THURSDAY, AUGUST 4, 1870

THE SCIENCE AND ART DEPARTMENT

THE Report of the Science and Art Department just issued is a document of such vast importance to all interested in Science or Education, that we take the first opportunity of saying something upon it. The work which has been done in Science by this Department is so little known, however, that it is necessary to preface our account of this year's report by a brief history of what has been attempted, and accomplished, in former years.

In 1853 the Board of Trade proposed to extend a system of encouragement, similar to that already commenced in the Department of Practical Art, to local institutions of Practical Science, and the Treasury at once wrote one of their classical minutes, in which they expressed the concurrence of "My Lords" generally, in the plans proposed by the President of the Board of Trade, "as the most effectual means of giving effect to the recommendation of Her Majesty at the opening of the Session, with a view to the advancement of Practical Science."

Experiments were tried in the way of Science—or Trade and Navigation—Schools at Aberdeen, Birmingham, Bristol, Leeds, Newcastle-on-Tyne, Poplar, Green's Sailor's Home, Stoke, Truro, Wigan, Wandsworth, and other places. Most of these experiments failed after a short time.

In June 1859 the minute which is the foundation of the present system of aid passed, but this minute has been greatly modified from time to time and greatly enlarged.

The plan pursued before 1859 followed, more or less, the analogy of the elementary school system. That is to say, a trained teacher was sent where a committee was formed, a certain salary guaranteed for a year or two, and so on. This kind of encouragement, however, failed. The requirement of the country was not only teachers to teach but people who wished to learn. After a short time teachers exhausted the guarantee and the schools were broken up.

The state of the country as respects science instruction for artisans at this time (eleven years ago) is well described by Dr. Hudson in a letter then written to the Education Department. In Lancashire and Cheshire, he says, there was no instruction in chemistry, except in "small classes chiefly for mutual improvement in elementary chemistry, and conducted without the aid of efficient teachers, which are in operation at Ballington, Hyde, Staleybridge, Stockport, and Burnley. In Yorkshire, the only night schools affording instruction in chemistry are at Bradford, Halifax, Huddersfield, Leeds, and Selby."

"No instruction whatever is afforded at any Mechanics' Institute in Yorkshire, Lancashire, or Cheshire; and mineralogy, as applied to mining, has only been recently added to the programme of class instruction in one single society—the Wigan Mechanics' Institution."

"In the whole district of Lancashire and Yorkshire, extending from sea to sea, there is no adult school or mechanics' institute in which theoretical mechanics is taught, ... or experimental physics." "The three Ridings of Yorkshire, with their 150 mechanics' and kindred institutions, only possess two societies, and these mere village institutes, in which instruction—Manston in Physical Science, and Shipley in Natural Philosophy—is afforded, and this to an infinitesimal amount. With two exceptions, there are no mechanics' institutions or mutual improvement societies in Lancashire in which any elementary instruction in Physics (Natural Philosophy or Mechanics) is given, and the county of Cheshire does not present one instance in which these matters receive attention in similar societies."

The essential point of the system which the department has organised to reach this terrible state of things, is that it pays simply for results with a preliminary test examination of teachers,—the Honours examination enabling teachers to show high qualifications if they possess them. And the aim has been to enlist all kinds of persons resident in different localities—sometimes the teachers of the ordinary day schools, at other times workmen who had an aptitude for teaching—to commence science instruction, and it looks very much as if this plan has met the difficulty. It has permitted small beginnings by persons conversant with a locality when outsiders could have had neither chance of doing anything, nor sufficient work to support them. It has, in fact, been a missionary effort, and as such has succeeded, and has been paid for.

So much for a general historical sketch of the *modus operandi* of the Department; let us now come to the description, and give evidence of a power at work, which, with proper encouragement, will in time do wonders. The "no schools" of 1859 were represented by 120 schools with 5,479 pupils in 1865, and by 779 schools and 34,283 pupils in the present year. Here are the general results in tabular form:—

	1868.	1869.		1870.
Number of Schools under Teachers examined	300	523		799
Number of Classes in the same	856	1,489		2,200
Number of individuals under instruction in Classes under Certificated Teachers . . .	15,010	24,865		34,283
Number of the above who came up for examination	6,875	12,988	(about)	17,000
Number examined in addition to the above who were not in Schools under Certificated Teachers.	217	246	(about)	700
Number of Papers worked in:— Subject.				
1. Practical, Plane, and Solid Geometry	1,337	2,638		3,359
2. Machine Construction and Drawing	1,671	2,987		3,656
3. Building Construction . .	1,185	1,998		2,631
3 (alternative). Naval Architecture	21	12		39
4. Elementary Mathematics	1,390	2,329	Stage I. II. & III.	3,837
			„ IV. & V.	108
5. Higher Mathematics . .	33	84	„ VI. & VII.	50
6. Theoretical Mechanics .	353	629		830
7. Applied Mechanics . .	167	294		551
8. Acoustics, Light and Heat	769	1,352		2,021
9. Magnetism and Electricity	1,038	2,509		2,613
10. Inorganic Chemistry . .	964	2,173		2,694
11. Organic Chemistry. . .	123	210		235
12. Geology	309	619		1,069
13. Mineralogy	38	67		63
14. Animal Physiology. . .	1,182	2,227		3,705
15. Zoology.	298	303		114
16. Vegetable Anatomy and Physiology.	112	144		400
17. Systematic and Economic Botany	73	90		140
18. Principles of Mining . .	41	48		64
19. Metallurgy	81	126		160
20. Navigation	219	303		260
21. Nautical Astronomy . .	86	107		68
22. Steam	106	149		311
23. Physical Geography . .	1,516	2,687		5,435
Total number of Papers worked	13,112	24,085		89,395

From the above table we gather that there were in May, 1869, 523 schools and 24,865 pupils; in May, 1870, 799 schools with 34,283 pupils, the number of teachers at present giving instruction in connection with the Department being nearly 1,000. Now, how is this work being done? In the first place let us say that it is going on among classes of the community which all our other educational means do not touch, and, as may be imagined, much of the work is night work; in some cases the working men taught have commenced their education by building their schoolrooms; and those who know the delights of a laboratory would think that the chemistry was acquired by apparatus and appliances which made even the simplest experiment an impossibility.

Secondly, let us say that all the year's work is brought to a focus by examinations held on the same night throughout the length and breadth of the land, the papers being sent from South Kensington to the local committees with infinite precautions, and the answers being returned sealed the same night to London. They then are handed over, with no indication as to name of candidate or place of examination, to the Government examiners, and when we state that these examiners include the names of Huxley, Frankland, Ramsay, Tyndall, and others of like calibre, we need say no more as to the rigour and fairness of the examination. Here is a table showing how this ordeal is passed:—

Year.	No. examined.	No. of Papers worked.	No. of Papers passed.
1867	4,520	8,213	6,013
1868	7,092	13,112	8,649
1869	13,234	24,085	14,550

It is impossible within the limits of an article to dwell upon the various points of inquiry and interest which lie around the working of the system: we shall be content if we have shown what it is doing, and how the teaching is being conducted. When these points are known there can be no doubt as to the importance of the work done, and, although many improvements may be required, it is clear that *in essentials* the Department is now on the right track and is doing great good. What is most required is systematising and formulating the instruction. Hitherto the teaching has been rather desultory. It is very desirable that regular systematic courses of instruction, adapted to the local requirements, should be imposed as soon as this can be done without checking the spread of instruction. Some examiners complain of "cram," but this is not limited to the South Kensington system; and the teachers complain of poor pay. This should certainly be corrected; the results they are accomplishing are too important to be ignored; and it would seem that the time had almost come for a complete inquiry into the whole system in order that this important national engine should work with the least possible friction and waste of power.

WHAT IS ENERGY?

IV.—THE DISSIPATION OF ENERGY

AT this point we can imagine some champion of perpetual motion coming forward and proposing conditions of truce. "I acknowledge," he will say, "that perpetual motion, as you have defined it, is quite impossible, for no machine can *create* energy, but yet I do not see from your own stand-point that a machine might not be constructed that would produce work for ever. You tell me, and I believe you, that heat is a species of molecular motion, and hence that the walls of the room in which we now sit are full of a kind of invisible energy, all the particles being in rapid motion." Now, may we not suppose a machine to exist which converts this molecular motion into ordinary work, drawing first of all the heat from the walls, then from the adjacent air; cooling down, in fact, the surrounding universe, and transforming the energy of heat so abstracted into good substantial work? There is no doubt work can be converted into heat—as, for instance, by the blow of a hammer on an anvil—why, therefore, cannot this heat be converted back again into work?

We reply by quoting the laws discovered by Carnot, Clausius, Thomson, and Rankine, who have all from different points of view been led to the same conclusion, which, alas! is fatal to all hopes of perpetual motion. We may, they tell us, with the greatest ease convert mechanical work into heat, but we cannot by any means convert all the energy of heat back again into mechanical work. In the steam-engine we do what can be done in this way; but it is a very small proportion of the whole energy of the heat that is there converted into work, for a large portion is dissipated, and will continue to be dissipated, however perfect our engine may become. Let the greatest care be taken in the construction and working of a steam-engine, yet shall we not succeed in converting one-fourth of the whole energy of the heat of the coals into mechanical effect.

In fact, the process by which work can be converted into heat is not a completely reversible process, and Sir W. Thomson has worked out the consequences of this fact in his beautiful theory of the dissipation of energy.

As far as human convenience is concerned, the different kinds of energy do not stand on the same footing, for we can make great use of a head of water, or of the wind, or of mechanical motion of any kind, but we can make no use whatever of the energy represented by equally diffused heat. If one body is hotter than another, as the boiler of a steam-engine is hotter than its condenser, then we can make use of this difference of temperature to convert some of the heat into work, but if two substances are equally hot, even although their particles contain an enormous amount of molecular energy, they will not yield us a single foot-pound of work.

Energy is thus of different *qualities*, mechanical energy being the best, and universal heat the worst; in fact, this latter description of energy may be likened to the dreary waste heap of the universe, in which the effete forms of energy are suffered to accumulate, and, alas! this desolate waste heap is always continuing to increase. But before attempting to discuss the probable effect of this process of deterioration upon the present system of things, let us look around us and endeavour to estimate the various sources of energy that have been placed at our disposal.

To begin with our own frames, we all of us possess a certain amount of energy in our systems, a certain capacity for doing work. By an effort of his muscles the blacksmith imparts a formidable velocity to the massive hammer which he wields: now what is consumed in order