COMPRESSED AIR SYSTEMS

AN UPDATE

BY

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Introduction

Compressed air may not be the most glamorous of naval engineering topics but nevertheless is of some passing interest to the submariner wishing to surface his boat, to the gas turbine MEO starting his engines, and to a WEO for conditioning his radar waveguides. It also has considerable impact on warship upkeep.

This article updates a previous one by (then) Commander J. T. G. Bowen[1] in June 1980 and outlines current developments in compressed air systems as sponsored by Section ME213 of the Sea Systems Controllerate (formerly D161c of Ship Department). It covers improvements to in-service equipments, new equipments due to be introduced into service, lessons from the Falklands campaign, miscellaneous system improvements, and developments in upkeep. If it appears to cover lots of little points then that is the way with compressed air systems.

COMPRESSORS

The heart of any compressed air system is the compressor. Improvements to in-service compressors and introduction of better machines is vital and is a major part of the work of the Section.

Existing HP Compressors

TC Series/R80/4000 Models

Present compressors in the Fleet are mainly the old TC series and the more recent R80/4000 machines of Compair (Reavells) manufacture. These were specially designed for R.N. service and use expensive shock-resistant and sea water corrosion resistant materials. The R80/4000 has particularly low noise and vibration. Only limited development testing was possible before these designs had to be accepted into service and they have been described[1] as 'monument[s] to Mechanical Engineering'. They have a less than wonderful reputation for reliability, with stage valves, relief valves, cooler, plungers, lubrication, drainage, and bursting discs contributing to a MTBF of 50 to 200 hours running and excessive repair times.

Readers at sea will be relieved to learn that improvements are in the pipeline for 1984. Stage valves (FIG. 1) will be available that use bowed washer springs instead of helical coil springs, leading to improved fatigue life and reduced likelihood of valves breaking up and causing consequential damage to the compressor. Valve life of

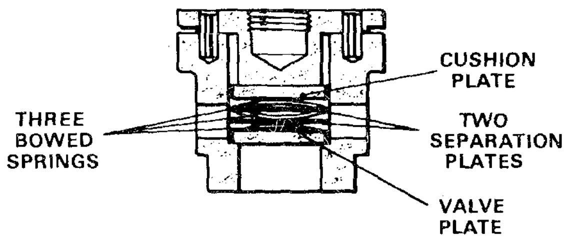

FIG. 1—TC/R80 IMPROVED 4TH STAGE VALVE USING BOWED SPRINGS

1000s of hours should be attained regularly and the requirement for attention will be indicated by gradual deterioration in performance rather than the sudden and often very damaging clatter that is the bane of the present compressor maintainer. Relief valves will be superseded by better proprietary items, successfully used on the new VHP36 compressor, and made of stainless steel with a ball valve lid.

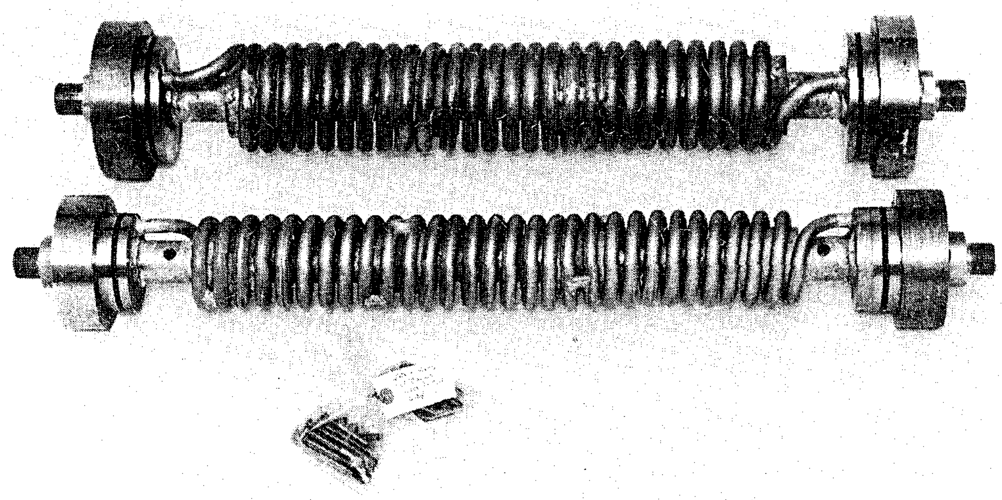

FIG. 2—TC/R80 SERIES IMPROVED 3RD AND 4TH STAGE COOLERS

Improved high pressure coolers (FIG. 2) are under trial in H.M.S. *Birmingham*, using an all-brazed coiled design that minimizes the possibility of air leakage and improves heat transfer. A drawback may be difficulty in cleaning the air side but initial results are most encouraging. Plungers of freer fit and supplied with conventional piston rings in a matched liner will reduce the incidence of plunger seizure on first running a refurbished machine, the cause of much bitter frustration as the last weekend of an AMP approaches. Changing the third and fourth stage oil lubrication feeds from direct into the cylinder to the air inlet passage reduces the pressure required to be developed by the oil pump and reduces the temperatures experienced by the small bore delivery pipe. Modification parts will be made available and significant reductions in blockage problems and more consistent lubrication are expected.

Good drainage of these compressors is vital and attention to this aspect pays dividends. The material of the diaphragms fitted in automatic drain valves has been improved and dramatic reductions in spares usage have been noted since. Some compressors still have drain valves operating in series but modification kits are available (DCI RN 541/83) to convert them to the superior parallel operation. The present design of bursting disc is the cause of frequent inadvertent washing down of deckplates, the copper material failing through a combination of corrosion and fatigue. The use of Melinex-lined and PTFE-coated bursting discs appears more successful and they may be made available after testing is complete.

Dunlop IC754

Mine Counter-Measure Vessels are fitted with the Dunlop IC754 HP air charging compressor, a lightweight machine selected for its low magnetic signature but really designed for intermittent light duty rather than the arduous duty of the vessel's main compressor. It is hardly surprising that failure rates are high. The use of synthetic compressor oil Anderol 500 (now OX-95) and various modifications have alleviated the situation but the real answer will be to replace the machine with a more rugged, continuously rated one.

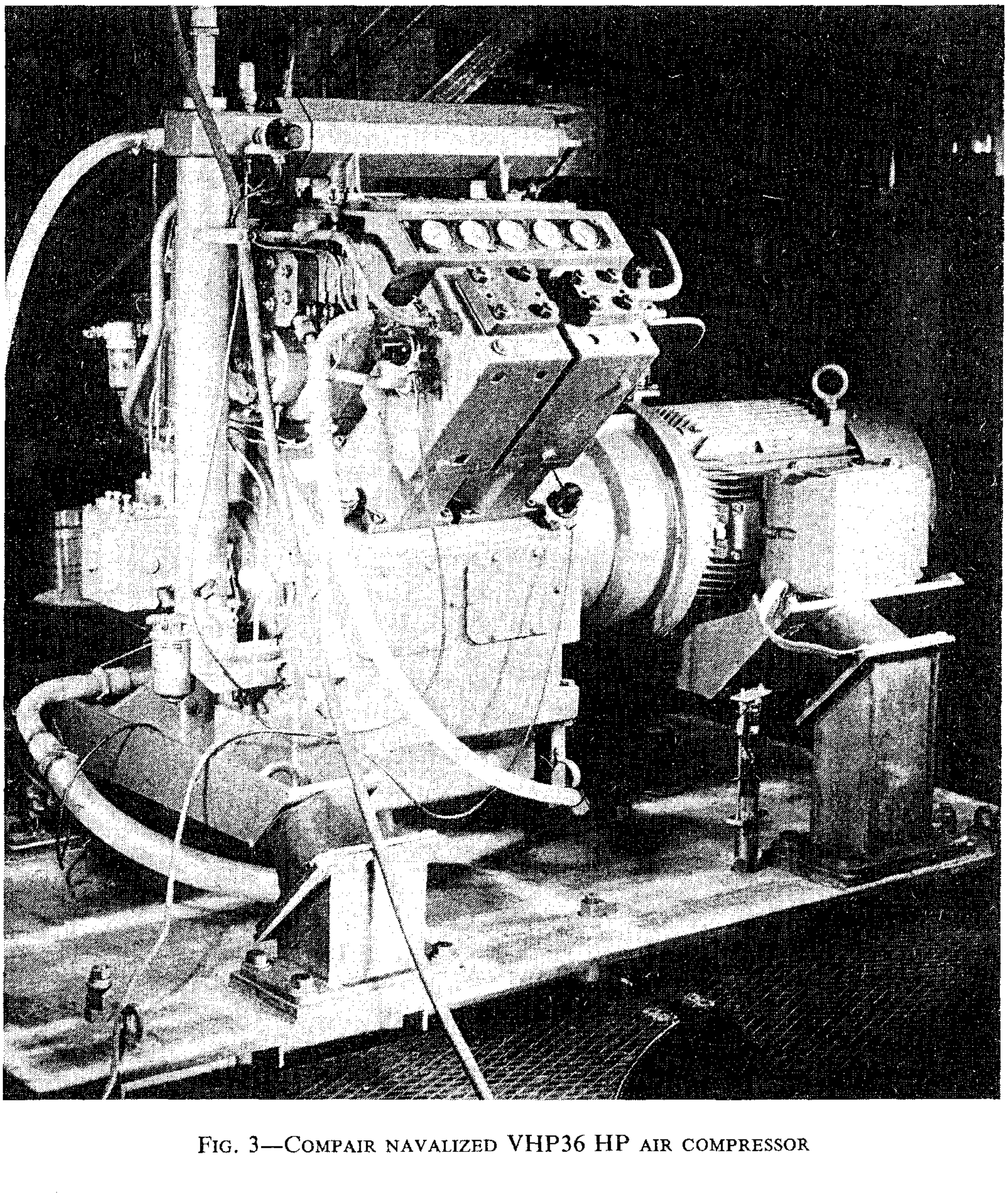

FIG. 3—COMPAIR NAVALIZED VHP36 HP AIR COMPRESSOR

New HP Compressors

The Type 2400, the first Type 23 frigate, and probably the Trident SSBN will use the Compair VHP36 HP air compressor (FIG. 3). This machine is a slightly navalized version of a successful commercial machine and has that rare combination of being both cheaper and more reliable than earlier naval compressors. Instead of the hundreds of running hours spent in development of the early TC and R80 machines, the R.N. will benefit from hundreds of thousands of hours of commercial running experience and 8000 hours development running at NAMD Haslar.

The compressor is manufactured mainly from SG (spheroidal graphite) Iron castings and has a 90° V-4 cylinder arrangement. When mounted on its special rubber mounts the machine has been proved to meet shock and vibration targets, and costs a fraction of previous special naval compressors. A comparison of the VHP 36 cast crankshaft in FIG. 4 with the older R80 crankshaft in FIG. 5 illustrates how costs have been kept down.

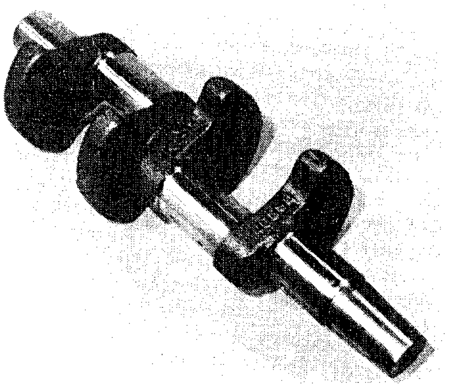

FIG. 4—VHP36 CRANKSHAFT

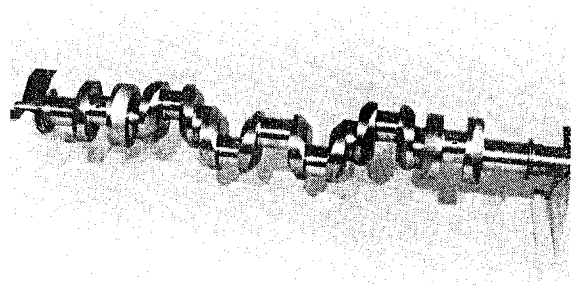

FIG. 5—R80/4000 CRANKSHAFT

The concentric valve arrangement[1,p.295] has proved to be very reliable in commercial service and on trial at NAMD Haslar. No valve has broken up during trials and the limitation appears to be carboning and gumming when standard naval oils OMD-113, OM-100 or OEP-69 are used, requiring some cleaning after 500 hours in service. The use of synthetic compressor oil, OX-95, has been shown to permit valves to last for several thousand hours' operation before attention is required, but whether the logistic and storage problems of yet another oil is worth the reduced valve maintenance has still to be decided.

A strong competitor for HP compressors in the future Fleet is the Hamworthy TH series of machines, an example of which is on trial at NAMD Haslar (FIG. 6). However it is some years astern of the Compair VHP36 both in terms of development and numbers sold commercially. The unit is similar to the VHP36 in that it is of SG Iron construction and employs concentric valves, but the four stages are arranged in a horizontal flat four configuration. An ingenious yoke links the opposing pistons (FIG. 7), with advantages in piston alignment and lubrication so that injection of oil into the high pressure stages is not required. This eliminates some of the cost and complication of previous styles of compressor. As with the VHP36, excellent valve life and ease of maintenance is being demonstrated on trial.

For MCMVs the William and James 'Triquad' (FIG. 8) is being introduced into service in 1984 to replace the Dunlop machine. The name reflects the combination of stages and cylinders that is possible to match output and pressure to requirements. Again the machine is a slightly navalized version of a successful commercial machine and was selected for having a reasonably low basic magnetic signature. Extensive shore and sea trials have demonstrated the machine's impressive reliability.

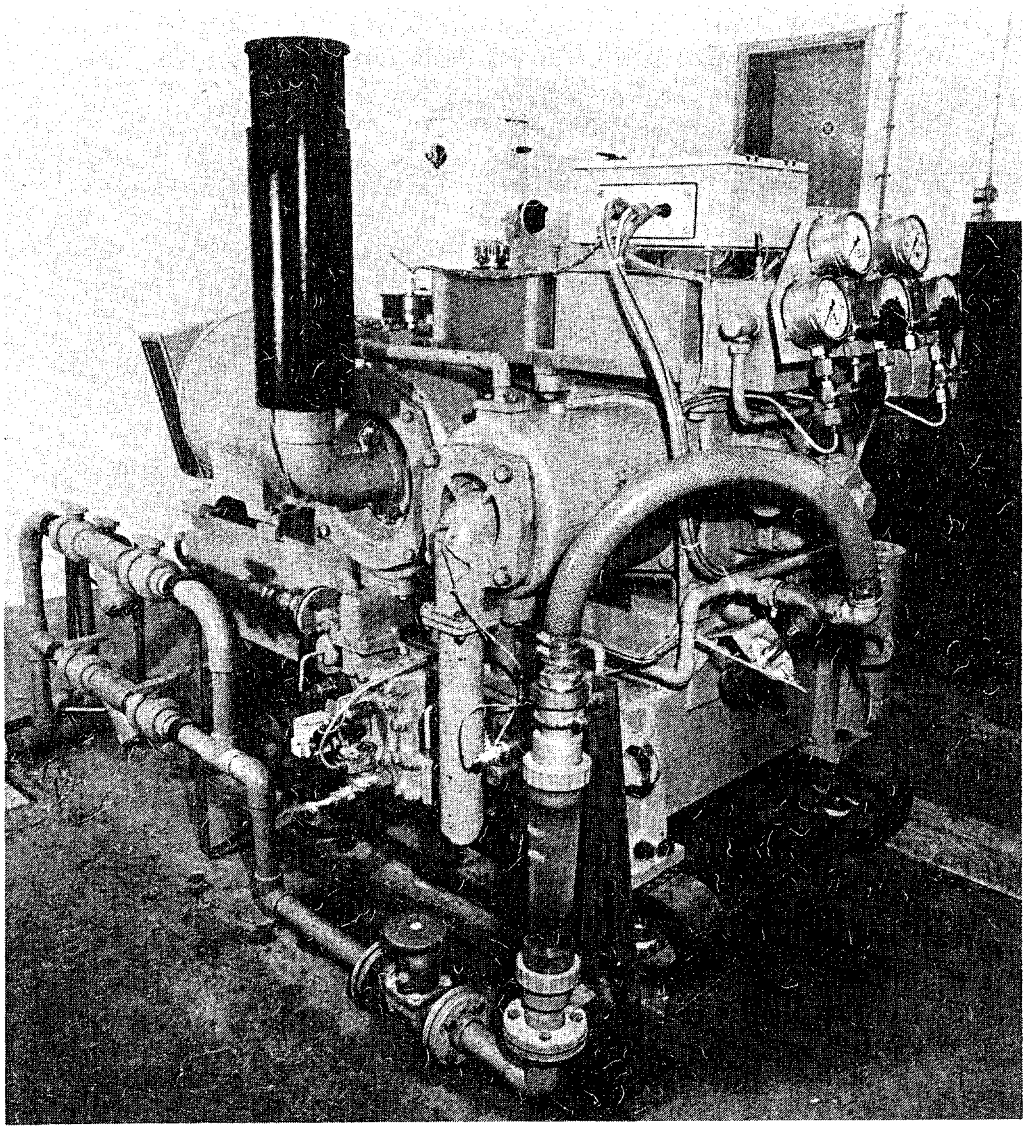

FIG. 6—HAMWORTHY 4TH HP AIR COMPRESSOR

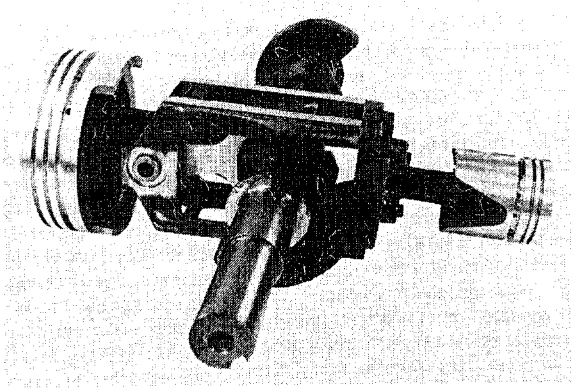

FIG. 7—HAMWORTHY HORIZONTALLY OPPOSED PISTONS AND YOKE

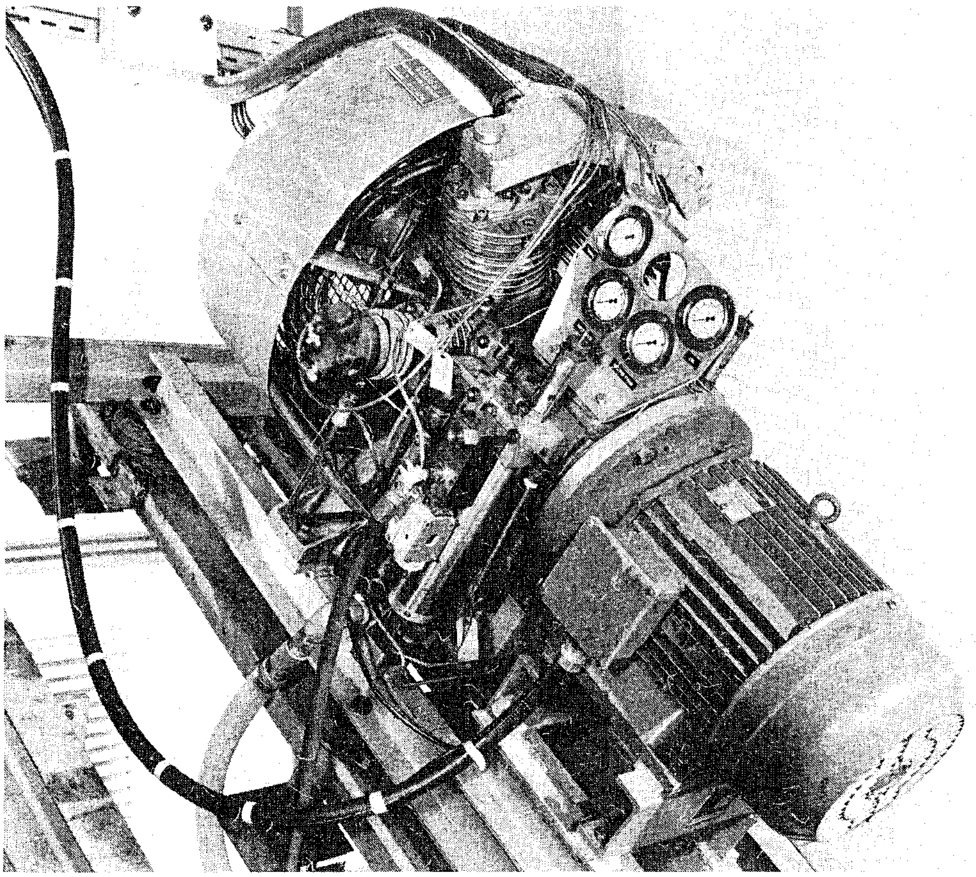

FIG. 8—WILLIAMS & JAMES 'TRIQUAD' MINIMUM MAGNETIC HP AIR COMPRESSOR (ON 40° HEELING TRIAL)

LP Compressors

The William and James Model 262 is the standard LP air compressor at sea at the moment. Other versions of this machine are used for Agouti special service air supplies and in old classes of ships. It is a two-stage oil-free machine built from expensive fabrications and bronzes and specially designed for R.N. use in 'monumental' style to meet stringent air quality, shock, and corrosion specifications.

The complex cylinder head and oil-free piston assemblies have not proved as reliable as hoped; repairs are lengthy and require considerable attention to detail for success. It has been difficult to determine the underlying cause of the high incidence of piston failures as many modes are possible and usually the piston is extensively damaged, disguising the cause in the effects. However it is believed many failures are associated with the steel springs backing the carbon segmental piston seals machining and fretting the aluminium piston, leading to slackening of the piston assembly over some 1 to 2000 hours running and then final failure. Well chamfered aluminium spring rings, soon to be introduced, will reduce this effect but the real cure may be a completely new style of piston perhaps taking advantage of modern materials such as PTFE. Improved cooling of the machine, especially when running unloaded, has been demonstrated in trials following a clever and simple suggestion from H.M.S. *Battleaxe*, and again a modification will be forthcoming.