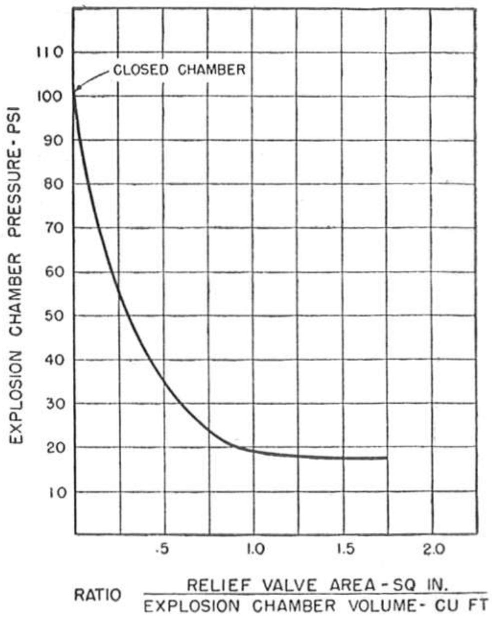

Fig. 10 Effect of Relief-Valve Area on Explosion-Chamber Pressure

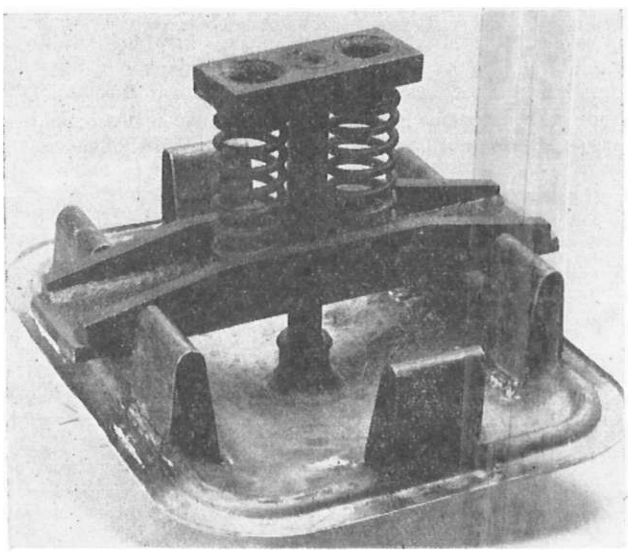

Fig. 11 Spring-Loaded Crankcase Cover

the correct design of a Diesel engine should be adequate provision, as has been illustrated, to cope with the possible dangers of crankcase explosions.

It is gratifying, however, to note that reports of crankcase explosions which have occurred since the application of the improved type doors indicate that the explosions have been contained, and that the dangers to personnel and equipment have been greatly reduced.

Conclusions

From the test work which has been completed the Navy has drawn the following conclusions:

1 The test setup and method which has been used are satisfactory for testing the adequacy of crankcase doors to withstand crankcase explosions.

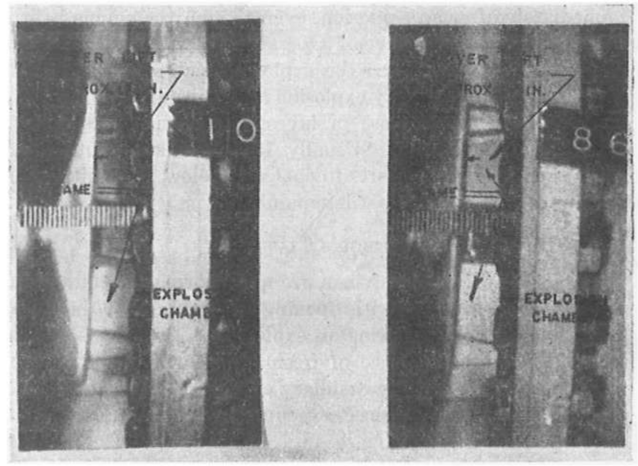

Fig. 12 Explosion Pressures Relieved by Spring-Loaded Cover—Typical Flame Pattern

2 The relief area for crankcases should be approximately 1.5 sq in. for each cubic foot of volume of the crankcase.

3 Lightweight multiple relief valves are desirable along the length of the engine crankcase.

4 Relief valves should be capable of relieving pressures in excess of 20 psi.

5 Good gasket cementing techniques, with some type of flame protection, should be used to prevent loss or burning of gaskets, as a result of an explosion.

6 All parts of a crankcase should be capable of withstanding an explosive force of 20 psi.

Discussion

R. L. Boyer[2] and T. O. Kuivinen.[3] The writers' company has conducted tests almost identical in nature with those described in the paper to obtain data for guidance in the design and application of crankcase-explosion relief valves to be mounted on our products. The detailed results and the description of the design of our relief valve are being presented as a portion of the discussion of G. W. Ferguson's paper.[4] It is interesting to note the close parallel between our findings and those of the tests at the U. S. Naval Engineering Experiment Station. These results and the valve description will not be repeated in this discussion.

We note the author's conclusion that the relief-valve design shown in his Fig. 7 gave a satisfactory solution to the investigation, yet the explosion shown in Fig. 1 illustrates the use of such a design, which apparently was not suitable, as the end crank door fitted with such relief valves actually blew off the engine. It is believed that the relief valves are too heavy, and the spring scale too high to relieve explosion pressure rapidly enough. We feel that our multiple-strip valve design with very light bow springs reacts more rapidly and closes very quickly to prevent a secondary explosion which frequently does occur with other types or means of relieving crankcase pressure. It should be stressed heavily that relief valves must be light so as to close quickly and prevent an inrush of fresh air as the pressure within the crankcase subsides.

In the author's conclusions, he did not mention that operating personnel should be warned never to open an engine crankcase

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[4] "Diesel-Engine Crankcase-Explosion Investigation," by G. W. Ferguson, published in this issue of Transactions: discussion p. 19.

immediately after an explosion, even though the engine is fitted with suitable relief valves. Operators should wait until the heated part that initiated the explosion had cooled sufficiently so as to avoid a secondary explosion at the instant of opening the crankcase for the purpose of investigating and correcting the source of the difficulty. Usually 15 min is sufficient time to allow such overheated parts to cool well below the ignition temperature of any oil vapors still remaining.

Author's Closure

Messrs. Boyer and Kuivinen are quite correct in pointing out the dangers associated with opening a crankcase to the atmosphere immediately following an explosion. Several cases are on record where the entrance of fresh air when the door was removed has resulted in a secondary explosion. In fact, it is best not to open up a hot engine too soon after stopping, especially if there has been some indication of trouble, even though there might not have been a primary explosion.

The explosion shown in Fig. 1 occurred prior to the Station's work outlined in this paper. It illustrates conclusion number six in that the crankcase is only as safe as its weakest part—in this case the strongbacks which hold the doors on the frame. When the explosion occurred the relief plates opened, as they were designed to do, in order to prevent the pressure from rising excessively. The strongbacks, however, were of the type shown in Fig. 5 and failed as shown, allowing the door to fly off, as in Fig. 4. Had the door been equipped with the heavy type of strongbacks, developed as a result of these tests, the relief plates would have opened and relieved the crankcase pressures as shown in Fig. 8. As shown in the paper, the relief valve relieved pressures in excess of approximately 20 lb while the crankcase door with the weak strongbacks failed at about 16 lb.