C. *Faults which could be Detected by Attendants.*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shortness of water .. | 7 | 10 | 9 | | | | |
| Deposit .. .. | 1 | 9 | 0 | | | | |
| Over pressure, from valves out of order .. | 4 | 1 | 1 | | | | |
| | | | | 12 | 11 | 10 | |
| Unknown, as vessel sunk | | | | 1 | 0 | 0 | |
| Total .. .. .. | | | | 39 | 21 | 41 | |

The exploded boilers were of the following kinds, the causes of explosion being stated as in the summary under the heads A B C.

*Cornish or Lancashire.*

| | | No. | Kd. | In. | No. | Kd. | In. | No. | Kd. | In. |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Weak tubes .. | 2 | 2 | 4 | | | | | | |
| | Rigid ends .. | 1 | 0 | 0 | | | | | | |
| | Seam-rips .. | 1 | 0 | 8 | | | | | | |
| | | | | | 4 | 2 | 12 | | | |
| B | Internal corrosion | 2 | 0 | 2 | | | | | | |
| | External corrosion | 3 | 0 | 4 | | | | | | |
| | | | | | 5 | 0 | 6 | | | |
| C | Shortness of water | 4 | 10 | 8 | | | | | | |
| | Deposit .. .. | 1 | 0 | 0 | | | | | | |
| | | | | | 6 | 10 | 8 | | | |
| | | | | | | | | 15 | 12 | 26 |

*Plain Cylinders.*

| | | No. | Kd. | In. | No. | Kd. | In. | No. | Kd. | In. |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Bad repair .. .. .. | | | | 1 | 0 | 2 | | | |
| B | Internal corrosion | 2 | 1 | 3 | | | | | | |
| | External corrosion | 2 | 6 | 3 | | | | | | |
| | | | | | 4 | 3 | 6 | | | |
| | | | | | | | | 5 | 3 | 8 |

*Locomotive Multitubular.*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Bad stays .. | | | | 1 | 0 | 1 | | | |
| B | Internal corrosion or furrow .. | | | | 2 | 2 | 1 | | | |
| C | Over pressure .. | | | | 3 | 0 | 1 | | | |
| | | | | | | | | 6 | 2 | 3 |

*Vertical or Crane.*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Bad joints .. | 1 | 1 | 1 | | | | | | |
| | Bad punching .. | 1 | 0 | 2 | | | | | | |
| | Bad stays .. | 1 | 0 | 0 | | | | | | |
| | | | | | 3 | 1 | 3 | | | |
| B | Internal corrosion | 2 | 0 | 0 | | | | | | |
| | External corrosion | 2 | 1 | 0 | | | | | | |
| | | | | | 4 | 1 | 0 | | | |
| | | | | | | | | 7 | 2 | 3 |

*Marine—Ship, Tug, or Boat*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| B | Internal corrosion | 1 | 1 | 0 | | | | | | |
| | External corrosion | 1 | 0 | 0 | | | | | | |
| | | | | | 2 | 1 | 0 | | | |
| C | Shortness of water | 2 | 0 | 1 | | | | | | |
| | Over pressure | 1 | 1 | 0 | | | | | | |
| | Unknown, sunk | 1 | 0 | 0 | | | | | | |
| | | | | | 4 | 1 | 1 | | | |
| | | | | | | | | 6 | 2 | 1 |
| | Total .. .. .. | | | | | | | 39 | 21 | 41 |

Of the fatal cases, two were in Scotland where no inquests are hold, and, in the other ten cases, the verdict was accidental death, with certain recommendations as to better inspection.

The Board of Trade has made preliminary inquiries under the Boiler Explosions Act of 1882, in thirty-one of the cases mentioned in the records, also on twelve of the slight cases mentioned in the appendix.

As four cases were at collieries, the reports will appear under the Mines Department, while those on shipboard under the Marine Department.

The most fatal cases have been at iron works. The class of boiler most frequently failing has been Cornish or Lancashire, as might be expected, as there are more in porportion to any other kind. The cause of explosion most prevalent has been corrosion which could have been detected by inspection ; and also others which might have been prvented by more care by the attendant.

The models used in making the sketches for the annual records were lent during the year to scientific societies or gatherings of engineers, at Middlesbrough, Newcastle-on-Tyne, and Stoke-on-Trent, and addresses were given with simple experiments upon various matters bearing on the subject of boiler explosions. Some of the these addresses are printed with full illustrations, and from an addition to the introduction of vol. ii. of the records.

The general extension of the system of covering all risks by assurance has caused a demand for large sums to be assured on boilers, with comparative indifference on the part of those asking for it, as to securing that inspection which should accompany it. The long experience of twenty two years confirms the importance of that independent periodical inspection which is the primary object of this company to provide, and it is hoped that the perusal of these records will assist in showing the owners of boilers the importance of making prvoision for the proper carrying out of inspection, in the interest of both safety and economy.

## WIRE-GUN CONSTRUCTION.

BY MR. JAS. A. LONGRIDGE.

Before entering on the specific subject of the paper, the Author referred to a number of documents received by the Institution from the Ordnance Department, U. S. A. These were mostly translations from the works of Virgile, Rosset, and Clavarino, and related entirely to the Hoop-Constructions of Guns. The conclusions and formulas arrived at by these authorities completely bore out those of the Author's Paper of 1860, and the fundamental formulas, agreed with those derived by Lamé, Hart, and Rankine. The formulas, however, required modification in certain circumstances, when account was taken of the action of lateral forces, whether of tension or of compression.

In guns constructed on the Author's principle there was no strain on the core or coil in the direction of the axis of the gun, so that only the radial compression-force had to be considered ; it was shown that in no case was this very important, and that its effect vanished when the modulus of elasticity of the material of the gun was the same throughout. Virgile came to the conclusion that no part of the gun should be strained beyond its elastic limit, whether in tension or compression. Whilst agreeing with this as regarded tension, the Author came to a different conclusion as regarded compression. This from his own experience might be largely exceeded without detriment, and in this he agreed with Clavarino, and expressed the opinion, fully confirmed by experiment, that a compression of three times the elastic limit was perfectly admissable. Both Virgile and Clavarino attached great importance to the proper determination of the shrinkages, in this respect agreeing with the Author, who had always contended that Sir William Armstrong and the Woolwich authorities were wrong in assuming that if the actual shrinkages were in excess of those indicated by theory, the gun would shake itself right by repeated firing. This view the Author contested ; he pointed out that it would only be true if the excess strain caused a permanent set just equal to the original excess shrinkage ; that it often happened that the permanent set was greatly in excess of this, and in such case the gun was reduced to the condition of deficient shrinkage, and it might be of no shrinkage, and would then inevitably fail. The Author next referred to the failure of a 6·3-inch gun on board H.M.S. "Daring" on the 22nd February, 1883, resulting in the death of two men and the wounding of three others during target-practice. From calculations made by him, the Author concluded that the failure of this class of gun was certain, if the powder-pressure was not kept down to about 10 tons per square inch, the effect of which on the efficiency of the gun need not be stated. He thought it probably that, owing to the method of construction, this gun did not actually burst, but was torn asunder by the successive permanent sets loosening the hold of the hoops upon each other between the breech and the trunnion. After referring to Rosset's experiments on "Special Elasticity," or the extension of the "Elastic Limit" by stretching, the Author pointed out that inasmuch as this only took place when stretching was the effect of mechanical force, and not when it resulted from contraction in cooling, this property was not available in the ordinary method of gun-construction, though it had some effect on the behaviour of a gun under fire. After careful consideration the Author was forced to the conclusion that the construction of a perfect hooped-gun was beset with enormous practical difficulties, and that the present armament of the country was unreliable.

Turning to wire-guns the Author remarked that there was a good deal of misconception on the subject. It was not that a