one hour, broke at 2,750 lb., while the third, heated for two hours, broke at 1,950 lb. This is a most remarkable showing under severe conditions. It should be borne in mind that these small beams were so slow in cooling down that they showed the effect of heating much longer than the time mentioned, say 24 hours. The flames, moreover, surrounded the beams on all sides. In tests at three and five year ages, the temperature was between 1,600 deg. and 1,700 deg. Fahr.; the 8 in. by 8 in. by 48 in. reinforced beams broke at 14,200 lb. when not heated, but at 4,920 lb. when heated. Smaller beams 6 in. by 6 in. by 48 in., not reinforced, broke at 1,300 lb. when not heated, at less than 100 lb. heated.

As a result of these tests upon the beams, it was evident that the failure of the specimens was in every case due to the rods pulling through the concrete. This is wholly a matter of insufficient anchorage, and these short beams are therefore not very helpful in giving information concerning the behavior of full-sized beams in buildings, and except as they give relative information concerning different mixtures, they are of very little value. The small cross-section of these beams tends to make the fire exposure abnormally high. It should be noted that all of the non-reinforced beams broke in handling, which suggests the severity of the tests as compared with the experience of actual conflagrations.

A series of similar beams was next made up of cinder concrete, the proportions of the mixture being 1: 2: 5. A portion of these were mixed with clean cinders, which showed upon analysis but little carbon; a second part was mixed with cinders to which 10 per cent. of fine bituminous coal had been added and the other beams were mixed with cinder, to which had been added 25 per cent. of fine coal. The 25 per cent. mixture can be disposed of in a word—when once thoroughly heated it burned until it fell to pieces. With the 10 per cent. mixture, however, no such action occurred; there was no indication that the concrete would support its own combustion even for a short time. It was apparent, however, that the 10 per cent. mixture was not so good a fire-resistive material as that which contained no added carbon. From the few specimens containing less than 10 per cent. which have been examined up to the present, it seems probable that the safe limit is close to 5 per cent. More information is now being secured on this point by the use of larger beams.

Specific Heat—The study of the specific heat of concrete was made by the ordinary calorimeter method, the "method of mixtures" of Regnault. Specimens of the concrete, usually fragments of the larger test pieces, were heated slowly in an electric resistance furnace to the desired temperature and then plunged into the calorimeter. The weight of the water and its rise in temperature give the amount of heat given off by the body in cooling. Extraordinary precautions were taken in getting the exact average temperature of the specimen in the furnace, and to insure its rapid transfer to the calorimeter. In most of the experiments a double calorimeter was used so that the specimen did not come in contact with the water of the calorimeter, so that any evolution of heat by hydration of the cement was avoided. Tables 2 and 3 give the specific heat of concrete and of other materials:—

Table 2—Specific Heat.

Temperature, Deg. Fahr.	Stone Concrete 1—2—5	Stone Concrete 1—2—4	Cinder Concrete 1—2—4
72 to 212	0.156	0.154	....
72 to 372	0.192	0.190	0.180
72 to 1172	0.201	0.210	0.206
72 to 1472	0.219	0.214	0.218

Table 3—Specific Heat of other Materials.

Material	Temperature	Specific Heat
Stone Concrete	72 to 500	0.210
Stone Concrete	72 to 800	0.204
Stone Concrete	72 to 212	0.180
Cinder Concrete	72 to 212	0.156
Red Brick	72 to 212	0.214
Red Brick	72 to 500	0.192
Red Brick	72 to 1100	0.200
Quartz	400 to 1200	0.308
		0.305
		0.279
Cement	room temperature	0.271
		0.186
Sand		0.191
Trap		0.201
	?	0.258
		0.270
Sandstone	?	0.220
Dolomites		0.222
Slag		0.169
Granite	?	0.173
		0.196
		0.200

Coefficient of Thermal Conductivity.—The measurements of thermal conductivity were made by a number of methods and have taken far more time and energy than all the others put together. The thermal conductivity is that property which determines how rapidly heat will travel through a substance and how rapidly therefore objects beyond will be heated by transmission. The conductivity becomes of prime importance in all questions of protection of the metal in reinforced concrete buildings. There is a limited amount of data to be found relative to this important property of any of the common materials of engineering and such data as are to be found are not concordant. As to the conductivity of concrete or its variation with temperature and with composition, practically nothing has been known.

The methods adopted for the measurements will be here described in outline only. The formula showing the relation of the temperature upon the two sides of a plate to the amount of heat which would flow through is as follows:—

$$Q = \frac{K\ (t_1 - t_2)\ sA}{d}$$

$$\text{or } K = \frac{Qd}{(t_1 - t_2)\ As}$$

where

K = the coefficient of thermal conductivity dependent upon the nature of the material and its temperature.

Q = the quantity of heat flowing through the plate in the area measured

A = the area

t_1 = the temperature of the hotter side of the plate

t_2 = the temperature of the cooler side of the plate

d = the thickness of the plate

s = time during which Q units flow through the area A.

The formula will be seen to be merely an expression of the following relations, that the flow of heat is proportional to the area, to the temperature and to the time, and that it is inversely proportional to the thickness.

After spending many months in attempting to develop other methods, the electrical method used by the writer for the past 15 years in studying the flow of heat through steam