volve varying the relative quantities of cement, water and aggregate, the size and grading of the aggregates, etc.

It was with a view to securing definite information on some of these problems that the tests covered in this report were carried out. Two forms of test were used:

(1) Compression tests of 6 by 12-in. concrete cylinders.

(2) Wear tests of concrete blocks, 8 ins. square and 5 ins. in thickness.

The wearing resistance of concrete is of great interest in view of the widespread use of concrete for the construction of roads, pavements, floors, walks, etc. The wear tests were made in the Talbot-Jones rattler.

Over 3,800 specimens were made in the experiments covered in this report. The 1-year compression test cylinders have not been made. For the conditions of the tests, definite results were secured on the following topics:

(1) Influence of quantity of mixing water on the strength and wear.

(2) Effect of time of mixing (15 sec. to 10 min.) on the compressive strength.

(*a*) Concrete of different consistencies.

(*b*) Concrete of different cement content.

(*c*) Concrete made of aggregates of widely different size.

(3) Effect of time of mixing on the wear of concrete of different consistencies.

(4) Relation between wear and compressive strength.

(5) Effect of rate of rotation of mixer drum on the strength of concrete.

(6) Effect of temperature of mixing water on the strength of concrete.

(7) Effect of age on the strength of concrete.

(*a*) For different times of mixing.

(*b*) For different mixes and consistencies.

(*c*) For different sizes of aggregates.

(8) Comparison of machine-mixing with method of hand-mixing used in the laboratory.

(9) Uniformity of mixer tests.

These experiments form a part of the researches in the properties of concrete and concrete materials being carried out through the co-operation of the Portland Cement Association and Lewis Institute at the Structural Materials Research Laboratory, located at Lewis Institute, Chicago. The tests must be considered as merely preliminary to any comprehensive investigation of the performance of concrete mixers. Such an investigation would include machines of many types and capacities and numerous other factors which have not been studied. It is hoped that an opportunity will be found for extending these mixer investigations beyond their present limits.

Acknowledgment is due to the Chicago Gravel Company, Chicago, for their courtesy in supplying the aggregates used in these tests and to the T. L. Smith Company, of Milwaukee, who donated one of their 3½-cu. ft. "Mascot" concrete mixers for use in the laboratory.

Outline of Tests

For convenience, each group of experiments is given a series number. It is believed that confusion will be avoided by referring to the tests by the series numbers. Table 1 gives the titles of the series and the number of tests of each kind.

The tests on effect of time of mixing covered in this article were made on concrete mixed in a tilting mixer with a double-cone drum, capacity 3½ cu. ft., manufactured by the T. L. Smith Company. In all these tests the mixer was loaded to capacity and the entire batch was made into test pieces.

Table 1—Outline of Test Series

Series No.	Title.	Total Number of Tests, Compression.	Wear.	Miscellaneous.
81	Uniformity of Machine-Mixed Concrete	44	...	70
89	A Study of the Time of Mixing Concrete (Effect of Consistency)	612	...	70
93	A Study of the Time of Mixing Concrete (Effect of Mix and Size of Aggregate)	1,344	240	82
96	Study of Rate of Rotation of Mixer Drum	576	...	70
97	Effect of Temperature of Mixing Water on the Strength of Concrete	660	...	70
	Total	3,236	240	362

Series 81 was preliminary in nature, carried out for the purpose of studying the variation in the compressive strength of specimens made from different parts of the same batch of machine-mixed concrete. Three batches of different consistencies were mixed. Compression tests on 6 by 12-in. cylinders were made at 7 and 28 days.

Series 89 included a study of the effect of time of mixing, using concretes of consistencies varying from a fairly stiff to a wet mix, the proportion of cement and the grading of aggregates being the same in all tests. Batches of each consistency were mixed for periods ranging from 15 seconds to 10 minutes. Compression tests were made at ages of 7 and 28 days and 2 months, and year tests at 2 months. This is the only series in which wear tests were made.

In series 93 a study was made of the effect of time of mixing, varying both the mix and the size of aggregate. The first part of the series consisted of variations in the quantity of cement from a 1-15 to a 1-2 mix, using aggregates of the same grading (0-1¼ ins.). In the second part of the series a 1-5 mix was used, the aggregate ranging in size from sand all of which passed the 14-mesh sieve to a sand and pebble mixture graded up to 2 ins. Batches of each mix, etc., were mixed for periods of 15 seconds to 10 minutes. Parallel sets of tests on hand-mixed concrete were made for comparison with the machine-mixed specimens in both of the groups mentioned above. In the hand-mixed concrete only one mixing period was used. Compression tests were made at ages of 7 and 28 days and 3 months. The 1-year tests are not yet due.

Series 96, "Effect of Rate of Rotation of Mixer Drum," concrete of 1-5 mix, aggregate graded to 1¼ ins. in size was mixed for 1 minute at six different rates, ranging from 8 to 30 r.p.m. The rate recommended by the manufacturers for this mixer is 18 r.p.m. Concrete of four different consistencies was used for each rate. Compression tests were made at ages of 7 and 28 days and 3 months. The 1-year tests are not yet due.

Series 97, on effect of temperature of mixing water on the strength of concrete is somewhat foreign to the subject-matter of this article, but since the tests were made at the same time, using the same materials and under similar conditions, it is considered desirable to include the results here.

The temperature of the mixing water was varied at intervals of 10° C. from 0 to 100° C. Four different consistencies were used. Duplicate batches were mixed for