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B. BURNS ET AL

1,896,286

BURNER PLATE

Filed Jan. 23, 1929

Fig. 1.

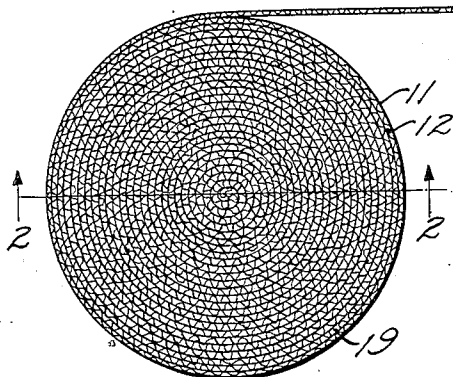


Fig. 1A.



Fig. 2.

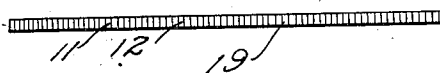


Fig. 4.

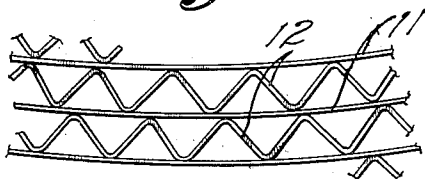


Fig. 5.

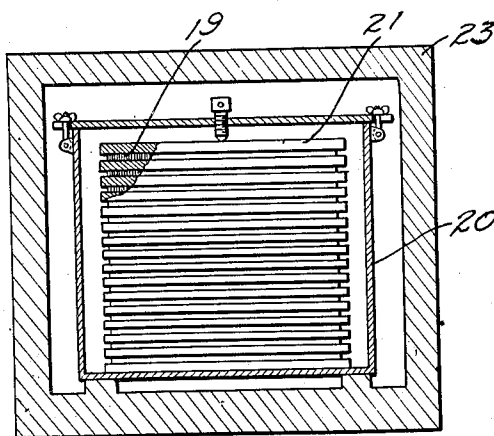
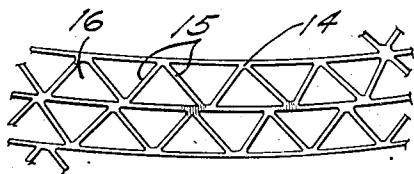


Fig. 3.



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BURNER PLATE

Application filed January 23, 1929. Serial No. 334,588.

This invention relates to burner plates and their manufacture.

One of the objects of the invention is to provide a burner plate which is proof against flashback which is the burning of the combustible mixture back through the burner plate to the high-pressure side of the burner plate.

Our invention provides a new type of burner plate operating upon what we believe to be an entirely new principle and producing a new and distinctive result. We have found through experimentation that a gas mixture of proportions proper for complete combustion exhibits in its flame certain phenomena which are closely analogous to those of surface tension in liquids. We have found that when the openings through a burner plate are made very small the flame manifests great reluctance to enter these openings, and when the openings are made sufficiently small the flame will be invariably extinguished without penetrating below the surface of the burner plate. This characteristic is quite independent of the cooling effect which the plate has on the flame.

To prove this we have constructed and tested burner plates which were so arranged that it was impossible for them to dissipate heat absorbed from the flame. The burner plate was raised to a red heat as the zone of combustion drew closer and closer, but the flame was invariably extinguished at the surface of the burner plate upon any attempt of the flame to force its way through.

A further object of our invention is to provide a burner plate having openings of such a small size that a flame is extremely reluctant even in entering the mouths of the openings.

A still further object of the invention is to provide a burner plate in which the minute openings are so closely spaced that the open area of the burner is sufficient to equal or exceed the open area of the average burner.

It is another object of our invention to provide a burner plate which will intimately mix the combustible and the combustion-supporting gases when they pass there-
through.

It is a further object of our invention to provide a burner plate in which the adjacent walls of the openings are welded together to form an integral construction.

In the following description we shall point out other objects of the invention and the important advantages achieved.

For the purpose of illustrating the invention, the accompanying drawing which illustrates one form of burner plate, will be referred to.

At this time we wish to emphasize the fact that the invention is based upon a new principle which may be embodied in different specific forms. In choosing the form of the invention illustrated, we do not wish to place any limitations on the invention, but wish it to be interpreted in the light of the claims appended to the description.

Referring to the drawing:

Fig. 1 is a plan view of a preferred form of burner plate of our invention.

Fig. 1A is an enlarged plan view of a portion of the burner plate of our invention.

Fig. 2 is a cross-section taken as indicated by the line 2—2 of Fig. 1.

Fig. 3 is an enlarged fragmentary section showing the manner in which the metal pieces are molecularly united.

Fig. 4 is an enlarged fragmentary view similar to Fig. 3 but showing the pieces in assembled position but before they are molecularly united.

Fig. 5 is an elevational view illustrating a step in the process of manufacturing the preferred form of burner plate illustrated herein.

Referring to the drawing in detail the burner plate is composed of two metal members. The metal member 11 is a flat strip, and the member 12 is a corrugated or crimped strip. In the form of the invention illustrated the metal strips 11 and 12 are about two-thousandths of an inch thick and about one-fourth of an inch wide; they are preferably formed of white nickel but it should be understood that other metals having suitable characteristics, as will be pointed out hereinafter, may be used if desired. The

strips 11 and 12 are coiled, as illustrated in Fig. 1, in clock-spring fashion.

As illustrated in Fig. 3 the windings of the corrugated strip 12 are separated by windings of the flat strip 11. The burner plate, therefore, consists of alternate layers of corrugated and flat strips. The corrugated and flat strips adjacently arranged contact each other at the crests or bends of the corrugated strip 12 as indicated at 14 in Fig. 3. At the points 14 the strips 11 and 12 are united together in a suitable manner. Although various uniting means may be used we prefer to molecularly unite the strips together as shown. This manner is preferred because a much stronger and better burner plate may be provided. The sides 15 of the corrugated strip 12 cooperate with the flat strip 11 to provide openings 16 of substantially triangular cross-section. By reshaping either the strip 11 or the strip 12 openings having other shapes of cross-section may be provided. Such changes as this fall within the scope of our invention.

The openings 16 of the burner plate being very minute cannot be exactly produced in the drawing. We have, however, in actual practice produced a burner plate which has an average of 2500 holes to the square inch and which is over 70% open. The area of cross-section of each of the openings in this plate is less than one twenty-five hundredth of a square inch. The large relative opening of the plate permits a burning of large quantities of fuel at a high rate in a combustion chamber of small volume.

In experimentation, to ascertain the results obtainable by the burner plate, we have burned 120 pounds of gasoline per hour in a space eleven inches in diameter and two feet long, giving a combustion rate of over 90 pounds of fuel per hour per cubic foot of combustion space. On the other hand, the ability of the burner plate because of the characteristics of the openings in preventing flashbacks permits us to reduce the rate of combustion to a very low figure. The same plate mentioned above will operate indefinitely at a rate of less than five pounds of fuel per hour even where the surface temperature may be as high as 1500° F. and the mixture velocities through the openings of the plate less than 1½% of the velocity of flame propagation. With the plate operating under the unfavorable conditions last cited, we have artificially produced in the combustion chamber explosions developing excessive pressure, but the plate still effectually extinguishes the flame which the force of the explosion tends to push back through the openings of the burner plate.

It is of primary importance that the openings 16 be many times longer than they are wide. In practice we find that openings which are twenty times as long as one side of

a square having the same area as the cross-section of the opening is a very satisfactory proportion. It is, of course, possible to vary these proportions according to any differences of fuel according to the exigencies of the occasion without departing from the invention.

The sizes which the openings may be and still prevent the flame from entering have not been definitely determined, but the invention includes any burner plate in which the openings are of such a small size that the flame will not enter them. In actual practice it is preferable to have the area of each opening not more than one seven-hundredth of a square inch.

The burner plate, just described, and also other burner plates constructed according to the principle herein disclosed will have a large capacity. This is due to the fact that 70% of the burner plate is open. In view of the large capacity a large volume and consequently a great intensity of heat may be procured in a combustion chamber. The burner plate of the invention also has a low capacity. It is possible to shut the burner down so that it will burn but a small amount of gas.

As pointed out heretofore the flow of gas may be cut down so that it is only 1½% of the flame propagation. This feature of the invention is extremely important and evolves from the smallness of the openings employed. The combustion will be very complete as a result of an intimate mixture of the combustible gas and the combustion-supporting gas which takes place in the long openings of small area of cross-section.

The burner plate of our invention may be very economically produced by the method which will now be described.

After the strips 11 and 12 have been wound in clock-spring fashion as illustrated in Fig. 1, the two strips 11 and 12 are in contact as illustrated in Fig. 4, but are not molecularly united together as illustrated in Fig. 3. Since this structure consisting of the two ribbons merely wound together would be lacking in strength and stability, it is necessary that some means be employed to weld or form a molecular union between the ribbons at their multitudinous points of contact. It was readily realized that while it may have been theoretically possible to weld the ribbons at each individual point of contact, as they were wound together, in practice such a procedure would not only be prohibitive in cost, but also exceedingly difficult if not impossible of accomplishment with the ordinary welding methods and without burning the exceedingly thin nickel ribbons by the direct action of a welding flame.

To weld the ribbons after being wound together, by the use of a welding flame, would also be prohibitive for the same reasons and

also would be impossible since a welding flame could not be projected into the very fine openings 16 which are small enough to extinguish any flame.

5 These considerations led to the employment of the present process which not only forms a perfect welding bond between the two ribbons (as indicated at 14 in Fig. 3) but also effects a change in the quality of the ribbons; that is, in the example now being described in which iron is used as a welding metal, the iron combines with the nickel to change the nickel ribbons to an iron nickel alloy of great tensile strength, thus greatly increasing the strength and stability of the structure.

As shown in Fig. 5, one or more burner plates, which we will designate by the numeral 19, are placed in a closed container 20 between plates 21. These plates 21 are iron plates which have been pickled. By "pickling" we mean steeped in an acid bath. In carrying out the process according to the example now being described, we find it satisfactory to prepare the iron plates 21, which are preferably about half an inch thick, by placing them in a dilute hydrochloric acid solution of about 20%. We specify the plates 21 as being formed of iron, but it should be understood that they may be formed of steel or any other suitable metal, and it should also be understood that any other suitable acid may be employed.

After the burner plates 19 have been placed in the container 20 between the treated plates 21, the top of the container 20 is secured in place to exclude any additional air from entering. The container is thereafter placed in a furnace indicated by the numeral 23 where it is subjected to a high temperature. We have found that a temperature in excess of 1500° F. is desirable, but that a higher temperature approaching the melting point of iron may be used. In actual practice the temperature of 1600° F. may be maintained for a duration of forty-two hours. If a lower temperature is used, which is possible, the duration of time is made longer, and if a higher temperature is used the duration of time is shortened.

10 This heat treatment has the effect of molecularly welding or uniting the nickel strips together at each point of contact and of alloying the welding metal with that of the ribbons to change the nickel ribbons to ribbons of iron-nickel alloy. The result of this process is to produce a homogeneous foraminated unit of maximum strength and stability and having great heat-resisting qualities.

While we are able to advance certain theories which we believe will explain the action which takes place within the bomb or during the carrying out of the process, it is to be understood that we are not certain of the accuracy thereof; therefore, without any desire to limit ourselves and at the same time

disclaiming any inaccuracies of our explanation which may later come to light, we offer an explanation of what we believe to occur.

When the iron plate is subjected to the acid bath, the hydrochloric acid reacts with the iron of the plate to form ferric chloride. The part of the iron which dissolves in the acid to form the ferric chloride is generally that between the fibres of the iron, and after the pickling the iron plate therefore has a porous appearance. Now, on heating the plate together with the nickel ribbons in an enclosure to a high temperature, the ferric chloride, which has been formed between the iron fibres in the iron plate, is vaporized and fills the enclosure. On heating still further, the ferric chloride, in the presence of the nickel ribbons and under the influence of the tendency of iron to enter into solid solution into nickel at this temperature, decomposes and deposits iron on the nickel ribbons, the chlorine being set free. The deposited iron then goes into solid solution, forming with the nickel an iron-nickel alloy, and the free chlorine returns and unites with some of the remaining iron of the iron plate, again forming ferrous chloride which passes over to the nickel ribbons, decomposes, and deposits more iron, at the same time freeing the chlorine. This may suggest the question of why the free chlorine does not attack the iron which has been deposited as easily as it attacks the iron of the plate. Broadly, the explanation of this seems to be that the iron is held by the nickel in solid solution more firmly than the iron is held to itself in the plate.

As will later be explained, our experiments tend to support a theory that this preferential affinity of one material for certain other materials is dependent upon the relative atomic volumes of the materials and probably in many instances also upon the type of their crystal structure.

It has been found that iron can be employed as the welding material only with metals where this preferential affinity predominates in favor of the metals to be welded. For example, iron cannot be deposited on iron, and this is particularly noticeable in the iron welding of nickel ribbons where, after about one hour, almost the same amount of iron is deposited as after many hours of heating. The reason for this is that the iron which is first deposited goes into solid solution, but gradually changes the exterior of the ribbons to more nearly pure iron than pure nickel, until finally almost a pure iron surface is presented to the ferrous chloride. When this situation arises, no more iron will be deposited until the iron which has already been deposited penetrates farther into the nickel, causing the exterior of the ribbons to again be more nearly a nickel-iron alloy. More iron will then be deposited.

The same action can be made to take place

by placing in the bomb with the nickel ribbon, instead of an iron plate, some iron, preferably powdered, and a small amount of ammonium chloride or, in fact, any of many halogen compounds. Taking the case of iron powder and ammonium chloride, the action is as follows:

The ammonium chloride, at a comparatively low temperature, decomposes, forming nitrogen, hydrogen and chlorine. The nitrogen plays no part in the reaction. The hydrogen acts as a reducing agent, keeping the ribbon clean and unoxidized. The chlorine unites with the iron to form ferrous chloride, which is a vapor at the temperature which is employed. This ferrous chloride decomposes near the surface of the nickel ribbon, depositing iron and freeing the chlorine to go back and unite with more iron.

The process continues until an amount of iron is deposited which is entirely independent of the amount of iron put into the bomb originally; that is, the process is not affected by iron which may be in the bomb in excess of the iron actually deposited upon the ribbons, and independent, also, of the amount of chlorine up to the point where all the chlorine may be exhausted through leakage or adsorption. The amount of iron which is deposited is solely dependent upon the nature of the surface on which the deposition takes place, and on the temperature and length of time during which the process is continued. The higher the temperature and longer the time, the farther into the nickel does the iron penetrate, and therefore the more nearly is the surface of the ribbon a nickel surface; hence, the more will be the iron deposited.

The process can also be carried into effect by placing a ribbon to be welded and a small amount of ferric chloride or ferrous chloride in an air-tight closure, and heating as before. Here the action is identical with the exception that after the iron chloride has decomposed, there is no more iron for the freed chlorine to unite with. This is an unfavorable situation as regards welding of thin sheets, because it appears that the chlorine which is freed builds up a pressure great enough to cause considerable absorption of the chlorine by the metal to be welded. If this metal is thin, the result is a decided embrittling effect, so that in some cases the metal can be powdered between the fingers.

This shows the advantage which attaches to the method of welding in which only a small amount of chlorine is present and in which that small amount is used over and over again, so that there is never a high pressure of chlorine in the enclosure.

The process can also be carried out using ammonium bromide, ammonium iodide, ammonium fluoride, or many other compounds containing a halogen. It is advantageous, however, to use the ammonium compounds in-

asmuch as hydrogen is one of the products of dissociation, and the work is then kept clean in the process. This is particularly advisable when dealing with nichrome or any of the chromium alloy ribbons, because even the small amount of oxygen which is in the enclosure originally will cause oxidation of the chromium and this makes impossible a good bond between ribbons.

While the specific example, which is above described in detail, deals with the manufacture of a burner plate which in this specific instance is formed of nickel or nickel alloy ribbons welded together by the employment of iron as the welding material, it is to be understood that we do not wish to be limited in this regard since such example is merely intended as an illustration of one exemplification of the broad scope of the present invention, which is intended to include any burner plate having the characteristics and functional advantages of the specific burner plate herein described.

In actual practice we have found that metals of high atomic volume will deposit on any metal of lower atomic volume but that those of lower atomic volume will not deposit on metals of higher atomic volume. Thus, we find that iron (atomic volume 7.1), if placed in a totally enclosed bomb with nickel (atomic volume 6.7) and suitable chemicals, will deposit on the nickel, but nickel will not deposit on iron since iron has a higher atomic volume than nickel.

We have further found that nickel (atomic volume 6.7) will not deposit on cobalt (6.8), copper (7.15), manganese (7.4), chromium (7.5), zinc (9.1), magnesium (14.0), or tin (16.3), but that any one of these will deposit on nickel which is of lower atomic volume. Also we have found that cobalt (6.8) will not deposit on iron (7.1), copper (7.15), or chromium (7.5); that iron (7.1) will not deposit on manganese (7.4), chromium (7.5), zinc (9.1), magnesium (14.0), or tin (16.3), while it will readily deposit on cobalt (6.8); and that copper (7.15) will not deposit on chromium (7.5), zinc (9.1), magnesium (14.0), or tin (16.3), while it will readily deposit on cobalt (6.8). We have been successful also in depositing manganese (7.4) on iron (7.1) or nickel (6.7); chromium (7.5) on copper (7.15), iron (7.1), cobalt (6.8), or on nickel (6.7); zinc (9.1) on copper (7.15), iron (7.1), or on nickel (6.7); magnesium (14.0) on copper (7.15), iron (7.1), or nickel (6.7); and tin (16.3) on copper (7.15), iron (7.1), or on nickel (6.7).

While these experiments are not exhaustive, they appear to verify a theory generally applicable to all metals and metalloids which may be employed in our process, such theory being that a metal will deposit on another metal when the attraction of the atoms of

the depositing metal to the atoms of the metal on which the deposit is made is stronger than the attraction of the atoms of the depositing metal to themselves. It is generally admitted in metallurgical theory that the attraction between atoms of high atomic volume and atoms of low atomic volume is greater than the attraction between two atoms both of high atomic volume. Therefore it follows that atoms of high atomic volume should prefer to deposit and stay on atoms of lower atomic volume rather than to stay with atoms of the same or higher atomic volume. The theory is thus shown to agree with the results which we have obtained in actual practice.

This law seems to apply generally to all metals and it appears to be that the greater the difference in atomic volumes of two metals, the greater is the deposition of the metal of higher atomic volume on the metal of lower atomic volume. However, the amount of deposition is not always proportional to the difference in atomic volume between two metals. This is due to a number of uncertain factors, but at least one factor is probably the relative crystal structures of the metals. It is probable that if the two metals have the same type of crystal structure, the deposition will be greater than if the metals have different crystal structures.

Thus, if a metal has a body-centered hexagonal crystal structure, it will not deposit so easily on a metal having a face-centered hexagonal crystal structure as it will on another with body-centered crystal structure, even though the metal of unlike crystal structure has a much different atomic volume.

We have also obtained highly satisfactory results by the employment of phosphorus and chromium, in which instance chromium phosphide is formed and vaporized, the vaporized compound being decomposed to deposit its chromium radical which goes into solid solution to alloy with the metal to be welded and the phosphorus being freed to return and unite again with more chromium in a repetition of the cycle. We have, in the same manner, employed arsenic and chromium in which instance chromium arsenide is formed and vaporized and decomposes to deposit the chromium, the freed arsenic returning to again combine with more chromium.

From the above it will be apparent that the foregoing process of manufacture depends upon the decomposition of the vaporized metal or metalloid compound employed and the deposition upon the metals to be welded of the metallic radical of said compound, without interchange of metallic atoms between the welding metal and the metal to be welded, and with a complete release of the non-metallic radical of said compound, whereby said released non-metallic

radical may again combine with the supply of welding material to form more of the volatile metal or metalloid compound in a repetition of the cycle.

The freed radical of the vaporized compound thus acts as a one-way conveyor; that is, it conveys the welding material to the metals to be welded where through the decomposition it is freed, and since the decomposition and deposition do not involve an interchange of metallic atoms, it follows that the released non-metallic radical returns in a free state to the supply of welding material and does not during such return convey atoms of the welded metals.

While the specific form of burner plate and the method of its manufacture herein illustrated and described are fully capable of accomplishing the objects primarily stated and while the theory set forth is thought to be a correct explanation of the actions which take place in the process employed and of the natural laws which render said process operable, it is to be understood that we do not wish to be in any manner bound by such explanations or restricted beyond the actual scope of our invention as defined in the claims which follow.

We claim as our invention:

1. A homogeneous integral burner plate with openings for permitting the passage therethrough of combustible gaseous mixtures and for preventing the passage therethrough of flame formed of ribbons of heat resisting material spirally wound and, characterized by the fact that each of the openings on a section in a plane at right angles to the direction of flow of the mixture has an area of not more than one seven-hundredth of a square inch.

2. A homogeneous integral burner plate with openings for permitting the passage therethrough of combustible gaseous mixtures and for preventing the passage therethrough of flame, characterized by the fact that each of the openings, on a section in a plane at right angles to the direction of flow of the mixture, is roughly triangular in section and has an area of not more than one seven-hundredth of a square inch.

3. A homogeneous integral burner plate for gaseous and liquid fuel burners, comprising a plurality of ribbons of thin heat-resisting material wound spirally together, one ribbon being corrugated transversely to form fine openings through said plate, said ribbons being molecularly united at all contacting points.

4. A homogeneous integral burner plate for gaseous and liquid fuel burners, comprising a plurality of ribbons of heat-resisting material wound spirally to form between adjacent windings a series of fine openings, said ribbons being molecularly united at all contacting points.

5. A homogeneous integral burner plate for gaseous and liquid fuel burners, comprising means providing a multiplicity of fine and closely spaced openings which are substantially twenty times as long as one side of a square having the same area as the areas of cross-section of said openings.

6. A combination as defined in claim 5 in which the area of cross-section of each of said openings is not greater than one seven-hundredth of a square inch.

7. An integral burner plate for gaseous and liquid fuel burners, comprising a plurality of ribbons of heat-resisting material wound spirally to form between adjacent windings a series of openings each of which has a cross-sectional area normal to the direction of flow of the fuel of not more than one seven-hundredth of a square inch, said ribbons being molecularly united at all contacting points.

8. An integral burner plate with openings for permitting the passage therethrough of combustible gaseous mixtures and for preventing the passage therethrough of flame, characterized by the fact that each of the openings on a section in a plane at right angles to the direction of flow of the mixture has an area of not more than one seven-hundredth of a square inch and that the aggregate of such areas of said openings constitutes approximately seventy per cent of the total area of said plate.

9. A burner plate for gaseous and liquid fuel burners, comprising a plurality of ribbons of heat-resisting material as thin as two-thousandths of an inch cooperating to define between adjacent ribbons a series of fine openings, said ribbons being molecularly united at all contacting points:

10. A burner plate for gaseous and liquid fuel burners, comprising a plurality of ribbons of heat-resisting material as thin as two-thousandths of an inch cooperating to define between adjacent ribbons a series of openings, the area of each opening being not more than one seven-hundredth of a square inch, said ribbons being molecularly united at all contacting points.

In testimony whereof, we have hereunto set our hands at Los Angeles, California, this 18th day of January, 1929.

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