DISTILLING PLANTS

BY

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During the last ten years, ever increasing thought and effort have been given to improvement of distilling plants in H.M. ships. Progress has been slow, but in the last three years long planned research and trial facilities have come into being and are now providing the data needed for radically new and better design. In the interval hard things have been said of the plants now in H.M. ships, and invidious general and inaccurate comparisons with U.S. plants have been made. Accurate comparison reveals, however, that British plants can hold their own with any other as regards weight, size and first cost for a given performance.

The cause of the troubles which have aroused so much criticism is not the plant design but the way in which the domestic water allowance increases, and actual consumption runs ever ahead of it. For many years it has been Admiralty policy to install in new construction distilling plants with a clean coil output double the estimated requirements for make up feed and domestic water. The basis of this policy is that the continuous output of a distilling plant over a long period is approximately 75 per cent. of the rated clean coil output and that there should be a 50 per cent. margin of continuous output over requirements.

This generous policy has been overtaken, and in most ships nullified, by increases in allowance and consumption of domestic water. Before 1937 the allowance was nine gallons per head per day. As a result of difficulties experienced during the Italian-Abyssinian War period, when ships in the Mediterranean were on a war footing and could not obtain shore water supplies, the allowance was increased to 13 gallons per head per day. This was the basis of the design of distilling plants in most H.M. ships now in service. In 1945 comparisons between the water allowances in R.N. and U.S.N. ships in the Pacific Fleets resulted in the R.N. allowance being raised to 20 imperial gallons per head per day, the same as the U.S.N. 24 American gallons per head per day. In most H.M. ships the distilling plant margin just covered this with a little to spare. In fact, however, when bathrooms were modernized and laundries fitted the consumption far outstripped the allowance, and the objectionable expedients of water rationing and bathroom restrictions were inevitably re-imposed. If unrestricted use of water is allowed, the consumption rises to 30 gallons per head per day in most large H.M. ships. The average consumption for England and Wales is 20 gallons per head per day and the higher figure for H.M. ships does indicate that waste takes place. An Admiralty investigation of all factors affecting allowance and consumption is now being carried out.

It will be seen from the foregoing that distilling plants in H.M. ships fight a losing battle against water expenditure and the design and performance is maligned as a result, but quite unjustly. To provide for increased domestic water allowance and expenditure additional distilling plants are being fitted in H.M. ships as opportunity offers, but this can be done only during very long refits or modernization and is further limited by financial stringency. The capacity of distilling plants being fitted in new construction takes all known factors into account and is generous by the standards of the past.

The high water consumption of the modern Navy does, however, make distilling plant design a factor to be incorporated in the overall heat balance of the machinery installation. When single effect plants are used to reduce weight and space to the minimum, the fuel expended for distilling can easily be 10 per cent. of the total fuel consumption at economical speed, on which endurance is based. In some ships feed heating requirements do not absorb all the auxiliary exhaust steam, and fuel economy can be attained by using the surplus exhaust in the distilling plants provided these are properly designed to this end, which has not been so in the past.

In all recent new construction the distilling plants are designed to operate under all conditions on auxiliary exhaust steam, and where the surplus of this over feed heating requirements meet distilling needs to the full, single effect plants can be fitted. As auxiliary machinery design improves and its steam consumption decreases, or more motor driven auxiliaries are used, the surplus of auxiliary exhaust is likely to become insufficient for all distilling and it will then be necessary to employ double effect or even triple effect plants.

Distilling plants designed for operation on low pressure auxiliary exhaust steam require larger heating surfaces than those using coil steam up to 25 lb/sq. in. gauge. The reason for this is the limit set on the lower end of the temperature difference between the coil steam and the boiling sea-water. For sterilization reasons the latter must be subjected to a temperature of at least 160°F. It will be seen that for a given output an evaporator using coil steam at 8 lb/sq. in. gauge (235°F.) will require 40 per cent. more heating surface than one using coil steam at 25 lb/sq. in. gauge (267°F.). Thus economy by use of auxiliary exhaust steam can be attained only by using larger and heavier evaporators. This disadvantage is accentuated when double or triple effect plants are used because the coil surface of each shell must be the same as that for a single effect evaporator for a given overall temperature difference. If orifice control is used with auxiliary exhaust coil steam the pressure is reduced from 8 lb/sq. in. gauge to 4 lb/sq. in. gauge (225°F.) and the coil surface must be further increased.

This need to increase coil surface and evaporator size can be avoided if higher heat transfer rates can be attained, by either entirely preventing the formation of scale or removing it more completely as it forms. With clean copper coils a heat transfer rate 'K' of 900 B.Th.U/sq. ft/°Fhr. can be attained. The K value attainable continuously, with scale being broken off regularly by use of Admiralty Evaporator Compound and a daily cracking off routine, is approximately 300 and it is on this low figure that all new distilling plants for H.M. ships are being designed. The coil area could be reduced to one-third of present practice if scale formation could be entirely prevented.

Experimental work and full-scale trials during the last three years have shown that this can be done by injection of acid into the sea-water feed, and that the most effective acid chemical generally available for this purpose is ferric chloride. The quantity of this required to prevent scale formation completely and maintain a K of 900 is approximately 0·2 lb per ton of sea-water feed. A K of 300 can be maintained by use of 0·05 lb of Admiralty Evaporator Compound per ton of sea-water feed. If a storing period of three months is assumed, the weight and space required for a small surface evaporator and the necessary stock of ferric chloride are more than for a large surface evaporator and a stock of Admiralty Evaporator Compound. An additional disadvantage of ferric chloride is its acid nature when damp. It provides its own dampness if in warm surroundings as its water of crystallization then separates out and a violently acid solution is formed. For this reason it must be stored in special acid resistant containers. If a lump or two were accidentally dropped into a damp bilge when preparing the injection solution, perforation of the bottom plating might well occur.

An alternative to acid injection for prevention of scale has been successfully tested at the Admiralty Distilling Experimental Station after preliminary laboratory research work at the Admiralty Materials Laboratory. This process is known as contact stabilization. It consists of introducing into the evaporator sea-water feed a quantity of fine grains of silica which permeate the boiling water as a suspension and act as nuclei on which scale can form instead of on the heating surfaces. In the tests of this process so far carried out, the scale which normally forms in the plant concerned has been completely prevented and after 1,000 hours operation only a thin powder, easily wiped off, was found on the heating surfaces. The plant performance was in no way reduced by this powder. The quantity of silica required is approximately the same as that of ferric chloride for the acid treatment, but silica has the great advantage that it is not acid and can be recovered from the brine for further use.

A still better way of maintaining a high K value is to remove all scale as it forms. This can be done by the use of suitably shaped heating surfaces and a regular cracking off routine. The heating element of the American Maxim evaporator described later in this *Journal*, is a good example of this practice and its form is illustrated in FIG. 1. This evaporator is of comparatively recent design but has several years performance at sea to its credit, and this indicates that a K value of approximately 600 can be maintained. Other features of this evaporator are a cyclone separator and feed heating to remove carbon dioxide, the latter being said to reduce scale formation. The cyclone separator performance is similar to current British practice, and it is known

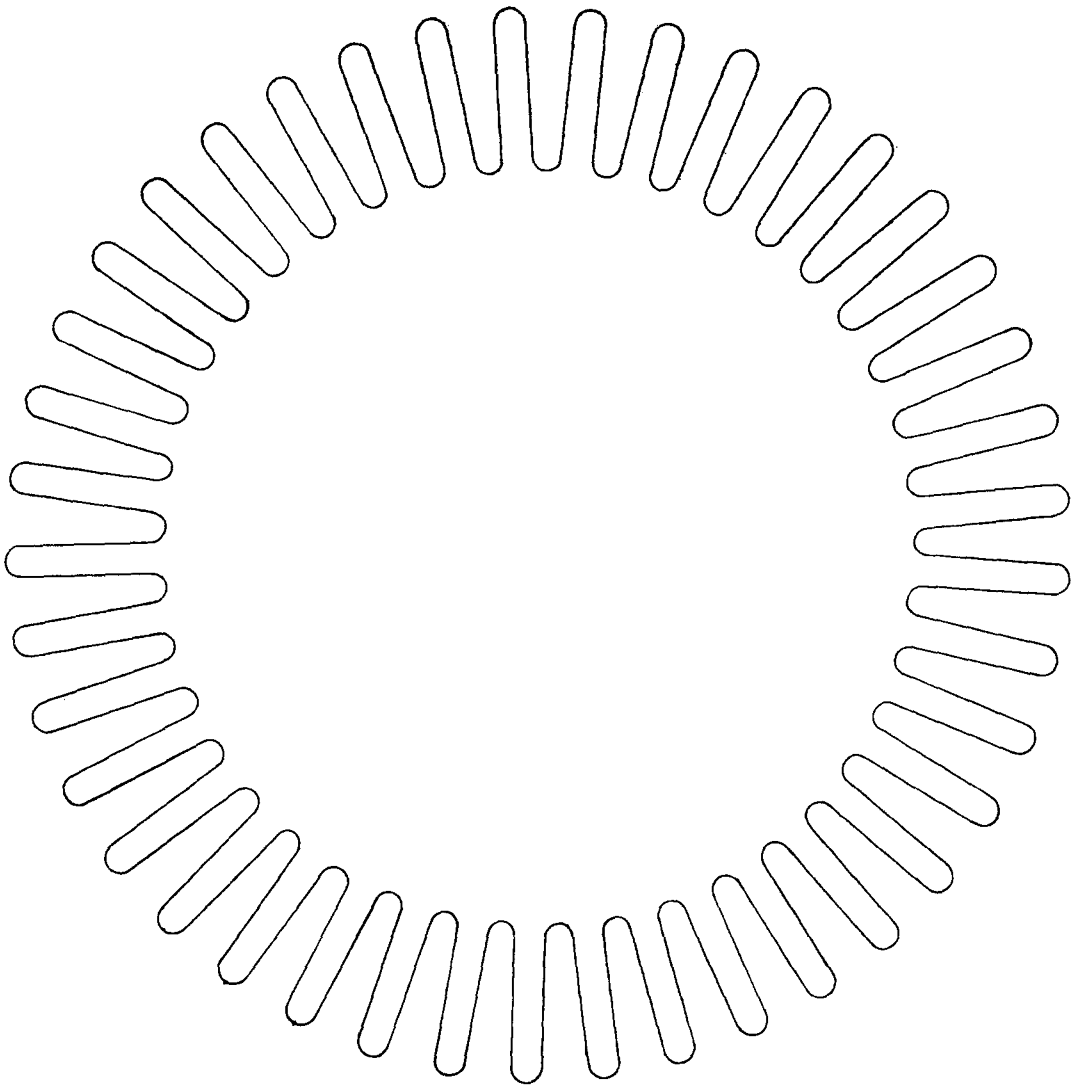

FIG. 1—MAXIM EVAPORATOR HEATER

that carbon dioxide removal from the sea-water feed does not reduce formation of scale, though it may cause a reduction of calcium carbonate at the expense of an increase of magnesium hydroxide and a corresponding reduction of K value. There can be no doubt, however, that the Maxim heating element has given a lead in the right direction. It is far better to attain a reasonably high K by this mechanical scale removal process than to rely on supplies of chemicals to prevent or remove scale. Such chemicals might well be difficult to come by on foreign service in time of war. It is anticipated that current Admiralty design and development will go some stage further on this road.

Other methods of scale prevention have been put on the market. Examples of such methods are electrical treatments, in which the feed is passed over electrodes with a small voltage applied across them. This has been tried on a sea-water distilling plant without having any observable effect on scale formation, but in some evaporators distilling hard shore-water for boiler use the scale formed has changed texture and become more easily removed after installation of such apparatus. There is some little advantage in the perforated electrode plate of this apparatus as if not a scale preventer it is at least a good weed trap. Another apparatus consists of high frequency oscillators which are intended

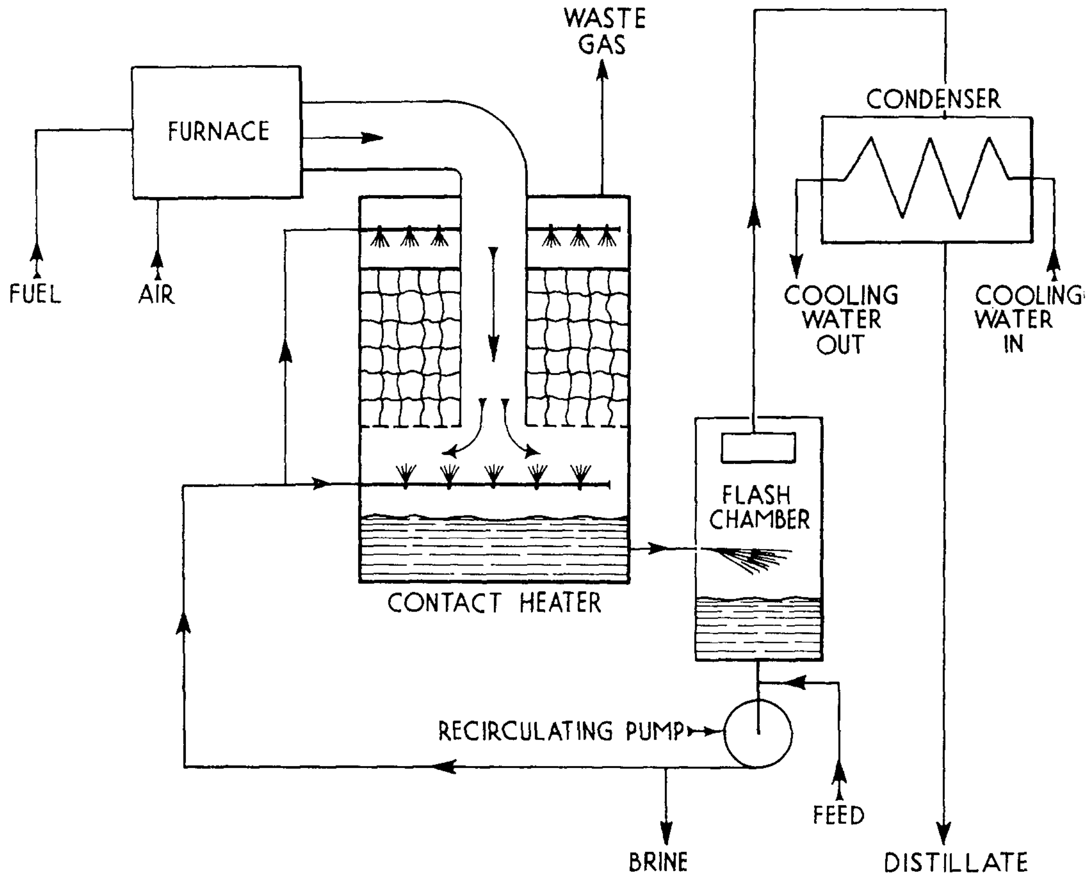

FIG. 2—ADMIRALTY CONTACT HEATED DISTILLER

to keep the scale forming particles in such a state of jitters that they do not cling to the heating surfaces. When tried on one plant it merely packed the scale particles much tighter than usual, forming a very thin hard egg-shell scale of unimpaired heat insulating properties.

A distilling plant of some promise developed to the prototype stage in the last three years is the Admiralty contact heated type. In this the sea-water feed is heated by direct contact with hot gases from a furnace or other suitable source, and then is sprayed into a flash chamber in which a high vacuum is maintained and where a portion of the hot sea-water flashes off as steam which is condensed in the usual way. A portion of the residual sea-water in the flash chamber is re-circulated together with the incoming sea-water feed to the contact heater and there is re-heated. The other portion is discharged overboard to limit the brine density to a convenient value. This process of heating by direct contact with hot gas completely overcomes the problem of scale insulation of evaporator heating services. It does, however, introduce the problem of counteracting the acids formed due to the sulphur content of furnace gases. Due to this sulphur, when the crucial test ‘Does the water make good tea?’ was first applied, the result was an undrinkable deep blue brew. This problem has been successfully overcome and a plant on these lines is being built for sea trials. FIG. 2 shows the general arrangement of this plant.

A novel flash type distilling plant said to overcome the scale problem is being developed in the U.S.A. by the Bethlehem Company and is illustrated in FIG. 3. In this plant sea-water is heated under pressure and then passed through two high vacuum flash chambers in series. The residual water not

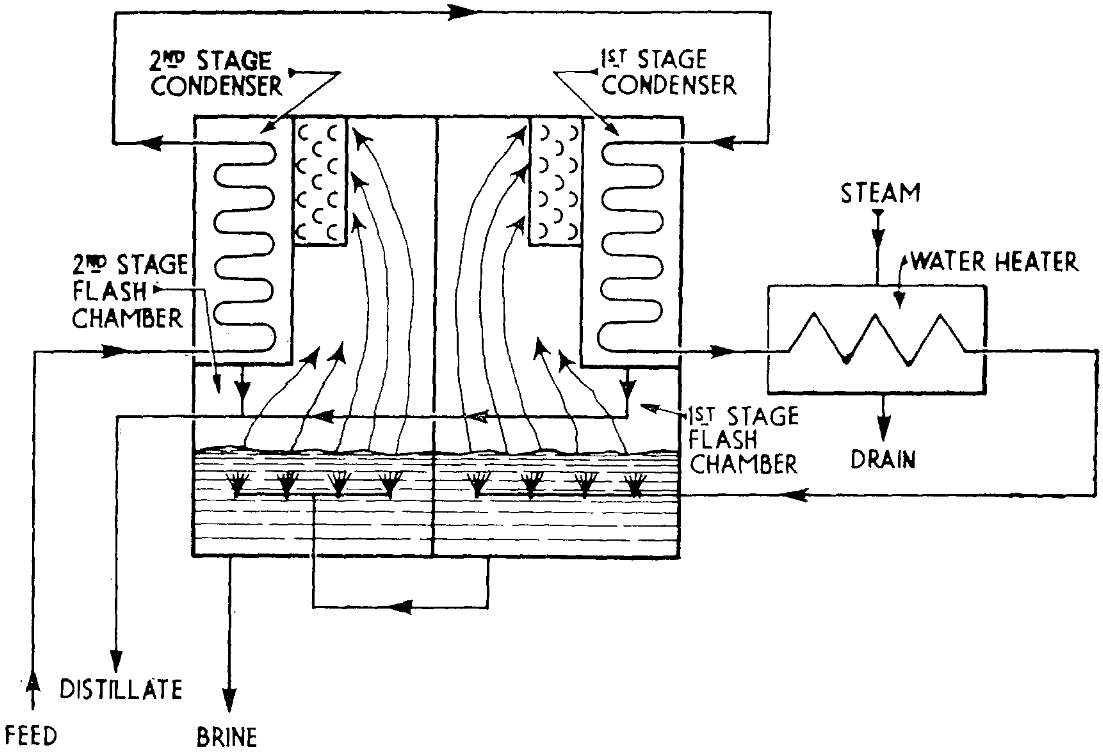

FIG. 3—BETHLEHEM FLASH DISTILLER

flashed off in either flash chamber is discharged overboard. By avoiding re-circulation of brine by this once-through process, and by heating under pressure to prevent evaporation at the heating surfaces, it is expected that scale formation will be negligible. The sea-water feed is first used to condense the vapour generated in the flash chambers with a view to conservation of the latent heat of this in the plant. As a result, it is necessary to pass 15 pounds of sea-water through the plant for each pound of distilled water made. A thorough evaluation of the heat balance of this plant under various sea temperature conditions has been carried out by E.-in-C. Department, and it is apparent that under the most favourable conditions of sea-water at 85°F. the performance is not quite equal to that of a normal double effect plant, and with sea-water below 60°F. is worse than that of a single effect plant unless very high flash chamber vacuum is maintained. This adverse effect of sea-water temperature on performance, and the complicated and expensive method of construction of the plant, must be set against the advantages of probable negligible scale formation. It is thought that the Maxim method of regular and complete scale removal shows more promise.

The principle of increasing heating surface to permit use of surplus auxiliary exhaust and to suit a K of 300 is being applied to all new distilling plants for both new construction and modernized ships, and will be applied to existing plants as an ‘ A. and A.’ as far as practicable. Action is being taken to introduce the Maxim principle of regular complete descaling with a resulting K of 600 as soon as possible. At present the rating of distilling plants is being based on the output per hour attainable for long periods with a K of 300 and on 20 hours useful distilling per day, this giving reasonable time for descaling and maintenance.

When distilling plants are arranged to use auxiliary exhaust steam surplus to feed heating, it is necessary to maintain a reasonably steady exhaust range

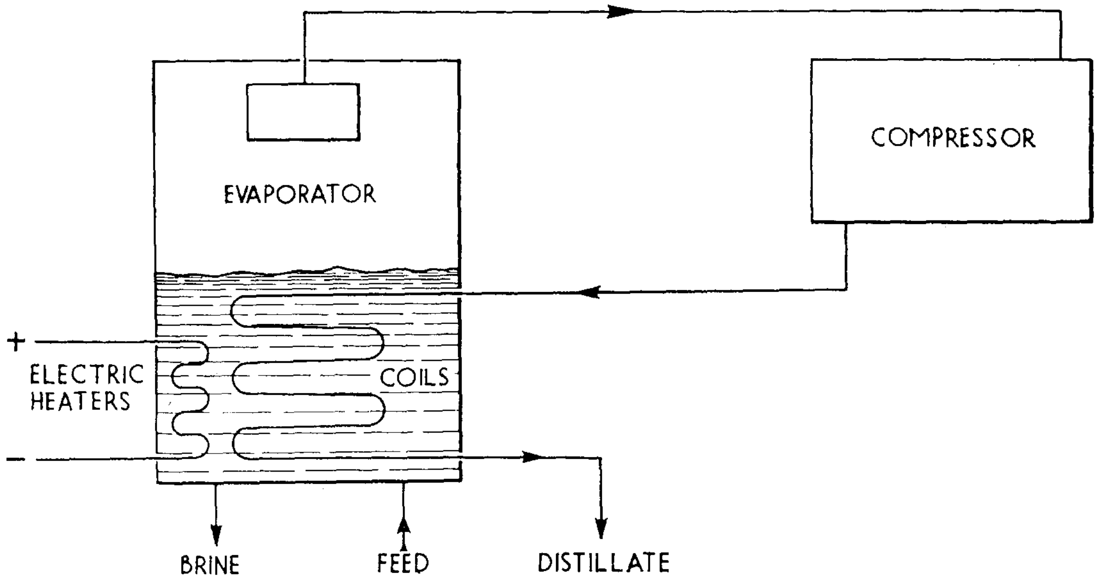

FIG. 4—VAPOUR COMPRESSION DISTILLER

pressure. When steaming at sea, wide variation of this pressure and the amount of exhaust steam available for distilling can occur due to feed flow changes. It will be necessary to bleed boiler steam from a boiler steam range into the auxiliary exhaust range. This bled steam must be automatically controlled to provide just enough additional steam to augment the exhaust so that feed heating and distilling requirements are exactly met under all feed flow conditions. In the unlikely event of excess exhaust, this must be discarded to a condenser. An alternative to bleeding from a boiler steam range will be to do so from a suitable main turbine stage.

Vapour Compression Distilling Plants

The vapour compression (V.C.) distilling plant is one in which the made vapour is compressed and used to provide heat for evaporation of further vapour from the liquid being distilled. This compression maintains the temperature difference necessary to transfer the latent heat of condensation of the made vapour to the boiling liquid through the heating elements, and thus to conserve it in the heat cycle. Economy of heat input is thereby attained as compared with the standard evaporator and condenser plant, in which the latent heat of the made vapour passes to waste in the condenser cooling water. The basic principle of this plant is shown in FIG. 4. Evaporation in the shell is initiated by electric or other heaters, and the vapour so formed is passed through the compressor. Here its pressure is raised, so that its condensing temperature is sufficiently above that at which evaporation is taking place to permit heat transfer from the compressed vapour to the evaporating liquid, through the heating elements. The made vapour thus becomes the ' coil steam ', and the latent heat it surrenders during condensation is used to generate more vapour.

The ratio of water made to operating heat input is much higher in a V.C. distiller than in evaporator and condenser plants, but is influenced greatly by the size of heat transfer surface and the method of driving the compressor and supplying heat to make good losses. The efficiency of the V.C. distiller in this respect varies inversely as the compression ratio, on which depends the power input to the compressor. The water/heat-input ratio is increased by use of larger heat transfer surface and lower temperature difference, and hence a lower compression ratio and compressor power input. In all cases, losses occur which must be made good by an external heat supply. In V.C. distillers with electric motor driven compressors this is done by electric heaters, and in those with I.C.E. driven compressors the engine waste heat is used. Table I compares the water/fuel ratio of single, double and triple effect evaporator and condenser plants with V.C. distillers. In this Table, and subsequently in these remarks, the water/fuel ratio of V.C. distillers using electric motor driven compressors and electric heaters is calculated on the assumption that the electric power is supplied by diesel generators with a fuel consumption of 0·6 pounds per kilowatt. In V.C. distillers the formation of scale on the heating surfaces involves a decrease of heat transfer rate and an increase of temperature difference and pressure ratio (P.R.) if a given output is to be maintained. This causes increase of compressor power and decrease of water/fuel ratio.

TABLE I.—DISTILLING PLANT WATER/FUEL RATIO

Type		Water/Fuel Ratio
Single Effect		14
Double Effect		24
Triple Effect		33
Vapour Compression		
Electric Motor Driven Compressor and Electric Heaters	P.R. 1·7	44
	P.R. 1·3	91
I.C.E. Driven Compressor and Exhaust Heaters ...	P.R. 1·3	250

The V.C. distiller was developed in the U.S.A. by Professor Kleinschmidt in the 1930s, but apart from some small application to chemical distillation it was not used extensively until the Second World War. Then the American Services used a large number of small plants for supply of drinking water to forces in island areas where natural supply was limited. The German Navy used it in submarines, a policy which was subsequently followed by the Royal Navy.

From 1943 onwards, V.C. distillers with an output of 4 gallons per hour were fitted in H.M. submarines. The compressor was a three-lobe modified Rootes blower driven by an electric motor. Electric heaters in the evaporator space supplied starting heat and made good losses during evaporation. The pressure ratio was 1·5 and the water/fuel ratio 20. Since 1950 all new and modernized submarines are being fitted with 15 gallons/hour V.C. distillers of improved design. The compressor design and drive is unchanged apart from increased capacity, but the heating surface and brine/feed and distillate/feed heat exchangers are of improved design. The pressure ratio is 1·5 and the water/fuel ratio is 45. Also, since 1950 three prototype 25 ton/day V.C. distillers have been built and tested, and an improved version of one of these is being fitted in the A/A and A/D Frigates. These three prototypes were made by Weir, Caird & Rayner, and Buckley & Taylor respectively.

The Weir 25 ton/day V.C. Distiller arrangement is shown in FIG. 5. It consists of a standard evaporator shell in which open surface evaporation takes place around the coils, an electric motor driven Lysholm compressor, brine/feed and distillate/feed heat exchangers, feed, brine and distillate pumps, and an electric heated steam generator to provide additional steam to make good heat losses. The last item uses distilled water and the electric heaters

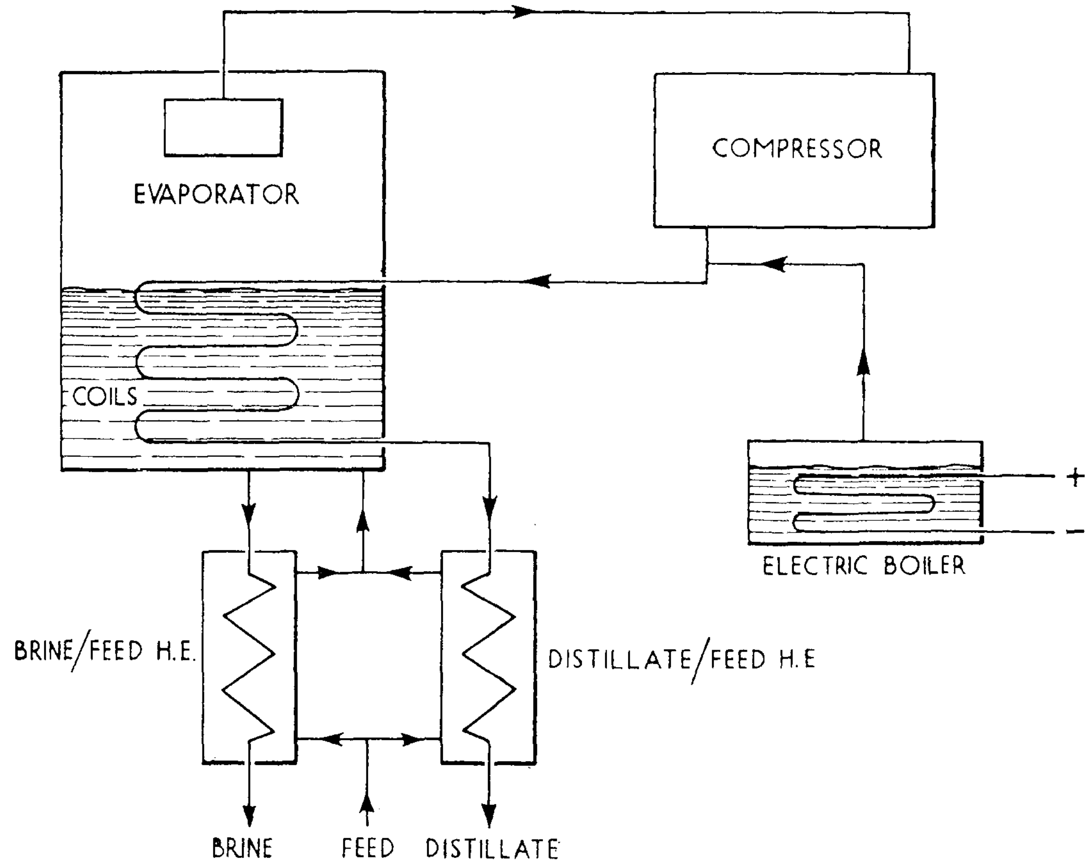

FIG. 5—WEIR VAPOUR COMPRESSION DISTILLER

therefore do not become covered with scale. Extensive trials of this plant distilling sea-water were carried out at Portobello Power Station in 1951 and included three periods each of 1,000 hours duration. One was without chemical injection, one with chemical injection of ferric chloride and one with injection of sodium bi-sulphate. Both these chemicals kept the coils completely clear of scale but the quantity of ferric chloride required was only 0·2 pounds per ton of sea-water against 0·5 for sodium bi-sulphate. During the trials without chemical injection scale formed at an average rate of 0·001 inch thickness per 30 tons of distilled water made. The pressure ratio varied from 1·7 with clean

TABLE II.—WEIR V.C. DISTILLER PERFORMANCE

	Clean	1,000 Hours
Output ... ... Tons/Hour	1·4	1·4
Compressor Suction ... ... lb/sq. in. abs.	7·3	7·5
Compressor Discharge ... ... lb/sq. in. abs.	12·0	18·0
Pressure Ratio	1·7	2·4
Compressor Power ... ... kW	76	107
Heater Power ... ... kW	60	60
Pump Power ... ... kW	10	13
Total Power ... ... kW	146	180
Water Fuel Ratio	37	30

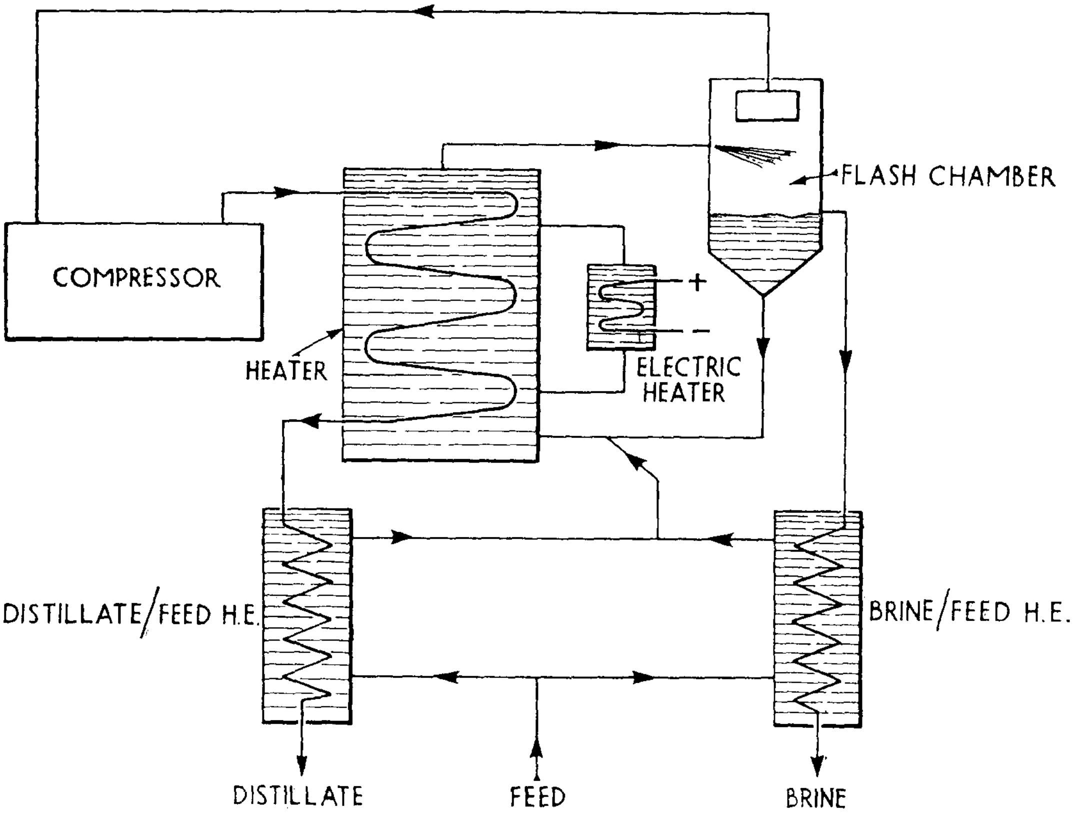

FIG. 6—CAIRD AND RAYNER VAPOUR COMPRESSION DISTILLER

coils to 2·5 after 1,000 hours running without chemical injection. The corresponding water/fuel ratios were 37 and 30. When chemical injection was used to prevent scale formation the performance remained at the clean coil rate throughout each trial of 1,000 hours duration. Table II shows the performance details of this plant. This prototype plant is to be erected at the R.N.E.C. for demonstration purposes.

The Caird & Rayner V.C. Distiller is shown in FIG. 6. It consists of a water heater, a flash chamber, a compressor, brine/feed and distillate/feed heat exchangers, electric heater chamber, and feed, brine and distillate pumps. The water heating and steam release arrangements of this plant are distinctly novel. The sea-water is heated by steam coils in the heater, which it fills completely, so that no separation of water and steam takes place therein. The mixture of water and small steam bubbles passes from the top of this heater into what is known as the flash chamber, although this is a misnomer because no pressure drop and flashing effect is employed. The water and steam mixture enters this chamber tangentially and flows round and down the inner surface, thereby spreading over a large area and facilitating the release of steam. The water not evaporated passes from the bottom of the flash chamber down a large diameter downcomer pipe, into which the sea-water feed is injected, to the bottom of the water heater through which it rises again and is reheated to evaporation point. A steady circulation is thus obtained. The steam released in the flash chamber passes through a separator to the compressor from which it is discharged to the heating coils where it is condensed and drawn off as distillate. Brine/feed and distillate/feed heat exchangers are fitted to conserve heat within the plant. Heat losses are made good by electric heaters in a small chamber connected in parallel with the main water heater.

The Caird & Rayner V.C. Distiller has undergone extensive trials distilling sea-water at the Admiralty Distilling Experimental Station, and the majority of the separate trials have each been of 1,000 hours duration. The early trials were carried out with a Lysholm compressor and the later ones with a two-stage centrifugal compressor. The continuous rating of the motor used to drive both these compressors has imposed a limit on the output of this plant. The clean coil output is 1·2 tons per hour but it has been necessary in most trials to reduce this steadily as the trial has proceeded and scale has formed, to avoid the resulting natural increase of pressure ratio and compressor power overloading the driving motor. During trials of this plant without scale prevention treatment, scale formed at an average rate of 0·001 in. thickness per 60 tons of distilled water made, only half the rate experienced in the Weir V.C. Distiller. This is attributed to the novel process of closed vessel water heating and separate steam release. The trials have included over 1,200 hours operation with a contact stabilization scale prevention treatment in use, and no more than a thin powdery film has formed on the heating coils. The electric heaters have collected more definite scale with a resultant fall in output, but cleaning these heaters, which is a simple operation, has at once restored the output to its maximum value. This indicates that the powdery film on the main heating coils does not affect heat transfer through them, and the required output can be maintained indefinitely by contact stabilization and periodic cleaning of the electric heaters. Table III shows the performance details obtained during the trials. The water/fuel of this plant is 44 with clean coils and 28 after 1,000 hours without scale prevention treatment. This performance was sufficiently above that of the Weir plant to cause the Caird & Rayner design to be adopted for the A/A and A/D Frigates. In order further to improve performance the pressure ratio of the production plant will be 1·5 instead of the 1·7 of the prototype. The V.C. distillers of the A/A and A/D Frigates replace the boiler and double effect plants originally designed for these vessels. They will occupy one-third less space and weigh 16 tons less per ship, and will use 8 tons less fuel for distilling in each standard operational period. This 24 tons saving can be carried as fuel to increase the endurance of the ship.

TABLE III.—CAIRD & RAYNER V.C. DISTILLER PERFORMANCE

		Clean	1,000 Hours
Output	Tons/Hour	1·25	0·95
Compressor Suction	lb/sq. in. abs.	12·2	8·7
Compressor Discharge	lb/sq. in. abs.	20·7	18·7
Pressure Ratio		1·7	2·2
Compressor Power	kW	77	79
Heater Power	kW	27	46
Pump Power	kW	3	3
Total Power	kW	107	128
Water Fuel Ratio		44	28

The Weir and Caird & Rayner 25 tons per day V.C. Distillers were developed and built against Admiralty contracts and entirely at Admiralty expense. When Buckley & Taylor decided to follow their competitors' lead no further money was available from Navy Votes. This firm therefore obtained an American design and built the plant at their own expense.

The Buckley & Taylor plant differs from the others in using straight tubular heating surfaces instead of individually removable coils. It does therefore

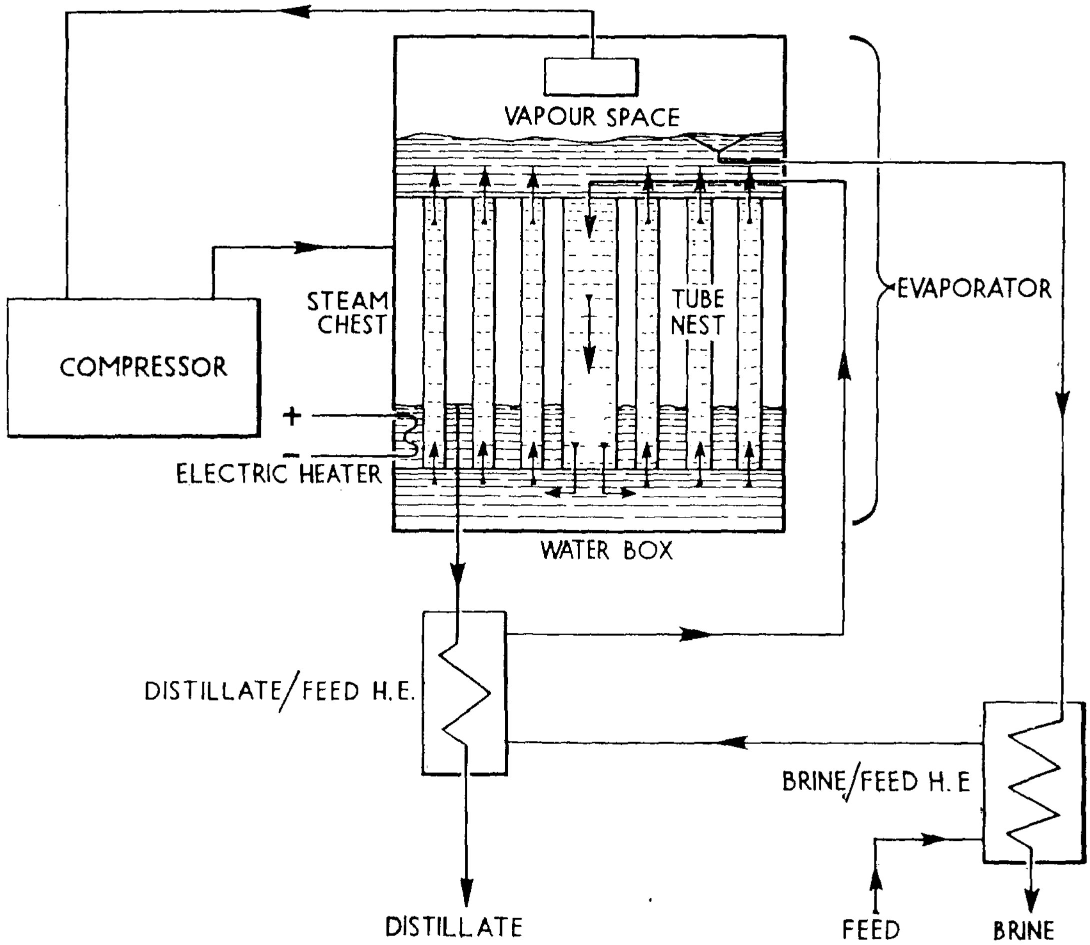

FIG. 7—BUCKLEY AND TAYLOR VAPOUR COMPRESSION DISTILLER

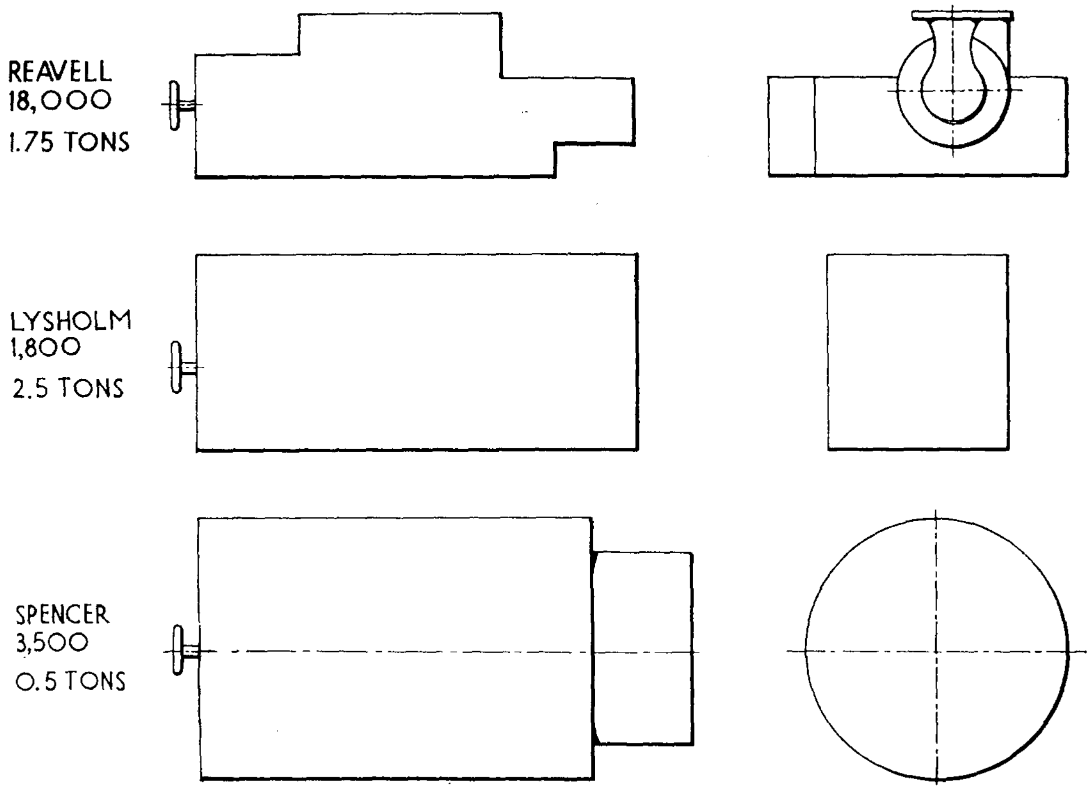

FIG. 8—VAPOUR COMPRESSION DISTILLER COMPRESSORS

rely on acid descaling, but this is a simple process. FIG. 7 shows the general arrangement of the plant. It consists of an evaporator, an eight stage centrifugal compressor, brine/feed and distillate/feed heat exchangers and the necessary pumps. The evaporator consists of a bottom water box, a central vertical tube nest surrounded by a steam chest, and a vapour space. The sea-water feed is injected into a central downcomer pipe joining vapour space and water box. The water rises from the latter through the heating tubes in which steam is generated and released from the water in the vapour space. The water not evaporated circulates back to the water box through the downcomer, being assisted in this by the feed injection. The vapour passes from the vapour space through a separator to the compressor from which it is discharged to the steam chest around the tube nest. The distillate collects in the bottom of the steam chest and leaves through a standpipe which ensures that there is always a depth of six inches of distillate there. In this are immersed electric heaters which keep it on the boil, and thus supply the heat for starting up and to replace losses during operation. One of these heaters is switched on and off automatically by pressure changes in the vapour space, thus keeping the plant in automatic balance. This plant is designed for a clean tube output of 1·5 tons per hour and a pressure ratio of 1·3. Its heating surface is over double that of the Weir and Caird & Rayner plants, but being in the form of closely pitched tubes it does not make the evaporator unduly large. The clean tube water/fuel ratio is 91. The prototype plant is now installed in H.M.S. *Cumberland* for sea-water performance evaluation trials. Performance details are given in Table IV.

TABLE IV.—BUCKLEY & TAYLOR V.C. DISTILLER PERFORMANCE

		Clean
Output	Tons/Hour	1·4
Compressor Suction	lb/sq. in. abs.	15·4
Compressor Discharge	lb/sq. in. abs.	20·7
Pressure Ratio		1·3
Compressor Power	kW	48
Heater Power	kW	7
Pump Power	kW	3
Total Power	kW	58
Water Fuel Ratio		91

Several sizes and types of steam compressor have been tried with V.C. distillers. In the small capacity plants a modified Rootes blower has proved satisfactory and this type is in general use in U.S.A. It tends to be heavy in the larger sizes, however, and its efficiency is not high. Two-stage centrifugal compressors running at 14,000 to 18,000 r.p.m. have run satisfactorily for periods of up to 3,000 hours with the Weir and Caird & Rayner 25 ton/day Distillers and at pressure ratios up to 1·9. These particular compressors are driven by 1,800 r.p.m. electric motors with step up epicyclic gearing. They are noticeably small and light in weight. The Buckley & Taylor V.C. Distiller compressor is an eight stage 3,500 r.p.m. machine of U.S.A. design with a pressure ratio of 1·3. It is of course larger than the British two stage machines but is particularly lightweight in construction. The two sizes of Lysholm compressor have run satisfactorily for periods of over 3,000 hours with the Weir and Caird & Rayner 25 ton/day V.C. Distillers. This compressor is a positive displacement machine with helical lobed rotors. Lysholm compressors for these plants have been 1,800 r.p.m. machines and at this speed are much larger and heavier than the high speed centrifugal compressors of the same output. A Lysholm compressor running at 3,500 r.p.m. has been designed and is more competitive as regards size and weight but its performance when compressing steam has not yet been tested.

Positive displacement compressors of the Rootes and Lysholm type have a great advantage over the centrifugal compressor for use with V.C. distillers. They can operate satisfactorily with a wide range of pressure ratio at a steady speed which the centrifugal cannot do. The Lysholm compressors used with the V.C. distillers have run satisfactorily at pressure ratios rising from 1·7 to 2·5 as scale formed on the heating surfaces. Such scale formation in the V.C. distiller with a constant speed centrifugal compressor inevitably causes the output to fall. A comparison of size and weight of two stage centrifugal, Lysholm and U.S.A. eight stage centrifugal compressors for 25 ton/day V.C. distillers is shown in FIG. 8.

Future distilling plants in H.M. ships may well be diesel or gas turbine driven V.C. distillers.

The Admiralty Distilling Experimental Station

The A.D.E.S. has been mentioned several times in the foregoing remarks. This establishment provides facilities for research and experiment using full size distilling plants and real sea-water. This procedure is indispensable if real progress is to be made in distilling plant design, because laboratory experiments with synthetic sea-water cannot truly simulate actual conditions, though they do give very useful leads. The A.D.E.S. was planned from 1944 to 1950 but it is only in the last three years that it has been built and put into operation. The information being obtained from it is already proving of considerable value.

The experimental work done on full sized plants at A.D.E.S. is usually a continuation of laboratory research carried out by R.N.S.S. staff at A.M.L. with whom an excellent entente exists.

Honourable tribute must also be paid to the assistance provided by the technicians and chemists of the distilling plant manufacturers' staffs, and in particular the detailed work on scale formation carried out by Messrs G. & J. Weir during the last few years.