of circular transformations of the plane. These with their appropriate symbols and invariant figures are as follows:

1. $mG_6$. No invariant figure.
2. $mG_4(A)$. A single invariant point.
3. $mpG_3(A)$. A single invariant point.
4. $mG_3(\bar{C})$. A real invariant circle.
5. $mG_3(i\bar{C})$. An imaginary invariant circle.
6. $mpG_2(A)$. A single invariant point.
7. $mG_2(AA')$. An invariant point pair.
8. $mhG_2(A\bar{C})$. An invariant point and a circle through it.
9. $mhG_1(AA'\bar{C})$. A pair of invariant points and a pair of orthogonal circles.
10. $mpG_1(A\bar{C})$. An invariant point and an invariant circle.
11. $meG_1(AA'C)$. An invariant point pair and an invariant circle.

LAWRENCE KANSAS,
*January* 18, 1901.

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# PURE MATHEMATICS FOR ENGINEERING STUDENTS.

BY PROFESSOR A. S. HATHAWAY.

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## I. ITS UTILITY.

I HAVE had opportunity to become acquainted with the written opinions of graduates of from one to many years' standing, with regard to the benefit and utility of their instruction in all departments of technical work, and have also taken the opportunity of conferring personally with graduates in respect to my own department. In discussing this subject, I shall therefore appear, not as a special pleader for pure mathematics, but as one who proposes to present its claims in their true proportions to the other necessary work of the student.

In the first place, mathematical analysis is not so directly useful to the average engineer as the mathematician might expect. The mathematics that an engineer is obliged to use regularly is of that cut and dried form which is found tabulated in engineering handbooks of easy access, so that only a little arithmetic or algebra, and occasionally some