proaches, between the utilitarian features and the ornamental details, but with the surroundings.

Symmetry may or may not be essential to a pleasing design, although it usually is necessary if a truly architectural structure is to result. Where the bridge has a great length, unsymmetrical features are not so noticeable as in a shorter one which may be all taken in at a glance. As is often true in a landscape, balance may frequently be secured by including an unsymmetrical feature. That is, where in one portion of a structure such as a draw or other unbalanced feature must be included that will destroy the symmetry, something must be introduced in the other portion to restore the balance, although symmetry does not result.

Proportion is necessary that the three preceding principles may be realized, and usually when the economical proportions have been determined, they are pleasing. However, in many cases modifications must be made to reach the point where economy and beauty can both be satisfied. Proportion of details employed for ornamentation is quite another thing, and to be harmonious they must have the proper balance.

Examples may be seen in every structure of the proper application of some of these principles, but more often we find one or the other flagrantly violated, so that the remark of S. Shaler Smith to one of his assistants, should be well remembered by him who would reach high rank in his profession—"most bridges are examples of what not to do." Seldom, if ever, do we find a structure that complies with all of the fundamentals, although many bridges approach so nearly to the ideal that careful consideration and analysis are necessary to determine just where improvement could be effected.

Simplicity is best illustrated in its pleasantest features by suspension bridges and arches with no decorations or embellishments of any kind. Harmony is best exhibited where no part of the structure seems to be extraneous and where the structure seems part of the surroundings. Symmetry in its simplest form is where one-half of the structure is exactly like the other. Proportion is most nearly reached when the structure is most pleasing and the truth expressed most accurately.

The basis for a real architectural system for bridges must come, of course, from building architecture and on studying the columned or arched facades of buildings we find an uneven number of openings or arches are employed in the great majority of the world's notable and best pieces of architecture. Where there is an entrance it is nearly always in the centre, with one or more arches symmetrically disposed on either side.

Careful study and analysis of the examples of Egyptian, Roman, and medieval buildings discloses the fact that such an arrangement is most pleasing to the senses and where it has been violated the design is unpleasant. This, then, we may take as the starting point of any design, an opening instead of a pier at the centre, with the remainder of the structure arranged symmetrically on either side. Carried to its logical conclusion, where there is an approach it should have an uneven number of openings, and where there are spandrel arches employed in an arch bridge, they should be of an uneven number.

The Knoxville arched cantilever, designed by the writer, was of five main spans and two anchor arms, thus giving an opening at the centre and a perfectly symmetrical structure, except that one abutment was longer than the other, but not apparent to the eye in a structure a third of a mile long. Economy was violated in the depth of the anchor spans in order to make the bridge harmonious, and the basic rules were all as nearly adhered to as is often the case.

The Market Street arch at Youngstown, Ohio, designed by the writer, was a very difficult problem to solve on account of the side spans having to clear the railway tracks, and on account of the 4% grade of the roadway. The design, however, is symmetrical with the exception of the grade and the approaches, and was made quite harmonious by carrying the sub-trussing of the side spans through at the same elevation as the lattice truss over the arch.

The Mill Creek Park arch, while a short span, shows the possibility of designing artistic bridges for ordinary locations.

Comparing the Memphis bridge by Morison with the Thebes bridge by Modjeski, we can readily see how much is gained in architectural appearance by the symmetrical arrangement of the spans in the Thebes bridge. Comparing the approaches of the Thebes bridge with the approaches of the Forth bridge, we see how much more in harmony with the main structure are the approaches of the Forth bridge than those of the Thebes bridge, although considered alone the latter are of the best design architecturally.

The Grosvenor Dee bridge, at Derby, England, with its 200-ft. masonry span, is one of the greatest bridges of the world, but the paneling of the abutments and spandrels, and indeed all the decorations, are so out of harmony with the great span, that they dwarf it and ruin the design. Compare this with similar details of the Eden Park, Cincinnati, reinforced concrete arch and we find such ornamentation entirely appropriate and harmonious for the smaller span.

European bridges are more often well designed architecturally than those of other countries and the great bridge over the Rhine at Bonn, Germany, is an example where simplicity, harmony, symmetry and proportion are all as fully met and satisfied as has ever been the case in any bridge structure.

The Camelback bridge in the Imperial Palace grounds at Peking, China, is also one of the most perfect of the world's bridges from the architectural point of view and satisfies the cardinal requirements of design.

The best design in the United States is the Connecticut Avenue bridge in Washington, D.C., with its five great concrete arches, and very little fault can be found with the design, except the inappropriate decoration of the wing walls of the abutments. The designing of harmonious and appropriate details in the proper proportion is a study in itself and entirely beyond the scope of this paper. Should designers, however, carefully observe the cardinal principles herein laid down much more pleasing structures would result and a great stride forward be made in bridge engineering and architecture.

The necessity for good construction, especially of foundations, is obvious.

The total output of petroleum in the world for 1913 has been compiled from reliable estimates for foreign countries and from preliminary figures of the United States Geological Survey for the United States, and is given as about 378,000,000 barrels of 42-gallon capacity, as compared with 351,178,236 barrels in 1912. In 1906 the world's output was 201,777,228 barrels, so that within a 7-year period, there has been an increase of over 80 per cent. The United States has furnished the greater part of the increase, and is at present providing almost two-thirds of the world's annual output. The 1913 production of the United States was equivalent to about 65 per cent. of the world's total.