

ART. XXI.—*Machinery and Processes of the Industrial Arts, and Apparatus of the Exact Sciences*; by FREDERICK A. P. BARNARD, LL.D., United States Commissioner to the Paris Universal Exposition.

IF the imperial decrees of June, 1865 and subsequent dates, which gave origin to the Paris Exposition that opened on the first of April, 1867, were grand and comprehensive in their scope and intention, they were equally illustrious in the success and completeness of their execution. More than fifty thousand exhibitors brought together on that occasion several millions of objects, all different and all deserving attention. These were gathered from some forty nations and countries, covering the entire civilization of the globe. Taken together they formed a representation of the art, the industry and the inventions of mankind, and of every ideal yet realized for the comfort, the elegance, the operative power, and the progress of the human race. From the material to the implement the completed structure or the machine; from the staple to the fabric; from the massive and gigantic—the products of Cyclopean forges or Titanic engines—down to the infant's toy and the gossamer vestment; from the ponderous gearing to the tiny time-piece all were

spread out, an accumulation of series upon series, and every series showing an almost complete and continuous gradation.

The field of the Exposition was the parade ground, or Champ de Mars, easy of access, and supplemented by annexing the island of Billancourt in the Seine, together comprehending an area in excess, by a few acres, of one-fourth of a square mile. Spacious grounds outside the building, or *palace* as it was called, but without much very palatial in its aspect or construction, were allotted to 'structures that ranged from the nomadic hut of an Esquimaux to the gilded palace of the Sultan,' and to such living, or agricultural, or other objects and groups, as could not suitably be admitted within. In deference, we suppose, to French propensities, the number of groups was just ten; but, by a marvellous aberration, the number of subdivisions or classes was but ninety-five. Seven of these so classified groups were arranged in seven oval galleries, one story high, successively surrounding one another, and divided systematically into commodious apartments, the entire assemblage of which comprised an area of forty acres and a circuit of almost a mile. In the center was a pavilion holding sets of the various national coins, weights and measures, and surrounded by a florally ornamented space from which sixteen avenues radiated to the outer space or circumference of the palace. In the sixteen sections thus formed the various nationalities had their products and groups arranged in a series, and all the series corresponding to one another from circumference to center. By passing around the galleries the spectator would come in succession upon similar groups of the different nationalities; while by passing along the avenues he would take successively the various groups of any and every nationality, each through its own entire series. Accordingly a tour of ten miles judiciously disposed, was enough to bring to an observer's attention the entire aggregate of groups within the building. By such means therefore, the best practicable facilities were supplied to each nationality to exhibit its own products to advantage, at once in union and in comparison with the like of other countries, while also the one 'special jury' and the ninety-four 'juries of classes,' for awarding testimonials and degrees of merit—the *prizes*, the *medals* and the *honorable mentions*—and, with them, the ten 'juries of groups,' for revising these awards under the final revision of a 'superior council,' all had the most ready and commanding observation of the objects composing the entire exhibit.

Were it a possibility to continue in permanence such an exhibit—a single area into which all the national arts were gathered and concentrated, like differently colored lights in the focus of an object-glass—there might thus be afforded to visitors

an ever accessible telescopic vision, as it were, of the various civilizations of the earth, although ever so remote or scattered. But, even then, the visitors, however great their multitude, could never be expected to comprise more than a small fraction of the thinking and inquisitive classes of society. The best substitute therefore which the case admits of plainly seems to be of the sort adopted and carried out by the Federal Government for the use and satisfaction of these United States; that is to say, a well appointed and sufficiently numerous commission to witness, examine and report upon the Exposition and the groups and classes of objects therein represented; and the Reports to be printed by the Government for general distribution. Besides the primary 'General Survey of the Exposition,' from the pen of Charles B. Seymour, chairman of the Committee, instructed for that purpose by the Department of State, and its preface by N. M. Beckwith, U. S. Commissioner General, and President of the Commission, the Reports are before us, so far as their publication has been completed. By far the most voluminous, various and extended of the number is that of President Barnard, the title of which is employed above as an introductory heading to these remarks. It is an octavo of 650 pages, filled with descriptions, illustrations and theoretic determinations, illustrated with numerous clearly executed cuts on the pages, and concluded by eight elaborate and finely wrought engravings. The finished artistic execution of this and of all the volumes or reports is obviously due, in no small measure, to the taste, good judgment and accuracy of Prof. W. P. Blake, who superintended the publication, as its editor. It sets off to advantage the intrinsic value and eminent adornments of the report,—both the matter and the author's style of rendering it. Next to the privilege of one's own presence amid the immense and diversified assemblage of objects in the Exposition, is the experienced satisfaction and advantage of finding one's self in presence of a large collection of the most select and suggestive of the number, brought into one view through the medium of luminous, graphic and illustrated descriptions. The author not confining himself to mere delineation, as he passes from object to object, takes pains to instruct us in their subsisting mutual connections and dependencies, and to explain in each the distinctive uses of parts, the modes of general operation, and the rationale of effects. Often indeed, if we will stay to go deeper, he puts at our disposal his well understood powers of analysis, dissipates the fallacies which becloud the mechanician's conceptions, and reconciles those paradoxes which, to the popular mind, often carry the semblance of an inevitable discord between those two

AM. JOUR. SCI.—SECOND SERIES, VOL. XLIX, No. 146.—MARCH, 1870.

wedded and indissoluble partners, Theory and Practice. And we attend to these all the more earnestly that our author's opening chapter had impressed us, as at the vestibule and entrance of our survey, with the intimacy and imminence of 'The relation of invention to industrial progress.' That model chapter traces and exhibits with unwonted distinctness the dependence of art upon other art, and of art upon its own created auxiliaries: thus the steam engine first put within the workman's reach those operative and refined tools to which the steam engine itself owes its progressive improvement and existing completeness. In following out the like connections and dependencies we are also led to perceive, not indeed for the first time but with intensified vividness, how deeply art and invention project their influences into economic and social life, into trade and commerce, into civilizing effects abroad, into the habits of thinking and feeling at home, and even into politics and the nations's destiny. Thus, the cotton-gin expanded itself into a prime mover not only of all-pervading activities in the manufactory and on the ocean, but even of the vast combinations and issues themselves of war and peace. Here is no exaggeration; still we conceive, with our author, that not the individual inventor alone is to be recognized as the originating instrumentality of all this, except as one which the age itself had brought up into preparation for his invention, and in whom the invention sprang up because the age had created a demand for it.

The dependencies of industrial art may be spoken of in various senses,—*massively*, for instance, as resting upon force, its modifications and applications,—or *quantitatively*, as resting for the abundance and multiplication of its products, upon facile machinery, manipulation and skill,—or *inductively*, as resting upon knowledge and ingenuity for its origination and progress. A glance at the table of contents and headings of the chapters of the report, will suggest how considerably some such natural classification, whether or not so intended, has influenced our author in the selection of his subjects and in their arrangement. Of the eighteen chapters, five are occupied with the subject of *power* in its various mechanical relations; as, first, the prime movers, steam, air, water, electricity and their enginery; next, the transmission of power, then its accumulation, then its measurement and registration, and, lastly, its massive applications. The eight middle chapters are taken up mainly with the appliances, the methods and the instrumentalities of ingenuity, tact and sagacity, as used for the purpose of *production*, and acting through all the range and agencies of heat, cold, excitation, pressure and motion,—sometimes the production of improved material, and sometimes the production of improved

effects, or of articles and implements for ornament and use, in their variety, their finish, and their aptitudes, as well as the rapidity and multitude of their manufacture. The concluding four chapters are occupied with the 'exact sciences' considered in their mechanical and practical relations. We read with wonder of the success with which measurements are carried to an exactness well nigh rivalling, to all intents, the mathematical itself,—of rods ascertained to a millionth of an inch in length, and of balances that perform to a twenty-millionth part of their burden. We are delighted to trace anew the progress by which the human eye has become enabled, through the perfection of object-glasses enormous in dimension, on the one hand, or of minute sizes on the other, to penetrate into the universe outwardly, and into the bosom of nature inwardly. We are let into the surprising secret by which mechanism is made to render numerical computations with greater exactitude and with immeasurably greater promptness than the mental faculties of the computer himself could realize. We are instructed how to make sound itself a thing of visible undulations, and how to apply a measuring scale to their continuance. Not much, it is true, of the Exposition, as the author himself is careful to say, was absolutely new, as respects *elementary* inventions; and, therefore, not much of that quality and essence could have place in any faithful account of it. The report is simply, and admirably, a representation by just and varied selections, of the stage of progress which industrial art and invention had reached in the year 1867. Although necessarily partial it still embraces a collection ample for its purpose; that is to say, for giving a near birdseye view of the Exposition, and, like the walks and avenues of the Exposition itself, diversified by occasional fragments of history and relics of legendary lore. Taken together it forms a resort where the engineer may obtain reassurance, the mechanic experience, the inventor impulse guidance and correction, and the man of intellect or of letters choice entertainment. The report is printed as a public document, and has not been ordinarily obtainable otherwise than by and through members of the United States Senate, each of whom, as we are informed, had the distribution of some fifteen entire series, each corresponding to the one of which this report is a constituent.

The United States was not largely represented, as respects numbers, in its own section of the Exposition. The country was too much occupied with new and extraordinary domestic questions. Industry was unsettled in many respects. The subject had not attracted the earliest attention; and the field was very distant. Yet our national exhibit, although not extended in scale, was excelled in quality only by France

itself—and that in no very considerable degree—while the percentage of awards relative to the number of exhibitors was double the corresponding percentage for England and her colonies.

No extracts which our space would allow could do justice to the report, especially if not accompanied by the cuts or engravings; and if we were to instance and enlarge upon passages and descriptions that appear specially important, it would convey no conceptions to the reader comparable with what he will obtain by a reference to the work itself. We only add, in justice to the distinguished author, that, while he is thoroughly American in a due anxiety to set forward the claims of his countrymen, it is with an obvious impartiality toward all the competitors, and with a diligence whose regulating principle is truth and an endeavor for the benefit of mankind in general.