Jan. 11, 1955

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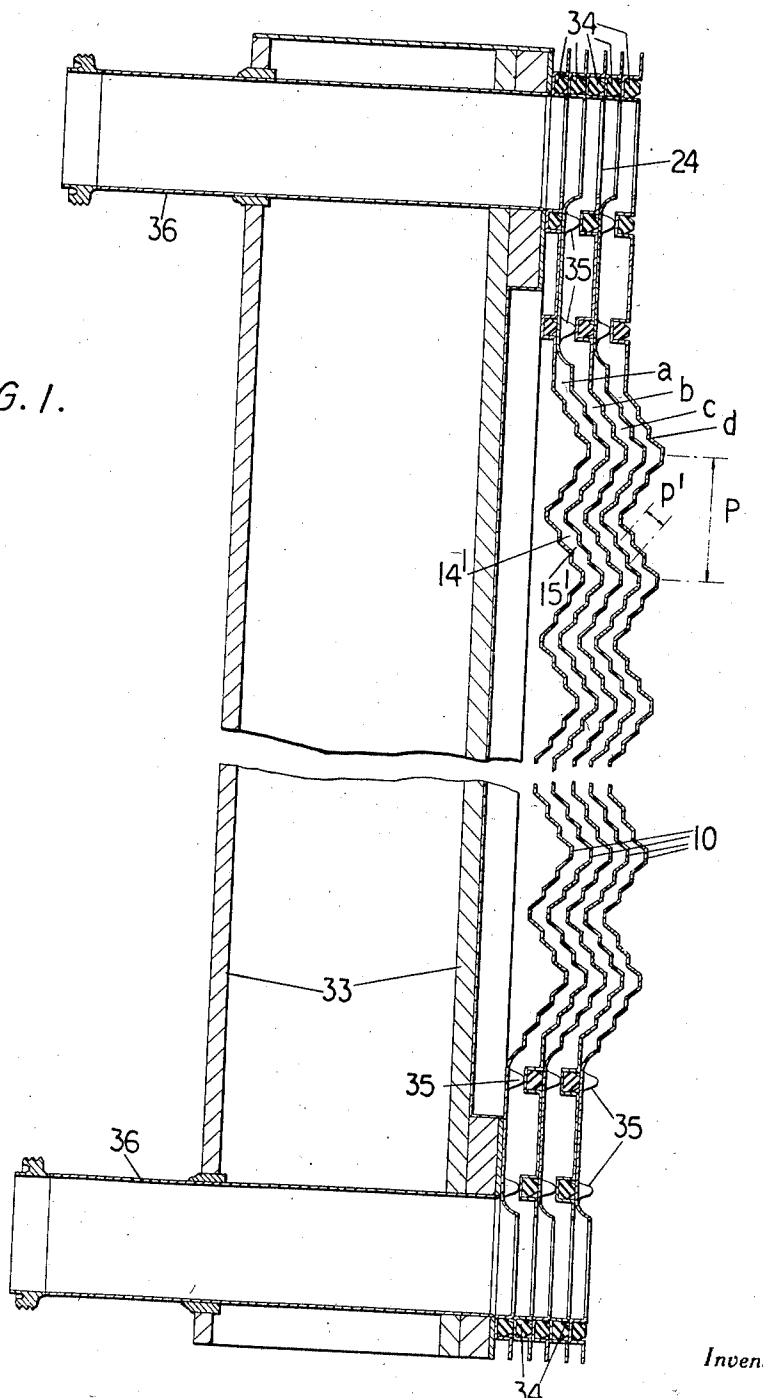
2,699,324

PLATE TYPE HEAT EXCHANGER

Original Filed Jan. 9, 1950

3 Sheets-Sheet 1

FIG. 1.



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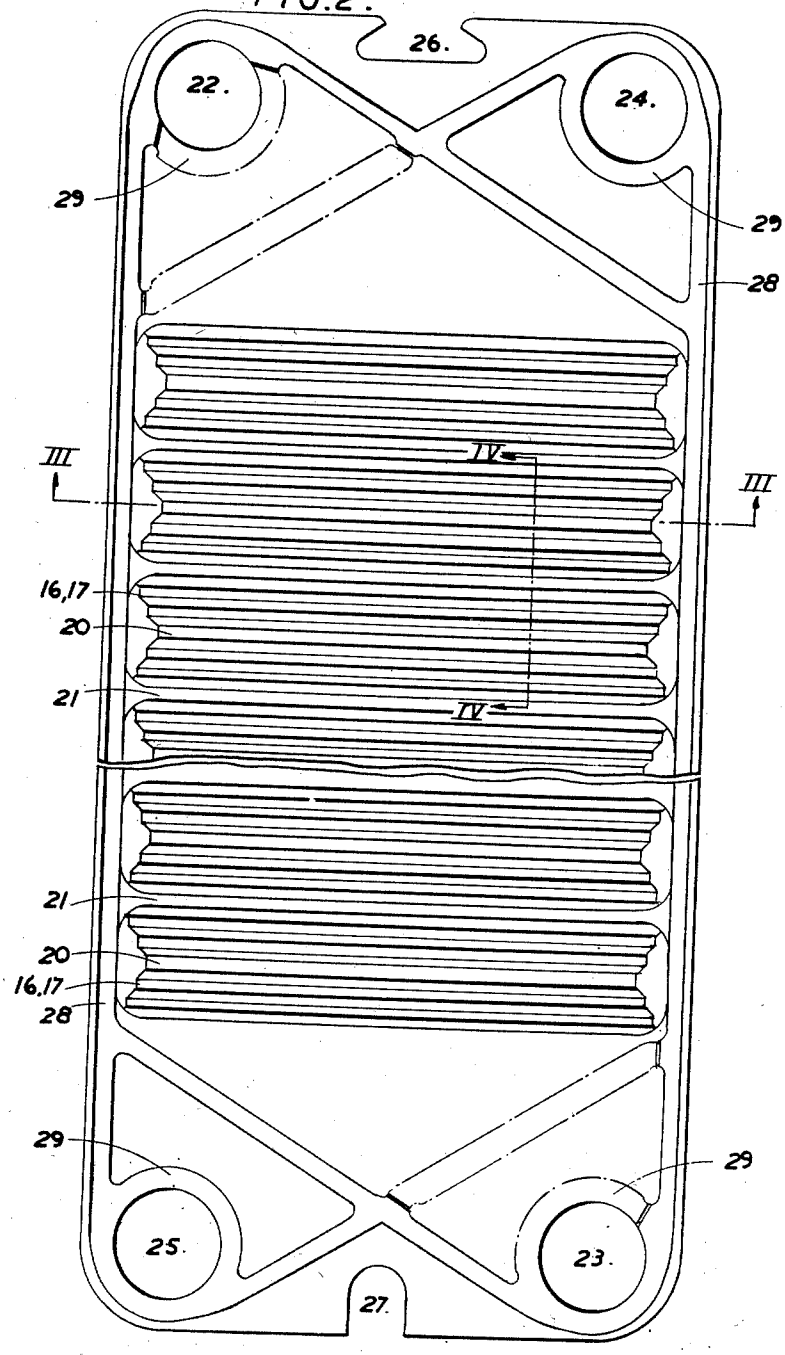
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PLATE TYPE HEAT EXCHANGER

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FIG. 2.



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3 Sheets-Sheet 3

FIG. 3.

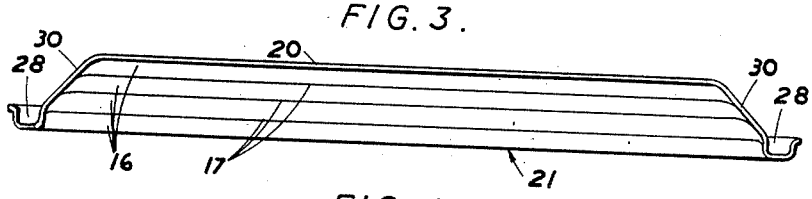


FIG. 4.

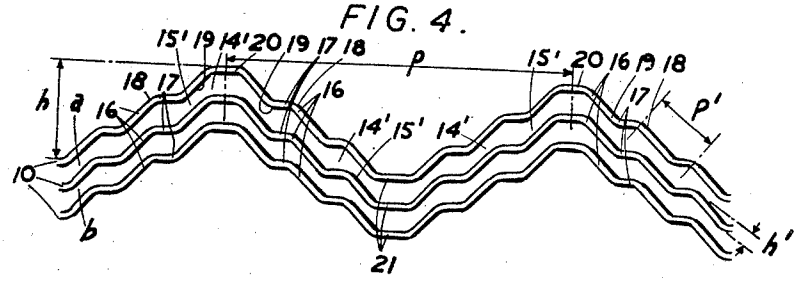
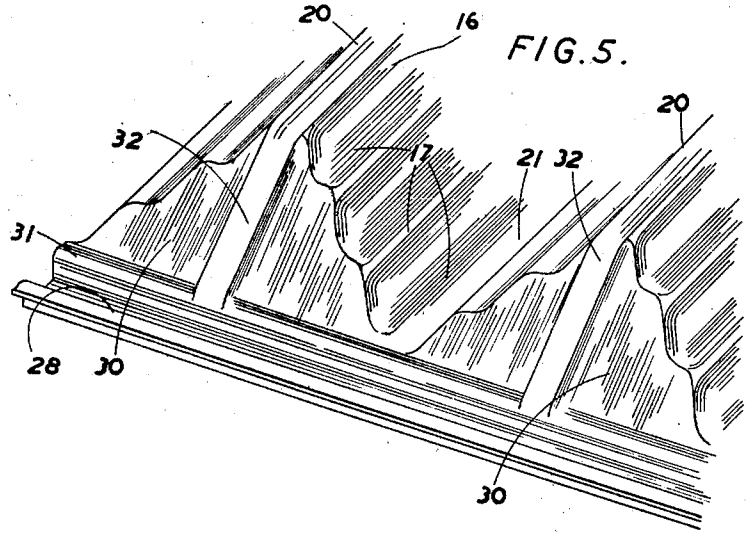


FIG. 5.



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PLATE TYPE HEAT EXCHANGER

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Continuation of abandoned application Serial No. 137,619, January 9, 1950. This application April 28, 1952, Serial No. 284,743

Claims priority, application Great Britain January 13, 1949

4 Claims. (Cl. 257—245)

This invention relates to heat exchangers of the plate type in which a number of plates are assembled in spaced relationship to provide between them flow channels the fluids between which heat is to be exchanged being caused to flow through adjacent channels.

This application is a continuation of my co-pending application, Serial No. 137,619, filed January 9, 1950, for improvements in or relating to heat exchangers, now abandoned.

More particularly, the invention is concerned with heat exchangers in which the plates are formed with corrugations which extend transversely to the direction of flow of fluids through the channels, the corrugations of adjacent plates cooperating to define each flow channel as a series of chambers which are disposed in a regular succession in the path of flow and are interconnected by restricted passages. A heat exchanger made in this way is described in the U. S. specification No. 1,992,097 and has gone into extensive use because of its efficiency.

The efficiency is derived from the fact that the corrugations are so formed that each restricted passage directs the fluid passing through it across the succeeding chamber to at least one of the heat exchange walls of the chamber. The efficiency is furthermore due to the changes in direction of the flow of liquid and, owing to the discharge from the restricted passages into the relatively large chambers, the changes in velocity which necessarily occur.

It follows therefore that up to a limit, an increase in the efficiency of heat exchange occurs with increase in the number of corrugations and the consequent number of restricted passages and chambers.

However, the corrugations are relied upon to impart mechanical strength to the plates to enable them to withstand the pressure differences to which they are subjected by the fluids flowing through the flow channels. Obviously this strengthening action will decrease as the corrugations are made smaller for the purpose of increasing the efficiency of the heat exchange.

Thus, the two conditions one to increase the heat transfer efficiency and the other to maintain the mechanical strength of the plates are conflicting and in the result the form of the plates had to be based in the past on a compromise between the two conditions.

The main object of this invention is to provide such a form of corrugated plate as will enable the necessity for compromise to be avoided, i. e. by enabling the questions of mechanical strength of the plate and of its heat transfer efficiency to be dealt with as independent and not conflicting conditions.

A further object of the invention is to provide corrugated plates which will enable improved operating conditions to be obtained.

With the foregoing objects and still other objects in view which will appear from the following description, the invention consists in the combinations and arrangements of parts and details of construction which will now be described with reference to the accompanying drawings and more particularly pointed out in the appended claims.

In the drawings, Figure 1 is a vertical sectional elevation of a part of a heat exchanger incorporating plates made in accordance with this invention, this figure being a section taken on the line I—I of Fig. 2. Figure 2 shows a face elevation of a plate shown in the assembly of

Figure 1, Figure 3 is a transverse section on line III—III of Figure 2, and Figure 4 is a detail sectional view on line IV—IV of Figure 2 showing to an enlarged scale parts of three adjacent corrugated plates defining between them two flow channels.

Figure 5 is a detail perspective view showing a modified construction of plate according to the invention.

It will be convenient to refer first to Figures 1 and 2. The heat exchanger comprises a number of similar corrugated plates **10** which are assembled in face-to-face relationship, the plates being clamped together between by end frames of which only one is shown at **33** in Figure 1 and the plates having upper and lower recesses **26, 27,** by which they are carried by supports not shown. The plates are formed with marginal recesses **28** to receive sealing gaskets **34** which are clamped between the plates when the end frames are urged together, the plates having local projections **35** to hold them apart at the required distance. The adjacent plates clamped together in this way define between them flow channels or passages *a, b, c, d,* every other passage receiving the flow of one of the fluids between which heat exchange is to be effected and the intermediate passages receiving the flow of the other fluid. Thus each plate forms a dividing wall between the flow of the two fluids, the exchange of heat being effected through the plate itself.

Each of the plates is formed with ports which are indicated in Figure 2 at **22–25**: these ports are used, in accordance with the normal practice as the inlet and outlet ports for one of the fluids and as the inlet and outlet ports for the other fluid and also as transfer ports to transfer the fluids from one flow passage to another depending on the particular requirements. The ports **22** and **23** which are diagonally opposite one another apply to one fluid and the ports **24, 25** apply to the other fluid, the ports **24, 25** as shown in Figure 2 constituting the inlet and outlet ports for the fluid which is to traverse the plate shown in Figure 2 while the other ports **24, 25** constitute the transfer ports which serve to conduct the other fluid past the plate shown in Figure 2 to another flow passage.

For the purpose of using the ports in the manner referred to the gaskets **32** are shaped to provide a flow space of parallel piped form as shown in Figure 2, the gasket passing partly around the inlet and outlet ports **22, 23** of that flow space and isolating the other or transfer ports **24, 25** from that flow space, the gasket having extensions to pass completely around the transfer ports to complete their isolation as is indicated at **29** in Figure 2. The end frames **33** are provided with flow ducts **36** of which only two are shown in Figure 1, these ducts being aligned with the aligned series of ports and constituting supply or return ducts for the two fluids as the case may be.

As has been stated, the invention employs plates of the corrugated form to provide sinuous flow passages: for consideration of heat transfer efficiency the number of impingements or changes in velocity and of changes in direction of the fluids flowing through the flow passages requires to be large but the corrugations have at the same time to be made large and deep to afford mechanical rigidity to the plates; these two conditions are conflicting for the one requires small corrugations and the other large corrugations and it is the purpose of this invention to obtain the benefits of both small and large corrugations.

Reference will now be made particularly to Figure 4 which shows to an enlarged scale the form of the plates **10** in accordance with this invention. The plates are pressed out from a sheet to provide a succession of large corrugations having a pitch *p* and by providing in the flanks of the large corrugations small corrugations having a pitch *p'*.

When the plates are assembled as is shown in Figures 1 and 4, the flow passages *a, b, c,* etc. are given a sinuous form by reason of the large corrugations of pitch *p*: the sinuous flow passages themselves are themselves formed by a series of chambers connected by restricted passages, this formation being due to the cooperation of the small corrugations of pitch *p'*.

Each small corrugation has relatively inclined sensibly plane wall portions **16, 17** which are joined together at their apex by a crest portion **18** and at their bases by

other base portions **19** to the next adjacent wall portion. The uppermost small corrugation on each large corrugation is shown as including a short flat wall portion **20** and the lowermost small corrugation of each large corrugation is connected to the lowermost small corrugation of the next adjacent large corrugation by a short flat wall portion **21**, the wall portions **20** and **21** being parallel with the plane of the plate.

It will be clear from Figures 1 and 4 that the small corrugations of pitch p' cooperate to form chambers (indicated by the reference **14'**) connected by restricted passages **15'** the passages **15'** directing the fluid flow against the wall of the chambers **14'** while at the same time the fluid is caused to have velocity and directional changes, the changes in direction arising not only on account of the small corrugations but also on account of the sinuous nature of the flow passages *a*, *b* etc. themselves in following the large corrugations of pitch *p*. Because each large corrugation embraces a number of small corrugations, the heat transfer efficiency is maintained at the same time that the required mechanical strength is given to the plates. Thus by reason of the invention the rigidity or stiffness of the plates can be determined by the larger corrugations and the pitch and the form of the small corrugations can be selected purely on the basis of the heat exchange requirements so that the overall efficiency and performance of such a heat exchanger will be increased.

The invention provides other advantages: it enables a heat exchanger using such plates to be maintained in a clean condition more easily for the reason that the corrugations are more open so permitting easy brushing: when the plates are, as is usual, of metal it would permit thinner metal to be employed in view of the rigidity or stiffness which is imparted by the large corrugations: in cases in which a metal of low ductility is employed the form of corrugation according to this invention will be easier to produce by pressing without danger of fracture of the metal.

There is also the further important advantage that for a given stiffness of plate and rate of heat transfer, plates made in accordance with the invention may have a substantial minimum clearance between them, this benefit minimizing the risk of choking the flow passages, either because of the large particles which may sometimes be carried by the liquids or because of the tendency of some liquids to build up a coating on the surfaces of the plates.

The pitch *p* of the large corrugations, may, as shown, be greater than their depth *h*. For example, the pitch *p* may be from two to six times the depth *h*. Similarly the pitch p' of the smaller corrugations may be greater than their depth h', as also shown in Figure 4. The pitch p' of the small corrugations may be about one third to one eighth of the pitch *p* of the large corrugations and the depth h' of the small corrugations may be one quarter to one twentieth of the depth *h* of the large corrugations. Preferably the pitch size and depth of the respective corrugations in one plate are identical with those in adjacent plates.

It is to be observed that the provision of the small corrugations does not materially, if at all, provide any increased stiffness against deformation under the pressure of the liquid, but serves mainly the purpose of promoting a higher rate of heat transfer or, for a given rate of heat transfer, an increased minimum spacing between adjacent plates.

As illustrated in Figure 3, the ends **30** of the large corrugations can be outwardly inclined towards the marginal recess or channel **28**. In the arrangements illustrated the plates are produced by pressing metal sheets, for example, of copper or stainless steel, and if the large corrugations extend abruptly to the inner edge of the channel **28** there is a tendency towards breaking during the pressing operation. To avoid this, the large corrugations may terminate a short distance from the channel **28**, as illustrated at **31** in Figure 5. However, when constructed in this way, the assembled plates would leave channels extending along the marginal portions of the plates parallel to the sides of the gasket recess **28** and through which the liquids tend to by-pass thereby reducing the overall efficiency of the plates.

To eliminate or reduce this tendency, according to a further feature of the invention, a small corrugation **32** (Figure 5) is provided in each end **30** of each large corrugation, this corrugation **32** extending down from the upper edge of the corrugation to the inner edge of the recess **28**, the remainder of the end of the corrugation terminating short of the said edge of recess **28**. The corrugations **32** may, as shown, be continuations of the small corrugation at the crest of each large corrugation. These small end corrugations **32** of adjacent plates provide restrictions in the flow passage formed between the ends of the plates: these restrictions restrict the flow and produce a change in direction of liquids tending to by-pass the plates adjacent to the recess **28**, and thus minimize or eliminate this. The two end walls of the apparatus are respectively formed with depressions and projections inter-mating with the large and small corrugations in the adjacent plates.

I claim:

1. A heat exchanger comprising an assemblage of plates each having flow openings which are spaced apart along the length of the plate which has extending across the width of the plate large stiffening corrugations which have end walls extending down to the marginal edge portions of the plate, the side walls of the large corrugations being formed with small corrugations along the length of and parallel with the large corrugations and the end walls of the large corrugations being formed with at least one small corrugation and means securing the plates in spaced face-to-face relationship with the large and small corrugations similarly directed and parallel so that the large corrugations of adjacent plates not only stiffen the plates but also cooperate to provide between each pair of plates flow channels of sinuous form extending transversely across the flow path from opening to opening while the small corrugations in the side walls cooperate to constitute each sinuous flow passage as a succession of chambers connected by restrictions which produce changes in velocity of the fluid flow, the small corrugations in the end walls of the large corrugations cooperating to provide restrictions to the flow of fluid between the end walls of adjacent plates.

2. A heat exchanger comprising an assemblage of plates each having flow openings which are spaced apart along the length of the plate and which has extending across the width of the plate large stiffening corrugations which have end walls extending down to a sealing component at the marginal edge portions of the plate, the side walls of the large corrugations being formed with small corrugations along the length of and parallel with the large corrugations and the end walls of the large corrugations being formed with at least one small corrugation, and means securing the plates in spaced face-to-face relationship with the large and small corrugations similarly directed and parallel so that the large corrugations of adjacent plates not only stiffen the plates but also cooperate to provide between each pair of plates flow channels of sinuous form extending transversely across the flow path from opening to opening while the small corrugations in the side walls cooperate to constitute each sinuous flow passage as a succession of chambers connected by restrictions which produce changes in velocity of the fluid flow, the small corrugations in the end walls of the large corrugations cooperating to provide restrictions to the flow of fluid between the end walls of adjacent plates.

3. A heat exchanger comprising an assemblage of plates each having flow openings which are spaced apart along the length of the plate and which has extending across the width of the plate large stiffening corrugations which have sloping end walls extending down to a sealing component at the marginal edge portions of the plate, the side walls of the large corrugations being formed with small corrugations along the length of and parallel with the large corrugations and the sloping end walls of the large corrugations being formed with at least one small corrugation, and means securing the plates in spaced face-to-face relationship with the large and small corrugations similarly directed and parallel so that the large corrugations of adjacent plates not only stiffen the plates but also cooperate to provide between each pair of plates flow channels of sinuous form extending transversely across the flow path from opening to opening while the small corrugations in the side walls cooperate to constitute each sinuous flow passage as a succession of chambers connected by restrictions which produce changes in velocity of the fluid flow, the small corrugations in the sloping end walls of the large corrugations cooperating to provide restrictions to the flow of fluid between the end walls of adjacent plates.

4. A heat exchanger comprising an assemblage of plates each having flow openings which are spaced apart

along the length of the plate and which has extending across the width of the plate large stiffening corrugations which have end walls extending down to the marginal edge portions of the plate, the side walls of the large corrugations being formed with small corrugations along the length of and parallel with the large corrugations and the end walls of the large corrugations being formed with at least one small corrugation, and means securing the plates in spaced face-to-face relationship with the large and small corrugations similarly directed and parallel so that the large corrugations of adjacent plates not only stiffen the plates but also cooperate to provide between each pair of plates flow channels of sinuous form, extending transversely across the flow path from opening to opening while the small corrugations in the side walls cooperate to constitute each sinuous flow passage as a succession of chambers connected by restrictions which produce changes in velocity and additional changes in direction of the fluid flow, the small corrugations in the end walls of the large corrugations cooperating to provide restrictions to the flow of fluid between the end walls of adjacent plates.

5. A heat exchanger comprising an assemblage of similar plates having spaced flow openings and between the openings a number of large stiffening corrugations and

in the wall of each large corrugation a number of small corrugations parallel with the large corrugations, and means to secure the plates in spaced face-to-face relationship with the corrugations of the plate similarly directed and parallel so that the large corrugations of adjacent plates not only stiffen the plates but also cooperate to provide between each pair of adjacent plates flow channels of sinuous form extending transversely across the flow path from flow opening to flow openings while the small corrugations of adjacent plates cooperate to constitute each sinuous flow channel as succession of chambers connected by restrictions which produce changes in the velocity of the fluid and change in direction of flow additional to that produced by the sinuous form of the flow channel.

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