A SOLAR HEATED SWIMMING POOL

BY

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It was realized long ago that H.M.S. *Fisgard's* open air swimming pool which had been built over the years by the staff and apprentices of the Establishment, would require some form of heating. The Author arrived in June, 1961 when the pool apart from this was complete and, as the pool came under his control, he was given instructions to produce, without delay, a heating system.

Heating by conventional means had already been considered and discarded because of the running costs ; at this time the pool was not an Admiralty liability but was maintained solely from the Apprentices' fund.

One or two articles had appeared in the technical Press on the solar heating of small pools and it was decided that this was possibly the only way for us. A study of the problem began from the limited facts available and it soon became apparent that the idea was feasible although, in England, it had only been applied to pools of one quarter the size of *Fisgard's*. However, there seemed no reason why it should not work on a larger scale.

Solar heating, although comparatively new to this country, has been put to good use in many parts of the world. Basically, the principle used is that the solar radiation is absorbed by a collector plate which is exposed to the sun at a suitable angle and then transferred to the medium being heated. A glass front and an insulated back are normally fitted to minimize heat losses due to infra-red re-radiation and convection losses. In theory, one has only to supply enough heat to the pool water to overcome the natural heat loss from the pool. The normal heating effect of the sun will then raise the pool temperature until an equilibrium temperature is reached. For an open pool in the south of England this will be about 70—72 degrees F. The average drop will be about 2 degrees per day. Over 50 per cent of this will be from the surface and this percentage will rise as the air velocity over the water surface increases. A large pool, however, will tend to remain at a more constant temperature than a small pool which will fluctuate considerably.

Fisgard's pool holds 157,000 gallons of water so the daily heat loss is of the order of $3{\cdot}14 \times 10^6$ B.T.U.s. On an average day the solar radiation falling on the earth's surface is between 250 and 300 B.T.U.s. per hour per square foot of surface. Therefore to make up the natural heat loss a heat-collecting area is needed of :

$$\frac{3{\cdot}14 \times 10^6 \text{ B.T.U.s}}{250 \text{ B.T.U./hr/sq ft} \times 8 \text{ hrs}} = 1570 \text{ sq ft}$$

After much midnight oil had been burnt once again studying the Specialist Course Heat Transfer Notes it was confirmed that the required amount of heat could be transferred to the pool water using a simple heat exchanger.

At this stage we learnt that the Nuffield Trust for the Forces of the Crown had granted us £3,300 for the project and so detailed design got under way.

Imperial Chemical Industries had provided the copper heat-absorbing elements for the solar heating plants already in operation and it was decided to use these in our design. Some readers might have come across the ' copper tube in strip ' elements, an ingenious answer to heat transfer problems, in which a sheet of metal has a number of parallel tubes within the sheet and made

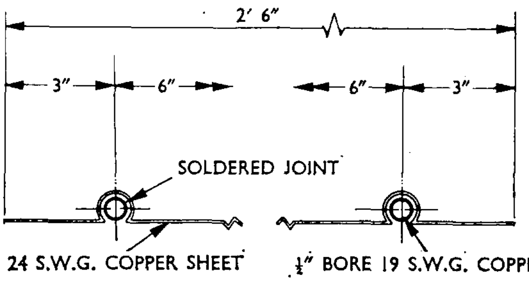


FIG. 1—CROSS-SECTION OF HEATING PANEL

from the material of the sheet. The tubes are formed integral with the sheet by a special process and the material is not made by welding the sheet to the tube or by pressing two sheets together. Unfortunately when we made inquiries it was found that they had ceased production due to insurmountable corrosion problems.

FIG. 2—THE ROLLERS BEING PULLED ALONG A TUBE. NOTE THE CLAMPS FITTED TO PREVENT THE SHEET PULLING AWAY FROM A COMPLETED TUBE

It was therefore decided to produce our own heating elements and soon weird and wonderful ideas from many people were being transformed into prototypes in the workshops. One took the form of two thin sheets (24 S.W.G.) between which the water was to pass, a gap of $\frac{1}{8}$-inch being maintained by distance pads sweated to the sheets. Under test, this bulged so much that it resembled an over-filled hot water bottle. It was soon realized that the near perfect heat transfer properties of the ' tube in strip ' would have to be sacrificed in order to achieve a practical heating element which had the necessary strength. The method adopted in the end was to form 24 S.W.G. copper sheet round approximately 90 per cent of a $\frac{1}{2}$-inch bore 19 S.W.G. copper pipe.

The size of each heat collecting panel was fixed at 20 feet long by 2 ft 6 in.

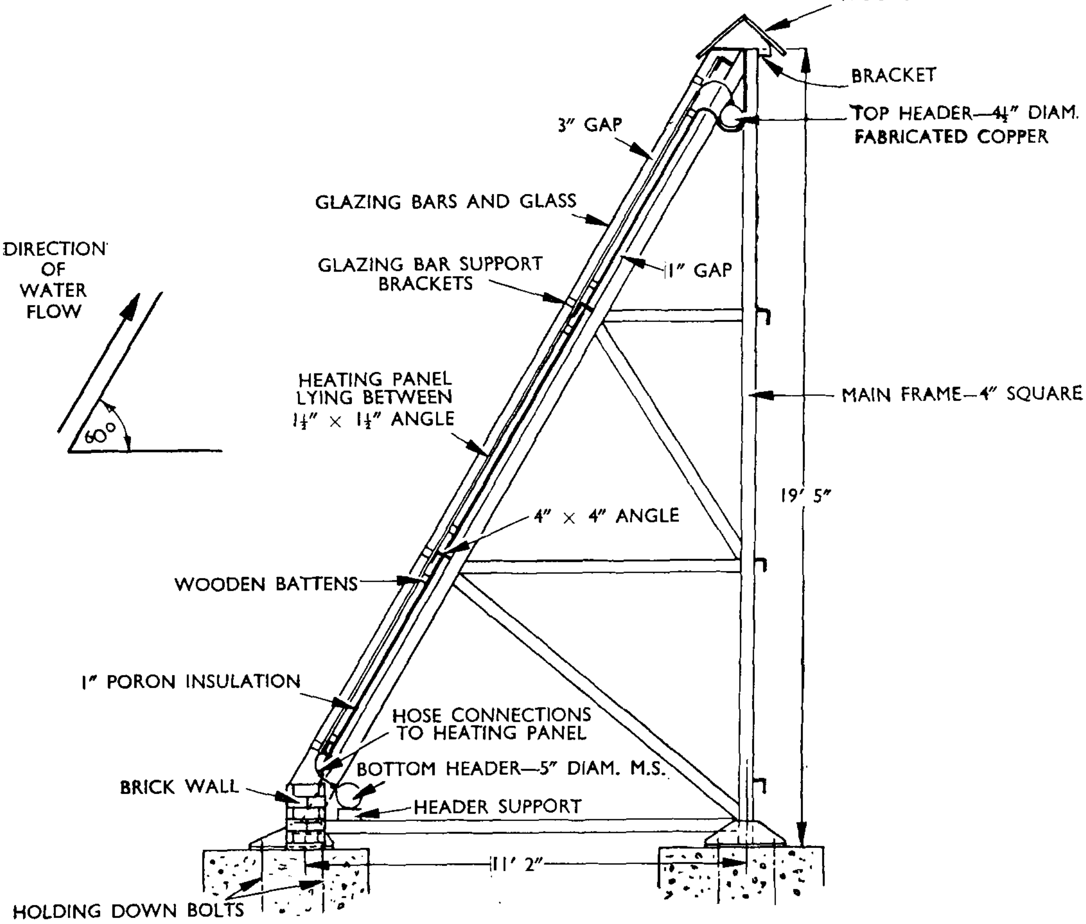


FIG. 3—CROSS-SECTION OF SOLAR HEATER

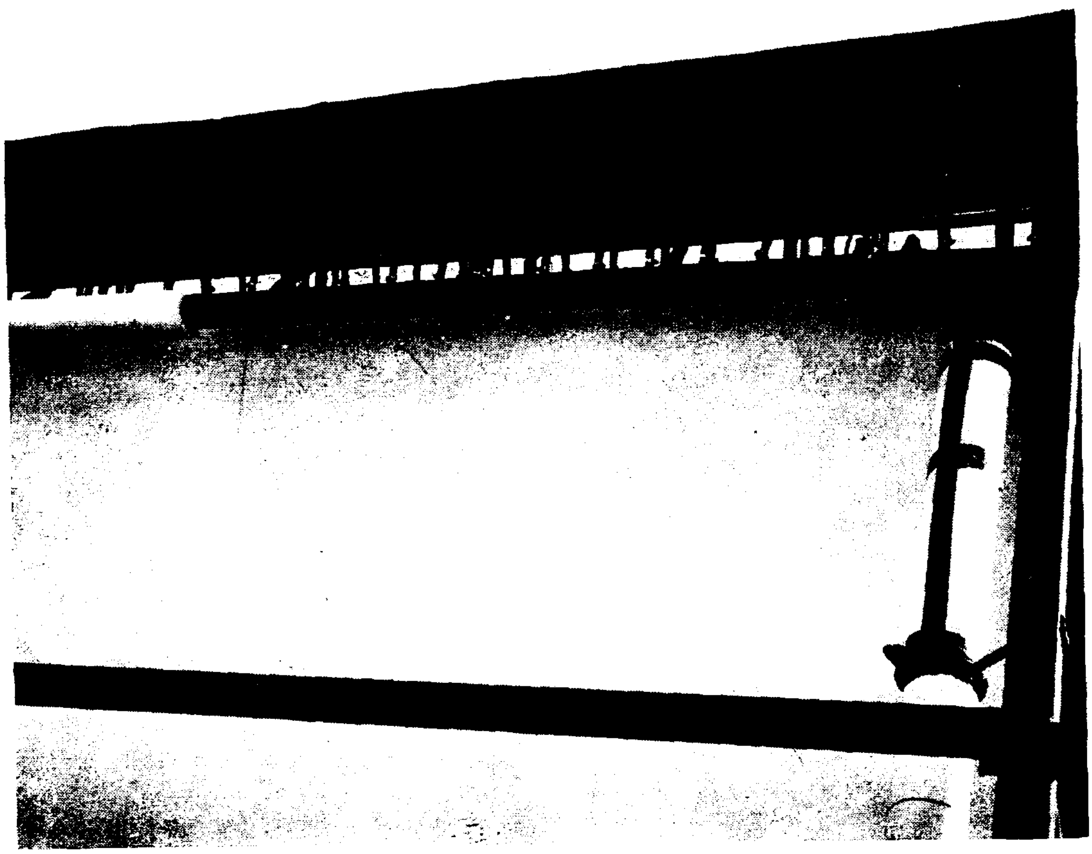


FIG. 4—SECTION OF THE TOP HEADER AND ONE OF THE DOWNCOMERS, CONNECTING HOSES AND INSULATION

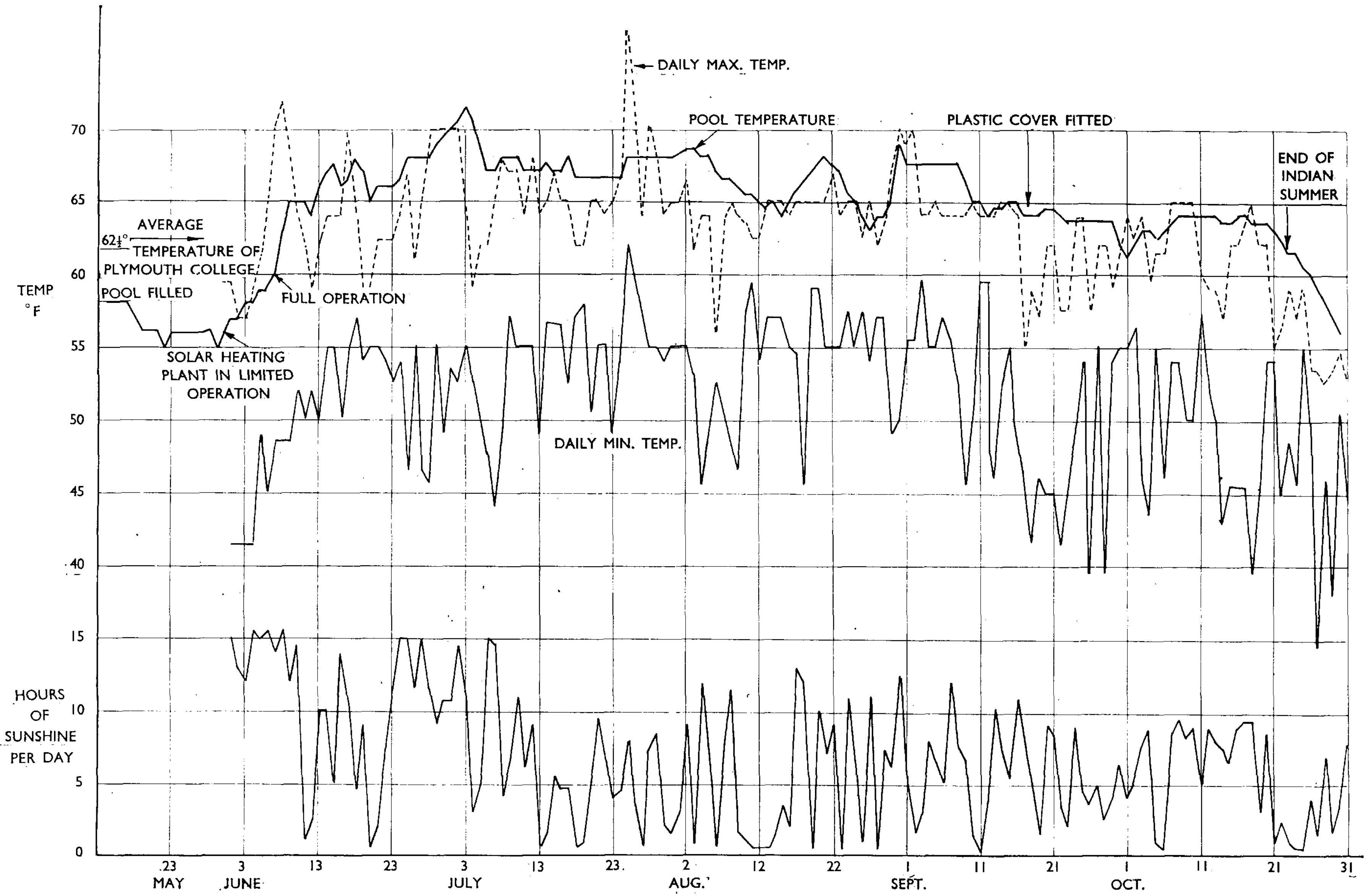
FIG. 5—CLOSE-UP OF THE ENDS OF TWO GLAZING BARS WITH A DRAUGHT EXCLUDER STRIP BETWEEN THEM

wide. Thirty-two of these side by side would make up a total of 1,600 sq ft. Each panel has five tubes running its entire length at 6-inch intervals (see FIG. 1), giving a total of 160 tubes in parallel for the water to flow through. The principal dimensions of the complete heater are therefore 80 feet long by approximately 21 feet slant height.

A special production line was set up in the workshops to produce the panels. The copper sheet was cut out into 5 ft × 3 ft sections for ease of handling. Five U-shaped troughs were then pressed into each section. Four sections were then laid over five 20-foot long pipes on a specially constructed bench. The sheet was then formed round approximately 90 per cent of the tubes by a set of special rollers which were drawn along the length of the tube, as shown in FIG. 2. These rollers were designed and made by the workshop staff. The final stage was to run soft solder into the small gap between the tube and the sheet. The accuracy of the rollers was such that this gap was extremely small and sections taken from trial panels showed near perfect penetration of the solder. For maximum heat absorption the fronts of the panels were sprayed with a matt black paint.

While the heating panels were being produced by the instructors in the workshops the apprentices were hard at work preparing the site. A large amount of ground had to be cleared, foundations dug and 72 cubic yards of concrete made and poured to form twelve blocks on which the main frames would sit. As the whole structure was going to be 80 feet long by 21 feet slant height, the manufacture of the main frames to carry the heat collector was entrusted to a local firm. These were built to our specification and in compliance with British Standards. The six main frames at 16-foot intervals are tied together front and back by 4 × 4-inch mild steel angles. On to the front angles are welded 33, $1\frac{1}{2} \times 1\frac{1}{2}$-inch mild steel angles running up the slope to form 32 divisions for the heating panels. These small angles also support the glazing bars on the front, and on the back the wooden battens to which the heating elements are fixed and the insulation is secured. FIG. 3 shows a cross-section of the heater.

Water is pumped by the existing filtration plant pump to a 5-inch mild steel


DAILY MAX. TEMP.
POOL TEMPERATURE
PLASTIC COVER FITTED
END OF INDIAN SUMMER
AVERAGE
62½°
TEMPERATURE OF PLYMOUTH COLLEGE
POOL FILLED
FULL OPERATION
SOLAR HEATING PLANT IN LIMITED OPERATION
DAILY MIN. TEMP.
TEMP °F
70
65
60
55
50
45
40
15
10
5
0
HOURS OF SUNSHINE PER DAY
23 MAY
3 JUNE
13
23
3 JULY
13
23
2 AUG.
12
22
1 SEPT.
11
21
1 OCT.
11
21
31

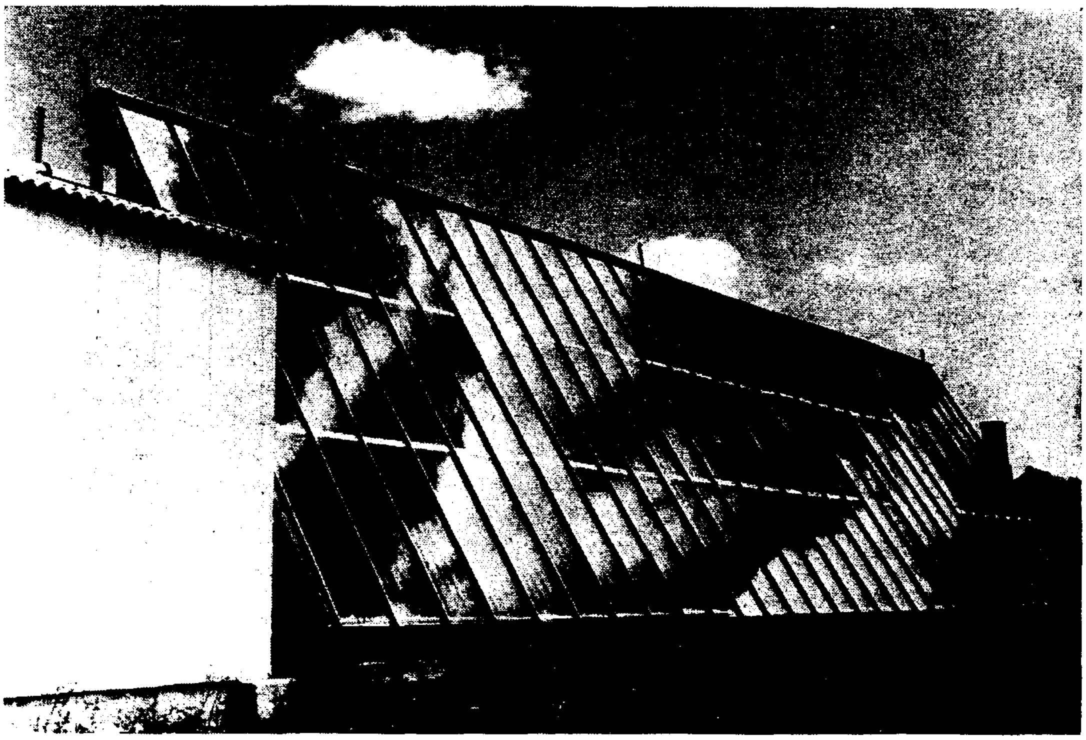


FIG. 6—VIEW FROM THE FRONT OF THE COMPLETED SOLAR HEATER

bottom header into which $\frac{1}{2}$-inch bore stub-pipes are welded opposite the element tubes. Connection is by rubber hose and jubilee clips. The top header is in two sections and fabricated for lightness from 21 S.W.G. copper sheet (FIG. 4). Two downcomers join into a 5-inch return to pool line.

Insulation of the back is by Sunfoil paper and one-inch thick Poron (expanded polystyrene) sheets. All 'hot' pipework is insulated either by preformed Poron pipe sections or by wrapping thin Poron sheet to a thickness of $\frac{3}{4}$-inch, as shown in FIG. 4.

The glass front is fixed to 33 anodized aluminium patent glazing bars each of which is approximately 21 feet long (FIG. 5). Each heating panel is covered by three panes of glass each approximately 2 ft 6 in. $\times$ 7 ft. Due to the unusually large glass size, $\frac{3}{16}$-inch drawn glass is used to give the extra strength needed. The glass together with the insulation forms a completely sealed box round the heat collecting panels as can be seen in FIG. 3.

Towards the end of May, 1962, the plant was complete, except for the glass, and water was pumped round the circuit for the first time. Out of 700 joints, the majority of which were made by apprentices, only three small leaks were discovered. Just as we were congratulating ourselves disaster struck. As the water was turned off, the top header collapsed due to the vacuum conditions created by the sudden emptying of the pipes, although a vent was fitted. A steam roller could not have made a better job of it. The pipes were removed to the workshops, blown up using 50 lb/sq in. air pressure and replaced within a very short time. It says a lot for the workmanship that not one leak developed in either of these operations. The vent pipe was resited and enlarged to prevent a repetition. From then on there were no further snags and we waited for the sun. FIG. 6 shows a front view of the completed plant.

Preliminary results were encouraging even without the glass. As soon as this was fixed the true results began to show. The pool temperature rose steadily to 72 degrees F by 1st July. The temperature under the glass with water flowing through the tubes on an average day was between 95 and 110 degrees F. This gives a temperature rise of 3—5 degrees with 200 gallons of water per minute flowing through the tubes. It has been found that more B.T.U.s can be extracted with a high rate of flow and small temperature rise than vice versa. The outlet temperature has been as high as 100 degrees F, but to achieve this the flow was very small. From these figures it can be seen that with a 4-degree rise over a 7-hour heating day more than $3{\cdot}14 \times 10^6$ B.T.U.s. can be gained. It must be pointed out that it is not necessary for the sun to be actually shining. Provided the cloud cover is not too dense the solar radiation will still be present as can be witnessed in a closed greenhouse on a cloudy day.

At the beginning of September, a floating plastic cover was purchased to put on the pool at night. The effect of this can be readily seen from FIG. 7. It is considered that if this had been used throughout the season the temperature would have been over 70 degrees F most of the time.

FIG. 7 also shows the daily maximum and minimum air temperature, the afternoon pool temperature and the hours of sunshine each day from the end of May until the pool was closed in October. The air temperatures and hours of sunshine are those recorded at the R.A.F. Station, Mountbatten, but they can be regarded as being representative of the area. Apart from showing what an awful summer we had, the initial rise shows how effective the heater was. The fall during the last week in August is probably accounted for by maloperation of the plant during the leave period. The effect of the plastic cover is illustrated by the fact that the pool temperature remained constant during the cold period commencing 16th September, whereas in cold spells commencing 3rd June and 2nd August the pool temperature fell appreciably. The average pool temperature between 7th June and 11th September was approximately 68 degrees F. Unfortunately records were not kept at any other pools in the Plymouth area but the nearest similar pool only averaged 62½ degrees F according to an estimate from the owners over this period.

The only modification found to be necessary is in the support for the bottom panes of glass. Due to slight misalignment of the glazing bars the glass is resting unevenly on the small brackets and some fractures have occurred. For convenience the hot water return to pool line is being re-routed. To complete the scheme, the back and sides have been enclosed to give a large storage space and changing rooms are in the process of being built adjacent to the plant.

In conclusion it can be said that the project is a success. It has been a most interesting exercise in design and production and both the staff and apprentices alike have learnt a great deal from it. It is not often these days that one is given a free hand to spend £3,300. As a result H.M.S. *Fisgard* has the largest solar heating plant in the country, if not in Europe.

Question

What are the most important of the points which suggest themselves to you in connection with the management of marine engines?

Answer

The attendants upon engines should prepare themselves for every casualty that may arise by considering possible causes of derangement and deciding in what way they would act should certain accidents occur. The course to be pursued must have reference to particular engines and no general rules can therefore be given ; but every marine engineer should be prepared with the measures to be pursued in the emergencies in which he may be called upon to act and where everything may depend upon his energy and decision.

The above is an extract from *The Catechism of the Steam Engine*, by J. Bourne, 1854.