tional, this stretch of 0.2 per cent. would mean an increase of stress of about

$$\frac{0.2}{30.0} \times 30,000 = 200 \text{ lb.}$$

But, the characteristic of stress-strain diagrams is that there is a sudden yielding accompanied by a very considerable stretch with no increase in stress or even a slight falling off. To be sure, in assuming any sharp angle in the diagram, there is a slight error, as the corner should be rounded. It would be more exact to say that the lines assumed are tangent to the curves, but the effect of this rounding may be disregarded without invalidating the theory. Referring to Fig. 3, the above assumptions may be expressed algebraically as follows:

Letting $a+b=1$, we find that the equation for y assuming a as a variable is a parabola with its vertex at the neutral axis of the section of ½e, the parabola passing through the origin. This equation is $y=\left(a-\frac{a^2}{2}\right)e$, or $2a-a^2=\frac{2y}{e}$.

Expressing this result in words, it amounts to this: If a rectangular bar is bent so that it has any permanent set the internal maximum fibre stress may be obtained if we know to how great depth the outside portion of the section has been stressed beyond the elastic limit. The amount of this internal stress can never exceed one half the elastic limit, and between o and ½ e it varies according to the abscissas of a parabola of which the axis is the neutral axis of the section.

We may determine the depth to which fibres are stressed beyond the elastic limit, if we know the radius of curvature and the thickness or depth of the section. We know from mechanics that $\frac{1}{r}=\frac{e}{Ed}$, in which r is radius of curvature, e is elastic limit of the material, E is the modulus of elasticity and d is distance from the neutral axis to the extreme fibre. Using 30,000 for e and 30,000,000 for E, this formula becomes $r=1{,}000d$. In other words, the distance from the neutral axis to the fibre which is strained just to the elastic limit will be one thousandth of the radius of curvature; hence, if we know approximately the radius of curvature, we can tell at once what part of the thickness of the section is not overstressed, and, subtracting this from one half the total thickness, can find a. Taking a practical example of this we should obtain the following results.

Assume a bar 3-in. by 1-in. to be somewhat crooked edgeways and to be straightened in a press. Let us assume that in straightening it is curved to a radius of 12 ft., a very moderate assumption.

The width of metal not overstressed would be $\frac{12 \times 12}{1,000}=$ 0.144 in. each side of the neutral axis.

$$a \text{ would therefore} = 1.5 - 0.144.$$
$$= 1.356 \text{ in.}$$

or, on the basis of $a+b=1$.

$$a=\frac{1.356}{1.5} \times 1 = 0.9.$$

From the diagram, Fig. 4, we find that under these circumstances y, the initial fibre stress, amounts to 0.495 e, tension on one edge, and compression on the other, or approximately to 15,000 lb. per sq. in.

This means that in a bar which is quite straight and wholly innocent in appearance there may exist a compressive stress along one edge of 15,000 lb. per sq. in., while along the opposite edge is a tensile fibre stress of an equal amount; in other words, an inherent tendency to bend out of line on the least provocation. This condition cannot be detected by any of the usual methods of inspection, but might be suspected if we knew its history.

It will be noted that the above analysis applies only to a rectangular section. In the case of an irregular section such as an I-Beam, it is evident that if the bending is in the plane of the web, a lesser stress in the extreme fibre will produce equilibrium on account of the decreased area of the section in the parts nearer the neutral axis. On the other hand, however, if the bending is at right angles to the web, the converse is true, and the extreme fibre stress will be greater proportionally, and may easily approach nearer to the elastic limit. The same is true of a bar with a circular cross section.

Let us now consider the practical effect of these internal stresses. Referring again to Fig. 1, we see that if we apply an axial stress to a member which is already subjected to this condition of internal stress the effect will be to produce a condition as shown by Fig. 5

In this case we see at once that the areas of stress will be unbalanced so far as the rotating moment is concerned. The effect of this unbalanced condition will be to produce a tendency to spring out of line. If the axial stress is in tension, this tendency is offset by the axial stress itself, and even in case the extreme fibre stress exceeds the elastic limit, a slight yielding of these fibres soon distributes the stress more uniformly and so no serious results can occur. But if the axial stress is compressive, the tendency to spring is very serious and immediately throws the strut out of equilibrium, so that the bad effect of the internal fibre stress is accentuated. If the elastic limit is passed, the buckling may even go on to the point of failure.

It is not the present purpose to enlarge upon applications of the above theoretical considerations, but perhaps enough has been said to show the tremendous importance of eliminating cold straightening so far as possible from the ship treatment of metal which goes into compression members.

A copy of telephone statistics of the Dominion of Canada just issued shows that the total number of telephones in service in Canada is 370,884, 212,732 common battery and 158,152 magneto. During 1912 there was an increase of 37,738 in the number of telephones operated by common battery, and an increase of 30,387 in the number operated by magneto. The total number of miles of wire is given as 889,572. This is divided into urban and rural as follows: Urban, 636,961; rural, 252,610. This indicates that there is one mile of telephone wire in use for every 8.1 of the total population of the Dominion, and one telephone for every 19.3. There was one telephone for every 2.3 miles of wire. The class of wire used was as follows: Galvanized, 271,191 miles; copper, 20,096; overhead cable, 232,393; underground cable, 364,875; submarine cable, 1,015. The aggregate capital expenditure in telephones is now placed at $46,276,851, though the cost of real property is placed at something over $10,000,000 beyond this figure. This works out to a capitalization of $124.75 per telephone in use. The gross earnings from all telephone companies for the year amounted to about $12,250,000, as compared with a little over $10,000,000 the previous year. Operating expenses were 74.0 per cent. of gross earnings as compared with 69.32 for the previous year. Gross earnings work out to $33.90 per telephone in use or $13.79 per mile of wire.