sooner. The result in practically every case is a void or "draw" at the juncture point, bad enough in any case, but made worse by the presence of the large fillet. Of course there may be trouble from such intersections where no fillets at all are used, but the fillets should be kept small, with the idea of allowing both walls and juncture to remain as nearly uniform in thickness as possible, and to have as nearly as may be the same capability for simultaneous shrinkage and solidification.

Jacketed Cylinders.

Among other classes of difficult castings I would place jacketed cylinders in the list requiring careful consideration in design. In considering the case of a gas engine cylinder which is to be jacketed, the inner wall which resists the strain of explosion must be quite thick in order to afford the requisite strength against explosion pressures of ordinary nature and also against abnormal pressures due to preignition and other causes. A cylinder of this sort, whose internal diameter might be 40 in., could well have a thickness of cylinder wall amounting to 3 inches or more. The outer wall forming the jacket has only to stand the ordinary pressure of the cooling water, which might be quite low, often not exceeding 60 to 80 pounds per square inch, even where water is used direct from the city mains, and an outer jacket wall 1 inch thick might on ordinary engineering assumptions, be regarded as ample to care for this pressure.

If the cylinder wall and the jacket wall are continuous; that is to say, if each extends rigidly from one end of the cylinder to the other, there is likely to be trouble when such a cylinder is cast or cooled. Even if it does not break at the start it is quite likely to break in service because a wall of metal 1 inch thick located out near the sides of the flask, which act as cooling media, will not shrink in time with the inner wall whose thickness is three times as great and whose opportunity for radiation is quite inferior. It is reasonable to expect that the outer wall will cool first; will take on its final dimensions while the inner wall is still very hot. At a later period the inner wall will shrink to normal temperature and will find that its desire to contract is restricted by the compressive strength of the outer jacket wall. The effect is a high degree of tension in the working cylinder wall. In such a case one good feature of design is to interrupt the jacket wall, so that the inner or working wall may have its own way and be unhampered in contracting; afterward it is closed up and rendred water tight by suitable mechanical means.

In such a case as that just cited, if the jacket wall must be cast continuous with the cylinder wall, it should not be designed solely in connection with its own theoretical stresses, but should be thickened up and made to approximate the working cylinder wall, so that it may cool down and contract more nearly simultaneously with the latter. Such outer walls, and all such attachments to a large casting, as bosses and pads, should be designed not alone out of consideration to the working strains which will be applied to them, but the tendency of the iron to chill at such spots must be considered. Ofttimes the pads or the bosses require to be made several times as large as mere reasons of strength would dictate, to avoid a hardening and whitening of the iron in thin sections that would prevent its being machined to required dimensions.

Handling of Cores and Risers.

After the foundryman has accepted the design and begun the work he may have several things to do in order to produce a reliable casting. If it is a cored casting he must guard against the cores being so strong that when confined within the contracting casting they will produce rupture of the metal. Among the usual means employed for producing a collapsible condition of core may be mentioned the use of sawdust or coke or ashes, or a combination of them all, some of which ingredients will burn out as the casting cools and provide thereby for a collapse of the core. In other cases removable pieces, collapsible core arbors, straw wrapped core arbors and the like, tend to prevent castings from cracking because of an unyielding core.

In order to serve engineering purposes, castings should be not only apparently sound but really so. For this purpose risers and sinkheads should often be employed on iron castings where they are not at present used. Steel foundry conditions compel such precautions to insure soundness, but in large iron foundry work interior cavities may exist without detection, and some of these may be avoided by the use of suitable feeding devices, risers and sinkheads. If risers are not employed, the upper or cope side of the casting is likely not to be solid, because of the metal in the upper portions flowing or bleeding away from the interior of these sections to feed the shrinkage and the contraction in the lower portions of the casting. The top surface of such a casting may apparently be solid, but if drilled deeply, as for stud bolts or other purposes, it is likely that cavities and extreme openness of grain will be disclosed. In some such cases good can be accomplished by the use of local chills placed under the top flange, if a cylinder, for instance, the chills setting the metal in the flange before it has time to feed out of this region into any lower portion.

Variations in Strength.

In some large castings intrinsic strength per unit section may not be a serious requirement. In other cases the engineering design may require high quality of material because high working strains per unit section are to be imposed upon the finished casting. In such cases engineering attention should be paid to the size of the test specimen which is to furnish an index of quality, and to the relation which exists between the strength of cast iron in light test pieces and that of the same metal when cast into heavy sections. The writer has taken specimens from an iron casting having at one point tensile strength as high as 30,250 pounds per square inch, and as low as 20,502 pounds per square inch in another and heavier section. The difference was wholly related to the thickness of the section and to the rate of cooling, with its consequent effect upon the grain. It might be said that large sections cannot be cast to yield the high strength that is sometimes associated in engineering minds with specimen test pieces cast in smaller sections of prevailing sizes.

It is well that the foundryman be acquainted to some extent with the purposes for which castings are intended. This will enable him to pay particular attention to such parts of the casting as are specially critical and to such as are to be machine finished. He can usually arrange to place his chaplets, anchors and core vents so as to keep them clear of the working or sliding machined surfaces, and he can then better provide for producing a casting which is a clean one at these critical points. The moulder, if left to himself will probably put chaplets and anchors directly in the path of a machined slide. Sometimes this kind of information would seem to be obvious, but often it is not so, and a hollow cylindrical casting with flanges on each end might, for all the moulder knows, be a pipe having no special requirements; whereas it was intended to be a cylinder which must be bored, faced and generally machined, and must be perfectly free from defects—a casting in which chaplets and anchors are utterly inadmissible.

Certain points on a large casting may require to be drilled and tapped and may demand a high quality at that spot. A suitably located chill will insure soundness and solidity here if the foundryman knows what is demanded; if he does not know, the casting is made, looks good to him, is shipped out, and when machined is found to be hollow, cavitated or spongy at the critical spot.

In ordinary cases designs for castings should be such that it will not be necessary for the foundryman to pay particular attention to heat treatment, because in the press of other matters such treatment may occasionally be forgotten and omitted, or it may be imperfectly done by inexperienced men. A casting is best designed if it can be uncovered promptly after pouring, lifted out of its bed and deposited on the floor of the chipping shop. This is what is done with 95 per cent. of the output of the average foundry, and it is what the workmen are accustomed to. Special cases soon become irksome and some one will perhaps assume the responsibility of saying: "This special treatment is all foolishness and the casting is just as good without it." There are, however, cases in which it is necessary to design castings that do demand this special treatment.

A Special Crank Disk.

Fig. 1 illustrates a peculiar crank disk which was made in an iron foundry under the author's management some five or six years ago. The first casting was poured in the usual and ordinary manner, and after a decent delay in the flask was uncovered and removed to the chipping shop. It lay on the floor of the latter department for a day or two after cleaning; it was then shipped to the machine shop, which is located about 12 miles away. When the casting arrived at the shop it was found that a large piece had not only broken away from the balance of the casting, but it had jumped clear off the railroad car on which it was being conveyed, the missing piece being found by a track walker alongside of the railroad track a few hours after its loss was reported. The line of breakage is indicated in Fig. 1, and the missing piece weighed perhaps $1\frac{1}{2}$ to 2 tons. This case was studied carefully. The heavier interior member, being the last of the casting to cool, had set up violent internal strains which caused the casting to rupture.

We arranged the next casting so that a few minutes after pouring had been done, a small stream of water in a regulated quantity was caused to drop into the hollow cores A and B,