ductility and tensile strength. The facts mentioned afford an excellent example of the importance of the physical effects produced by repeated changes of temperature. The change effected by one heating and cooling is so small that a cumulative test is the only method by which a really useful result can be obtained. If a wrought-iron bar is heated expansion takes place; if the bar is then suddenly cooled in water it contracts, and the amount of the contraction exceeds that of the previous expansion, so that the bar is now smaller than it was before being heated. If these operations are repeated, the contraction increases during many successive operations. Thus a bar $1\frac{1}{8}$ in. square by 30·05 in. long, heated to a dull red and cooled in water, contracted after first cooling ·04 in.—after 15th cooling ·68 in. or a percentage of 2.26 in fifteen operations. That was common iron; the best gave the same degree of contraction for the first two or three operations, but on the 15th cooling was found to have contracted only 56 in. or 1·86 per cent. of its length.

Similar bars heated to redness and allowed to cool in air do not exhibit any change in dimensions, but if they are raised to a white heat a slight contraction does occur. Some wrought-iron hoops welded up from bars of the same section as the iron employed in the previous experiments yielded almost identical results—the contraction progressing steadily during twenty-five coolings. Pieces of wrought plate planed up into a nearly accurate rectangular form, were then tested, with the result that after cooling in water a reduction of specific gravity was discovered amounting to 1 per cent. after 50 coolings, and 1·57 per cent. after 100; further heatings and coolings not appearing to effect any change. A reduction of the surface takes place after each heating and cooling, due to two causes, viz., scaling, which amounts to ·00057 in. reduction of thickness after each immersion in water; and a persistent contraction, which takes place vigorously after each immersion up to fifty, and probably to a much greater number. Bulging is noticed in the case of plates, which thicken towards the centre, while the edges are thinned. Professor Stokes has explained the bulgings, the scaling is well understood, but the contraction can be accounted for only on the supposition that a molecular change in the iron occurs when the red-hot metal is suddenly cooled. Cast-iron bars, on the contrary, whether cooled suddenly in water or gradually in air, expand slightly, while cast-copper rods exhibit no change when cooled in air, but expand slightly after being several times suddenly cooled in water. Some of the most valuable and interesting of Mr. Wrightson's experiments were made upon bars and rings partly immersed only when being cooled. From the results recorded above, it would be imagined that if a thick hoop, or portion of a hoop, were cooled by partial immersion, the portion in the water would contract, while that allowed to cool in the air would exhibit no change. Such a conclusion, however, is entirely erroneous, for when a hoop 18 in. in diameter, forged out of iron $3\frac{1}{2}$ in. broad by $\frac{1}{2}$ in. thick, was half immersed in water, it showed, after twenty successive heatings and coolings, that the water-cooled edge had increased 1·24 in. or 2·14 per cent. in length, while the air-cooled half had contracted 7·9 in., or 13·65 per cent., so that the hoop had become a section of a cone. To ascertain whether the form had anything to do with this curious result, a wrought-iron bar $3\frac{1}{2}$ in. deep, by $\frac{1}{2}$ in. thick by 28·4 in. long, was treated in a similar manner, when the dipped edge was found to elongate, while the upper edge cooled in air contracted—so much so that the originally straight bar became curved, the water-cooled edge becoming convex, while that in the air became concave. After the twelfth immersion the lower edge was found to have expanded 44 in., while the upper had contracted 1·96 in. An experiment was also made to test the effect of reversing the bar. A similar bar to that previously described after five coolings was curved so that the reversed side of its air-cooled edge measured $1\frac{1}{2}$ in. The concave edge was then placed in the water, and five immersions brought the bar within an $\frac{1}{8}$ in. of the straight, and the eleventh cooling threw the concavity on the other side of the bar.

These experiments were subsequently repeated in a more elaborate manner with steel and wrought-iron hoops actually turned and bored, and immersed to varying depths. The explanation was furnished by Col. Clark, R.E., some years ago, after similar experiments made at Woolwich. The immersed portion, being quickest cooled, is the stronger metal, and tends to pull in the upper part, which, besides, contracts as it slowly cools, so that the excess of contraction rests with the air-cooled portion. Col. Clark does not appear to have noticed the expansion of the water-cooled edge. These experiments are unquestionably of value, and the knowledge gained by them may be utilised in the arts; hence it would be advisable to issue the tables and the diagrams, together with the descriptive matter, in a separate form. In making the experiments above noticed, Mr. Wrightson's attention was naturally drawn to the changes occurring in cast-iron when passing from the solid to the molten condition, and *vice versa*. It is well-known that a piece of cold cast-iron will float upon a bath of molten cast-iron, and much has been written to account for the apparent anomaly that cast-iron which has in cooling contracted about 1 per cent. from the original size of the mould in which it was cast, should, with a presumably higher specific gravity than the molten metal, float in the same. The ordinary way in which the experiment is performed is to take a small piece of cold iron and throw it into a ladle of molten metal. It sinks at first, and then rises buoyantly to the surface. The assumption is made that the sinking is due only to the momentum acquired in falling; but the fact is, the cold iron sinks because it is heavier, and rises to the surface as it becomes heated and expands—the density being thus diminished. Mr. Wrightson had spheres cast, 1 in., 2 in., 3 in., 4 in., and 5 in. in diameter, which were lowered, not thrown, into the molten metal, and he devised an instrument which registered the amount of sinking and of flotation, below and above a line of equilibrium. The diagrams obtained with this instrument show that in every case the ball sinks when first lowered into the metal, the duration of the sinking period being, as a rule, longest with the smaller balls. The outside surfaces of a ball expanding only to a small degree affects the volume more in proportion as its diameter is larger (the surface varying as the square and the volume as the cube of the diameter). Hence, as a rule, five or six seconds may be sufficient to expand a five-inch ball to the floating point, while a two-inch ball would require a much longer time before it would float. Thus the index, at the moment the ball enters the metal, crosses the line of equilibrium and sinks below it; then it rises gradually until it attains its maximum above the line, and then falls again as the ball melts until it reaches the line, the fork and spring holding the ball being adjusted to remain in equilibrium. It may be reasonably assumed that the diagrams read backwards convey a correct impression of the changes going on when molten iron is cooling to the solid. The mould is usually made about 1 per cent. larger than the casting is required to be, and the metal when poured in is always supposed to expand; hence the sharpness of the impressions. This expansion is marked on the diagrams by the quick rise of the line between the molten point and the point of greatest volume. Mr. Wrightson says that in carefully observing the cooling of a casting it will be noticed a considerable contraction takes place some minutes after the iron is partially set. A few minutes after the "git" is closed and congealed there is a sudden breaking open of the same, and a sponging out of the hot liquid from the interior, as though the internal part had suffered a sudden squeeze. This phenomenon is indicated by the sudden fall of the line on the diagram, and indicates in this case the passage from the plastic to the solid state.

WORCESTER'S GREAT SEWER.

The following, from the Worcester *Gazette* of the 22nd of November, gives an interesting account of a very large sewer, which has been built in that city at a heavy expense. It is in many respects a remarbable engineering work. Its extraordinary form appears to be due to the fact that it has a large amount of storm water to carry off in addition to the sewerage and water of the brook mentioned:

The section of sewer now so near completion consists of a covered arch of 18 feet span and 13 feet high in the centre; the structure really consists of two walls and two arches, one of them inverted, substantially as shown by the above diagram.

The side walls have an inside face of 5 feet and are 5 feet in thickness. The upper arch springs from a beveled face near the top of the wall, and has a rise of 4 feet and a span of 18 feet. It is of rough ashlar work laid in cement. The bottom of the sewer consists of an inverted arch of stone and concrete, with the same span and radius.

As there has been considerable correspondence of late in relation to the best form of sewers, we give the above with illustration, which may help to elucidate the question.

Testing Cellars for Dampness.—Provide yourself with a thermometer, a glass tumbler filled with water; and a piece of ice; then notice how low your thermometer, when placed in the tumbler, has to sink before any moisture begins to show itself on the outside of the vessel of cold water. The lower the temperature to which the thermometer has to sink before any moisture is precipitated, the less there is of it in the moisture of the cellar.