by the same system of pipes, and the drainage of the sinks is simple and not liable to get out of order. The drain pipes connect with four-inch delivery pipes on each side of the room, by sanitary T's, and these discharge into soil pipes in the corners. All the drainage is thus taken from the building by four pipes provided with traps, with an additional sewer pipe, of course, to drain the lavatories.

The plan of the building also provides for a system of high pressure steam pipes from the university engineering shops, for blast and vacuum pipes for each room, and for distilled water to be prepared in the attic by boiling water with the high pressure steam. The distilled water is then conveyed to the different laboratories by means of block tin pipes.

There has been expended upon the building the sum of $55,000, leaving some of the less important rooms unfinished, and the furnishings in others incomplete. It is estimated that when the building is completely furnished, as the plans provide, the total cost will be about $80,000.

In the construction of this laboratory no great originality is claimed, but the effort has been made to combine the best features of several of our most modern buildings, as far as this could be done at moderate expense. So far as tested the arrangements for heating and ventilation, perhaps the most important points in laboratory construction, which have some novel features, seem to be very effective. It is believed that greater utility can with difficulty be secured anywhere at the same cost.

E. H. S. BAILEY.

SCIENTIFIC BOOKS.

A Treatise on the Theory of Screws. By SIR ROBERT STAWELL BALL, LL.D., F.R.S., Lowndean Professor of Astronomy and Geometry in the University of Cambridge. Cambridge, The University Press; New York, The Macmillan Company. 1900. Pp. xix + 544, quarto.

Ball's famous work was first given to the world in 1876; later (1889), in a German treatise edited by Gravelius with Ball's cooperation and additions by the editor. Both of these having become inadequate, the present monumental publication, containing a systematic presentation of the present state of knowledge on the subject, was undertaken and completed by the original author. The theory of screws in relation to rigid dynamics begins, on the one hand, with the kinematic theorem of Chasles, that any displacement of a rigid body may be reached by a translation along a definite line called the central axis, and a rotation around it; and on the other hand with the dynamic theorem of Poinsot, that any number of forces or of torques actuating a rigid body in any way may be reduced to a single force and a single couple (collectively a wrench), with the axis of the latter parallel to the direction of the former. The reasoning thence is naturally along the lines of modern geometry or of quaternions, for a screw is a linear magnitude with a definite unit called pitch (advance per radian) associated with it. A twist thus bears the same relation to a rigid body that a vector does to a point. Hence the reader wishing to derive full advantage from Ball's great treatise must be familiar with the modern treatment of geometry. A good account of Ball's theory is given in Schell's 'Theorie der Bewegung und der Kräfte' (Vol. II., Chapter VIII.), as well as in Routh's 'Treatise on Analytical Statics.' However, such is the lucidity of Ball's style, that the reader who knows only the ordinary dynamic methods will find the book accessible somewhere in almost all parts except those specially devoted to higher geometry.

The chapters follow an orderly development: After the fundamental principles are laid down in the first five chapters, equilibrium, inertia, potential, harmonic motion are successively discussed in the four chapters following. Thereafter the six orders of freedom are treated consecutively in nine chapters. The eight remaining chapters deal with the higher development of the subject in ordinary as well as in non-euclidean space. The generality of the methods will be seen even when the scope of the investigations is limited to conservative forces and infinitely small displacements, for the form of the body does not enter the discussions.

To give an analysis of the book or of Ball's method would be presumption, as Ball did this himself in his inimitable address before the British Association at the Manchester Meeting in 1887, reprinted in *Nature* of the same year, as many of the readers of SCIENCE will remember. Though the address is fourteen quarto pages long, it preserves its exquisite flavor throughout. Ball begins thus: "There was once a rigid body which lay peacefully at rest. A committee of natural philosophers was appointed to make an experimental and rational inquiry into the dynamics of that body. The committee received special instructions. They were to find out why the body remained at rest, notwithstanding that certain forces were in action. They were to apply impulsive forces and observe how the body would begin to move. They were also to investigate the small oscillations. These being settled, they were then to—but here the chairman interposed; he considered that for the present, at least, there was sufficient work in prospect. He pointed out how the questions already proposed just completed a natural group. 'Let it suffice for us,' he said, 'to experiment upon the dynamics of this body so long as it remains in or near to the position it now occupies. We may leave to some more ambitious committee the task of following the body in all conceivable gyrations through the universe.' "

"The committee was judiciously chosen. Mr. Anharmonic undertook the geometry. He was found to be of the utmost value in the more delicate parts of the work, though his colleagues thought him rather prosy at times. He was much aided by his two friends, Mr. One-to-one, who had charge of the homographic department, and Mr. Helix, whose labors will be seen to be of much importance. As a most respectable, if rather old fashioned member, Mr. Cartesian was added to the committee, but his antiquated tactics were quite outmanœuvered by those of Helix and One-to-one. I need only mention two more names. Mr. Commonsense was, of course, present as an *ex officio* member, and valuable service was rendered even by Mr. Querulous, who objected at first to serve on the committee at all. He said that the inquiry was all nonsense, because everybody knew as much as they wished to know about the dynamics of a rigid body. The subject was as old as the hills, and had all been settled long ago. He was persuaded, however, to look in occasionally. It will appear that a remarkable result of the labors of the committee was the conversion of Mr. Querulous himself.

"The committee assembled in the presence of the rigid body to commence their memorable labors. There was the body at rest, a huge amorphous mass, with no regularity in its shape—no uniformity in its texture. But what chiefly alarmed the committee was the bewildering nature of the constraints by which the movements of the body were hampered. They had been accustomed to nice mechanical problems, in which a smooth body lay on a smooth table, * * * in fact the chairman truly appreciated the situation when he said the *constraints were of a perfectly general type.*" Later in the proceedings Mr. Querulous is heard from. "'How could you,' he said, 'make any geometrical theory of the mobility of the body without knowing all about the constraints? And yet you are attempting to do so with perfectly general constraints of which you know nothing.'" The committee having got to work assigned certain duties, whereupon that 'most respectable if rather old fashioned member,' gives an account of himself: "Mr. Cartesian having a reputation for such work, was requested to undertake the inquiry and report to the committee. Cartesian commenced operations in accordance with the well known traditions of his craft. He erected a cumbrous apparatus which he called his three rectangular axes. He then attempted to push the body parallel to one of these axes but it would not stir. He tried to move the body parallel to each of the other axes but was again unsuccessful. He then attached the body to one of the axes and tried to effect a rotation around that axis. Again he failed for the constraints were of too elaborate a type to accommodate themselves to Mr. Cartesian's crude notions."

After further elaborate proceedings, "'Is this all?' asks the chairman. 'Oh no,' replied Mr. Cartesian, 'there are other proportions in which the ingredients may be combined so as to produce a possible movement,' and he was proceeding to state them when Mr. Commonsense interposed. 'Stop! Stop!' said he, 'I can make nothing out of all these figures. This jargon about x, y and z, may suffice for your calculations, but it fails to convey to my mind any clear or concise notion of the movements which the body is free to make.'"

So we might continue quoting every paragraph of this amusing but seriously constructed essay, with equal zest. The book closes with an elaborate bibliography containing all the work relating to the theory of screws from its inception with Poinsot, Chasles, Grassmann, Hamilton, Möbius and Plücker, to the modern advances of Clifford, Klein and their confrères and Ball himself.

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TOPOGRAPHIC ATLAS OF THE UNITED STATES.

The second folio of what promises to be a magnificent topographic atlas of the United States, published by the United States Geological Survey, has recently been issued. This second number, like the first, bears Henry Gannett's name, and like its predecessor, also presents illustrations of typical topographic forms for the use primarily of students and teachers of physiography. From the large number of topographic sheets issued by the Geological Survey, ten have been selected which furnish admirable examples of well-developed physiographic features, such as a coastal swamp, a graded river, Appalachian ridges, alluvial cones, etc., and bound in a folio, together with brief descriptions and explanations.

The maps have been well selected and in themselves, so far as one can judge who is not intimately acquainted with the areas represented, are all that could be desired. Not only does the field-work seem to have been carefully executed, but the engraving and printing is excellent.

The text accompanying each map is intended to supplement and explain the topographic and culture features shown on it. These descriptions are for the most part evidently compilations from the writings of geologists and geographers, who have studied the areas represented or other similar regions, although no acknowledgments of the sources of information are made. Such references are much to be desired not only in justice to the original investigators, but for the purpose of directing the reader to sources of more extended information. In some instances the maps chosen represent topographic forms which have been carefully studied elsewhere, and might profitably be accompanied by citations from the descriptions of the type examples. Such references and citations could easily be made, as the printed text seldom occupies an entire page: in fact much valuable space is wasted.

Instructive and pronounced features on some of the maps are not referred to in the text, although there is space available. For example, in the description of the Norfolk sheet, the origin of the drowned stream valley, the prominent hills near the ocean's shore presumably dunes, and well-marked characteristics of the shore topography, due to the action of waves and currents, are not mentioned, but in place of such information a questionable explanation of the origin of Lake Drummond is presented. Again, in the text accompanying the excellent map of alluvial cones, no reference is made to the conspicuous channels excavated in their upper portions.

The pictures in the text are poorly printed, and one of them bearing the objectionable name of 'hogback,' is reversed in reference to right and left; this reversion throws the picture out of harmony with the diagram beneath it, intended to show the structure on which the monoclinal ridge depends. In the title of the picture just referred to—and the same is true in at least one other instance—no reference is made to the geographical position of the scene represented.

The diagram described as a 'volcanic neck,' might be accepted as representing a cross-section of a peculiar plutonic intrusion, but by no stretch of the imagination can it be considered as illustrating the structure of a volcanic neck. In attempting to indicate the 'stratified beds now eroded away' they are carried completely