem Lake were 14 inches in diameter; and in the *Warrior* and *Achilles* the pair of engines are nominally 1,250 or 1,300 horse-power, but really work up to 5,000 or 6,000 horse-power.

When more than this is wanted, it may be expedient to divide it, as was done in the *Great Eastern*, between two sets of engines; for it is not only the cylinder, but the crank shaft, and all the gear, that require to be increased in the same ratio. Although the power of our factories to produce the immense forgings requisite for these purposes has been increased tenfold within the last thirty or forty years, and is daily increasing, there are inconveniences in dividing power, where there is room to do so, that will probably prevent any great increase in this direction.

The Cotton Manufacture.—In England it is calculated that, when the cotton manufacture is thriving, there are thirty millions of spindles constantly employed in spinning cotton alone; so that if every man, woman and child in the three kingdoms were to devote twelve hours a day to this occupation, they could not effect as much; and it would require another population of nearly equal extent to prepare the cotton for the spindles, and a very large number of persons to supply the place of the 300,000 power-looms that are employed to weave it, and to supplant all the mechanical appliances that finish it and fit it for the market. All this is required for cotton; but when we add to this the amount of power employed in spinning and weaving flax and wool, and all the different classes of fibres which we have enlisted in our service, the power employed in cotton alone sinks to a mere fraction.

Steamships.—Till the invention of the compass, long sea voyages were of course impossible, and large vessels were consequently not needed for commercial purposes; but the discovery of the uses of a keel, or something to enable a vessel to hold a wind, even if she could not beat to windward, was almost as important, for propulsion by oars must always have been very expensive and inefficient in large vessels. An immense impulse was also given to the improvement of vessels by the discovery of America, and of the passage round the Cape, and since then the progress has been rapid and steady; but it was not till propulsion by steam cleared the problem of all extraneous considerations of weatherlyness, steadiness and handiness in the manœuvering, &c., that marine architects fairly grappled with the subject.

In order to explain the problem the shipwright has before him, it may be necessary to state that a vessel, for instance, of 1,500 tuns, 36 feet beam, 250 feet long, and with 20 feet draft, displaces 20 tuns of water for every foot she moves forward, and the question is, what is she to do with this? If she heaps it up before her, as the old bluff-bowed vessels did, she has not only to climb over it, but she has wasted an enormous amount of power in lifting what she might have left lying. As every contractor knows, he is paid the same for wheeling stuff twenty yards forward as for raising it one yard high; and what the naval engineer seeks to do is to spread his displaced water laterally, evenly and flatly, over as large a surface as possible. The progress already made in this direction will be understood if we take, for instance, the resistance of a square box as our unit. By simply rounding off the corners, the power requisite to force the box through the water is diminished by one-third; by introducing such lines as were usual in the best ships thirty years ago, the resistance is lessened by two-thirds; whereas now, in consequence of the improved lines, which are mainly due to the long scientific investigations of Mr. Scott Russell and his coadjutors, the resistance is only one-twelfth of that of the box first mentioned; and this fraction may before long be reduced to one-twentieth or even to one-twenty-fourth. The consequence of this is, that twenty years ago engines of 500-horse power barely sufficed to drive a vessel of 1,000 tuns burthen ten knots through the water; the same engines would now propel a vessel of 1,500 tuns at least fourteen knots; and better results than this are being attained. Already twenty miles an hour has been reached, the Holyhead packets working steadily at that rate; and even an armed dispatch vessel has just left this country for China, which, with all her armament on board, can do as much, and that without any extraordinary exertion. Having reached this speed, we cannot long be content with less. Vessels must cross the Atlantic at the rate of 500 miles a day. It would be expensive to build a vessel to do this to-day, and it might be at some waste of power she would accomplish it; but day by day it is becoming less difficult, and before long it will be easy. Had the *Great Eastern* been built for speed alone, she could easily have accomplished this; but carrying power was her great object, and her calculated speed was fifteen miles, which she accomplishes with singular evenness in rough weather as well as smooth. She has run 475 miles in twenty-four hours, but her average speed is about 360, or fifteen miles per hour, or about the average speed of the best ocean steamers of the present day. This they accomplish easily, without the sacrifice of any of their qualities as sea-going vessels, while retaining the capability of accommodating a large number of passengers and a considerable amount of cargo for a voyage of 3,000 miles—the distance (speaking in round numbers) of New York from Liverpool.

But it is not only in speed that such progress has been made, as vessels have increased in size in even a greater ratio. Thirty years ago, 1,300 tuns was the measurement of our largest Indiamen, and 2,000 tuns of a first-class line-of-battle ship. We were all astonished, some ten years ago, when we heard of the *Duke of Wellington* being launched, of 3,800 tuns; and the *Himalaya*, of 3,600, built since that time, was the largest merchant vessel the world had ever seen. Now our first-class iron-plated frigates measure at least 6,000 tuns. The *Great Eastern* is 691 feet long, 83 feet wide, and registers 18,914 tuns, though her real capacity is nearer 25,000 tuns, and the indicated power of paddle-wheel engines is equal to 3,600 horses, and that of her screw to 4,800, making together 8,400 horse power. If she has not obtained, commercially, the success that was anticipated, it is not that our engineers did not know how to design and build her, or how to furnish her with the requisite power, but simply that she was born before her time. The world is not yet ready for vessels of her size. Without disrespect to any one, we may say that until vessels of very large size become more common than they are, and until nautical experience has been enlarged by the use of such ships, there cannot be captains capable, in the highest sense, of commanding, or sailors and engineers sufficiently educated to work so gigantic a machine.

WATER AND ORGANIC MATTER.

In a recent article in the *Sanitary Reporter*, after describing the unfitness of the water with which the City of London is supplied for drinking purposes, the writer says:—

Nature herself rejects it as unfit for her use in the animal economy. It is on account of the organic matter which it contains, and the carbonic acid which it does not contain, that it is so undesirable and mawkish a beverage. Organic matter exists in two states in water, solid and in solution. By filtration, the solid portions may be removed, but no filtration with which we are acquainted can remove the soluble organic matter any more than it can separate the earthy and alkaline salts, which water also holds in solution.

The organic matter in water is in a peculiar condition, it is in a transitory state, which experience has long proved to be inimical to the vital functions, and much stress has been very properly laid upon the necessity of our being supplied with water of a quality fit for drinking; for that which we now have is only fit for washing purposes. It becomes, to a certain extent, ameliorated by boiling, but even then it is very far from possessing that desirable quality which we look for in good and wholesome spring water with which the metropolis ought to be supplied. Let us look into the changes which vegetable and animal matter are capable of undergoing; and, first, as regards vegetable matter. The term *fermentation* is applied to those changes to which vegetable matter is liable after the vital principle of plants is extinct. The same kind of decomposition or fermentation is not common to all vegetable products, but four distinct kinds are observable—the *saccharine, vinous, acetous*, and *putrefactive*. All vegetable compounds, however, are not equally prone to decomposition, but several of them may be preserved a considerable time without their properties being altered.

Starch is one of these, and is a vegetable principle that we shall now consider. It, perhaps, may be thought bold to assert that starch is not only the end and the beginning of all vegetable matter, but is also the principle through which all animal nutrition is derived; nevertheless, it is the truth. By the *end* is meant that it is the object or nature of every plant to produce it. It is found in the seeds and roots of plants, and is the pabulum or storehouse of vitality for a succeeding organization, similar to that from which it was itself derived—"the herb yielding seed after its kind, and the tree yielding fruit, whose seed is in itself after its kind." Now, as animal matter is entirely derived from the vegetable kingdom, starch therefore contains the vital principle, from which not only all vegetable, but all animal organization is produced. It would be useless to insist further upon this, as the fact must be obvious to every one who reflects upon the subject.

Latent vitality has been treasured up for centuries by means of starch in the seeds of plants preserved under peculiar conditions. It is combined with different principles in different seeds, yet to it alone is due the continuation of all organized matter.

The French word *Amidon* (starch) is evidently derived from *Ame* (the soul) and *donner* (to give), signifying that it is the *soul* or *life-giving* principle.

We shall now speak of the four fermentations enumerated above, which starch is capable of undergoing, and, first, of the *saccharine fermentation*. Starch is the only known substance capable of undergoing the saccharine fermentation. It consists of carbon, oxygen, and hydrogen, and when subjected to moisture, saccharine fermentation takes place, or, in other words, the elements in question, by arranging themselves in different proportions, give rise to the formation of sugar; the quantity of sugar produced is equal to about half the weight of the starch employed. This kind of fermentation takes place during the germination of seeds in the earth, and it is applied to domestic purposes in the process of making malt. Malting consists in submitting barley to the action of moisture, warmth and air. It is first steeped in water for about two days, which causes it to swell and become soft, and then it is laid in heaps of about thirty inches in depth for twenty-six or thirty hours. In this state, heat is generated, and germination begins to evince itself. To allow the germination to take place equally, it is next spread out in strata a few inches in depth on airy floors. Here it is allowed to remain twelve or fourteen days, until it has germinated to the extent required, being occasionally turned over so as to allow each grain to be properly exposed to the air, and to give to the whole an uniform temperature. The process of germination is then stopped by placing it in a kiln, the temperature of which is gradually increased from 100° to 160° Fah., or higher, so as to dry the barley, and prevent its future germination.

During the process of germination, oxygen is absorbed, and carbonic acid given out. In consequence of carbon being thus abstracted, barley, after malting, weighs lighter than before. Some water is also supposed to be formed by the union of oxygen and hydrogen, which is dissipated by drying, along with the water added during the process.

Vinous Fermentation consists in the conversion of sugar into alcohol, by a new arrangement of the principles already noticed under starch, viz., carbon, oxygen, and hydrogen. Thus if malt be macerated in hot water, and yeast be added to the infusion after it has drained off, as in making ale, vinous fermentation takes place, and the sugar of the malt gives rise to alcohol, which constitutes the stimulating and intoxicating principle of ale. We mention this as the most familiar instance of vinous fermentation in this country; but the making of wines and other fermented liquors may also be adduced as examples of this kind of fermentation.

A solution of pure sugar does not undergo the vinous fermentation without being mixed with yeast, or some ferment of this sort; but the saccharine juices of different vegetables do not require it to be added that the fermentation may take place, in consequence of their containing some principle capable of producing fermentation. Yet it is to be observed that when yeast has been added for the purpose of exciting fermentation, the presence of atmospheric air is not necessary for the process; but fermentation does not take place in the juices alluded to, unless they are exposed to the air, so that we may infer these juices contain some principle capable of forming yeast, or something analogous to it, by the absorption of oxygen.

The changes which take place during the vinous fermentation give rise to alcohol and carbonic acid; the latter is given off in the state of gas. The amount of alcohol and carbonic acid produced is found to be equal to that of the sugar which disappears during the process.

Acetous Fermentation.—If ale, wine, or any other liquor which has undergone the vinous fermentation, be exposed to the air in a warm situation, as in the process of making vinegar, a change is soon observable in it, and after a time the alcohol which it contained disappears, and acetic acid is produced. The same change takes place if a mixture of water, alcohol, and yeast be similarly exposed. The formation of acetic acid is owing to a new arrangement of the carbon, oxygen, and hydrogen, constituting alcohol; oxygen is absorbed from the atmosphere, and carbonic acid is evolved.

Putrefactive Fermentation is that which all vegetable substances undergo while putrifying or rotting. Moisture and a certain degree of temperature as well as exposure to atmospheric air, are necessary to the process; at least, if atmospheric air is not altogether requisite, it promotes the decomposition in question. By a new arrangement of the vegetable elements, water, some acetic acid, &c., are produced; while several gases, such as light carburetted hydrogen, carbonic acid (and ammonia when azote is present) are evolved; and some solid part remains after the process has ceased, which consists principally of carbon.

Animal Putrefaction.—The changes in animal matter only give rise to one kind of fermentation —namely, the putrefactive. As soon as the vital principle in animals is extinct, the different parts of the body soon evince a disposition to undergo the putrefactive process, during which, water, ammonia, carbonic acid, sulphuretted, carburetted and phosphuretted hydrogen are generated by a new union of the different elements; the first of these escapes in the form of vapour, and the other compounds are liberated in a gaseous state. The same conditions are necessary to this as to vegetable putrefaction. In respect to temperature, that from 60° to 90° Fah. is the most favourable. The process does not take place at the freezing temperature, and hence animal matter may be preserved unchanged for a great length of time in a frozen state. Animal matter, in a perfectly dry state, may also be preserved for a considerable time without change.

In conclusion, it is to be observed that animal or vegetable matter in a state of putrefaction is in that condition in which it becomes so offensive. It is in this state that we meet with it in our streets, courts, alleys, and in the water with which we are at present supplied for drinking purposes. Too much stress cannot be laid upon the unwholesome quality imparted to the water by the presence of organic matter, for in this state it is inimical to the health of the body, inasmuch as such matter is not in a condition capable of becoming assimilated to the animal structure, and the heat of the body assists, but does not arrest decomposition, giving rise to a disturbance in the secretions, ultimately leading to disease, especially when the use of bad water is long persevered in. The putrifying process must be completed before matter which has once been organized can again blend with vitality. On a former occasion we showed that nothing is ever regenerated or brought back to a living state, but that which has previously been possessed of life. There is a beginning and an end, and the end must arrive before a new beginning can take place. The changes, which are eventually effected, of transforming putrefaction into life, are through the agency of the vegetable kingdom, starch being the prime mover in the transformation of deorganized into organized matter.

PROLONGATION OF HUMAN LIFE BY THE MEANS OF COFFEE.

The above is the heading of an article in the very interesting publication by Louis Figuier, called *L'Année Scientifique.*

Doctor Petit, of Chateau-Thierry, published in 1862 an exposition on the prolongation of human life by the means of coffee. The facts on which the author rests, speak manifestly in favour of coffee, which article of consumption has, in our days, taken its domicile throughout the world, and has even brought about new social habits amongst us. Doctor Petit does not depend on purely individual or isolated observations, but on well supported facts of public notoriety, and which, by their general character, cannot be looked on as simple accidents, or as the results of a concurrence of fortuitous particular circumstances. Let us transport ourselves to the frontiers of the Department du Nord, to the coal mines of Charleroi, there where thousands of men are buried every day for twelve hours in the bowels of the earth for the purpose of extracting the enormous masses of coal required for feeding the furnaces of our factories. We there see vigorous workmen, whose exterior indicates robust health, and the greatest muscular development, and yet their food is neither substantial nor abundant; three or four cups of coffee a day and potatoes, and one pound of meat in the week, is all the nourishment supplied to the workmen in the coal pits of Charleroi. These men can live on one quarter of the food that is necessary to keep up the force of other individuals; 1500 grammes (? equals 1½ kilogramme) about 3$\frac{3}{10}$ lb. of daily nourishment will be amply sufficient for them, under circumstances that would make others require two kilogrammes (4⅖ lb.) In the neighbourhood of Riesenberg, in Bohemia, in the midst of the Krapack mountains, there exists a race of poor people who almost all follow the trade of weavers. These unfortunate men are almost destitute; for long years their food has been altogether insufficient, being composed solely of potatoes, they were reduced to such a state of wretchedness as to become to some extent degenerate. Fortunately the medical men of the country conceived the idea of placing them under a course of coffee. The trial succeeded beyond all expectation, and the weavers of Riesen-berg have no longer cause to envy the health and strength of the workmen of other countries. For the purpose of facilitating the acquisition of that salutary substance by the poor mountaineers, the Austrian Government has recently abolished the duties that used to be levied on the importation of coffee. These interesting facts were established on the spot many years ago by M. de Gasparin, who has lately been taken away from science and his country, and they further met with a very satisfactory explanation at the hands of this eminent agronomist. Coffee, says M. de Gasparin, renders the elements of our organism more stable. The labours of Duhamel, and those of M. Flourens have shown us that a double movement of molecular composition and decomposition is constantly going on in our organs; this constant movement of absorption and of formation of new tissues takes place as well in the blood as in the bones and muscles. If, therefore, coffee retains this double vital movement, the necessity for re-composition, and, consequently, for alimentation, must be proportionately less. In fact, it is observed that, under the influence of coffee, the produce of the secretions is more fluid, the respiration less active, and, consequently, the loss undergone by the absorbed substances less rapid. A diminution of animal heat has even been observed under similar circumstances. This last consequence helps us to understand the utility of coffee in hot countries; there, where the temperature is so difficult to bear that it seems, so to speak, to wear out the springs of life. Our military and naval authorities have for some time made coffee form a part of the rations of our soldiers and sailors on active service, and have reason to be satisfied with the result of the innovation. The use of coffee has been of immense benefit to our troops, as well in the African deserts as in the Crimea, in Italy, and in China; the crews of our fleets have also derived the same hygienic advantages. It is of infinite value to our soldiers in Mexico, and principally in the Tierra Caliente, at Vera Cruz, that hotbed of yellow fever. Coffee is the drink of hot climates, as are alcoholic liquors the natural necessities of northern countries. It is known that in 1814, the Russians consumed enormous quantities of spirits together with fat substances. These two systems of alimentation, that is to say coffee and alcohol, are in conformity to the respective necessities of such people, and to displace them would be contrary to the precepts of hygiene. As man advances in life, the bony tissue diminishes in quantity. We know, for instance, how easily the bones of old people are fractured. This accident is consequent on the slight resistance offered by the bone, which becomes weakened by the diminution of the organs. Now, to point out the consequences of this disappearance of the bony substance in persons of advanced age. The phosphoric particles of the bones are absorbed, carried away in the circulating torrent, and the molecules, thus moved along by the blood, end by obliterating the small blood-vessels or capillary tubes. One of our learned professors of the Faculty of Medicine, M. C. Robin, promulgated the idea of dissolving the phosphal deposits by means of a chemical agent; with lactic acid, for instance, it might be possible, perhaps, to prevent this obstruction of the vessels, which is the frequent cause of fatal congestions in the case of old people, and thus to extend the limits of human life. M. Petti is of opinion that it is better to prevent the obstruction of the vessels than to have to combat it, when once in existence. From the well established fact that coffee retards the movement of the decomposition of the organs, M. Petit concludes that by its habitual use the life of man might be prolonged beyond its ordinary limits. He recommends then the use of coffee by old persons; and by those who have reached the age of fifty it can be taken in doses of from one to four cups a day, according to the necessity, the circumstances, and the habit of the body of each individual. It need hardly be added that the use of coffee does not render other hygienic precautions less indispensable. M. Petit brings numerous examples to the support of his opinion, chosen from among the cases which the exercise of his art has enabled him to observe, and in the course of the supervision of his hydro-therapic establishment at Chateau-Thierry. These observations tend to prove that coffee may be considered as conducive to longevity. They also tend to recommend its employment in the treatment of cerebral congestions and hæmorrhages, affections which are almost always fatal, and against which art possesses but very few resources. This is, however, a point in medicine altogether in opposition to received practice, and which needs a more profound study, and to have the facts more thoroughly examined than are those put forth by the author. The property which coffee possesses of rendering the produce of the secretions more aqueous, leads Dr. Petit to recommend it as an agent for combating the gout, gravel, and calculous affections. On this point he agrees with M. Trousseau, who recommends it under similar circumstances in his treatise on "Materia Medica and Therapeutics," and who points out with reference to this subject that in the East and in the Antilles these complaints are all but unknown, where the consumption of coffee is enormous. These are the principal facts contained in the pamphlet of the Doctor of the Chateau-Thierry. We are not prepared to defend the opinions put forth by the author. But the views he expresses appear to us sufficiently original, and to be based on sufficiently serious scientific considerations to be reproduced in this work.

BOILER EXPLOSIONS. *

There is, perhaps, hardly a subject within the range of human knowledge, which has been invested with such mystery as boiler explosions. Almost every agency of nature, has been called in to account for those fearful catastrophes which have desolated happy homes, and but too often extended misery far and wide. Merely to attempt a recapitulation of the various theories advanced to account for the tremendous effects produced by the violent rupture of a steam generator, would fill pages; while an extensive library would scarce contain the reports of innumerable discussions and controversies, elicited by the promulgation of the different opinions held by the authors of these various theories. Able mathematicians; clever engineers, standing high in their profession; continental *savants*; American philosophers; have alike de-

* From Cor. Mechanics' Magazine.

voted their time and energies to the investigation of a question apparently obtruse, yet of the utmost practical importance to those who employ steam power. We certainly regard it as remarkable in the extreme, that these men have, one and all, overlooked the fact that, in the operation of getting up steam to the working pressure required, an amount of power is stored up within every boiler, almost without exception, sufficient to account for the most disastrous explosions on record. The mathematical investigation of this truth, we may safely leave in the hands of such men as Airy and Rankine; but the *Mechanics' Magazine* is perused by thousands, who have neither the time nor the ability, to study and comprehend profound mathematical disquisitions. We, therefore, once more place our explanation of the matter before our readers, convinced as we are that the violence of a boiler explosion, is as much the result of simple laws of nature, as the succession of day and night, or the fall of a body under the influence of gravitation.

It is impossible to communicate heat to water without immediately developing power, which we may or may not subsequently render available by means of a cylinder and piston. Every pound of coal consumed in a steam-boiler furnace, represents a certain amount of force either stored up for future use, or conveyed at once to the steam engine, and through its agency distributed in various ways. Explosions occur at various pressures; and the measure of their violence is, other things being equal, the quantity of coal required to raise the steam from zero to the pressure existing within the boiler at the moment of the explosion. This will of course, vary with the pressure, the quantity of water, the quality of the coal, and the construction of the boiler. But it may be in all cases approximately calculated from the quantity of fuel consumed per hour. For the sake of illustration, we will suppose the case of a boiler, of the simplest construction, of fifty effective horse-power, burning 300 lbs. of coal per hour. Such a boiler will probably require some sixty minutes to get up steam from cold water to a working pressure of 60 lbs. per square inch. The same quantity of fuel will be burned during this hour per square foot of grate, as though the engines were at work. Now, 50-horse power exerted for an hour, is equivalent to 1,650,000 lbs. raised a foot high per minute, or to 99,000,000 foot-pounds, if the whole exertion of force, instead of being extended over an hour, were concentrated in a single minute. Now, we have seen that power is continually—to make use of a metaphor—poured into the boiler for an entire hour, in the act of raising the steam. On starting the engine, the further accumulation of force within the boiler is arrested; but none of that already stored up is withdrawn until the pressure falls below 60 lbs. per inch. Were it possible to avail ourselves of all the energy retained in the boiler, it would suffice to raise 99,000,000 of pounds a foot high in one minute were the fire withdrawn.

Owing to the imperfections of machinery, and other causes on which we need not dwell, this we cannot do. Still the power is there, and cannot disappear, unless the steam is withdrawn from the boiler or this last suffered to cool down, "Power may be wasted, but it is never lost." When a boiler explodes, it is probably torn into fragments in a minute fraction of a second, and the entire amount of force, due to the combustion of 300 lbs. of coal, is called into action and extorted in that space of time. Even though the catastrophe lasted one entire second, the heat stored up in the water would exert a force great enough to raise 99,000,000 lbs. a foot high?—that is, the entire work of fifty horses exerted for an hour, concentrated in one second. The only thing remarkable is, that explosions are not more destructive than they are.

We have given this calculation to our readers, as though the heat employed in raising the water from 60 deg. to 212 deg. should properly be included in the total, from which the amount of work done by an explosion may be deduced. This is a point however, open to discussion; and as a quarter of an hour, would probably suffice to raise the steam to 60 lbs. in our supposed boiler, from water at 212 deg., we prefer to divide the number of foot-pounds given above by four, the result still giving an amount of power sufficient to produce the most destructive results by its sudden exertion. It is not necessary to call in exploding hydrogen, electricity, or any of the occult forces of nature to account for the ruin of buildings, or the destruction of life and property.

Simple as all this is thus far, and easily as the *violence* of an explosion may be explained, we find the causes which lead to the first rupture of a boiler surrounded by much that is mysterious. The primary cause of an explosion is a rupture above the water-line. Whether this rupture is the result of congenital weakness, or of corrosion, depends on particular circumstances not easily ascertained in most cases. The singular effects produced on the plates of a boiler by oxidation, trituration, vibration, &c., have received much attention, and an amount of research has been expended on this branch of the subject which will, we trust, soon divest it of the uncertainty which hangs around it at present.

In order to understand the *rationale* of a boiler explosion, it is only necessary to comprehend the following facts:—Every body of water is made up of an assemblage of spherical particular atoms, capable of free motion on each other. When heated, the atoms of water within a boiler are surrounded by, so to speak, an atmosphere of caloric, tending violently to repel each one from its fellows. This force is equilibriated by the pressure of the steam in the upper portion of the generator, resting on the surface of the liquid, and thereby forcing the constituent atoms into propinquity. The instant, however, that an opening is made above the water-line sufficiently large to remove the pressure instantaneously, the repulsive action of the heat comes into play, and the water is separated into its ultimate atoms with a force proportionate to the quantity of heat stored up; rending the boiler into fragments, and destroying everything in the immediate neighbourhood. It is a mistake to imagine that any true dynamic steam is produced during this stage of an explosion, or that the water is dispersed in masses. Every particle repels its fellows with equal force, and it is opposed to reason, to suppose that many of the atoms can remain in that close approximation, which enables them to constitute a liquid, while others are converted into true steam: such a result would only ensue, if the explosion were sufficiently tedious to permit the caloric to pass from one part of the mass of water to another. This supposition is inadmissible under the conditions, and disproved by experiment. The dispersion of the water is usually attributed to the agency of interstitial steam, but there is evidence to prove that we are more correct, in stating *that it is due to the direct action of interstitial caloric.* The error has arisen from performing experiments, and ascertaining the effects produced by the *gradual* reduction of pressure on the surface of heated water, by withdrawing steam through a safety-valve or stop-cock, a process in no way analogous to that which takes place in an explosion. A familiar instance of the direct repulsive action of heat on water, is afforded by placing a drop on a smith's anvil, and striking it with a bar of red-hot iron; the water is dispersed with a loud report, but no steam is produced. Water absolutely free from air may be heated to between 270 deg. and 280 deg., usually separating into its ultimate atoms with explosive violence but still without producing true steam. If we regard the matter from this point of view, we see how erroneous is the idea that water can explode *per se.* As well might we state that the plates forming a boiler exploded. The water is perfectly passive in the transaction. Its particles are separated in the first instance, and these, in their turn, separate the plates which contained them the moment before. One great fact may be adduced in support of our explanation of the phenomena. There are hundreds of instances on record in which every pound of the many tons of water which the boiler contained, vanished on explosion. Yet it is certain that this water could not possibly have been converted into steam. There are, it is true, instances where boilers have burst, yet remained nearly full of water; but none of these explosions have been absolutely instantaneous, or very violent in their effects. In such cases, the catastrophe may, perhaps, be correctly attributed to the rapid generation of steam on the sudden reduction of pressure.

Steam power can never be worked with safety until we have an organized system of inspection established throughout the length and breadth of the land. There is scarcely an explosion on record which cannot be traced to the imperfect original construction of the generator, or the deterioration of the plates. We have ere now alluded to this branch of the subject, and may return to it at another time.

SILICATED SOAPS.

Soap, strictly speaking, was formerly understood to mean a composition of oil or grease with an alkali, but the term has now a more extended application. Various other substances than grease and oil have been employed as mixtures, and are held to be legitimate constituents of soap. Formerly resin was extensively employed for this purpose; but owing to its scarcity since the war commenced, and the high price thence resulting, its use has been almost abandoned, and silica—the chief ingredient of sand and quartz—is now largely substituted. When pure, it is insoluble in most acids, or in water; and it is actually infusible in fire. Yet it can be converted into a liquid; and it is used to mix with soap; hence originated the term "silicated soap." Quartz sand subjected to a high degree of heat, and mixed with a caustic alkali, such as soda or potash, becomes soluble, and this is the substance now largely employed as a substitute for resin in soap making.

The application of the silicate of soda as a soap mixture has been long known, but several patents have recently been obtained for improved modes of treating and mixing it.

On October 14, 1862, Dudley B. Chapman, of Milford, Massachussetts, obtained a patent for making a silicated soap, which is described in his specification as follows:—"One part by weight of an alkaline silicate (such as silicate of soda) one part by weight of vegetable flour or farina, and one half part by weight of sal soda, The sal soda is to be melted with a little water, in a kettle, over a slow fire; the flour is then thoroughly mixed with it, after which the alkaline silicate is added, and the whole thoroughly incorporated together. This composition is to be mixed with soap made of grease or oil and alkali, when it is in the liquid state, and the whole of the ingredients boiled together for a few minutes." It is stated that vegetable flour assists the silicate in combining with the soap, and a larger quantity of the silicate may thus be used with a given quantity of soap. It also makes a firmer soap, and prevents it from efflorescing. The claim is for "the combination of a carbonate or caustic soda, an alkaline silicate and vegetable flour, with soap or a saponified oil or fat substance."

On January 20, 1863, Mr. Dudley obtained another patent for a silicated soap, described in his specification as follows:—"Hitherto the method of using soluble alkaline silicates in the manufacture of soap has been to make a soap in the usual manner, by boiling a hydrated alkali with grease, oil or tallow, one or more of these combined with resin; and while the soap was in a fluid state, to reduce the soluble alkaline silicate to a fluid, by the addition of water, then mixing it with the soap.

By this process an alkaline silicate containing an excess of free alkali (that is, more than sufficient alkali to hold the silica in solution, which most alkaline silicates do) cannot be used to advantage, because the excess of alkali in the silicate granulates or opens the soap in such a manner as to precipitate the silicated solution to the bottom. Therefore the use of highly alkaline silicates in soap has been generally abandoned. By my process I can use in soap a silicate containing any quantity of free alkali, and in such proportions that in some cases the quantity of alkaline silicate used will exceed in weight all the other ingredients combined, thereby materially cheapening, as well as improving, the quantity of soap.

"In manufacturing by my process, I first ascertain the quantity of free alkali which the silicate to be employed contains. I next, by the addition of water, reduce the silicate to a fluid or gelatinous condition; and when ready for use have it heated to about forty degrees (Centigrade). I next take a quantity of any one or more of the following ingredients sufficient to completely neutralise the excess of alkali which the silicate contains, to wit, grease, oil of any kind, tallow, resin, or any of these, combined with flour or starch of any kind, and prepare them by heating the grease, oil, tallow or resin, as the case may be, to about seventy degrees Centigrade, at which heat I add the alkaline silicate prepared as above, and mix thoroughly by stirring for a short time. Next, I mould the mixture in frames and allow it to cool. If I use flour or starch in the combination, I mix it in a dry state with the melted grease or fatty matter before adding the silicate. If the excess of alkali in the silicate is mostly caustic, the soap thus made will, in the course of three or four days, be fit to cut up, or to be formed into bars, either for use or sale. Should the alkali be mostly a carbonate, the mass should be re-heated, in a day or two, to about eighty degrees Centigrade, and next it should be framed, after which (in about two days) it will be ready to be cut or formed into bars. In this way I obtain a very fine neutral soap, in a much cheaper manner than by any other process.

"The excess of alkali in the silicate completely saponifies the ingredients used to neutralise it, and these ingredients in the process of saponification absorb all the excess of water with which we are obliged to dilute silicates in order to render them sufficiently fluid to combine with soaps. Therefore a soap made in this manner will not shrink in weight as much as a soap in which silicate is mixed after the soap is finished; for such soaps have already taken up about 40 per cent. of water from the hydrated alkali with which they are boiled, and the extra water in the silicate only tends to impair their value. Another advantage which this process ensures to the soap is, that the glycerine, having an affinity for the moisture contained in the atmosphere, prevents the soap from becoming too hard by age, as silicated soap is liable to do.

"I claim as my invention, and as an improved manufacture, a soap made in the improved manner hereinbefore described, viz., of a hot fatty matter or matters and a solution of alkaline silicate, combined at one operation, without the process of being boiled after the addition of the solution of silicate to the hot fat."

A patent (re-issue) was also granted to George E. Vanderburgh, of New York, on March 10, 1863, for a silicated soap, which is described in the specification as follows :—" I take any kind of common soap, reduce it to a fluid state, and add thereto any desired proportion of dissolved alkaline silicate, which contains by analysis less than one-half as much potash, or less than one-third as much soda or silica, and then, after thoroughly incorporating this mixture of soap and silicate, whilst they are kept at a proper temperature, I run the mixture into frames to harden, and afterwards cut the same into merchantable shapes."

The claim is "the use of a dissolved alkaline silicate as an ingredient in, and component of, soap; but this I only claim when the dissolved alkaline silicate thus employed contains, by chemical analysis, less than one-third as much soda, or less than one-half as much potash as silica."

The soap manufacture is of great importance as a branch of the useful industrial arts. Some philosophers have held that the quantity of soap consumed by a nation may be taken as an index of its civilisation; and this is not a chimerical idea, when it is considered that it is chiefly employed to promote cleanliness in person and clothing. But whether the use of silicates, resin, and other substances or mixtures with genuine soap, composed of oil, grease or tallow and alkali, is an improvement, is another question. Many persons believe that these are foreign mixtures which only increase the quantity.—*Grocer.*

TURBINES.

The class of water wheels known by the general term "turbine" supplies us with, perhaps, the most practically perfect means to be met with in the arts of obtaining the highest results from given mechanical effects. To all intents and purposes, the turbine is, if properly constructed, a perfect motor, capable not alone of working under all sorts of circumstances and under the most variable conditions, but of invariably giving out a high co-efficient of useful effect as well. Perhaps invented, at all events first rendered effective and economical, by Fourneyron, in 1837, it has gradually worked its way into general favour solely by its own merits. It is not easy to say how many of them are at work in Great Britain at the present moment. Messrs. Williamson, Donkin, Schiele, the North Moor Foundry Company, and many other firms, have, we believe, full employment found them in their construction; while abroad their use is even more extended than it is here in the fatherland of the steam engine—the giant who will scarcely brook the presence of a competitor within his territorial domains. In France and Germany the turbine enjoys great favour; the comparatively high price of fuel acting to some extent as a bar to the habitual use of steam machinery. In America the ordinary vertical water-wheel was exclusively employed—the breast wheel being considered best—until 1844. In 1843, Mr. Elwood Morris communicated to the Journal of the Franklin Institute, a translation of Morin's experiments on turbines, which attracted considerable attention. The year after, Mr. Boyden, an engineer experienced in the manufacture of hydraulic machinery, designed and constructed a horizontal water-wheel for the Appleton Company's mill, near Lowell, in Massachusetts, which at once embodied several improvements on the Fourneyron arrangement, and may be regarded as the first instance of this application of water-power in the States. In 1846, the same gentleman constructed three turbines, of about 190 horse power each, on the same general principles; the particular design being somewhat modified and improved. It is said that the mean maximum effect of two of these was found by careful experiment to equal 88 per cent. of the theoretical power due to the fall—a statement which, probably, contains a slight exaggeration. The general principles and mode of formation which distinguish the Fourneyron wheel are so well understood that it would be superfluous to dwell on them individually at length. The water, distributed in horizontal jets by peculiarly curved vanes or guides, issues from the circumference of an inner fixed wheel, composed of two discs kept apart by the guide plates, and passing through an outer annular wheel, fitted also with guides of a contrary curvature, puts it in motion; its interior periphery revolving as nearly as possible, in contact with the exterior periphery of the inner or guide wheel. This is the Fourneyron turbine in its simplest form. One of the most important improvements effected by Mr. Boyden was the application of the "diffuser," almost universally adopted since. The invention is embodied in the formation of two large stationary discs without and around the wheel, the space between which at the inner periphery is very little greater than that between the crowns of the wheel at the part next to them. These discs curve apart and outward, so that the space at their exterior periphery is twice as great. The section through which the water passes in escaping from the wheel is thus enlarged in the ratio of one to four; hence its action should fall from 1 to 1-16th in the same distance, provided the wheel be submerged. The effect of this arrangement is to reduce the pressure on the escaping water, and thus increase the power as though the fall were increased. The theoretical gain to be derived by this arrangement is equal to about 5 per cent. on the whole power; though from one cause or another only 3 per cent. is usually realized. Mr. Boyden suspended his turbine from above, and was the first to point out the expediency of employing very thin guide-plates and vanes. One of the greatest objections to the Fourneyron wheel and its modifications is, that being always submerged, it is, to some extent, inaccessible for repairs or examination. It is frequently far from convenient to drain away the water, especially when more than one turbine is supplied from the same race. As early as the year 1838 this objection was recognized, and the "Jonval" wheel introduced to obviate it. Instead of revolving outside the stationary guides, the buckets in this turbine revolve below them. Both the fixed and moveable wheels are placed within a tube of sufficient diameter, the orifice of which, placed below the level of the water in the lower race, is so contracted as to allow of only the proper quantity of water passing through, due to the velocity arising from the difference of the two levels above and below the turbine. By this arrangement the wheel may be placed in any part of the height of the fall deemed most desirable; the necessary force and velocity of the water being obtained by the pressure of the atmosphere on the upper surface of the suspended liquid column. When the supply of water is cut off by closing the upper sluices, the wheel is left high and dry for repairs, as the tube is usually large enough to afford ample space for a man to work in it with ease.

When the turbine is employed to render high falls available, the foot-step of the vertical spindle often gives much trouble, as well from the difficulty of lubricating it properly, as from the great weight which it has to sustain, and the high speed at which the shaft revolves. At St. Blasier, in the Black Forest, a wheel only 13 in. in diameter is put in motion by a column of water 354 feet high. Whether all the pressure due to this vast height is rendered available or not we cannot say. The wheel makes 2,200 revolutions per minute, driving 8,000 water spindles, with the necessary machinery for slubbing, roving, &c. Fifteen hundred revolutions per minute are by no means uncommon with larger wheels. Mr. Boyden, in America, and Mr. Mallett, in this country, cut the Gordian knot by hanging the revolving ring and its shaft, and all the weight of the water upon it, from a ring of conical rollers above the pen-trough, running between two faced-up iron plates, the central toe or step being used merely as a steadier. When the foot-step is retained the best practice is to form a cavity in the end of the shaft, which is fitted accurately to a hardened steel pin, projecting upwards, firmly fixed in the base of the wheel pit, on which the entire weight is sustained. The proper shape for this pin and its corresponding cavity has been made the subject of much mathematical disquisition. Oil is usually supplied through an aperture drilled up the centre of the pin, by a very small force-pump, put in motion by an eccentric on some slow running shaft in the mill above. In the great Fairmount Jonval turbines, intended to supply water to the city of Philadelphia, the central shafts are supported on stout cast-iron columns, bolted down to the iron bottom of the draft box or vertical tube. A socket resting on the top of this column contains a circular block of lignumvitæ, 15 in. in diameter and 8 in. or 9 in. thick. Its upper surface is rounded to a partially spherical shape, and a few spiral grooves are cut in its surface to permit the entrance of water, and thus secure constant lubrication. A cast iron socket, hollowed out to fit this block, is keyed on the lower extremity of the vertical shaft, thus forming the bearing. These wheels are, perhaps, the largest of the kind in the world, being not less than 9 ft. in diameter over the buckets; each wheel, we believe, drives a nearly horizontal double-acting pump, 18 in. in diameter, and 6 ft. stroke, intended to make twelve double strokes per minute when pumping against the head of water in the reservoir.

The construction of the turbine suggests some of the most complicated problems in hydraulics, and theory scarcely yet affords the means of solving them. Practice alone supplies us with thoroughly trustworthy results. From this reason there is little doubt that the statements of the usual effect realized from a given fall are frequently over-estimated, the quantity of water passing through the wheel being really in excess of that assumed from calculation. Still, making every allowance, there is no doubt that, with proper care, turbines usually give out a higher co-efficient of useful effect than perhaps any other moving power in existence. At first sight, it appears that the entering water should impart a severe shock to the curved buckets which oppose its motion. This disappears, however, when the wheel moves at a proper velocity. Under correct arrangements, the water enters the wheel without impact, and passing along the whole length of the blades which constitute the buckets, and exercising a pressure at every part, whereby its velocity is constantly reduced, while the direction of its motion is modified by their curve, it finally leaves the wheel with an insensible motion, being deposited as it were in the tail race, from which it flows in obedience to the law of gravitation at a velocity determined by the inclination of the floor on which it rests. In order to secure this action, the most extreme accuracy of workmanship is absolutely essential. It is useless to set out the proper curves with a strictly mathematical precision, if these are afterwards departed from by an erroneous method of practical construction. Theoretically, the guide curves should have no thickness; and, although this desideratum is unattainable, we can, at all events, approach almost indefinitely near to it. It is not easy to secure the necessary accuracy of fitting through all the details, by hand labour. The more extended use of machine tools specially designed to carry out the end in view, and of cast steel as a material of construction, may do much to reduce the first cost and improve the performance of the turbine; the latter imparting that stiffness and strength which cannot be obtained from the use of sheet-iron. It is impossible to over-estimate the importance of correct form, and it requires little reflection to show how easily thin guide plates may be deflected by the pressure of the water when the wheel is at work, although, when at rest, their shape may leave nothing to be desired Machine tools would rapidly and cheaply impart that smoothness of surface and delicately beautiful curvature to the guide plate and buckets, on which the efficiency of the machine almost wholly depends.—*Mechanics' Magazine.*

THE WONDERS OF THE PORT OF LONDON.

The custom-house port of London extends from London Bridge to the North Foreland, on the Kent coast, and the Naze, on the Essex coast, including not only the Thames, but the wide estuary below the river. This mighty port has grown up gradually.

There were no docks in London until this century, which has witnessed the expenditure of twelve millions sterling in the construction of docks on either side of the Thames. Six thousand ships now enter these docks annually, and the cry is "still they come!" All the docks are filled, though some do not pay well.

There are shipped off now, yearly, from the port of London alone, commodities to the value of thirty millions sterling, beside those from other ports of the United Kingdom, and there is imported a still larger quantity of colonial produce. The ships which actually belong to the port of London are not less than 3,000 in number, averaging about 300 tons each, or 900,000 tons of commercial shipping in all—a stupendous quantity to enter and depart from one single river. It is a quarter of the total amount for the whole kingdom. Five hundred of these are steamers, and one-half of all the mercantile steam navy of England belongs to and is registered in the port of London. No less than 30,000 ships enter the port of London yearly—more than 80 per day. Some of these ships make many voyages, but there are 30,000 arrivals with 30,000 cargoes. The vessels average 200 tons each, giving us an aggregate of 6,000,000 tons.

The coasting trade of London is most wonderful. Of the 30,000 vessels just named, 18,000 bring cargoes from other British ports, and 9,000 of these go back empty, mostly to coal ports. Five million tons of coal are burned annually in the metropolis, and about 12,000 cargoes of coal are brought into the Thames annually—one every hour, and a handsome surplus over. The spread of railways from London has had very little effect in diminishing trade by other modes of conveyance. The canal boats carry more than before railways were constructed, and the number of carriages and horses employed in Great Britain, the use of which railways were designed to supersede, is greater than it was before these railways were made. But the grandeur of the foreign trade of London strikes the imagination still more forcibly. All the corners of the earth seem to be brought to a focus in the river Thames: 12,000 ships now enter there yearly, bringing nearly 12,000 cargoes of all that the earth can produce of value and beauty. Every forty minutes during the year a ship passes Gravesend, bringing stores from some colonial clime, in many cases much more than London's own proportion. For instance, seven-eighths of all the coffee brought to all parts of the United Kingdom; seven-ninths of all the live stock; one-half of the sugar, tobacco, wool, fruit, rice, hides and skins; nearly one-half of the bacon, ham, barrelled salt meat, butter, cheese, eggs and lard; five-sixths of all the spices, and no less than fifteen-sixteenths of all the tea. London consumes just as much of all this as she wants, and sends the rest into the provinces and abroad.

It is truly wonderful where all the commodities go to: 10,000 pounds of pepper every year—the sound of the words makes one sneeze!—24,000,000 bushels of corn, 1,000,000 hundredweights of flour and meal, and more than 1,000,000 of oil cake entered the Thames alone in one recent year. Two ships every day, or thereabouts, of the average capacity of 700 tons, enter the Thames from India and China alone. The export trade is enormous. No less than ten or eleven millions sterling are in the forms of clothing and materials for clothing; £1,000,000 in boots and shoes, £1,000,000 in "millinery and haberdashery," £1,000,000 for apparel and slops, all go from one port in one year! Some of the items of imports are curious. Think of whole ship loads of Dutch eels, in cargoes of 20,000 pounds each, coming to London; oxen fattened for the London market in Schleswig Holstein; Ostend butter and Ostend rabbits, which are sure to find a market, in spite of the home supply.

Two million empty oyster shells were once brought over to London in one ship for the sake of that beautiful lining which constitutes the mother-of-pearl used for many fancy and ornamental purposes. One fact most instructive is observable in this vast trade of the port of London, viz.: whatever is brought over, in whatever shape, from whatever place, and by whatever persons, it is sure to find a market. The price may be beaten down, if the demand is languid, but they never think of saying "We don't want any."

Notwithstanding the vast commercial importance of London, the great American trade is mostly within the grasp of Liverpool, because the Mersey is nearer to America than the Thames, and cotton is most needed in Lancashire, and because the chief articles sold to America—such as metals, hardware, earthenware, &c.—are fabricated nearer to Liverpool than to London. In the trade with Australia, too, Liverpool beats London, as measured by the relative population of the two places.—*Chambers' Journal.*

HOW STEEL IS MADE.

The following description of the manufacture of steel is condensed from the *Ironmonger* (London). It is contained in an article by a correspondent, giving an account of the establishment of Watkin & Co., at Stourbridge, England; celebrated for its manufactures of shovels, spades, scythes, forks, anvils, pickaxes, horse shoes, nails and black ironmongery in general. We direct the attention of our American tool makers to the subject; because instead of making their own steel they purchase it, while almost all the great tool manufacturers in England make their own steel, being thus enabled to obtain the material at a much less cost:

"There are various kinds of iron, English, Russian, Spanish, German, but particularly Swedish, for making steel, by the process of cementation, which may be briefly described as follows: The converting furnace of cementation presents the shape of an oblong quadrangle, divided by a grate in the centre into two parts. On each side of the grate runs a long trough or chest, technically called a "pot," about 13 feet long by 3½ feet wide and 3½ feet deep. The furnace is covered in by a semi-circular arch, with a round hole, about 12 inches diameter in the centre, which is opened when the furnace is cooling. A large and tall conical chimney or hood, open at the top, is built over the furnace, which serves to shelter it within, to increase the draught of air, and to carry off the smoke. There are two openings about 8 inches square, in front of the arch, one above each chest or post; these serve for the introduction and removal of the bars, which are slid in and out upon a piece of iron placed to that end of the opening. A much larger opening in the middle, between the two pots, serves to admit the workman. An iron platform is laid along the grate between the two pots; upon this the workman takes his stand. He first sifts a layer of cement—that is, a mixture of about nine parts of ground charcoal made from hard wood, and one part of ashes, with a little salt added to it—on the bottom of each pot or chest, to the depth of about half an inch, taking care to spread the mixture as evenly as possible. He then proceeds to place on this a row of iron bars, cut to the length of the pots. He always leaves about an inch between every two bars. The row of bars thus placed is covered again with a layer of cement about one inch thick, as the carbon here is intended to serve for the bars above as well as for those below. Another row of bars is placed upon the second layer of cement, in such manner that the portion of the bar composing it corresponds vertically with the interstices left between the first row. Then comes another layer of cement and another row of bars, placed in the same relative position to the second as the latter is to the first, and so on alternatively in succession up to within six inches of the top (which makes about ten inches altogether). A final layer of cement is spread over the last row of bars, and the whole is then closely covered in with clay, or with so-called wheel-swarf (the earthy detritus found at the bottom of grindstone troughs) entire exclusion of the air being thus ensured. A few bars are left longer than the others; the extremities of these are left projecting through small openings made in the ends of the chests, closed by doors in the outer walls. These openings, which are called tap-holes, are placed near the center of the end stones of the chests, that the bars projecting through them may serve to indicate the average stage to which the process of conversion has proceeded throughout the entire mass of iron in the troughs. The projecting bars are called test-bars, or trial-rods; their projecting ends are encrusted with fire-clay, or imbedded in sand.

"When the pots are properly charged, all the openings in the furnace are bricked up air-tight. A large fire is lighted in the grate, the flame rising between the two pots, and passing below and around them, through a number of horizontal and vertical flues and air-holes leading to the chimney; the fire is carefully regulated and steadily maintained for the whole period of time required for the cementation of the iron bars in the furnace. It generally takes about four days to heat the iron through; on the sixth or seventh day, according to circumstances, a test-bar or trial-rod is drawn out through one of the tap-holes, to see how matters are going on. The conversion is considered complete when the cementation is found to extend to the centre of the test-bar, which generally takes about eight days for soft steel, and from nine to eleven days for the harder sorts.

"The furnace is solidly constructed of refractory bricks; the two chests or pots being mostly built of fire-stone grit.

"When the trial-rod shows that the desired end has been attained, the fires are extinguished and the furnace is left to cool. The converted iron bars, or, more properly speaking, steel bars, are taken out; they are found, upon examination, to have slightly increased in length and in weight, which is owing to the absorption of the carbon from the cement. On breaking a converted bar across, the texture is found to be no longer fibrous, as it was in the original iron bar, but granular or crystalline. The surface of the bar is covered with blisters, which have procured for the article the name of blistered steel. These blisters are occasionsd by imperfections in the iron, the metal dilating in the unsound parts, and gaseous carbon forcing its way between the imperfectly-welded laminæ. This blistered steel is chiefly intended for the manufacture of edge tools, &c. In the state, however, in which it leaves the converting furnace, it will not answer this purpose; but it has to pass through another process, viz., that of tilting, or, as it is also termed, shearing; to this end the converted bars are broken or clipped into lengths of about thirty inches. Six or eight of them are piled or fagoted together, the ends being secured within an iron ring, terminating in a bar of about five feet long, which serves as a handle. The faggot is then raised to a welding heat in a wind furnace, and is covered with sand, which, melting on the surface and running over it like liquid glass, forms a protecting coat to defend the metal from the ordinary action of the air. When the proper degree of heat has been attained, the faggot is removed from the furnace and placed under a hammer, which unites the piece into a rod or bar and closes up internal fissures. This bar is again brought to a welding heat, and is in that condition subjected to the action of the tilt-hammer, which makes from 200 to 300 strokes per minute. Water is constantly kept pouring on the frame-work to keep it cool. The workman generally sits in front on a moveable seat—a kind of swing formed by a board suspended by iron roads from the ceiling. In this posture he can, with a very slight motion of his feet, advance or recede with great rapidity, and place himself at pleasure in front or on either side of the anvil, and guide the bar or other object under the hammer so as to distribute the blows evenly over the whole surface. The effect of the process of tilting is to restore the original fibrous character of the metal, and to close up the loose parts and seams. Tilted steel, or, as it is more commonly called, shear steel, is close, hard and elastic, and retains the property of welding; it is also capable of receiving a certain degree of polish. It is more especially made use of for the manufacture of tools composed jointly of steel and iron.

"In former times shear steel was almost exclusively employed for the better class of goods; but since the introduction of cast steel the latter article has to a very large extent displaced its use for superior edge-tools. The reason for this is, that shear steel always labors under inequality of texture and hardness, the outer parts being unavoidably more strongly carbonized than the inner or central layers; whereas cast steel is of uniform texture and hardness throughout. Cast steel is more especially suited for the manufacture of cutting tools made entirely of steel. It is also largely used for tools made jointly of iron and steel. Some sorts, however, will not stand welding; they are therefore, of course, altogether unfit for the latter purpose."—*Scientific American.*

THE MINERAL WEALTH OF THE UNITED KINGDOM.

The number of collieries at work in Great Britain has increased from 2,397 in 1853, to 3,088 in 1862. In these collieries there were employed in 1861, no less than 235,590 colliers. The quantity of coals produced in and sold in 1861 amounted to 83,635,214 tons, this being the largest quantity produced in any one year. Owing to the interruptions which several of our manufactures experienced in 1862, the amount of coals which passed into the market, or were consumed at the place of production, fell to 81,638,338 tons. Very large stocks have been stored in Lancashire and other districts; the actual drain, therefore, upon our coal beds was probably as large as it was in the previous year.

In 1861 it is stated in these returns that nearly two millions and a half tons of coal were burnt or wasted at the pits in Durham and Northumberland alone. In the publication for 1862, Mr. Hunt says, "the amount of the coals burnt or wasted at pits has been so differently represented, and appears such an uncertain, although very large quantity, that it is for the present omitted." Since attention has been directed to the rate at which the exhaustion of our coal mines is going on, it becomes a really important element to determine with all possible accuracy the extent to which this system of waste prevails on the surface, and it is no less important to determine the waste which takes place in the mine. In Derbyshire about one-sixth of the quantity of coal raised, which amounted last year to 4,534,800 tons, is left in the colliery, and this is not much in excess of the quantity of coals lost in the working of coal in other districts. In estimating, therefore, the rate at which we are draining our coal mines of their fossil fuel, we cannot take less than 90,000,000 tons as representing the annual rate of exhaustion.

The exportation of coals in 1862 amounted to 7,671,670 tons, which was an increase of 448,952 tons on the exportation of 1861.

The quantity of iron ore raised in 1862 in these islands amounted to 7,562,240 tons, and we imported 36,270 tons. This was used to feed 561 blast furnaces, which were distributed as follows: in England, 306; in Wales, 130; in Scotland, 125; the quantity of pig iron smelted being 3,943,569 tons, which is an increase upon the two previous years. In 1860 we made 3,826,752, and in 1861 3,712,390 tons. The value of pig iron at the place of production last year is estimated at £9,858,672.

The number of copper mines worked in these islands in 1862, was 230; of these 201 are in Cornwall and Devonshire. For several years there has been a steady decline in the rate at which copper has been produced from our mines; the produce of the last three years has been in the aggregate 4,614 tons.

Our imports, which were 74,163 tons of ore, and 20,317 tons of regulus in 1861, increased to 82,054 tons of ore and 35,388 tons of regulus in 1862.

The returns of dues paid to the Stannary Court, which are made up to the 29th of September in each year, give the production of the tin mines of Cornwall and Devonshire at 11,841 tons of ore, producing of white or metallic tin, 7,478 tons, valued at £879,048. The Keeper of Mining Records gives the production of the whole year 1862, as 14,127 tons of tin ore, producing 8,476 tons of metallic tin, valued at £983,216. This is the largest quantity of this metalliferous ore which has ever been produced in any one year, the probability being that this will be exceeded by the yield of the Cornish tin mines in the present year.

For certainly more than 2,000 years tin has been obtained from Cornwall and Devonshire, and yet we find the granite and clay slate rock of these counties yielding a larger quantity than ever to the industry of man; and there does not appear any reason for supposing that we are exhausting any of the stanniferous districts. A fear has been expressed by many that the copper mines of Cornwall are nearly worked out. That there has been a falling off in the quantities of ore mined for some years past, is certain; but if ever mining is permitted to be carried on again with honesty and zeal, so that the full amount of the subscribed capital shall be expended in subterranean explorations judiciously directed by experienced miners, we believe it will be found that ample stores of copper are yet to be discovered.

The produce of lead has shown a steady increase In 1862 the returns were 69,013 tons. The silver produced from this lead in 1862 amounted to 686,123 ounces.

From time to time, after long intervals, there have been small quantities of gold produced in various parts of these islands, and consequently on the discovery there has been much excitement. The discovery of gold in the Lead-hills, Lanarkshire; at Wicklow, in Ireland; and more recently in the neighborhood of Dolgelly, in North Wales, are examples in each case of enthusiastic hope deferred.

We have, however, in the returns before us a reliable statement of the production of one gold mine (Vigra and Clogau) for the past two years. In 1861 the quartz lodes upon which they are working gave 2,784 standard ounces of gold, which were sold for £10,816 17s. In 1862 the production reached 5,299 standard ounces, which were sold for £20,390.

We find by the lists of mines given in the Appendix to the *Mineral Statistics*, that no less than twenty-four workings are entered as gold mines. From none of these have we as yet any return of gold; we shall wait with much curiosity the publication of the statistics in 1864.

The returns of zinc ores, of iron pyrites, and of other less valuable metalliferous and earthy minerals, are given; the total results being as follows for the year 1862:—Value of British metals, £14,281,453; coals, 81,638,338 tons, £20,409,584. Total, £34,691,037. Earthy minerals, such as barytes and lime, salt and the more valuable clays, are estimated at £1,750,000; and we find, by a return compiled by Mr. Robert Hunt in 1859, that the value of building stones, slates, &c., amounted to £7,954,075. We learn, therefore, that the actual wealth added to the national store, as obtained from our native rocks, amounts to nearly £45,000,000 sterling.—*London Ironmonger.*

Miscellaneous.

How to Shoe Horses.

"To shoe horses with ordinary feet we would suggest the following directions to the farrier:— With your drawing-knife take off from the ground surface of the crust as much as may represent a month's growth. Remember that there is generally a far more rapid growth of horn at the toe than at either the heels or the quarters. More, therefore, will require to be taken off the toe than off other parts; in other words, shorten the toe. Be careful to make the heels level. Having lowered the crust to the necessary extent with the knife, smooth it down level with the rasp. Round off the lower edge of the crust with the rasp. Do this carefully and thoroughly. If a sharp edge be left, the crust will be apt to split and chip. The preparation of the foot is now complete. It remains to fit the shoe to the foot. Let the shoe be made with a narrow web (¾ inch), or even width all round, except at the heels (direction No. 8), flat toward the sole, and concave to the ground. Turn up the toe of the shoe on the horn of the anvil. The degree of "turn-up" must be regulated by what you find necessary in each horse to make the wear nearly even all over the shoe. It will be found in practice that most horses take much about the same degree of "turn up." Make five counter-sunk nail holes in each shoe, viz.: three on the outside, and two on the inside. Make the anterior hole on each side immediately posterior to the "turn-up." Let the second and third holes on the outside divide evenly the remaining space on the heel. Let the second hole on the inside be opposite to the second hole on the outside. Let the nail-holes be punched coarse, *i.e.*, nearly in the centre of the web, brought out straight through to the other side. This may be done with safety where a good crust has been preserved. Fit the shoe accurately to the foot. It must be as large as the full unrasped crust, but no part must project beyond. The shoe must be continued completely round toward the heels, as far as the crust extends. The web must be narrowed at the heels, so that its inside edge may cover the line of the bars and no more. Slope off the heels of the shoe in the same direction as the heels of the crust, so as to prevent the possibility of their catching in the hind shoe. Select nails that will fit exactly into and completely fill the nail holes. Twist off the clenches as short and stubby as possible, and lay them down flat with the hammer, and let the pincers during this time be firmly pressed against the heads of the nails. The clenches are not to be filed either before or after turning down, nor is a ledge to be made in the crust to receive the clenches. For ordinary hind feet the pattern of shoe in common use is recommended, but with a clip on each side, immediately anterior to the first nail, instead of one only at the toe. This double clip keeps the shoe steadier in its place than the single. The web should be made somewhat wider at the toe than at other parts, in order to allow space for the thorough sloping of its inner edge. For reasons which have been already explained, the hind foot does not require to be shortened at the toe like the forefoot; but the other directions given above—namely, as regards lowering the crust, rounding its lower edge, accurate fitting without rasping, punching the nail holes coarse, nailing and clinching with the total absence of rasping, paring, opening the heels, cutting away the frog or bars, &c.—apply equally to hind as to fore feet. Six nails—viz., three on each side—are needed for the hind shoe. Without the third nail on the inside, shoes are apt to "twist" on the feet. The horse is now shod. Nothing more must be done for the sake of what is called appearance. The best iron only should be used for shoes. Good iron makes a light shoe wear as long as a heavier one of inferior metal.—*Irish Country Gentleman's Journal.*

Making Horse-shoes by Machinery.

Horse-shoes are now manufactured in large quantities at Providence, R.I., and at Troy, N.Y., the machines, however, being entirely different in construction at the two places. At Providence the shoes are all made from scrap iron, fagoted up, welded together, and afterwards rolled into long rods. These rods are creased for the nail-hole in passing through the rolls, and afterwards punched complete in one operation—eight holes being made in each one. The shoes are bent into shape by a peculiar apparatus, and hammered by a trip-hammer while in the machine, so that they do not spring when taken out or alter in shape. It was a matter of great doubt among mechanics at one time whether horse-shoes could be made by machinery to equal those produced by hand-labour; but, we believe, all apprehension on this score is set at rest, and that machine-made shoes are in all respects as good as those made in the old-fashioned way. The Providence factory is now running night and day, turning out 200 tons per month for Government use.

Oils for Mixing up Paints.

Linseed oil is undoubtedly the best mixture for paints that are to be exposed to the weather. It absorbs oxygen, and becomes solid and water-proof, and yet it always possesses some elasticity which prevents it from cracking. Oils contain a considerable portion of glycerine, which is hygroscopic fat. It has been found that some metallic oxides possess the quality of combining with glycerine in in the oil, and rendering it susceptible of readily drying in the atmosphere. The oxide of lead, sulphuret of zinc, and the oxide of manganese boiled with oils, communicate to them great drying properties, and for this reason oils treated in this manner are called drying oils, and are in common use. Some works recommend the use of both sulphate of zinc and the acetate of lead mixed together for making drying oils. These two metallic salts, when brought together, produce two new compounds by double decomposition—namely, the acetate of zinc and the sulphate of lead, and the oil is restored to its natural condition. The acetate of zinc should never be employed in paints, because it is a bad drier. The drying of linseed oil has such an affinity for oxygen as to promote chemical union with it and the coloring pigment, and thus destroy the beauty of the color. There are many delicate pigments which cannot be employed with oil in paint without suffering injury. This is the case with chrome yellow, verdigris, gamboge and a number of the lakes. But wax is a very useful corrective for this deteriorating quality of the oil. Wax is a powerful antiseptic, and has great preservative powers. Added to painters' varnishes it tends to prevent them cracking—an evil which has destroyed the beauty of many excellent works of art. It is said that Titian painted on a red ground, and imbued his canvass on the back with beeswax in oil. Bleached wax is easily dissolved in hot oils, both volatile and fixed, it is not changed by exposure to the atmosphere, and is but very feebly acted upon by the strongest acids. Its appropriateness, therefore, as a mixture for paints is self evident. Many persons mix shellac varnish with common paint, in order to render the latter less expensive, because a considerable quantity of water can be added to the varnish and combined with the paint. Thus, if we take three ounces of the oil of bicarbonate of soda, and place it in three pints of soft water, it will dissolve a pound of gum shellac by boiling, thus making a lack varnish. To this is usually added half-a-pint of alcohol and two quarts of soft water, and it is then mixed with common oil paint. For inside work in houses it may answer, but it should never be applied to the outside of buildings because it cannot resist atmospheric influences like paint which contains only oil and a pigment. Gum shellac varnish made with the carbonate of soda does not stand the action of rain so well as varnish for which alcohol has been employed as a solvent. It should, therefore, never be used for any work exposed to the weather. In *Pasmas* it is stated that M. Dusbry, of Antemb, France, has found that benzine and coal oil are the best vehicles for paints of metallic bases (lead, zinc, &c.) as they dry rapidly, and have no smell after the first twenty-four hours.

Cold Weather and Steam Engines.

During the winter much more care is necessary to preserve steam engines from injury than in milder seasons. Feed pumps are particularly liable to be damaged by frost, and much delay and expense results from inattention to them. Every pump should be provided with a small cock, so that the water could be drawn off every night, and the same should be left open so that no driblets or leaks from the suction or supply pipe could run in and cause damage, as pumps are so situated that this might occur sometimes. A steam cylinder needs a warm coat in winter as much as a man does, and if at no other time of the year, the pipes and all other parts containing steam should be "lagged" or felted heavily, as the loss by radiation is something to be considered. Engineers who pride themselves on a good reputation in small bills for fuel and supplies, should see to it that they do not overlook this matter. It is no argument to say that the engine room is itself warm enough, for this is not so; heat is radiated from all bodies, whether their temperature be the same or nearly the same as surrounding bodies; for it is the tendency of heat to place itself in equilibrium. The strain on a feed pump, induced by freezing the contents, amounts to one-eleventh of their bulk, as water expands in that ratio by freezing. An unloaded shell, it is said, was once filled with water and exposed during a cold day. The hole was stopped with a plug which was thrown violently out of the shell, when the water froze, to a distance of 400 feet, while a cylinder of ice eight inches long protruded from the aperture. This experiment is one easily tried by our soldier mechanics, and though it may not be entirely successful, it serves to illustrate the force with which freezing water expands. In excessively cold weather, where steam boilers are allowed to get entirely cold over night and are fired up again in the morning, they will soon become leaky; as the constant extremes of expansion and contraction tend to produce that effect. An immense amount of fuel is wasted every year, even with the most careful supervision; but the quantity becomes enormous when little or no care is taken to prevent loss. In the winter this is particularly the case, and some steam pipes are as cold as if they had never had a pound of pressure in them; the result is easily seen at the end of the year.—*Scientific American.*

Steel Boilers in Prussia.

A steel boiler of the egg-end shape, 4 feet in diameter and thirty feet in length, without flues was tried. It had a steam drum 2 feet in diameter and 2 feet in height, and the plates were one-fourth of an inch in thickness. Beside it there was placed another boiler, similar in every respect, excepting that the plates were of iron 0·414 of an inch in thickness. The steel boiler was tested by hydraulic pressure up to 195 pounds on the inch, without showing leakage, and both the iron and steel boilers were worked under a pressure of 65 pounds on the inch for about one year and a half. During this period, the steel boiler generated 25 per cent. more steam than the iron one, and when they were thoroughly examined after eighteen months' practical working, there was less scale in the steel than in the iron boiler. The former evaporated 11·66 cubic feet of water per hour; the iron boiler 9·37 cubic feet. The quantity of coal consumed was on an average 2,706 pounds for the steel one in twelve hours, and 2,972 pounds for the iron boiler. The plates of the steel boiler over the fire were found to be uninjured, while those of the iron one were about worn out. In Prussia several worn out plates of iron boilers have lately been replaced with steel, which, it is stated, lasts four times as long. As steel is twice as strong as iron, thinner plates of the former may be employed for boilers, and more perfect riveting can be secured. A greater quantity of steam can also be generated in the steel boiler on account of its thin plates, and thus much fuel may be economized.

Steel Ships.

On Wednesday forenoon two large vessels built of steel were launched from the building-yard of Messrs. Jones, Queggan & Co., at Liverpool. One was a sailing-ship named the *Formby*, of 1,271 tons tonnage, built for the East India trade; the other a paddle-wheel steamer named the *Hope*, of 1,492 tons. At a *dejeuner* which took place after the launch, Mr. Jones made some remarks on these vessels. He said that steel is much stronger than iron, weight for weight, and, consequently in shipbuilding, that equal strength can be given with less weight of steel than of iron. The strain resisted by iron-built ships had been found to be from 19 tons to 20 tons per square inch, while the resistance of steel is found to range from 42 tons to 48 tons, giving a mean of 45 tons for steel, or considerably more than double that of iron. Keeping these results in view, the *Formby*, a vessel built of steel, required 500 tons of material in her hull, while a similar ship made of iron would have required 800 tons. The difference in weight of hull would cause a difference of nearly 2 ft. in displacement in favour of the steel vessel, requiring also less propelling power. In the case of steamers, the advantages were still more obviously in favour of steel. If the *Persia*, a steamer of 3,600 tons and 900-horse power, had been built of steel instead of iron, her displacement would have been diminished about one-sixth, and she would have been enabled to carry double her present cargo. Mr. J. Reed, the Chief Constructor in the Royal Navy, who was present, said he should watch with great interest the career of the two ships which had just been launched. He remarked that merchant ships can be built to test a principle when war-ships cannot, as the former can be examined and repaired annually, while the latter are sent abroad for periods of three or four years. He perfectly agreed with what had been said of the importance of steel for the construction of small ships, and stated that the Government took great interest in the question of employing steel as a material for shipbuilding.

Case-hardening Iron.

A new method of case-hardening iron has been patented in Germany by M. Martignoni. The process consists in rubbing the surface of the iron, while at a red heat, with the following composition:—5 parts of cow-hoof, reduced to fine shavings; 5 parts of quinquina; 2·5 parts of common sea-salt; 1·5 parts of saltpetre; and 10 parts of coarse black soap. This mixture is formed into a paste, and applied by a roller, on which it is smeared. The iron is subsequently tempered in cold water.

Substitute for Paint over Plaster.

A Frenchman has discovered a substitute for paint over plaster. A coat of oxide of zinc, mixed with size, and made up like a wash, is first laid on the wall, ceiling, or wainscot, and over that a coating of zinc, prepared in the same way as the first wash is applied. The oxide and chloride immediately effect a sort of combination, forming a cement, smooth and polished as glass, and possessing the advantage of oil paint without its disagreeable odour.

New Gas Material.

At a stated meeting of the Franklin Institute, held in Philadelphia, November 19th, Professor Fleury exhibited samples of a new artificial fuel and gas material, the invention of Mr. William Gerhardt. This invention consists in preparing porous bricks, balls, or otherwise shaped fireproof material, which are fully saturated with gas-tar, coal-oil, or any other hydrocarbon of a similar nature. These bricks are afterwards dried, and used for the purpose of producing illuminating gas or fuel. The oil having burnt out, the material is used over again; it leaves no ashes, and preserves its porosity. The use of fuel that is free from sulphur is of the highest importance in the manufacture of steel, iron, glass, &c., and it is claimed that this artificial fuel is well adapted for these purposes, as well as for other uses, because the price of manufacture is not so high as the present price of coal.

How Change of Sex is Accomplished in a Beehive.

Carpenter informs us that in every hive of bees the majority of individuals are neuters, which have the organs of the female sex undeveloped, and are incapable of reproduction, that function being restricted to the queen, who is the only perfect female in the community. If by any accident the queen is destroyed, or if she be purposely removed for the sake of experiment, the bees choose two or three from among the neuter eggs that have been deposited in their appropriate cells, which they have the power of converting into queens. The first operation is to change the cells in which they lie into royal cells; which differ from the others in form, and are of much larger dimensions; and when the eggs are hatched, the maggot is supplied with food of a very different nature from the farina or bee bread which has been stored up for the nourishment of the workers, being of a jelly-like consistence and pungent stimulating character. After the usual transformation, the grub becomes a perfect queen, differing from the neuter bee, into which it would otherwise have changed, not only in the development of the reproductive system, but in the general form of the body, the proportionate length of wings, the shape of the tongue, jaw and sting, the absence of the hollow in the thighs where pollen is carried, and the loss of power of secreting wax.

Forests a Necessity of Fertility.

The value of forests to a country in retaining moisture is well illustrated by the late severe freshets of the Connecticut valley. The snow melts quicker in an open country, and is retained longer among groves. Formerly the Connecticut river and its tributaries were clothed with forests; now they are largely denuded, and we have reason to expect greater freshets than formerly. The present barrenness of Greece and Palestine as contrasted with their former fertility, is similarly accounted for. Dr. Unger, a celebrated naturalist of Vienna, claims that the climate lacks its original moisture. He says the hordes of warriors who have followed each other for centuries on that soil, have burned up the forests, and every effort of nature to make restoration is subdued by a superabundance of goats. The population live on the products of the goats, and the goats crop every twig, thus bringing barrenness. If the forests should ever again grow. Dr. Unger thinks fertility would be restored.

Apparatus for enabling persons to remain under Water.

At the last sitting of the French Academy of Sciences, a new apparatus for enabling persons to remain under water, or in places filled with deleterious gases, was described. The apparatus consists of a piece of wood having the form and dimensions of the human mouth when open. To this piece of wood two india-rubber tubes are fixed, of any length, according to the exigencies of the case. The man engaged in the operation is further provided with a nose pincher, or instrument for compressing the nostrils, so as to prevent the introduction of the deleterious gas or of water, as the case may be. The operator puts the piece of wood into his mouth, and puts on the nose pincher; he stops up one of the orifices with his tongue, and inhales pure air from the other; after which he shifts his tongue to the latter orifice, and exhales his breath through the other. He continues thus regularly shifting his tongue from one orifice to the other in the order of the inspirations and expirations; but even a mistake would be of little consequence.

Popular Science.

Of the sixty-two primary elements known in nature, only eighteen are found in the human body, and of these, seven are metallic. Iron is found in the blood, phosphorus in the brain, limestone in the bile, lime in the bones, dust and ashes in all. Not only these eighteen human elements, but the whole sixty-two of which the universe is made, have their essential basis in the four substances—oxygen hydrogen, nitrogen, and carbon—representing the more familiar name of fire, water, saltpetre, and charcoal. And such is man, the lord of earth —a spark of fire—a drop of water—a grain of gunpowder—an atom of charcoal!

Cheap Coal Gas.

In the city of Liverpool, England, the price of gas has been reduced to about 86 cents per 1,000 cubic feet. It is also stated that this price pays a fair profit to the stockholders.

The first Iron-Clad Ship of War.

In 1613, William Adams, in a letter from Japan, dated December of that year, in a mention of his voyage from Firando to Oösaka through the Inland Sea, by the Strait of Simonoseki, writes thus:—

"We were two daies rowing from Firando to Faccate. About eight or tenne leagues on this side the straights of Xeminaseque we found a great towne, where there lay in a docke a juncke eight hundred or a thousand tunnes burthen, sheathed all with yron, with a guard appointed to keep her from firing and treachery. She was built in a very homely fashion much like that which describeth Noah's arke unto us. The naturals told us that she served to transport soulders to any of the Islands if rebellion or warre should happen."

Photosculpture.

References from time to time have appeared in the papers respecting this novel application of photography. Preparations are being made in Paris for carrying it out on a very extensive scale. The results are stated to be very successful. The *modus operandi* will be easily understood. The sitter or object to be sculptured is placed in the centre of a well-lighted, spacious apartment; twenty-four or even a larger number of cameras are ranged in a circle around him, at equal distances from each other, with plates duly prepared, and by a simple mechanical arrangement the operator, by one movement of the hand, simultaneously uncovers all the lenses, and after a sufficient length of exposure closes them. The plates are then developed in the usual manner, a sufficient number of operations being employed for the purpose, and proofs are subsequently printed. There are thus obtained twenty-four or more views of the subject from twenty-four or more different points of sight. Each view is then in succession, by means of a magic lantern arrangement, thrown upon a screen on an enlarged scale. In order to transfer these likenesses from the photographs to the modelling clay, an instrument on the principle of the pentagraph is then made use of, having a tracer at one end and a cutting tool at the other. The lump of modelling clay is fixed on a stand capable of turning on its axis, with divisions corresponding to the number of photographs employed, and is placed in a position so that while the tracer of the pentagraph passes over the outline of the photograph thrown on the screen, the cutting tool at the other end cuts the clay into the corresponding outline. The clay is then shifted one division on its axis, and the next corresponding photograph thrown on the screen, and the operation repeated, and so on in succession till the clay has the twenty-four or more outlines accurately transferred to it. It then only remains for the artist to connect these tracings or outlines on the clay, and here, of course, his skill is shown. Tke artist thus has a large amount of work mechanically and rapidly prepared for him, and he is enabled, in a comparatively short time, to execute a model combining all the truthfulness of mechanism and the skill of the artist. From this model casts in plaster, or statues in marble, can be taken in the usual way. It is stated that the sculptures thus produced are remarkably good, and can be supplied at a very cheap rate, as compared with sculpture produced entirely by hand.—*Journal of the Society of Arts.*