# DISTILLING PLANTS

PART I

## ORIFICE CONTROL

by

COMMANDER (E) J. F. LEWIN, R.N.

*The following article is an extract from letters contributed by Commander Lewin on some of his experiences of putting B.R. 1333—" The Distilling Plant, Theory and Operation "—into practice. This B.R. was written by Commander Lewin in association with Messrs, G. & J. Weir Ltd., with assistance from Messrs. Drysdale & Co. Ltd., and Messrs. Buckley and Taylor Ltd.*

B.R. 1333 was written largely from a theoretical standpoint and even the practical recommendations contained in it were based on theory rather than on practical sea-going experience. On commissioning H.M.S. *Theseus* I was determined to test, as far as possible, the practical recommendations which this book contained. Our first set-back was that we found it impractical to operate the plant with 20 in. Hg vacuum in the shell with clean coils, since the corresponding coil steam pressure was only 4 lb./sq. in. which was insufficient to lift the coil drain up to the drain cooler. We could, of course, have opened the coil steam valve to the " correct " setting, which would have taken some time to determine and allowed the coils to flood up until sufficient heating surface was destroyed and a high enough coil steam pressure obtained to discharge the drain water, but I am doubtful whether operating conditions would have been very stable until the coils had scaled-up a bit. In any case, we decided to drop the vacuum to 15 in. We then decided by reference to the trial results plotted in the form of Fig. III in B.R. 1333 (Fig. 1), the output we reckoned we needed. Our experience in operating the plant was to aim at an output of 4.5 tons/hour from one plant with 20° density and a shell vacuum of 15 in. Having set the after plant to this output we made a " U " piece for one coil steam valve (B.R. 1333, paras. 3. 4 and 3. 5) and one vapour valve, the openings of the valves on the other shell being set to give the same coil steam pressure and shell vacuum.

### Watch-keeping Difficulties

With a newly commissioned ship, however, so long as the plant turned out an adequate supply of good water, it was extremely difficult (without making

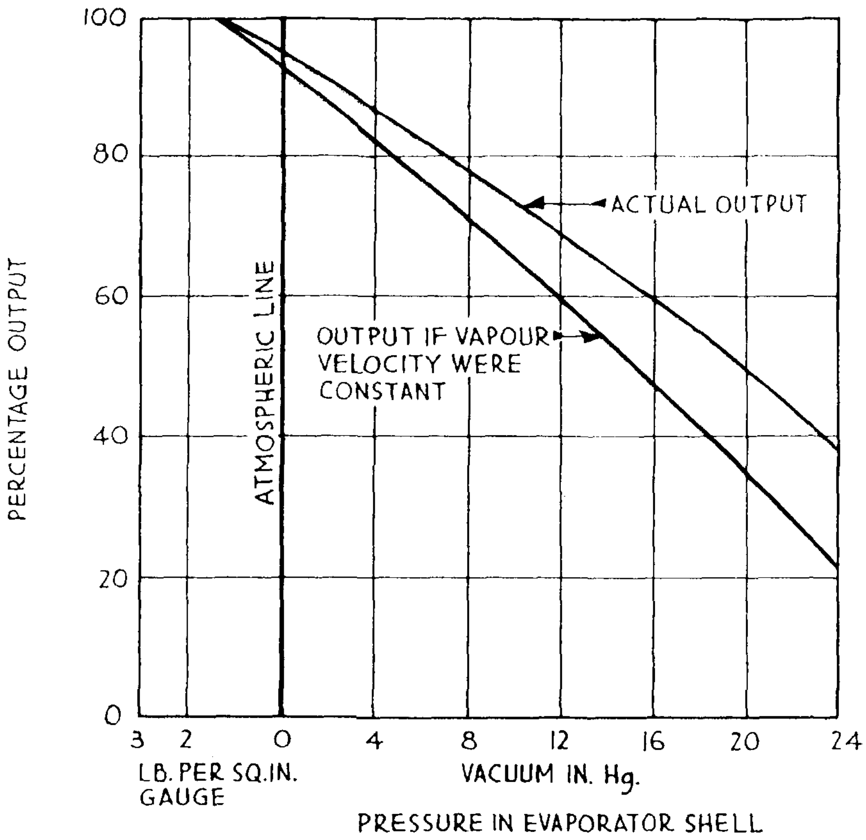


FIG. 1.—(B.R. 1333, FIG. III)

myself a " pain in the neck " to the whole department, which would have been a bad start to the commission) to get the detailed attention paid to operating conditions which were really required. Several times I found that the watch-keepers had removed the " U " piece because they found the coil steam pressure rising and were afraid they would thus be blamed for making the plant prime. Even with it in, however, I found it impossible to prevent the hand-wheel nut from slacking back, thereby allowing the valve to be shut slightly and this allowed the output to be reduced to about 3.5 tons/hour. From the point of view of constant output, therefore, it was soon clear that this method of control could not be regarded as 100% successful. But at that stage I had not given up hope that, as experience was gained and supervision improved, it might be possible to ensure that the hand-wheel nut was always tight and the " U " piece never removed.

When the plant had run for over 2,000 hours we had to change the coils as for the previous 200 hours we had to remove the " U " piece and accept a lower output to keep the coil steam pressure below 25 lb./sq. in. On completion of this run I made a fairly careful study of the evaporator log between 500 and 2,000 hours and I am afraid it was only then that I fully realised how much variation in output there had been and found that the mean output over the whole period was more like 3.7 than 4.5. However, at about 1,800 hours an output of 4.5 tons/hour was recorded for a period of several hours.

## Orifice Plates

During the time we were in dock in August I remembered Mr. Hillier having said that he would like to be able to control the output by the use of orifice

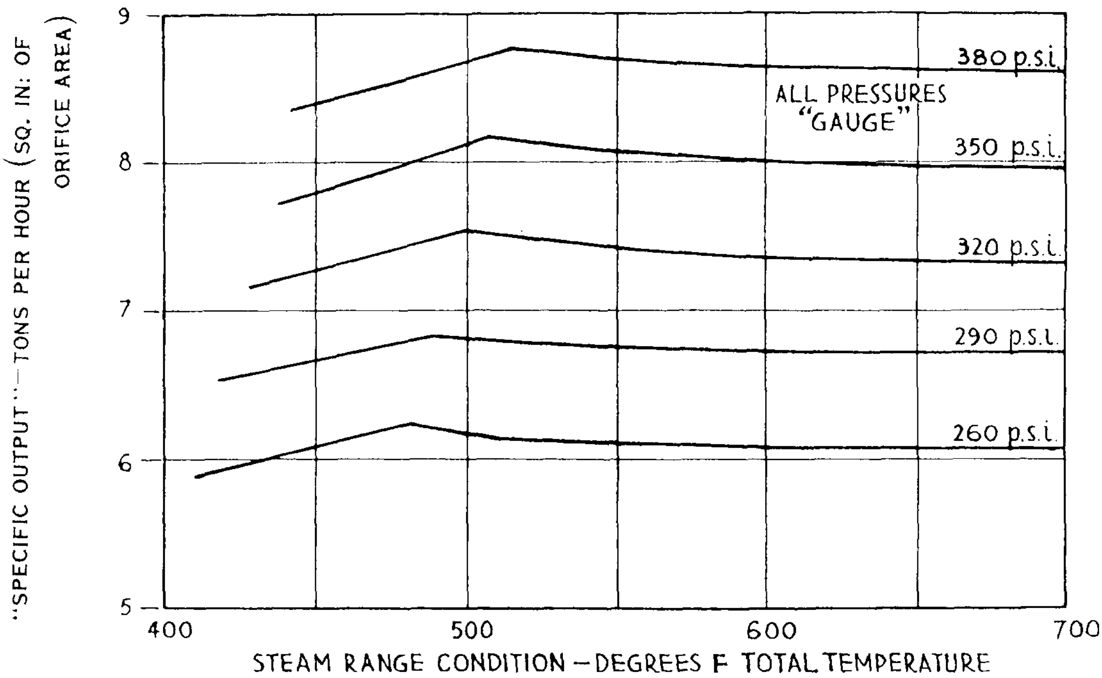


FIG. 2.—EVAPORATOR OUTPUT CURVES. WITHOUT FEED HEATER. AVERAGE COIL DRAIN WATER AT 250° F.

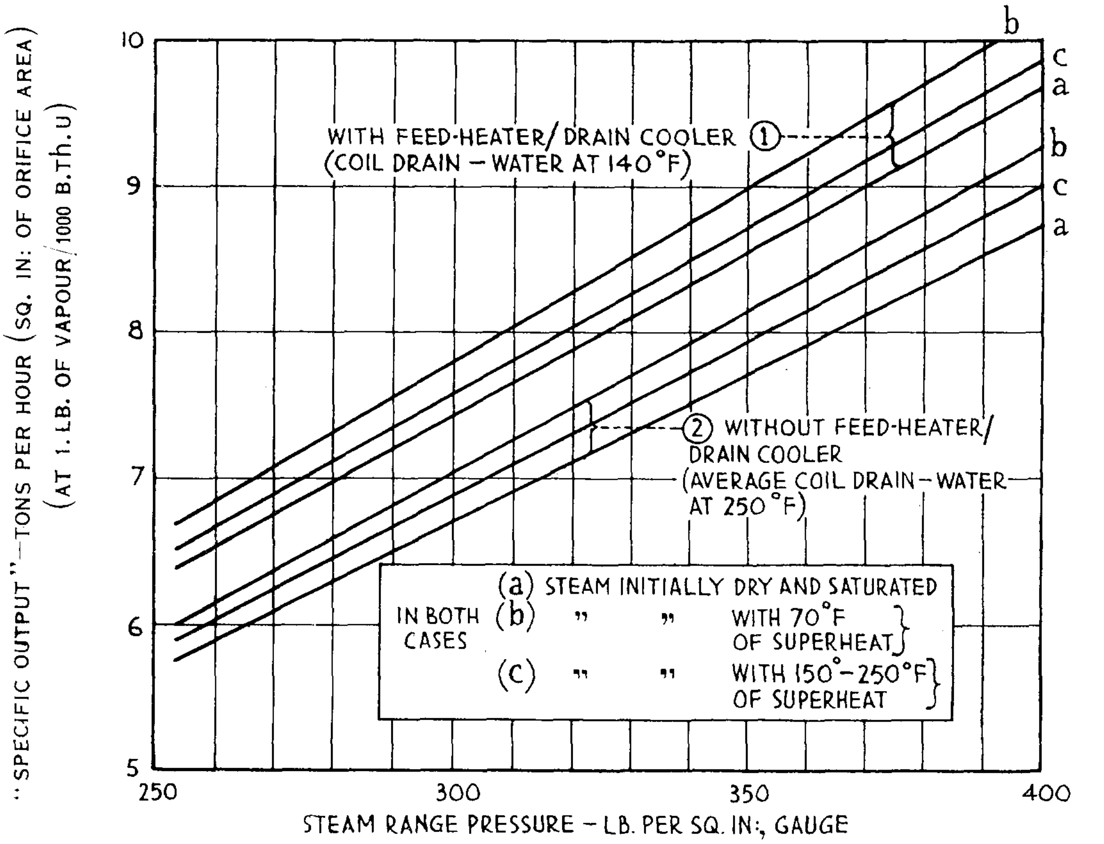


FIG. 3.—EVAPORATOR OUTPUT CURVES

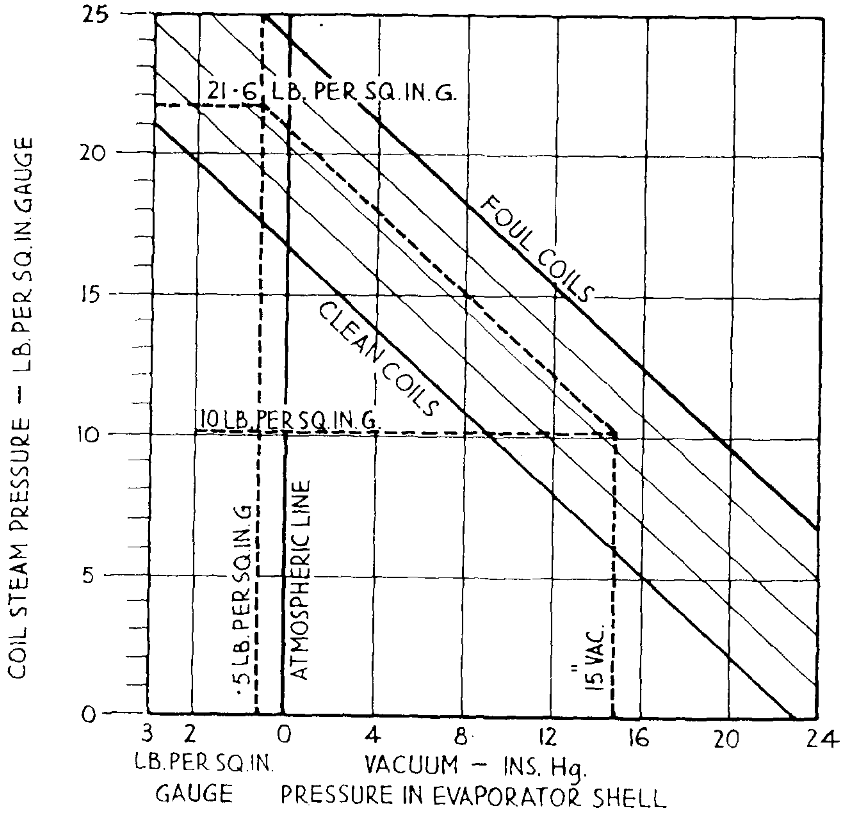


FIG. 4.—(B.R. 1333, FIG. X)

plates in the coil steam lines but for variations which would occur due to variations in steam conditions. I, therefore, calculated the size of orifice required to give me 4.5 tons/hour, with a density of 20°, a vacuum of 15 in. Hg. and assuming a nozzle efficiency of 97%, and that the coil drains left at saturation temperature corresponding to 15 lb./sq. in gauge. I assumed steam conditions of 380 lb./sq. in. gauge 650° F. and calculated the size of the orifice to be 0.641 in. diameter—one to each coil steam valve. At the same time I got one of my watch-keepers to plot curves showing variations in output with varying steam conditions (Fig. 2). You will observe (remembering the false zero) that these variations are negligible compared with those imposed by even an intelligent Leading Stoker.

The other objection seemed to me to be that one might want to operate the plant in emergency under pressure conditions so as to obtain a temporarily greater output, but after the first 500 hours or so the coil steam pressure is likely, under 15 in. vacuum conditions, to be reaching 13 lb./sq. in. between blow-downs which, referring to Fig. X, (Fig. 4) corresponds to a pressure of 25 lb./sq. in. under pressure condition. Thus, from this time onwards, it would be impossible to achieve a greater output by this means so that this objection was really not worth considering. Therefore I wrote to Mr. Hillier and asked him to confirm the size of the orifices. He replied that he had made the size $\frac{41}{64}$ (= 0.6406) in. diameter. He also told me of the existence of a $\frac{7}{8}$ in. orifice plate which was already fitted. We therefore made our nozzles in mild steel and screwed them into the existing orifice plates. The R.N.A.T.E., Rosyth have since made us four in stainless steel. We made a plug gauge to ensure accuracy of the throat diameter. On further consideration of the previous results we were so impressed by the running hours which had been obtained without starch with 20° density that we decided to lower the density even further in search of scaleless operation.

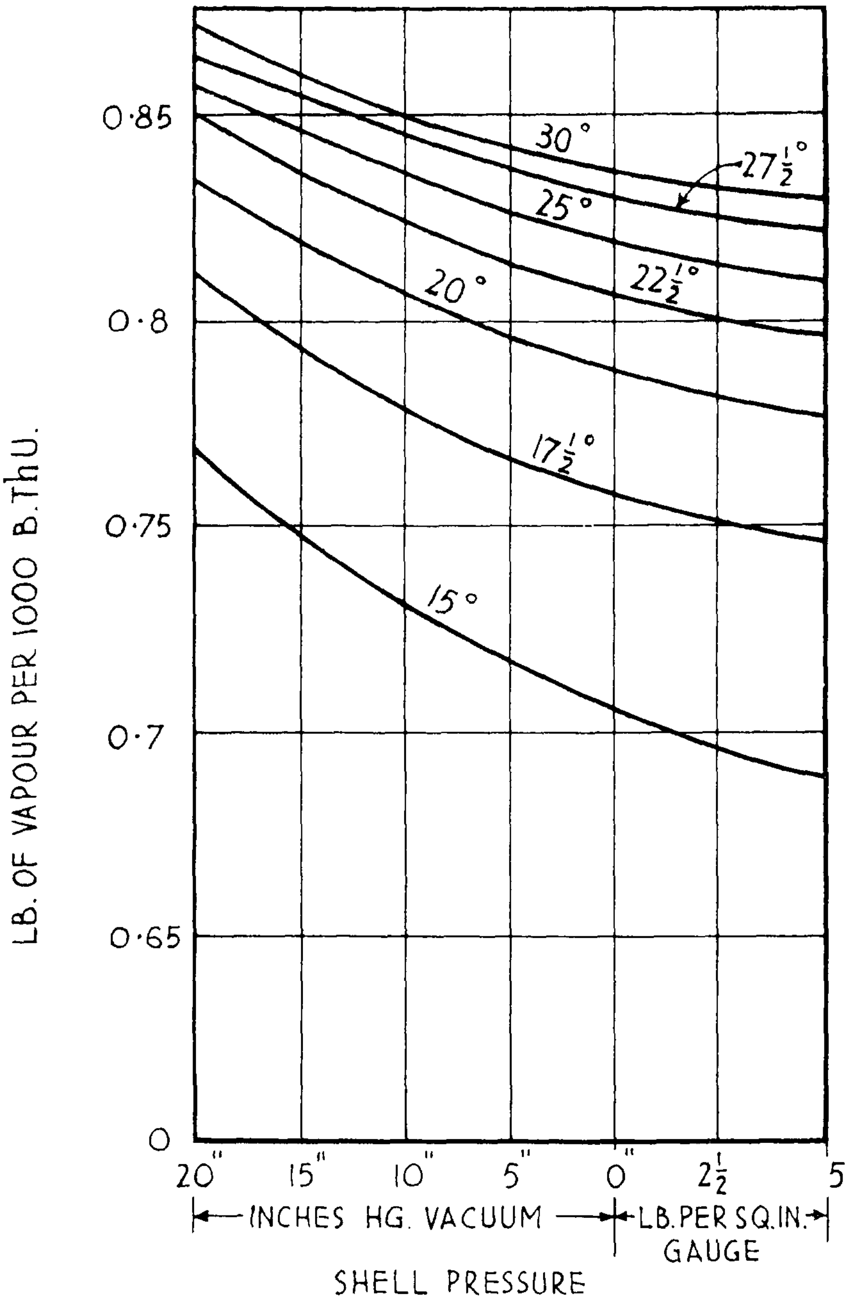


Fig. 5.—(B.R. 1333, Fig. XIV)

A reduction in the density from 20° to 17° would only reduce the designed output from 4.5 to about 4.35 tons/hour—see B.R.1333 Fig. XIV (Fig. 5), and as this was acceptable, we decided to run at the latter figure.

The output for the first 100 hours or so was considerably more than we had anticipated and remained as high as 4.75 tons/hour over quite long periods. I can only assume that the thermal resistance was so low that the drain water was cooled almost to the brine temperature before being discharged. Thereafter, the resistance of the scale becomes comparable with that of the steam boundary layer and little additional output is obtained from the sensible heat of the drain water. In any case, since then the output has been pretty consistently between 4.0 and 4.5 tons/hour according to steam conditions. Outputs of 4.5 tons/hour are rare, a steady average figure being 4.3 tons/hour, though a steady figure of 4.0 tons/hour under certain steam conditions is not uncommon. Steam conditions

| Total Hours | Length of Run (Hours) | Initial C.S. Pressure (lb./sq. in.) | Final C.S. Pressure (lb./sq. in.) |
|---|---|---|---|
| 48 | 48 | 7 | 7½ |
| 90 | 42 | 7 | 7 |
| 117 | 27 | 7½ | 7½ |
| 134 | 16 | 7 | 8 |
| 169 | 17 | 9 | 8 |
| 216 | 46 | 8 | 11 |
| 264 | 48 | 8 | 8 |
| 315 | 50 | 9 | 13 |
| 350 | 34 | 9 | 11½ |
| 394 | 43 | 9½ | 12 |
| 415 | 20 | 8½ | 12 |
| 431 | 15 | 9 | 12 |
| 454 | 22 | 9 | 10 |
| 503 | 24 | 9 | 9 |
| 542 | 38 | 8½ | 17 |
| 583 | 40 | 10 | 9 |
| 612 | 22 | 9 | 10 |
| 632 | 20 | 8 | 9 |
| 667 | 33 | 8 | 12 |
| 688 | 20 | 11 | 13 |
| 709 | 19 | 10 | 12 |
| 734 | 25 | 10 | 12 |
| 753 | 19 | 9 | 14 |
| 775 | 22 | 13/10 | 17/14 |
| 794 | 21 | 12/9 | 16/10 |
| 813 | 19 | 12/10 | 17/14 |
| 842 | 29 | 11/10 | 14/12 |
| 864 | 22 | 14/13 | 16/15 |
| 889 | 25 | 11/10 | 18/16 |
| 908 | 19 | 10/11 | 14/16 |
| 933 | 25 | 9/9 | 13/12 |
| 949 | 16 | 13/11 | 20/18 |

vary when main steaming with the speed of the ship and number of boilers connected and when auxiliary, with which machinery space is flashed up, there being nearly a 50 lb./sq. in. drop from forward to aft through the auxiliary steam line.

The table on page 75 shows the behavior of the coil steam pressure between blow-downs. Runs of less than 15 hours have been omitted.

During the seven weeks we were in the dockyard the coils were kept covered with fresh water. Since restarting on 30th January, the details of coil steam pressure and hours run are shown on page 76.

The significance of the respective columns is the same as before. In the third and fourth column the coil steam pressures for the two shells have been given separately. Some of the differences in pressure between one run and the next are due to variations in steam conditions, but the general rise with the increase of hours and the reduction of pressure at each blow-down are nevertheless apparent. I think we could probably have run the plant for a few

| Total Hours | Length of Run (Hours) | Initial C.S. Pressure (lb./sq. in) | Final C.S. Pressure (lb./sq. in.) |
|---|---|---|---|
| 977 | 23 | 8/15 | 8/15 |
| 1035 | 47 | 8/10 | 16/16 |
| 1056 | 20 | 10/8 | 18/13 |
| 1076 | 20 | 10/9 | 16/17 |
| 1093 | 17 | 10/11 | 13/13 |
| 1110 | 17 | 13/14 | 17/18 |
| 1132 | 21 | 9/9 | 16/17 |
| 1160 | 20 | 9/11 | 11/13 |
| 1193 | 33 | 10/10 | 12/12 |
| 1238 | 37 | 11/10 | 18/17 |
| 1262 | 22 | 15/14 | 24/24 |
| 1285 | 23 | 16/16 | 23/28 |
| 1310 | 25 | 9/9 | 15/16 |
| 1337 | 26 | 14/14 | 19/19 |
| 1357 | 20 | 10/14 | 18/22 |
| 1376 | 19 | 13/12 | 19/18 |
| 1391 | 15 | 10/13 | 24/24 |
| 1412 | 20 | 14/14 | 15/15 |
| 1451 | 37 | 10/9 | 20/17 |
| *1461 | 10 | 20/18 | 24/20 |
| 1489 | 27 | 10/14 | 21/22 |
| 1507 | 18 | 16/17 | 24/24 |
| 1527 | 19 | 13/15 | 24/24 |
| 1544 | 17 | 19/19 | 24/24 |

* Doors removed and coils hosed.

more hundred hours had we been prepared to remove the doors and hose down the coils at about 100 hour intervals, but high water consumption under tropical conditions rules out this course of action, owing to the uncertainty of being able to run the plant for the full twenty hours between blow downs (assuming four hours for a good blow down and rake out) without exceeding the specified maximum of 25 lb./sq. in. on the coils. It is possible that we might also have been able to prolong the total hours by such devices as soaking the coils for an extended period in fresh water, or boiling out with boiler compound, had we been able to spare the time. As it is we can say that we had a genuine 1,500 hours running out of this plant with no artificial aids and at an output which was constant throughout except for small variations due to varying steam conditions. That is, after the initial burst of enthusiasm with clean coils (see my previous letter), the output varied only from about 4.0 to 4.3 tons/hour.

I feel that orifice control operation has entirely justified itself in this trial and, unless there is an exceptional degree of uncertainty regarding the steam supply conditions, I should always recommend its use. It might be a good thing to summarise here the advantages claimed for this method of operation :—

(i) *Constant Output.* (See B.R. 1333, para. 3. 4). Variations in output can only be due to variation in steam supply conditions and in coil drain temperature. In plants fitted with a feed heater/drain cooler, variations due to the latter are likely to be insignificant.

(ii) *Ease of Control.* The one setting which upsets *every other setting* in the plant is the opening in the coil steam valve. With orifice control, the only things the watch-keeper has to keep steady are the density and foam surface level. The most general cause of priming is erratic operation and the most general cause of erratic operation is " hamfisted " manipulation of the coil steam valve. With orifice control there is *no* manipulation of this valve so that the major cause of priming is entirely eliminated.

(iii) *Indication of Scale Accumulation.* The coil steam pressure gives an immediate indication of the quantity of scale on the coils and from it one can estimate when the set should be blown down and how much longer the coils are likely to last before it becomes necessary to change them. This advantage is, in my opinion, sufficient alone to justify the use of orifice control.

**Orifice Size**

In order to enable the necessary size of orifice to be quickly calculated for any conditions of operation reference should be made to Fig. 3 which gives " specific output " per square inch of orifice area for various steam range conditions. "Specific output" being defined as the output in tons/hour assuming one pound of vapour is produced per 1,000 B.Th.U. of heat given up by the coil steam. To obtain the actual output per square inch of orifice area, read off from Fig. XIV on page 55 of B.R. 1333 (Fig. 5) the number of pounds of vapour produced per 1,000 B.Th.U. for the conditions under which the plant is to be operated, and multiply it by the " specific output." Knowing the output which it is intended to obtain from the set, the necessary coil steam orifice area can be arrived at by simple proportion. Two sets of curves have been plotted, one set with a feed heater/drain cooler (assuming the coil drain leaves the cooler at 140° F.) and one set without, assuming the coil drain leaves the coils at an average temperature of 250° F. (corresponding to a coil steam pressure of about 15 lb./sq. in.).

*Example* :—With a steam range pressure of 280 lb./sq. in. gauge, 600° F. it is intended to obtain an output of $1\frac{1}{4}$ tons/hour from a destroyer's single evaporator at 20° density with 10 in. Vacuum in the shell. No feed heater/drain cooler is fitted.

Saturation temperature at 280 lb./sq. in. = about 416°F.

600° F. at 280 lb./sq. in. = 184° F. of superheat.

Specific output = 6·47 tons/hour/sq. in. orifice area. See Fig. 3.

Evaporator output at 20° density, 10 in. vacuum = 0.807 lb. of vapour per 1,000 B.Th.U. See B.R. 1333, Fig. XIV (Fig. 5).

Actual output = 6·47 × ·807 tons/hour/sq. in. of orifice area.

Orifice area to produce $1\frac{1}{4}$ tons/hour therefore

$$= \frac{1.25}{6.47 \times .807} \text{ sq. in.}$$

$$= 0.2395 \text{ sq. in.}$$

Therefore diameter of orifice = 0.552 in.

The following is of little, even academic, interest but before plotting the curves I have already referred to, specific output, as already defined, was plotted against steam temperatures for varying pressures and the curves obtained as shown in Fig. 2. These explain why I have selected " dry and saturated," " 70° F. of superheat " and " 150-250° F. of superheat " as the three curves for each set in Fig. 3. Each curve in Fig. 2 is, for practical purposes, flat from 150°-250° F. of superheat and the " peak " occurs where the critical pressure crosses the saturation line on the Mollier diagram which occurs when the steam initially has about 70° F. of superheat. It will be seen from Fig. 2 that if, in Fig. 3, interpolation is required for superheat temperature, straight line interpolation between curves (*a*) and (*b*) or between (*b*) and (*c*) can be used without involving an error of more than about 0.1 %.

In case you would care to check any of these curves they were obtained from the formula :—

$$O = \frac{H\sqrt{2\ g\ h}}{3210\ Vc}$$

which is easily arrived at from first principles.

Where :—

O = Specific output of evaporator in tons/hour/sq. in. of orifice area at 1 lb. of vapour per 1,000 B.Th.U. of H (below).

H = Heat drop in B.Th.U. from initial steam condition to coil drain condition (i.e., to water at 140° F., or at 250° F.)

g = 32.2 ft./sec.$^2$

h = Heat drop to the critical pressure × .97 (the assumed nozzle efficiency).

Vc = Specific volume of steam at the critical pressure after reheat due to inefficiency of the nozzle.

I took my readings off a 75 × 85 centimeter Mollier and rationalised them by replotting them on a larger scale. Maybe you have a more accurate means at your disposal, I certainly hope you have a quicker one !

I doubt whether the curves in Fig. 3 should in theory be straight lines but over the range of pressures covered they appear to be straight for all practical purposes.

A small source of error which should have been mentioned in B.R. 1333 is that the curves in Fig. XIV (Fig. 5) are calculated for 60° F. sea water. Thus with 90° F. sea water and 20° density, about 60 fewer B.Th.U. are required to produce 1 lb. of vapour ; giving an increase in output of about 5 % with 20 in. vacuum in the shell.

*Note* :—My original idea was to express these curves in terms of nozzle area per ton of made water but I felt that inverting the units would give a clearer conception of what they were all about. Also, it enables them to be used directly for the correction of the designed output in the event of a variation in steam conditions.

## PART II

## STARCH INJECTION

*Since the introduction of the use of starch injection units for retarding the formation of scale on the steam coils of distilling plants, a number of reports have been received from sea indicating that while some ships have met with considerable success, others have reported unfavourably on the equipment.*

*There are so many variables in the operation of a distilling plant that the problem cannot be solved without knowing all the details in each instance—type of evaporator, coil steam pressure, shell vacuum, density of brine, and so on, and if one or more of the variables can be fixed for each experiment, as, for example, fitting orifice plates to the steam supply, then it should be easier to arrive at a satisfactory conclusion. The quality of the starch itself may be one of the variables. Particular attention is invited to H.M.C.S. " WARRIOR'S " letter.*

*Engineer Officers are invited to contribute their experiences, giving as much information as possible, in order that we can get to the " root of the trouble " ; the following are some extracts from letters which serve as examples of the divergency of views held by Engineer Officers on the efficacy of the starch injection equipment.*

**H.M.S. THESEUS.**—*Letter from Commander (E) J. F. Lewin, R.N.*

On leaving Portsmouth at the end of January, we started the forward evaporator with clean coils on continuous corn starch and boiler compound injection. In deciding on the method of injection we were guided by F.E.O., B.P.F.'s letter No. 238/19(j) dated 9th December, 1946, and by A.F.O. 4977/46, recommending that the proportion of boiler compound to starch be halved. We found that by diluting the mixture to a quarter the strength recommended in A.F.O. 3981/44 an absolutely steady rate of injection could be maintained. (A.F.O. 4977/46, para. 4, refers.)

The results of starch injection upon the rate of scale accumulation were most disappointing as will be seen from the following account. Details of the run up to 500 hours are as follows :—

| Total Hours | Length of Run (Hours) | Initial C.S. Pressure (lb./sq. in.) | Final C.S. Pressure (lb./sq. in.) |
|---|---|---|---|
| 140 | 140 | 8 | 8/9 B.D. & filled F.W. |
| 207 | 67 | 8 | 8 B.D. & filled F.W. |
| 233 | 26 | 8/9 | 7/8 (Aux. Aft) |
| 247 | 14 | 6/8 | 7/8 |
| 276 | 29 | 8/10 | 7/9 |
| 337 | 61 | 6/8 | 16 B.D. |
| 484 | 147 | 11 | 20/18 B.D. |
| 498 | 14 | 20/18 | 22/20 |

During this time there was no evidence of any scale being removed from the coils. The only indication of a reduction in thermal resistance was the reduction in coil steam pressure from 16 lb./sq. in. to 11 lb./sq. in. which occurred when the plant was blown down at 337 hours. I find this reduction impossible to explain, unless scale was actually dissolved, since at no time was any scale found to have been cracked off the coils. Examination of the scale, if it could be called a scale, on the bottom coil through the bottom door showed it to be of a powdery consistency similar to ordinary blackboard chalk and it could easily be scraped off down to the bare copper with the finger nail.

It should be mentioned at this point that we were not in a position, at that time, to do much experimenting since the after plant was nearing the end of its run (we had purposely not changed its coils at Portsmouth so as to complete the trial referred to above), also we were on passage and the ship's company were using up to 170 tons of fresh water per day. Since it was clear that the coil steam pressure of the forward set would soon be up to 25 lb./sq. in. and that it was impossible to remove the scale by blowing down we decided to try other means of removing it. In order to arrive at an answer as quickly as possible we tried different methods with the two shells.

Firstly, we filled the first effect shell above the level of the top coil with fresh water and added a whole tin of disencrustation powder. We then boiled this shell at atmospheric pressure for about 30 minutes, blew down the solution, washed through with salt water and restarted. There was no reduction in coil steam pressure. Whilst this was going on we boiled out the second effect shell with a solution of 4 lb. of boiler compound in fresh water for about 45 minutes at atmospheric pressure. We then blew out the solution, washed through, and restarted this shell. Again there was no reduction in coil steam pressure. By the time this was completed the first effect coil steam pressure was 23 lb./sq. in.

| Total Hours | Length of Run (Hours) | Initial C.S. Pressure (lb./sq. in.) | Final C.S. Pressure (lb./sq. in.) |
|---|---|---|---|
| 542 | 36 | 20 | 25 |
| 587 | 45 | 20/14 | 24/22 |
| 625 | 38 | 20/18 | 20/20 |
| 650 | 25 | 13/13 | 16/14 |
| * 673 | 23 | 12/10 | 14/11 |
| * 717 | 44 | 13/10 | 16/14 |
| * 735 | 18 | 15/15 | 20/20 |
| 759 | 24 | 18/19 | (C.E. 13)/23 |
| 779 | 20 | (C.E. 11)/20 | (C.E. 10)/24 |
| 799 | 20 | (C.E. 12)/24 | (C.E. 13)/24 |
| 818 | 19 | (C.E. 11)/24 | (C.E. 11)/24 |
| 839 | 21 | (C.E. 12)/20 | (C.E. 12)/12 |
| 886 | 47 | (C.E. 10)/20 | (C.E. 13)/24 |
| 905 | 19 | (C.E. 10)/22 | (C.E. 8)/25 |
| 925 | 20 | (C.E. 8)/23 | (C.E. 10)/24 |
| 937 | 12 | (C.E. 10)/20 | (C.E. 10)/25 |
| 994 | 57 | (C.E. 12)/12 | (C.E. 12)/17 |
| 1109 | 115 | (C.E. 8)/10 | (C.E. 12)/14 |
| 1128 | 19 | (C.E. 12)/10 | (C.E. 10)/12 |
| 1150 | 22 | (C.E. 10)/12 | (C.E. 9)/16 |
| 1159 | 9 | (C.E. 10)/10 | (C.E. 10)/12 |
| 1183 | 24 | (C.E. 10)/12 | (C.E. 10)/18 |
| 1213 | 30 | (C.E. 10)/18 | (C.E. 10)/20 |
| 1223 | 10 | (C.E. 10)/18 | (C.E. 10)/22 |
| 1239 | 16 | (C.E. 13)/19 | (C.E. 10)/23 |

so we emptied the shell and tried to wash the powdery deposit off the coils with a jet of salt water through the sight glass door and the bottom door. On restarting there was still no reduction in coil steam pressure. We then tried boiling out this shell with a solution of 5 lb. of tannin in fresh water for 30 minutes at atmospheric pressure, again with no effect. Incidentally, orifice control proved invaluable during these attempts since, had there been any removal of scale, the fact would have been apparent from a reduction of coil steam pressure within 10 minutes of starting up.

The scale in this evaporator was insufficiently hard to crack off, insufficiently soft to wash off and we had been unsuccessful in finding a solvent for it. In view of our urgent need for water, therefore, *it was decided to run the plant without starch and try to deposit a hard scale on top of the soft scale in the hope that this would enable both scales to be cracked off together.* The plant was therefore restarted without starch and at 542 hours the coil steam pressure of both shells was 25 lb./sq. in. Both shells were, therefore, blown down and descaled in the ordinary manner. On restarting the coil steam pressures were : 1st effect (which had been boiled out with disencrustation powder and tannin) 20 lb./sq. in., and 2nd effect (which had been boiled out with boiler compound) 14 lb./sq. in. A large sigh of relief was heaved by one and all. Some scale was collected from both shells (the first that had come off since the coils were clean) and samples of both are being forwarded to Mr. Leicester. These scales should be interesting since, apart from an egg shell thin hard scale on the outside, they were entirely formed under continuous starch injection conditions.

Since we had been forced to interrupt this trial and as our main requirement was water, no further attempts were made at starch injection for the time being. The behaviour of the plant since this " crisis " is shown in the table on page 80. The 1st effect has been run quite extensively on closed exhaust and this is indicated in the table but the 2nd effect coil steam pressure gives a reliable indication of how the plant has behaved at constant output.

You will notice that after 625 hours we had a really successful blow-down and cracked off a large proportion of the scale. We therefore decided to try injecting starch and boiler compound again, but this time using the boiler compound in the original proportion as recommended in A.F.O. 3981/44. Therefore, at 651 hours we restarted injection with the originally recommended proportion of boiler compound to starch but diluting the mixture as described earlier in this letter. The results, as can be seen from the table (*), were no more successful than before. You will observe that at 673, 717 and 735 hours respectively, in spite of very thorough blow-downs, there was hardly any appreciable fall off in coil steam pressure when the plant was restarted. At 740 hours, therefore, injection was finally abandoned as we thought it more profitable to allow a hard scale to be formed which was capable of being cracked off by blowing-down.

I am confident that we could have run this plant under these conditions for a further 200 or 300 hours but we wanted to get on with the tannin trial, and also to avoid the possibility of having to change too many sets of coils at once at short notice later on. We have now, therefore, changed the coils of the first effect (i.e. of the shell which had been in use on closed exhaust) and have restarted the plant on tannin injection in accordance with Mr. Leicester's instructions using live steam on both shells. By this means we are virtually carrying out two trials at once ; on the first effect, a trial which will produce comparative results with the two earlier trials, and on the second effect, a trial which will gauge the effect, if any, of introducing tannin injection when the coils are already partially fouled. As soon as I have any conclusive results I will report them. This should not be before 500 or after 1000 hours' running. Running hours do not build up very fast these days, as with the emphasis on fuel economy, we manage to get most of our drinking water from shore.

Our first trouble is that, as we were warned it would, the tannin has gone hard and we have to powder it with a hammer before mixing it. The tannin seems to produce a very thick foam.

Incidentally, I should explain that we did not dare start the after set on tannin when we changed the coils on arrival at Trincomalee as we were uncertain how long the coils in the forward set were going to last, and we therefore felt bound to run the after set by a method we knew to be reliable.

*Note :* It has occurred to me that we may have been " barking up the wrong tree " (or perhaps the wrong side of the right tree) in our search for reduction of scale. There is no doubt that the factors enumerated in B.R. 1333 reduce the rate of continuous deposition of scale, as does starch ; but, unless you can virtually eliminate the deposition of scale entirely or deposit a scale which is very readily soluble, it is no use *reducing* the rate at which it is deposited unless it is of such a form that it can be readily cracked off again and again. One answer to this, of course, would be very thin, oval section, monel tubes.

It may be that we are wrong to reduce the density even to 20° and that a higher density would produce a more brittle scale which could be cracked off more readily. We may be wrong to attempt to inject starch continuously ; possibly by intermittent injection we should obtain a succession of hard and soft layers which would crack off more readily. I am afraid I don't know the answer and the only method of finding out, that I can see, is by trial and error. But trial and error is useless unless the output and other conditions are maintained constant, and the only reliable method of ensuring constant output is by orifice control. That I do feel sure about. In an attempt to acquire more knowledge on this subject of descaling we are now running the after plant (without starch) without blowing down until the coil steam pressure reaches 20 lb./sq. in. and then doing it thoroughly. There is no doubt that the scale comes off in larger pieces by this method. Periods between blow-downs will of course become shorter as the scale becomes more irregular and less easily cracked off. When they are down to 24 hours it will be time to think about changing the coils.

**H.M.S. VANGUARD.**—*Engineer Officer's Quarterly Letter* (30*th June*, 1947).

The Caird and Rayner evaporators have continued to give satisfaction. One minor point of criticism is the unsatisfactory performance of the starch pump. For steady working of the evaporators it is essential to have a pump which gives a constant output. Owing to major fluctuations in steam pressure due to many causes, these reciprocating pumps cannot be relied upon. A motor-driven pump, fitted by ship's staff to " Y " distilling plant, has been most successful and it has been proposed that the remaining plants should be so converted.

**H.M.C.S. WARRIOR.**—*Commander (E) J. S. Horam, R.C.N., to the Engineer Superintendent, H.M.C. Dockyard, Esquimalt.* (4*th February*, 1947.)

H.M.C.S. *Warrior* is fitted with two Weir's 70-ton evaporators in each machinery space which can be run compounded or as separate units. It was found most advantageous to run the evaporators as separate units using closed exhaust steam 15 to 17 lb./sq. in. which gave 10 lb. on the coils of one shell and live steam at 10 lb./sq. in. on the other shell. Two 40-ton evaporators are fitted in the auxiliary machinery space below the workshop ; these are operated as single effect units with live steam at 10 lb./sq. in. in the coils.

The after machinery space evaporators were opened up for examination and cleaning after 2,216 hours running with continuous use of the starch injection unit. The scale formation on the coils was soft, and varied from $\frac{1}{32}$ in. to $\frac{1}{16}$ in. Vapour baffles were clean and the internal condition of the shell was good. Normal operating pressure in the shell was 20 to 22 inches of vacuum.

The starch injection valves originally fitted were too large to allow proper control of continuous injection of starch and U.S. compound mixture in correct quantity, so orifice plates were fitted in accordance with A.F.O. 4977/46 ; these also were found to be unsatisfactory owing to the small orifice continually choking and the plate having to be removed and cleaned. Eventually, the fine adjustment valves were made and fitted which have been found entirely satisfactory, these are so made that any desired quantity can be injected with a continuous operation of the starch injection pump ; the excess, returning via the relief valve, keeps the starch mixture in the tank in a state of constant motion which prevents settling of starch. It was found necessary, however, to halve the prescribed quantity of compound mixture quoted in Naval Order D.2 in order to give continuous injection and not exceed the total mount of compound mixture required per ton of distilled water made.

The normal output rate of two shells with clean coils is 4 to 5 tons distilled water per hour with no chlorine content. After 2,216 hours the output was $3\frac{1}{2}$ to 4 tons per hour.

The conclusion reached is that a continuous injection of starch and compound is necessary when evaporators are running in order to keep down the scale on

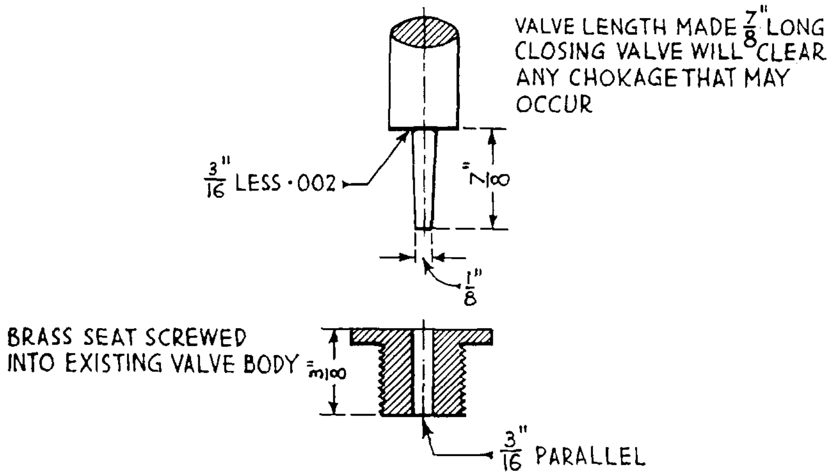


FIG. 1

the coils, and this is only possible through a very fine adjustment valve. A sketch of valves fitted in H.M.C.S. *Warrior* is enclosed for information. (See Fig. 1.)

**H.M.C.S. NOOTKA.**—*Lieutenant (E) G. K. Inglis, R.C.N., to Captain (E) B. R. Spencer, R.C.N., Naval Service Headquarters, Ottawa.* (28*th March*, 1947.)

I am sure you will be very interested to learn with respect to our evaporator performance when using starch injection that the results obtained during our recently completed Winter cruise have been very favourable indeed, especially is this evident when comparison is made with any dubiously successful results we may have claimed in the past.

I should like to express my appreciation for your consideration in forwarding B.R. 1333, as I am certain favourable results were only obtained through the information gained from this very useful and informative B.R.

I do not think it necessary to acquaint you with our many problems experienced in carrying the recommended low brine density, determining foam level, and consequently a steady brine level in the gauge glass, also positive control over the rate of starch injection, as we eventually discovered that all problems—with the exception of starch injection—originated in not carrying a brine level just high enough to prevent foam from travelling down the gauge glass, it having entered at the top orifice and, consequently, carried the brine level with it. On the other hand, too low a brine level exposed the top coil and set up priming within the evaporating unit itself.

The condition of the evaporator coils, as determined by the Base Boiler Water Laboratory representative (Lieut. Comdr. (SB) P. Bailey), is considered very good, as they are covered only with a very slight, easily removed powdery film of starch.

These coils have produced 480 tons of distilled water over a period of 319.5 operating hours. The interesting fact here is that the coils have remained in the above condition, as regards deposit, almost since first being fitted in Trinidad, February 18th, 1947, and it is not intended to change them at this time.

It will be appreciated that the evaporator under the conditions referred to above was operated at 75% of its normal maximum output of 2 tons per hour.