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E. A. DEWALD

METHOD OF MAKING FIN TUBE HEAT EXCHANGERS

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Fig. 7, Fig. 6, Fig. 4, Fig. 5

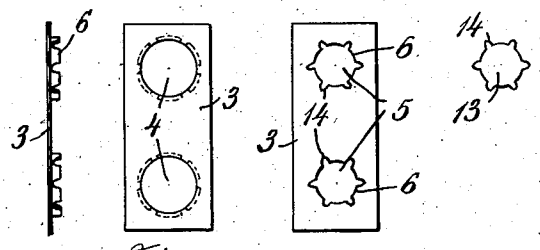


Fig. 1

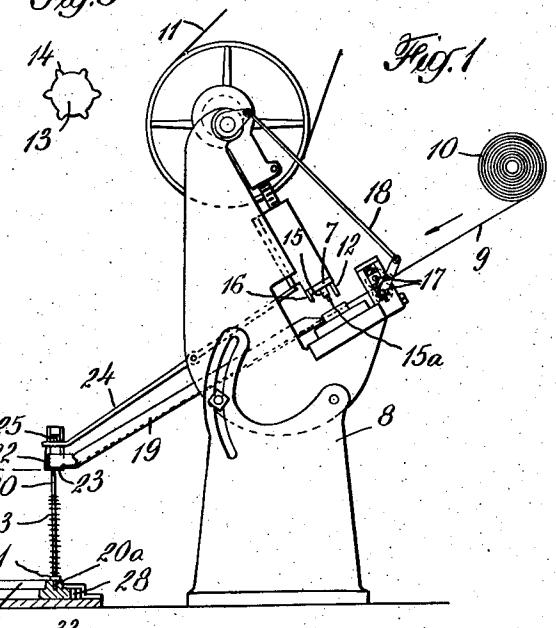


Fig. 1a.

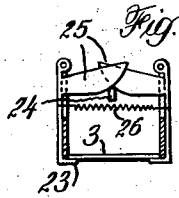


Fig. 2,

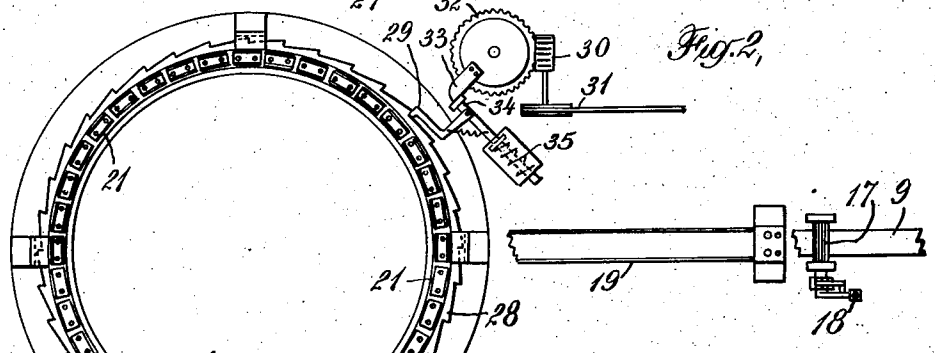


Fig. 3,

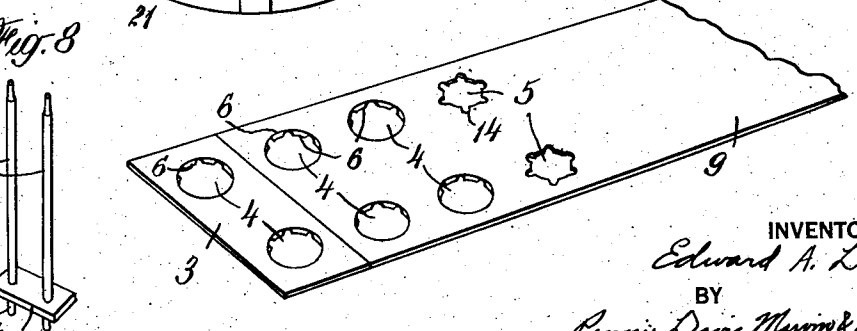


Fig. 8

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Fig. 11

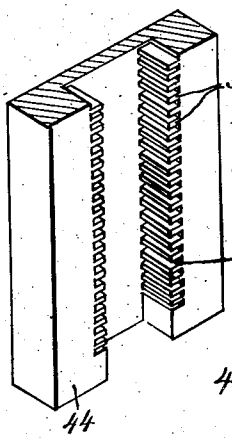


Fig. 9.

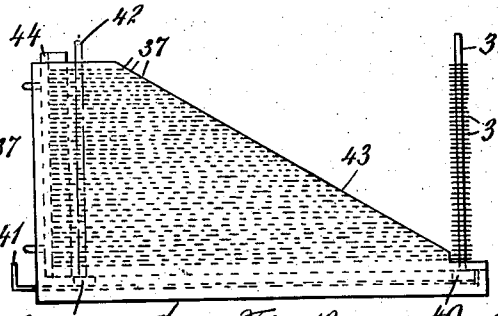


Fig. 10.

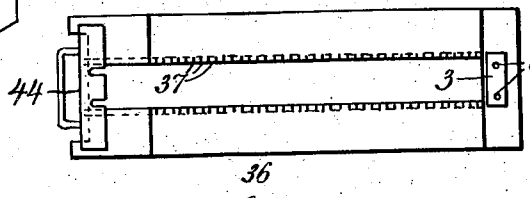


Fig. 12.

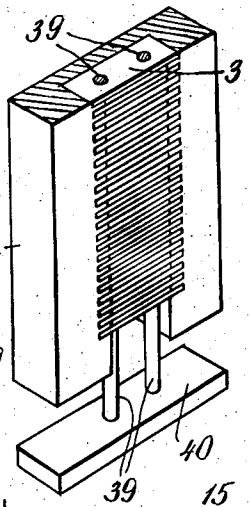


Fig. 13.

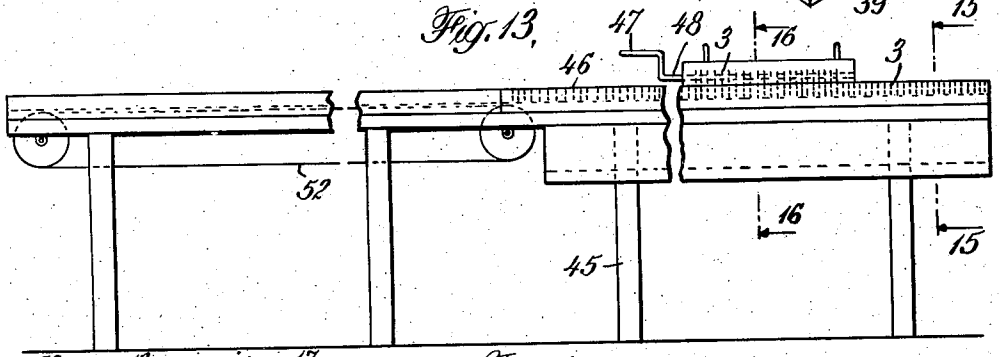
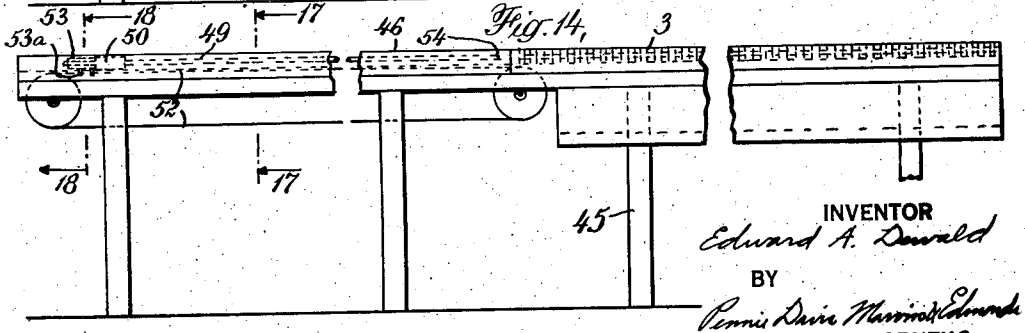


Fig. 14.



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Fig. 15

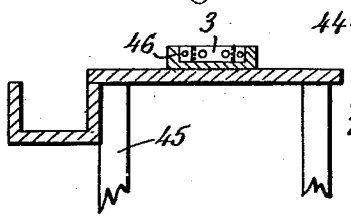


Fig. 16

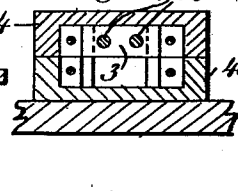


Fig. 17

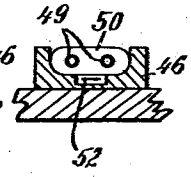


Fig. 18

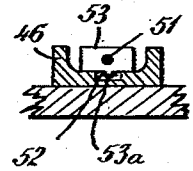


Fig. 19

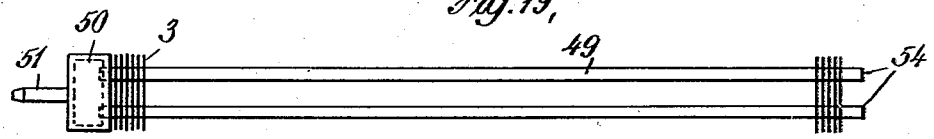


Fig. 20

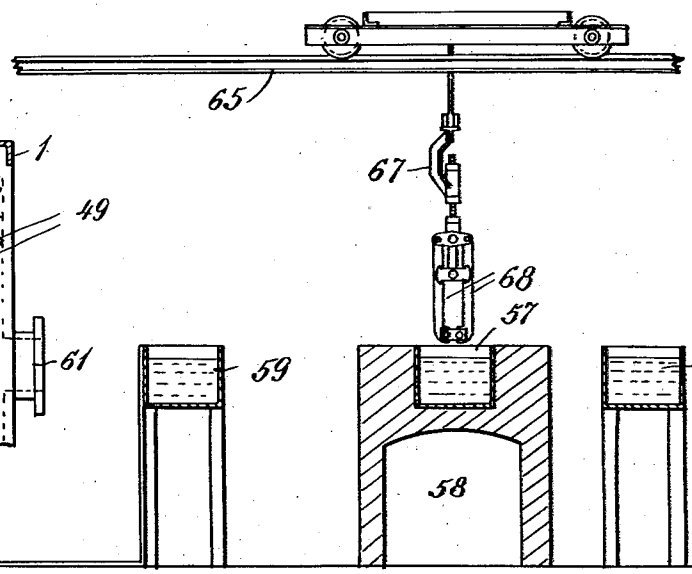


Fig. 22

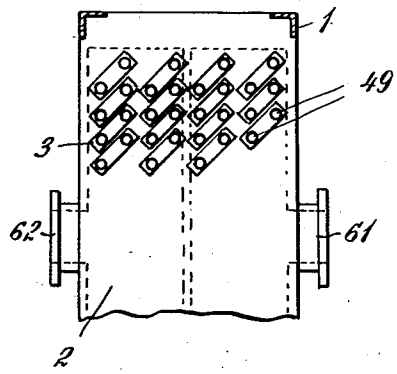
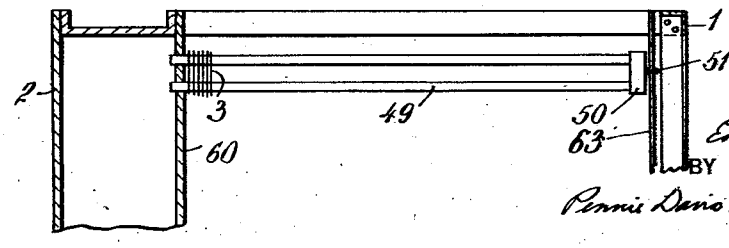


Fig. 21



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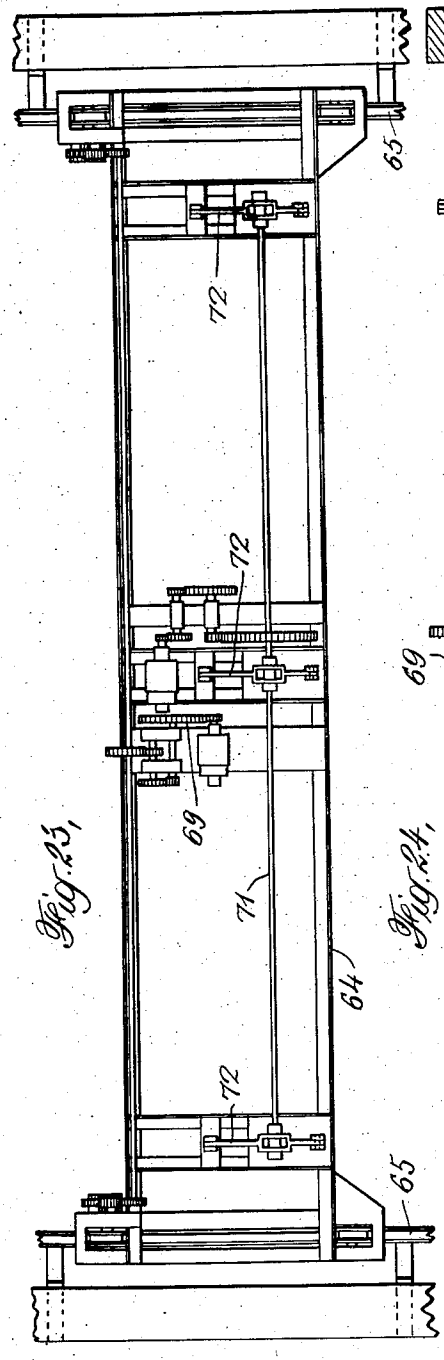


Fig. 23.

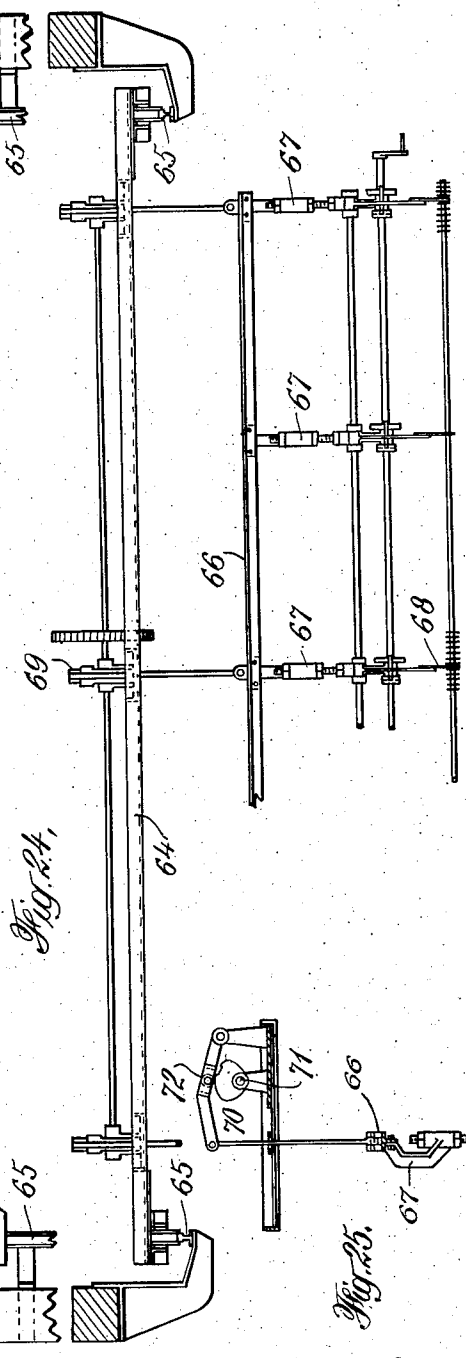


Fig. 24.

Fig. 25.

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UNITED STATES PATENT OFFICE.

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METHOD OF MAKING FIN-TUBE HEAT EXCHANGERS.

Application filed May 24, 1924. Serial No. 715,666.

The present invention relates to heat exchangers and has to do particularly with heat exchangers wherein one of the heat transferring fluids is a gas such as, for instance, air. More specifically this application relates to a method and apparatus for making in a commercial way heat exchangers of the type disclosed in the co-pending application of Joseph Price, Serial No. 645,735 filed June 16, 1923, and assigned to the assignee of this application.

Air is a notoriously poor heat conductor. Probably the greatest demand for air heat exchangers arises in connection with ventilating and cooling electric motors and generators. The former practice in cooling apparatus of this character was merely to provide for an ample circulation of air through the windings of the machine. No attempt was made to utilize this cooling air repeatedly or to subject it to any systematic means of cooling after its issuance from the windings. It is only in recent years that air coolers adapted for use in this connection have come into general commercial use. Some of these coolers have simply assumed the form of a casing traversed by a plurality of smooth surfaced water conducting tubes, the device being arranged in a closed circuit with the motor or generator so that the heated air issuing from the windings of the machine may come into contact with and circulate around the tubes of the cooler. Cold water is passed thru the tubes and serves as the cooling medium for the heat exchanger. Coolers of this type are invariably of large bulk and weight if effective cooling is secured. This difficulty arises from the poor heat conducting qualities of the medium being cooled, namely, air. To obviate this disadvantage it has been proposed to increase the heat transferring surface in the apparatus by providing the cooling tubes with ribs or fins secured in heat conducting relation to the metal of the tubes. These fins have assumed various forms. For instance, helical ribs proceeding from end to end of the tube and extending out at right angles to its axis have been provided. It has also been proposed to employ square fins, each fin having a centrally located hole by means of which it is slipped over the tube, the individual fins being then soldered or otherwise secured to the tube. Air heat exchangers of cast metal have also frequently been used, particularly in such fields as building heating and the like.

The endeavor in developing a heat interchanger for the heating or cooling of air is to provide a maximum area of heat transferring surface per unit volume of apparatus. The best class of cast metal apparatus of this type which is at present on the market, presents a maximum of about 18 square feet of heating surface per cubic foot of volume of apparatus. For this reason cast elements are exceedingly bulky and heavy compared to the amount of heat transfer which they actually effect. The fin tube type of cooler above mentioned employing square or spiral fins overcomes to some extent the difficulties inherent in an apparatus wherein the heat transferring surfaces are of cast iron or similarly formed material, but these fin tube coolers are open to certain objections, notable among which may be mentioned the extremely high cost of assembling the fins on the tubes and securing them in place and the usually inferior heat transferring union which can be produced between the fins and the metal of the tubes with methods which are at all commercially practicable. The completed apparatus of the above mentioned co-pending application has solved the operational difficulties such as poor heat transfer between tube and fins, vibration of the tube elements and the like which have heretofore been present in fin tube heat exchangers. With this apparatus it has also been possible to produce an efficiency operating air heat interchanger having as high as 88 sq. ft. of active heat transferring surface per cubic foot of volume of apparatus. In this apparatus, the heat transferring fins lie closely spaced in parallel relationship and the air traversing the apparatus is filmed into repeated and intimate contact with the fins.

It is a principal object of this invention to provide a satisfactory method of producing on a commercial scale an air heat exchanger having the advantages just described by means of which the apparatus may be produced at an entirely reasonable cost. In attaining this end the manufacture of the cooling fins has been facilitated and the cost of raw material has been reduced by feeding the raw material to the fin forming machine

as a continuous ribbon, and after the tube holes are punched out of the fins, shearing off the successive fins without waste of material. With this scheme the overall dimension of the finished fin is identical with the width of the initial ribbon and makes possible a considerable saving in material over the usual die stamping process wherein it is necessary to leave a marginal strip of metal of at least 1/8 inch. This advantage has been made possible by the special construction of the fin forming die and by the manner in which the raw material is fed and supported while it is being subjected to the action of the die.

It is also an object of the invention to provide for forming an ample contact area between the fin and the metal of the tube and to establish at this point a joint which is satisfactory in a mechanical sense and which also furnishes a good heat conducting path for transferring heat between the fluid in the tube and the air circulating about the fins. This connection or joint is accomplished in a speedy and inexpensive fashion and entirely avoids the difficulties heretofore encountered, such as inadequate heat transfer between the tube and the fin.

The invention also provides a novel means for spacing the fins on the tubes of the heat exchanger and for accomplishing the assembly of the fins in position on the tubes. These operations are accomplished without the necessity of individually placing each fin on the tube by manual means and for this reason are instrumental in greatly reducing the ultimate cost of the finished apparatus.

All of the above enumerated objects relate to the same idea, namely the provision of a commercially practical economical and speedy method together with suitable apparatus therefor, of evolving out of the raw material a heat exchanger possessing the characteristics and advantages above mentioned. The raw material is utilized with practically no waste, each fin is completely formed in but a fraction of a second, the fins are collected as they are made and are threaded upon the tubes and spaced by rapid and inexpensive methods, a large area of contact between the fin and the tube is provided, and a good heat transferring connection is established at this point. All of these steps are accomplished in a continuous process with relatively simple and inexpensive apparatus which requires but little manual attention. After completion the tube elements are compactly assembled into a suitable housing to constitute the finished apparatus.

I have illustrated a preferred embodiment of my invention in the accompanying drawing in which Figure 1 is an elevational view, somewhat diagrammatic, of the apparatus employed to form the fins and to collect and group them after they are made. Figure 1[a] is a detail of a portion of the apparatus of Figure 1. Figure 2 is a plan view of the apparatus shown in Figure 1. Figure 3 is a view illustrating the steps involved in forming the fin from the sheet of raw material. Figures 4 to 7 are detail views showing the character of the fin and the steps involved in its production. Figure 8 is a detail of the support which collects the fins as they are stamped out of the raw material. Figures 9 and 10 are an elevational view and a plan view respectively of the apparatus employed for spacing the fins in proper relation to be assembled on the tubing. Figure 11 is a perspective view showing the holder or retainer employed in connection with the spacing apparatus of Figures 9 and 10. Figure 12 is a perspective view of this retainer with a group of fins held in it. Figure 13 is an elevational view of the assembly table and illustrates the fashion in which the fins are arranged prior to the operation of threading them upon the tubing. Figure 14 is a similar view showing the manner in which the fins are assembled on the tubing. Figures 15 to 18 inclusive are transverse sectional views of the apparatus of Figures 13 and 14 taken respectively on the correspondingly numbered section lines indicated on those figures. Figure 19 illustrates a tubular element with the fins assembled in place upon it. Figure 20 is a diagrammatic view illustrating the apparatus employed in soldering the fins to the tubing. Figures 21 and 22 are partial sectional views taken laterally and transversely of the apparatus, respectively, illustrating the fin tube elements assembled into a completed apparatus. Figures 23 and 24 are plan view and an elevational view respectively of the apparatus for handling the completed elements during the soldering process and Fig. 25 is a detail view of a portion of the mechanism illustrating the mechanism provided for removing excess liquid from the elements after dipping during the soldering process.

The completed heat exchanger of this application as shown in Figures 21 and 22 consists of a frame or housing 1, within which are mounted the fin tube elements. The tubes of each element are interconnected at one end and are supplied with heating or cooling fluid at the other end by means of a suitable header 2. Each element of two tubes is provided throughout its length with a series of closely spaced fins 3 extending in parallelism to the direction of flow of the air thru the apparatus and constituting the greater part of the heat transferring surface. The compactness of the device makes possible an extremely large heat transferring area in an apparatus of given size and weight. The individual fins are best shown in Figures 6 and 7, each fin consisting of a

rectangular sheet 3 of brass or other suitable metal and having formed in it two holes 4 adapted to receive the tubes of the heating element when the fin is assembled into position on the tubing. The holes 4 are not formed by cutting away a portion of the metal of corresponding size and shape, but are formed by first punching in the metal sheet smaller holes of irregular outline, such as indicated at 5 in Figure 4, and then bending over the irregular edges 6, so that they will extend substantially at right angles to the body 3 of the fin and will lie along the tube surface in the finished apparatus and thus furnish an ample heat transferring path between the metal of the tube and the body of the fin. It will be noted that each element of the heat exchanger is rigidly braced by the many fins spanning the two tubes of the element and the resulting structure is rugged and secure.

The fins are formed from the raw material by means of a suitable die 7 operated in a punch press 8 of the ordinary type as shown in Figure 1. The material for forming the fins is supplied in the form of a long strip or ribbon 9 which may be drawn continuously from the supply roll 10 according to the requirements of the apparatus. The die 7 is here shown mounted on the usual reciprocating element of the punch press operated from overhead shafting through a suitable belt 11. The die 7 consists of 3 portions. The portion 12 is the one which acts first on the material of the fin and serves to stamp out of the material the hole of irregular outline, as may be seen from Figures 3 and 4, and also from Figure 5, a plan view of the piece of material 13 which is stamped out. The extremities of the irregularities 14 in the opening thus formed in the material of the fin extend out to such a distance that they lie substantially tangent to a circle representing the cross sectional area of the tube element over which the fin is to be threaded. The tube elements of the heat exchanger of this application each comprise two tubes and it will therefore be understood that the portion 12 on the die is provided in duplicate so that upon each operation of the die, two holes will be punched in the material after the fashion indicated in Figures 3 and 4. The second portion 15 of the die is a cylindrical member having a cylindrical tip 15ª of such dimension that it will pass through the hole 5 punched in the material. The body portion of the projection 15 is cylindrical and is of diameter equal to the outer diameter of the tubing over which the fin is to be threaded. As this projection 15 descends into the punched hole 5 the irregular edges 6 are bent over at right angles to the body of the fin as indicated in Figures 3 and 7. The opening in the fin is now large enough to receive the tube of the heat transferring element and the edges or flanges 6 will extend along the metal of the tube and furnish a large heat transferring surface between the fin and the tube. These bent over irregular pieces of metal also serve a useful function during the soldering of the fins to the tubes, in that they retain the solder along the irregular line which marks their juncture with the metal of the tube and thus provide an extensive and rigid line of union between the fin and the tube.

The remaining portion of the die is the shear knife 16, which, after the holes are punched in the fin, descends upon the material and shears it off to constitute a completed fin as shown in Figures 6 and 7. The shearing of the material is made possible by the particular arrangement of feeding the material which is employed and by the construction of the die itself. The material is preferably sheet brass and may be of such weight as to have a considerable body which will tend to prevent kinking or like deformation during the shearing process. It will also be noted that the projection 15ª on the middle die portion is longer than the shearing knife so that it will have passed thru the opening 5 stamped in the material of the fin before the shear knife comes into action. Likewise at the time the shear knife takes effect the portion 12 of the die will also be in contact with the material. In this manner the sheet of material is held rigidly flat on the die base and the shear knife severs the completed fin from the ribbon of the material without difficulty. This system is in contrast to the usual die stamping systems of this nature wherein the fin would be stamped out of a sheet of material somewhat larger than the maximum dimension of the fin, a quantity of waste metal occuring around the entire margin of the die. The ribbon of raw material is fed under the die by a pair of corrugated rolls 17 acting on opposite sides of the material and operated through a linkage mechanism 18 from the drive shaft of the punch press. The rolls are designed to advance the material a distance equal to the width of the fin at each operation of the die. From the above description it will be noted that after operation is begun, the process is entirely continuous and a complete fin is turned out at each reciprocation of the die.

After the fin is formed under the die 7, it proceeds down the chute 19 and is received on a support consisting of a pair of upstanding rods 20 and a suitable base 21 as shown in detail in Figure 8. The two holes in the fin are centered over the tips of the support rods 20 by reason of a stop 22 provided at the end of the chute 19, which causes the fin to come to rest in flatwise position directly over the receiving support. Referring particularly to Figure 1ª,

retaining members 23 are provided to prevent the fin from dropping through the chute, and these members are periodically released through the action of a cam lever 24 and cooperating cams 25. The lever is operated from the mechanism of the punch press and at each reciprocation of the die it rises, sliding along the surfaces of cam 25, thus forcing them apart and causing retaining members 23 to pivot outwardly whereupon the fin which is retained by them drops down upon the supporting rods 20 and is there retained. A spring 26 serves to bring the retaining members 23 back into operative position, and accordingly cams 25 move lever 24 downwardly and return it to its original position. It will be understood that this arrangement is provided merely for the purpose of insuring that the fins will come to rest in proper position at the end of the chute and will be properly threaded over the supporting rods 20. It is possible to eliminate the retaining members 23 and their actuating mechanism and merely provide at the end of the chute an opening of substantially the same size as the fin together with a suitable stop 22. When this arrangement is employed, we have found, however, that a fin occasionally drops through in other than flatwise position and is therefore apt to thread over only one of the supporting rods 20 or to drop through without being threaded on the supports at all.

The supporting rods 20 are extended below the piece 21 as indicated at 20^a in Figure 8. These projections 20^a fit into corresponding sockets in a rotary carriage 27 (Figure 1), the various supports being mounted in circular conformation around the carriage as best shown in Figure 2. When a sufficient number of fins has been collected on one of the supports, the carriage 27 is rotated so that a fresh support is brought beneath the retaining members 23 of the chute. The filled support may then be removed bodily from the carriage with the group of fins which it carries. Rotation of the carriage 27 at the proper time may be accomplished manually or it may be accomplished automatically by some such arrangement as here shown in Figure 2. The periphery of the carriage 27 is provided with a series of ratchet teeth 28 which engage with the ratchet 29. A worm 30 is provided to operate in timed relation with the punch press through a chain and sprocket drive 31. This worm 30 operates a worm wheel 32 which carries a cam 33 acting in turn on a plunger 34 upon which is mounted the ratchet 29. The ratchet 29 is spring pressed against the ratchet teeth and when the plunger 34 has been moved along longitudinally against the action of spring 35 a sufficient distance, the ratchet 29 will engage over the working edge of one of the ratchet teeth 28. At about this point cam 33 rotates out of engagement with the plunger rod 34 and the recoil of the spring 35 immediately returns rod 34 to its original position and in so doing rotates the carriage 27 circumferentially a distance of one ratchet tooth. This amount of rotation is just sufficient to bring a fresh support 21 underneath the end of the chute 19 as will be evident from the fact that each of the ratchet teeth 28 occupy circumferentially the same arc as does each of the detachable supports. The timed drive relation between the punch press and the ratchet actuating mechanism makes it possible to secure a rotation of the carriage 27 after a predetermined number of fins have been stamped out. This number will ordinarily be such that one support will be substantially filled to capacity at the time a fresh support is brought into action.

The fins collected upon the supporting rods 20 will be spaced apart somewhat due to the irregular portions 6 of the metal which are bent over at right angles to the body of the fin. The length of these projections 6 is approximately equal to the space allowed between successive fins in the completed apparatus for the reason that for purposes of good heat conduction it is desirable to have these portions 6 in intimate contact with the metal of the tubing over as great a length as is possible. It is desirable, however, to effect a further positive spacing of the fins after they are collected on the supports 20. The object of this is to produce a perfectly uniform spacing of the fins so that the completed article will present a finished appearance and will operate with the greatest effectiveness. A further purpose of spacing the fins is to provide a means for holding them securely in properly spaced relation while the tubing is inserted to form the completed heat transferring element.

For effecting the desired spacing of the fins, I have provided the apparatus shown in Figures 9 and 10 which consists essentially of a plurality of parallel guide-ways spaced apart a distance equal to the desired spacing of the fins. The spacing apparatus consists of a suitable frame 36 in whose sides are formed grooves 38, the tongues 37 serving as supports for the fins held in the apparatus. These grooves and tongues extend widthwise of the apparatus after the fashion shown in Figures 10 and 11. The entrance ways to these slots or guideways in the spacing apparatus recede in the direction of movement of the fins as they are introduced into the slots. This construction is illustrated in Figure 9. In this figure, 39 indicates a pair of supporting rods carrying a group of fins 3. The base 40 of the

fin support is mounted in a suitable guideway provided in the body member 36 of the spacing apparatus. A rod or handle 41 is associated with the fin support. By grasping the handle 41 and exerting a pull upon it, the operator may slide the fin support base 40 along the guideway in the member 36 and thus move the fin support to the rear of the spacing apparatus into the position indicated in dotted lines 42. When the fin support with its group of fins is moved along the spacing apparatus 36 in the fashion just described, the fins carried on the support will enter the respective guideways and will thus be properly spaced. The entrance to each guideway is tapered as indicated at 43, so that the front face of the spacing apparatus lies in a plane at an angle to the vertical. As the movement of the fin support 40 begins, the lowermost of the fins is introduced into the lowermost guideway of the spacing apparatus. As the movement of the fin support continues, the next lowermost fin enters the second lowest guideway on the apparatus and in this fashion the entire group of fins is spaced and each fin is introduced to its proper guideway as the fin support is pulled along toward the rear of the spacing apparatus. In case the fin does not lie in exact alignment with the guideway which is to receive it, the slanted face 43 of the guideway will serve as an entrance guide for the fin and will pilot it properly into place.

With this apparatus the spacing of a group of fins is accomplished in a fraction of a second. It is merely necessary for the operator to pull back the handle 41 with a rapid movement and the entire group of fins will be properly spaced and located in the respective guideways of the apparatus. The supporting rods 39 are similar to the supporting rods 20 which receive the fins as they issue from the die. In fact, if desired. the supports 20 may be so constructed that they may be placed in the spacing apparatus to there serve as supports for the fins during the spacing operation. As here shown, however, the fins must be transferred from the supports 20 to the supports 39. This may readily be accomplished by merely inverting the support 20 with the ends of the rods in contact with the upper ends of rods 39 whereupon the fins will slide down onto the supporting rods 39 in orderly fashion, after which the spacing operation may be accomplished.

The rear of the spacing apparatus 36 is shaped to receive a holder or retainer 44, shown in detail in Figure 11 in which are milled receiving slots 38 which are in register with the guideways of the spacing apparatus when the retainer 44 is in position on the spacing apparatus as indicated in Figures 9 and 10. The extent of the movement which it is possible to impart to the fin support 40 and its actuating rod 41 is therefore limited by the presence of the retainer 44. The fin support may be moved throughout the length of the spacing apparatus until the fins issue from the guideways of the apparatus and enter the slots 38 of the retainer 44. The retainer with its contained fins is then removed from the spacing apparatus, as shown in Figure 12, holding the fins in properly spaced relation for assembly on the tubing.

To accomplish the assembly of the fins on the tubing in a speedy and effective manner, I have provided the apparatus shown in Figures 13 to 18 which comprises essentially a table mounted on suitable supports 45 and having a top portion 46 built up of laminations constituting properly spaced grooves to receive the fins, after the fashion of the retainer 44. The table top 46 is of length sufficient to accommodate the entire fin tube element, and the fins are arranged in the grooves along the table top until a sufficient number of them have been accumulated to constitute a complete element. The grooves in the table top 46 are of the same spacing as those in the retainer 44 and the fins contained in the retainer 44 may be conveniently transferred to the grooves in the table top by merely laying the retainer 44 with its contained fins face downward upon the table top in register with the grooves therein. This operation is best accomplished as shown in Figures 13 and 16 by means of a tool having a handle 47 and having a pair of extension rods 48 which may be inserted through the holes in the fins. This tool is inserted thru the fins in the retainer 44 whereupon the retainer is inverted and laid face downward upon the table top 46 in the position shown in Figure 13. The arrangement of parts at this stage of the assembly is shown in Figure 16. The tool 48 is then lowered whereupon the fins contained in the retainer 44 will drop into the corresponding slots in the table top 46. Handle 47 is then withdrawn. This operation is repeated until a sufficient number of fins have been laid in the table top. The fins after being lowered into the grooves in the table top 46 lie in the relation shown in Figure 15.

Before being threaded thru the fins the tubular element 49 consists of a pair of tubes interconnected at one end by a chambered connection 50, as shown in Figure 19. The connection 50 may conveniently be made of cast metal and is provided with an extension 51 intended to fit into the supporting plate 63 (Figure 21) when the element is assembled in the completed heat exchanger. This furnishes a support for one end of the heating element and makes for rigidity of construction. The tubular element 49 is laid along the table top 46 on the left hand por-

tion thereof in the fashion shown in elevation in Figure 14 and in cross section in Figures 17 and 18. A removable driving member 53 comprising a rectangular block (see Figs. 14 and 18) having a longitudinal aperture therein is applied to the connection 50, the projection 51 of the connection being received within the aperture of the driving member. An endless drive chain 52 operated by a suitable power source engages lugs 53ª provided on the driving member 53 (see Fig. 14) and thus propels the tubular element along the table top toward the right so that the open ends 54 of the tubes will be forced thru the openings in the group of fins already assembled on the table top. The tubular element is propelled along the table top in this fashion threading itself thru the fins as it goes. At the termination of its movement the tubular element will have been threaded through all of the fins assembled on the table top and since the fins have been held in properly spaced relation they will be properly spaced upon the tube. The fin tube element is taken from the table, the driving member 53 being removed from projection 51 and applied to the next tubular element to be received upon table 46. The fin tube is then subjected to a solder bath for the purpose of effecting a good heat conducting contact between the metal of the fin and the tubing and at the same time affording a rigid mechanical connection between these parts. This operation may best be accomplished by an arrangement such as that shown in Figure 20 wherein the tubular element 49 with its assembled fins 3 is supported by a light derrick 55 arranged to accommodate the necessary horizontal travel and also adapted to lower the tube element into the bath and lift it out again when the treatment has been completed. In this figure, 56 indicates the acid bath in which the tube element is immersed before its treatment in the solder bath. The solder bath is indicated at 57 mounted over a suitable furnace 58 by means of which the desired temperature of the bath is maintained. The tube element is first immersed in the acid bath 56 and is then transferred immediately to the solder bath 57 in which it is left for a length of time sufficient to permit a thorough coating of the fins with solder and to permit the solder to thoroughly fill in the interstices between the fins and the tubing. The element is then removed from the solder bath and is immersed in the cooling water bath 59 whereupon it is ready for assembly in the heat exchanger. It will be understood that during the treatment in the various baths suitable precautions are taken to avoid entrance of liquid into the interior of the tube element. After the element is withdrawn from these baths, and particularly after withdrawal from the acid bath and from the solder bath, it is desirable that the excess liquid be removed from the element.

The apparatus for handling the tube elements at this stage of the process is shown in detail in Figures 23 to 25. A horizontal frame work 64 is provided movable on suitable tracks 65. Suspended from the frame work 64 is a hanger support 66 from which depends hangers 67 each hanger carrying at its lower end a pair of pivoted arms 68 designed to engage with and support the tubular element in the fashion shown in Figures 20, 24 and 25. The hanger support 66 is attached to frame work 64 through mechanism indicated generally by numeral 69 now to be described, and which is arranged to raise and lower the hanger support 66, and also to impart a vertical shaking motion thereto when desired. Eccentrically mounted cams 70 driven by a shaft 71 constituting a part of the mechanism 69 engage pivoted arms 72 from the outer ends of which the hanger support 66 is directly suspended by rods. In the position shown in Fig. 25 the cams 70 have raised hanger support 66, pivoted arms 68 and the tubular element 49 supported thereby, so that this element is elevated above the baths. When the cams 70 are rotated 180° from the position shown in Fig. 25 the hanger support 66 will be thereby lowered a considerable distance so as to dip the tubular element below the surface of the baths. It will be noted that in the upper portion of each of cams 70 (see Fig. 25) there is a small depression which is provided for the purpose of imparting the vertical shaking motion. This is accomplished by oscillating cams 70 back and forth which causes hanger support 66 to be given a violent vertical motion by means of these depressions, and this effectively shakes off from the tubular element any excess liquid or solder which might otherwise remain on the element after immersion in the baths.

The construction of the completed heat exchanger is shown in Figures 21 and 22. The open ends of the tube elements enter a tube sheet 60 and the header 2 is provided with partitions arranged in such fashion that cooling or heating liquid passes through one tube of each element in one direction and returns along the length of the apparatus through the other tube. An inlet opening 61 and an outlet opening 62 are provided on the header 2. The projection 51 at the interconnected ends of the tube elements are supported in holes provided in a supporting plate 63. The elements are preferably mounted so that they are rotated about their longitudinal axes about 45° as shown in Figure 22. This arrangement has the effect of presenting the tubes in staggered relation to the direction of flow of air through the apparatus. The compactness of the appa-

ratus is to be noted. With this arrangement a much greater area of heat transferring surface is presented per cubic foot of volume of apparatus than has heretofore been possible in heat interchangers of this general class.

From the above description it is evident that the entire method of producing this heat exchanger may be carried out rapidly and as a continuous process. The resulting apparatus is refined in appearance, the fins are uniformly spaced throughout the apparatus, and an immense amount of heat transferring surface is presented in the form of fins assembled in closely adjacent relation, so that the air traversing the apparatus will be filmed repeatedly into contact with the surfaces. All special apparatus which is required is simple and inexpensive. The punch press for stamping out the fins and the handling apparatus for treating the fin tube elements in the various baths are in general features both of the ordinary type found in machine shops. The operation of the punch press is rapid and a battery of 2 or 3 of these machines will turn out many thousand fins per day. Particularly rapid is the assembly of the fins on the tubing. One of the chief items of expense in the construction of fin tubing has heretofore been the enormous labor cost involved in threading the fins upon the tubing and effecting a proper union between each fin and the tubing. The present process entirely overcomes these difficulties and reduces the assembly cost to an amount which is entirely practicable in commercial applications. In short, the disclosure of the present application provides a method and apparatus for making fin tube heat exchangers of the class described which is an entirely practical commercial proposition and is productive of highly effective heat exchangers at a cost well within commercial limits. The process described in this application applies equally well to the manufacture of fin tube elements containing more than two tubes. For such elements, each fin would be provided with a number of holes corresponding to the number of tubes in the element and the entire process carried out in the manner above described.

I claim:

1. The method of making fin tubing which comprises stamping the individual fins out of the raw material, collecting and assembling said fins in closely adjacent relation as they are stamped out, and then threading the collected and assembled fins in proper relation as a unit upon the tubing.

2. The method of making fin tubing which comprises stamping the individual fins out of the raw material by means of a suitable die, collecting and assembling said fins into closely adjacent relation as they are stamped out, spacing at a single operation the fins so collected and assembled and threading the fins as a unit upon the tubing at a single operation.

3. The method of making fin tubing which comprises stamping the individual fins out of the raw material, grouping said fins in properly spaced relation for assembly on the tubing, threading said group of fins as a unit upon the tubing, and then treating the tubing with the spaced fins thereon to effect a joint of good heat conducting properties between each fin and the body of the tubing.

4. The method of making fin tubing which comprises stamping the individual fins out of the raw material, grouping said fins in properly spaced relation for assembly on the tubing, threading said group of fins as a unit upon the tubing, and then subjecting the tubing with the fins thereon to a solder bath to thereby effect a joint of rigid mechanical properties and of good heat conducting properties between each fin and the tubing.

5. The method of making fin tubing which comprises forming in a ribbon of raw material of suitable width openings corresponding in number with the number of tubes to be passed thru the fin and of area less than the cross-sectional area of the tubing, enlarging the respective openings to substantially the size and shape of the cross-section of said tubing by bending aside the excess material adjacent the opening, shearing off from the ribbon of material the portion containing said openings to thereby complete the fin, collecting said fins as they are formed, grouping the fins in properly spaced relation for assembly on the tubes, threading the tubing thru said group of fins, and then treating the tubing with the spaced fins thereon to effect a joint of good heat conducting properties between each fin and the body of the tubing.

6. The method of making fin tubing which comprises stamping the individual fins out of the raw material, continuously collecting said fins as they are formed and maintaining them in groups of substantially equal number, spacing the fins of each of said groups in proper relation for assembly on the tubing, placing a plurality of said groups of spaced fins in adjacent relation end to end and then threading the tubing thru all of said spaced fins at a single operation.

7. The method of making fin tubing which comprises stamping the individual fins out of the raw material, continuously collecting said fins as they are formed and maintaining them in groups of substantially equal number, spacing the fins of each group in proper relation for assembly on the tubing, placing a plurality of said groups of spaced fins in a holder which maintains each fin in properly

spaced relation with adjacent fins, then inserting the tubing through said fins while so held in properly spaced relation, and then treating the tubing with the fins thereon to effect a joint of good heat conducting properties and rigid mechanical properties between each fin and the body of the tubing.

8. The method of making fin tubing which comprises stamping the individual fins out of the raw material, continuously collecting and grouping said fins in closely adjacent relation as they are formed, spacing the groups of fins thus collected by introducing them into a plurality of spaced guideways, removing the spaced fins from the guideways in properly spaced relation, thereupon introducing the tubing thru the holes in said fins without disturbing the spacing of the fins, and then treating the tubing with the spaced fins thereon to effect a joint of good heat conducting properties between each fin and the body of the tubing.

9. The method of making fin tubing which comprises stamping the individual fins out of the raw material, continuously collecting said fins in closely adjacent relation on a bodily movable support, removing said support after a predetermined number of fins have collected thereon, spacing the fins so collected by moving them into a plurality of parallel guideways having successively receding entrance ways whereby the respective fins enter said guideways successively and the entire group of fins is spaced by a single movement of the fins along said guideways, removing the fins from said guideways in properly spaced relation, introducing the tubing into said fins without disturbing the spaced relation thereof, and then treating the tubing with the spaced fins thereon to effect a joint of good heat conducting properties between each fin and the body of the tubing.

10. The method of making fin tubing which comprises forming in a ribbon of material of width identical with a dimension of the finished fin, a plurality of openings of area less than the cross-sectional area of the tubing intended to be passed therethru, enlarging said openings to substantially the size and shape of the cross-section of said tubing by bending aside the excess material adjacent the openings, shearing off from the ribbon of material the portion containing said opening to thereby complete the fin, continuously collecting said completed fins in closely adjacent relation on a bodily movable support, removing said support after a predetermined number of fins have collected thereon, spacing the fins so collected by moving them into a plurality of parallel guideways having successively receding entrance ways whereby the respective fins enter said guideways successively and the entire group of fins is spaced by a single movement of the fins along said guideways, removing the fins from said guideways in properly spaced relation, and placing a number of such groups of fins in adjacent relation in a retainer adapted to maintain said fins properly spaced and threading the tubing thru said fins while supported in the retainer.

11. The method of making fin tubing which comprises forming in a ribbon of material of width identical with a dimension of the finished fin a plurality of openings of area less than the cross-sectional area of the tubing intended to be passed therethru, enlarging said openings to substantially the size and shape of the cross-section of said tubing by bending aside the excess material adjacent the openings, shearing off from the ribbon of material the portion containing said openings to thereby complete the fin, continuously collecting said completed fins in closely related relation on a bodily movable support, removing said support after a predetermined number of fins have collected thereon, spacing the fins so collected by moving them into a plurality of parallel guideways having successively receding entrance ways whereby the respective fins enter said guideways successively and the entire group of fins is spaced by a single movement of the fins along said guideways, removing the fins from said guideways in properly spaced relation, placing a number of such groups of fins in adjacent relation in a retainer adapted to maintain said fins properly spaced, threading the tubing thru the fins while supported in said retainer then dipping the fin tube elements thus formed in a suitable solder bath to effect a suitable mechanical and thermal connection between each fin and the tubing, and then assembling the completed elements in compact relation to constitute a completed heat exchanger.

12. The method of making fin tubing which comprises forming in a ribbon of material of width identical with a dimension of the finished fin, a plurality of openings of area less than the cross-sectional area of the tubing intended to be passed therethru, enlarging said openings to substantially the size and shape of the cross-section of said tubing by bending aside the excess material adjacent the openings, shearing off from the ribbon of material the portion containing said openings to thereby complete the fin, continuously collecting said completed fins in closely adjacent relation on a bodily movable support, removing said support after a predetermined number of fins have collected thereon, spacing the fins so collected by moving them into a plurality of parallel guideways having succes-

sively receding entrance ways whereby the respective fins enter said guideways successively and the entire group of fins is spaced by a single movement of the fins along said guideways, removing the fins from said guideways in properly spaced relation, placing a number of such groups of fins in adjacent relation in a retainer adapted to maintain said fins properly spaced, threading the tubing thru the fins while supported in said retainer then dipping the fin tube elements thus formed in a suitable solder bath to effect a suitable mechanical and thermal connection between each fin and the tubing violently shaking the tube element to remove excess solder therefrom and then assembling the completed elements in compact relation to constitute a completed heat exchanger.

13. The method of making fin tubing which comprises stamping the individual fins out of the raw material, grouping said fins in properly spaced relation for assembly on the tubing, threading said group of fins as a unit upon the tubing, dipping the assembled unit successively in an acid bath, a solder bath, and a cooling bath and violently shaking the unit bodily after an immersion in the solder bath to remove excess solder therefrom.

In testimony whereof I affix my signature.

EDWARD A. DEWALD.