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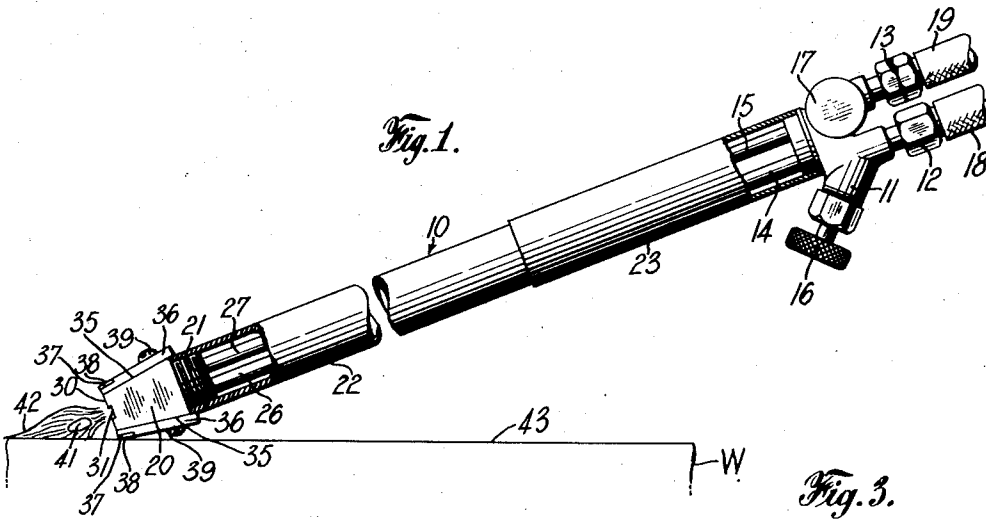
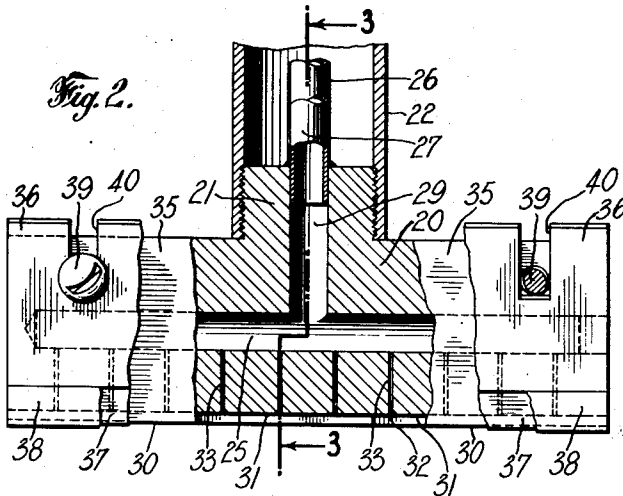
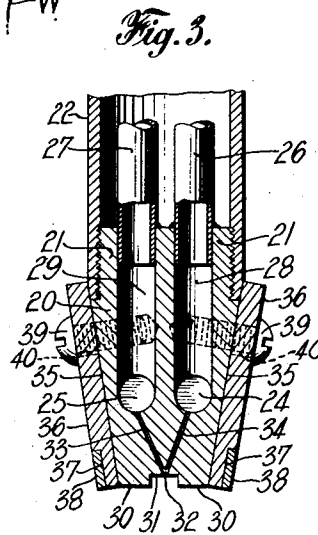
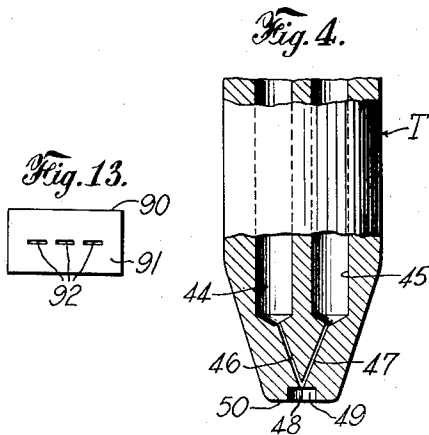
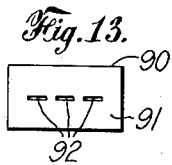
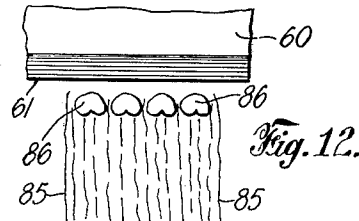
M. H. BARNES ET AL

2,356,196

BLOWPIPE APPARATUS

Filed March 30, 1940

2 Sheets-Sheet 1



INVENTORS
MALCOLM H. BARNES
CHARLES J. BURCH
WILLIAM G. EDWARDS
BY *E. H. Greenwald*
ATTORNEY

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BLOWPIPE APPARATUS

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2 Sheets-Sheet 2

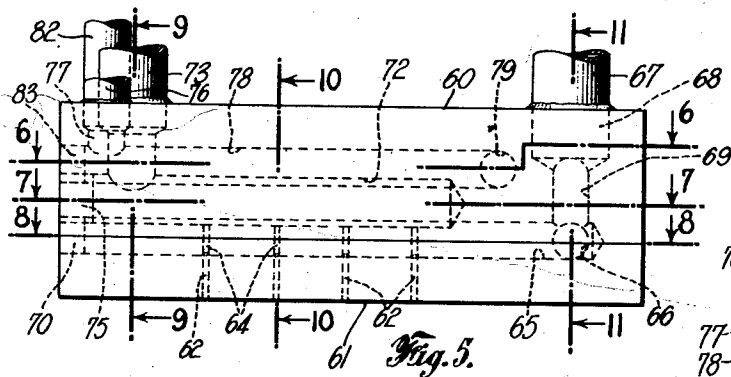


Fig. 5.

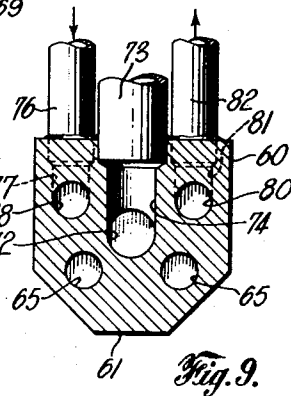


Fig. 9.

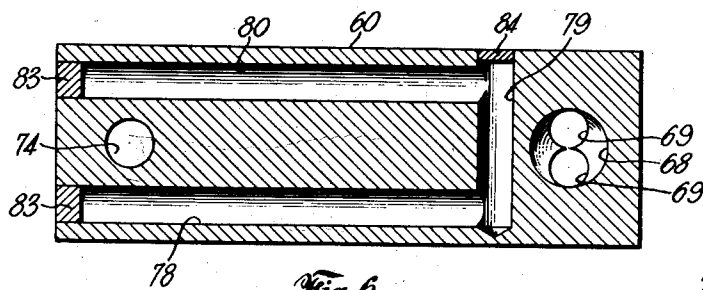


Fig. 6.

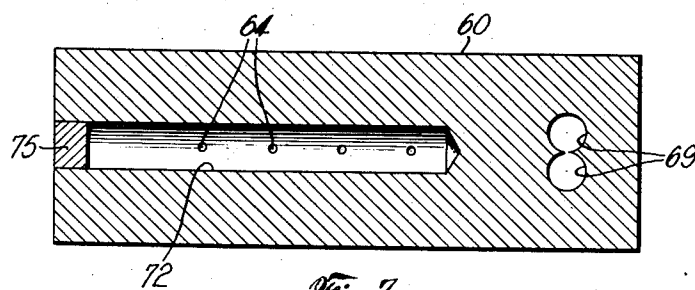


Fig. 7.

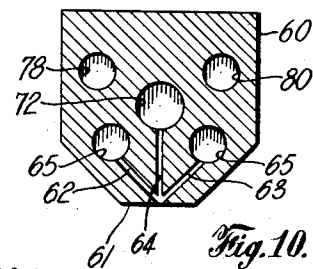


Fig. 10.

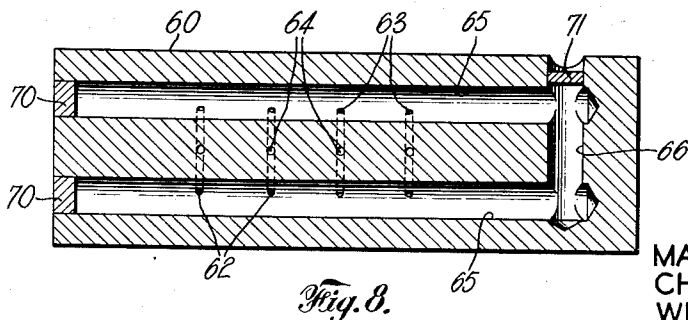


Fig. 8.

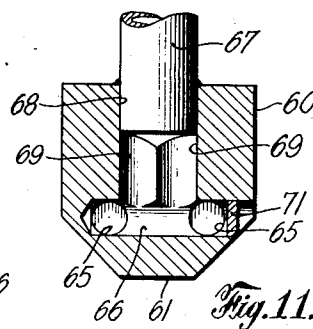


Fig. 11.

INVENTORS
MALCOLM H. BARNES
CHARLES J. BURCH
WILLIAM G. EDWARDS
BY *E. L. Breunwald*
ATTORNEY

UNITED STATES PATENT OFFICE

2,356,196

BLOWPIPE APPARATUS

Malcolm H. Barnes, Charles J. Burch, and William G. Edwards, Kenmore, N. Y., assignors to The Linde Air Products Company, a corporation of Ohio

Application March 30, 1940, Serial No. 326,880

7 Claims. (Cl. 158—27.4)

This invention relates to externally mixed flames, and more particularly to blowpipe apparatus for producing a new externally mixed flame for work treatment, such as flame hardening, softening, dehydrating, spalling, working and the like.

Conventional blowpipes generally are provided with an internal mixer for mixing gases, such as oxygen and acetylene, so that the blowpipe tip discharges a premixed oxyacetylene gas mixture generally composed of substantially equal volumes of oxygen and acetylene, the primary combustion of which yields hydrogen and carbon monoxide, both of which burn in an outer envelope of flame, uniting with oxygen of the surrounding air to form the final products of combustion, water vapor and carbon dioxide. In practice, this setting of the ratio of oxygen to acetylene supplied through the blowpipe to the flame is effected by adjusting the hand valves to obtain an "apparent neutral" flame. An apparent neutral flame is one in which there is no carbon feather, but which would have a yellow carbon feather with any slight decrease in the ratio of oxygen to acetylene by volume. As a result of the presence of a combustible mixture in the interior passages, this type of blowpipe is subject to flashback caused by overheating of the tip, or by disturbance of the primary combustion zone by flying particles, or by carbon clogging or accidental burring of the mixed-gas outlet port. Another inherent disadvantage of the conventional premixed gas blowpipes resides in the complicated and expensive nature of the mixers owing to the precision with which the mixer parts must be machined and assembled for efficient, effective and safe operation. Another disadvantage of premixed gas blowpipes is due to the fact that the primary combustion zone or inner cone is pointed and relatively small in transverse cross section and results in a highly localized reaction, which is undesirable where the flame is used in operations which require uniform heating such as flame softening, flame hardening, descaling and the like. For such operations, with multiple flame premixed gas blowpipes, the cost of the entire blowpipe is especially high because, even if the internal mixers for the several flames are replaced by common mixers serving more than one flame, the danger of flashback is great, requiring, for safe operation, nozzles or heads having exceedingly precisely bored mixed-gas discharge passages and very accurate gas mixers; and, because of the highly localized and fine needle-like inner cone, the flames must be placed close to-

gether which results in the need of a large number of small flames for uniform coverage of a treated surface. Where single flame screw-in tips are disposed adjacent one another, the spacing thereof is, of course, limited by the requirement that space be available for screwing in the tips with a socket wrench; making any close arrangement of the tiny inner cones produced thereby practically impossible. Further, due to the danger of flashback and popping because of overheating, some form of cooling system, such as circulating water, is usually required, which adds to the cost of manufacture and operation of multiple flame premixed gas blowpipes.

Another known type of blowpipe is one which discharges a central jet of fuel gas, such as acetylene, and a surrounding conical jet of oxygen or air, or both, the conical jet of oxygen in some cases being in the nature of a continuous annular envelope, and in others an annular series of individual oxygen jets which merge to form an envelope around the central jet of acetylene. The flame is termed a "diffusion" one because it depends more or less on diffusion of the gases for mixing. This type of flame is comparatively "soft" and inefficient, and often is troublesome to use because it either deposits soot on the workpiece or builds up carbon on the tip. The uses to which diffusion flame blowpipes have heretofore been confined were special applications, such as rock piercing, where it was more important to have flames which would not flashback than to have flames operating at optimum efficiency. While the latter is highly desirable, the former requirement is essential in rock piercing from the standpoint of safe and efficient operation.

Another application of the diffusion type flame has been as preheat for high quality shape cutting of steel. Such preheat is comparatively inefficient and cannot be used for economy cutting of steel. This type of cutting nozzle has not come into general use, because of the necessary complexity of nozzle design, and the accurate control required in operation.

Heretofore, known externally mixed flames, i. e., flames in which the combustible and combustion-supporting gases are mixed outside the blowpipe device, such as diffusion flames, have required, for best practice, a ratio of oxygen to acetylene that is greater than that theoretically required for complete combustion; which is not only uneconomical, but actually limits the use of such flames to work in which the highly oxidizing nature of the flame is not harmful. Thus, such

flames, if used for heat treating a ferrous metal body, for example, are liable to burn the latter. Also, due to the presence of free carbon, which results from poor mixing, the gas discharge ports quickly "carbon up" and operate unsatisfactorily, necessitating costly "shut downs" for cleaning the soot from the ports. The free carbon often is deposited on the workpiece, which deposition is objectionable in most cases.

The principal objects of the present invention, therefore, are to provide improved, simple, efficient and economical means for eliminating the undesirable features described above in connection with the prior art; novel blow-pipe means for producing an improved externally mixed flame that is characterized by a substantially stable and well-defined primary combustion zone; and improved externally mixed flame blowpipe that is simple and economical in its parts and efficient, effective, and safe in operation; an externally mixed flame means for flame treating work that is not only efficient but highly effective; and an efficient externally mixed flame that is effective not only for uses heretofore confined to premixed gas flames, but which is effective for uses heretofore confined to diffusion flames.

In accordance with the present invention there is provided blowpipe apparatus for producing an externally mixed high temperature flame having a stable and well-defined primary combustion zone and a substantially non-luminous secondary combustion zone. The primary combustion zone resulting from the intersection of an oxidizing stream, such as oxygen, and a separate fuel stream, such as acetylene, according to the invention, is of substantially heart shape with the pointed end thereof lying between the included angle of said streams. In accordance with another aspect of the invention, a series of such primary combustion zones are aligned to form a substantially continuous ribbon of flame for uniform heat treating properties, the ratio of oxygen to acetylene being substantially below that theoretically required for complete combustion.

Further, in accordance with the invention, there is provided an externally mixed flame blowpipe comprising means for discharging into free space one or more relatively small oxidizing streams, such as oxygen or air, at a relatively high velocity, and means for simultaneously discharging into free space one or more relatively small fuel streams, such as a gaseous hydrocarbon, at a relatively high velocity, both of the discharging means being disposed for so directing the oxidizing and fuel streams that they converge at high velocity in free space in a substantially common plane at an included angle such that their kinetic impact is effective to form a mixture, the combustion of which produces an intense substantially non-luminous flame of high temperature characterized by a stable and well-defined primary combustion zone. Such flame does not build up carbon on the tip, nor deposit soot on the workpiece.

Further, according to the invention, a blowpipe tip is provided having at least two outlet passages converging at an acute angle. One of such outlet passages is adapted to discharge a stream of fuel gas and the other, a stream of oxidizing gas at substantially equal velocities. The axes of such passages lie in the same plane and the discharge orifices of the passages coincide in the plane of a surface of the tip to form a common discharge orifice. Thus, the

fuel gas stream and oxidizing gas stream collide in such common discharge orifice substantially at the instant that both of the streams discharge from their respective passages, to produce a single combustible gas stream immediately externally of the tip. As a result, such single combustible gas stream, when ignited, produces in free space a high temperature flame having a stable, well-defined primary combustion zone, and a substantially non-luminous secondary combustion zone.

As used herein, the term "relatively small" as applied to the oxidizing and fuel streams may be defined as those of the order of the size of gas streams issuing from an outlet orifice of between No. 56 (.0465 inch diameter) and No. 80 (.0135 inch diameter) drill size; and the term "relatively high velocity" may be defined as that of the order of 250 feet per second and upwards. The oxidizing stream and fuel gas stream are preferably oxygen and acetylene, because acetylene is capable of producing a higher flame temperature when burned with oxygen than any other generally known fuel. In a preferred embodiment of the invention all of the oxygen and acetylene streams converge at substantially equal high velocities in free space in a substantially common plane at an included angle of not less than 30 degrees and not more than 100 degrees, although it will be understood that in some cases such preferred range may be increased without departing from the invention. The included angle and cross-sectional areas of the streams being determined, the desired externally mixed flame is produced by suitably adjusting the velocities of the converging streams until the secondary combustion zone is non-luminous or featherless.

The novel features which are believed to be characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects thereof, will best be understood by reference to the specification taken in connection with the accompanying drawings.

Fig. 1 is a view mainly in side elevation, with parts broken away and shown in section, of an externally mixed flame blowpipe embodying features of the invention in operation;

Fig. 2 is an enlarged view mainly in longitudinal section of the forward portion of the blowpipe;

Fig. 3 is a transverse sectional view taken on line 3-3 of Fig. 2;

Fig. 4 is a view partly in side elevation and partly in vertical section, of a single flame blowpipe tip embodying features of the invention;

Fig. 5 is a view in side elevation of another externally mixed flame blowpipe head embodying features of the invention;

Figs. 6, 7 and 8 are views in longitudinal section taken on lines 6-6, 7-7 and 8-8, respectively, of Fig. 5;

Figs. 9, 10 and 11 are transverse sectional views taken on lines 9-9, 10-10 and 11-11, respectively, of Fig. 5;

Fig. 12 is a fragmentary view of the blowpipe head of Figs. 5-11 in operation in free space; and

Fig. 13 is an end elevational view of a modified head having substantially flat rectangular orifices or ports in accordance with the invention.

Referring particularly to Figs. 1, 2 and 3 of the drawings, there is shown an externally mixed oxy-acetylene flame blowpipe 10 comprising a gas

inlet valve block 11 having an oxygen inlet connection 12 and an acetylene inlet connection 13. The gas inlet valve block 11 also is provided with oxygen and acetylene outlet connections 14 and 15, the flow of oxygen and acetylene between such inlet and outlet connections being controlled by an oxygen valve 16 and an acetylene valve 17. The separate inlet connections 12 and 13 are in communication with suitable sources of oxygen and acetylene, respectively, under pressure by way of flexible conduits 18 and 19. The blowpipe 10 is provided with a unitary head 20 comprising a body of any suitable material, such as copper, having a centrally-disposed rearwardly extending projection 21 to which is threaded a cylindrical stem 22, the rear portion of which is covered by a cylindrical sleeve 23, secured to the gas outlet end of the valve block 11 and providing a convenient handle portion for the blowpipe 10.

The head 20 is provided with separate oxygen and acetylene distributing passages 24 and 25, respectively, which are disposed in substantially spaced parallel relation longitudinally thereof, the distributing passages 24 and 25 being supplied with oxygen and acetylene through central conduit means including pipes 26 and 27 which communicate with the outlet connections 14 and 15 of the valve block 11 and bores 28 and 29, respectively, in the head 20.

The front end face 30 of the head 20 is provided with a recess, such as the substantially centrally disposed longitudinally extending substantially rectangular groove 31, about $\frac{1}{8}$ inch wide by about $\frac{1}{100}$ inch deep, having a bottom wall provided with a series of ten substantially equally spaced centrally disposed gas outlet ports 32 having a port-to-port spacing of about $\frac{3}{16}$ inch. The groove protects the outlet ports from damage in use, but may be omitted if desired. Each gas outlet port 32 communicates with an acetylene outlet passage 33 extending from the acetylene distributing passage 25 and an oxygen outlet passage 34 extending from the oxygen distributing passage 24. The longitudinal axes of the passages 33 and 34 preferably intersect at the center of the port 32 in the plane of the bottom wall of the groove 31. Such axes, as shown by Fig. 3 form equal angles with such plane, that is, the angle between the oxygen passage 34 and the plane is equal to the angle between the acetylene passage 33 and such plane. The acetylene and oxygen outlet passages 33 and 34 have a drill size of about No. 65 and preferably are disposed with their axes in common transverse planes for discharging into free space relatively small streams of acetylene and oxygen at relatively high velocity, such as about 300 to 500 feet per second and upwards. Such common planes are disposed at right angles to the plane in which the outer ends of the orifices 32 lie. The included angle between the oxygen and acetylene outlet passages 33 and 34 is an acute angle preferably of not less than about 30 degrees, being about 45 to 60 degrees, so that the acetylene and oxygen streams converge in free space; the included angle, velocity and cross-sectional area being such that the kinetic impact of the streams is effective to form a mixture which, when burning in air, produces an intense substantially non-luminous flame of high temperature characterized by a stable and well-defined primary combustion zone of unique shape. The ratio of oxygen to acetylene by volume in such mixture is substantially below that theoretically required for complete combustion, being in the order of 1.2 to 1.3 parts of O_2 to 1

part of C_2H_2 by volume, which is a decided departure from the prior art concerning diffusion flames.

The longitudinal sides 35, 35 of the head 20 preferably are tapered inwardly at an angle of about 10 degrees or more toward the face 30 and are covered by scraper plates 36, 36 of any suitable wear-resistant metal, such as stainless steel, each of the plates 36 being provided with a longitudinally extending corner recess 37 which is provided with a facing edge 38 of hard metal, such as a "Stellite" alloy, preferably welded thereto. The plates 36 may be held in adjustable position on the sides 35 of the head 20 by any suitable means, such as screws 39, threaded to suitable sockets in the head and extending through vertically opening slots 40 located near opposite ends of the plates.

In considering the operation of the blowpipe 10, the flexible conduits 18 and 19 being connected to a suitable source of oxygen under pressure and a suitable source of acetylene under pressure, respectively, opening of the oxygen and acetylene valves 16 and 17 results in the delivery to the oxygen outlet passages 34 of oxygen under pressure by way of pipe 26, bore 28 and distributing passage 24; likewise, there is delivered to the acetylene outlet passages 33 acetylene under pressure by way of pipe 27, bore 29 and distributing passage 25. Thus, each pair of opposed oxygen and acetylene outlet passages 33 and 34 discharge at high velocity through the meeting or common ports or discharge orifices 32 into free space separate relatively small streams of oxygen and acetylene which, by virtue of the size and arrangement of the passages 33 and 34, converge and collide with one another at the instant that both of such streams discharge from their respective passages to produce a combustible gas stream the gases of which are so mixed as to form, when ignited, an intense, non-luminous, high-temperature flame, characterized by a well-defined primary combustion zone of limited extent.

Referring to Fig. 1, the light blue primary combustion zone of the resulting externally mixed flame is indicated at 41 and the substantially invisible secondary combustion zone at 42. By delivering the oxygen and acetylene to separate discharge passages which discharge to the atmosphere so that the oxygen and acetylene are externally mixed after leaving the port 32, the possibility of flashback is entirely eliminated. Relatively small streams of oxygen and acetylene are desirable because the mixing thus is effected in a required short time and space with great velocity, resulting in intensified primary combustion. The angle of convergence of the gas streams and their velocity, preferably are such as to cause the primary combustion to take place in a sharply-defined and limited zone 41 distinct from the outer more extended zone 42 of secondary combustion. If the resulting gas velocity, as determined by the velocities and angles of intersection and sizes of the component jets, is too great, the primary combustion flame front will be blown out from the head 20 to such an extent as to make its propagation unstable. On the other hand, if such resulting gas velocity is too low, the flame front will move back to the face 30 of the head 20, resulting in less effective mixing and a lower intensity of combustion.

It will be understood that the several flames produced by the multiple flame externally mixed flame blowpipe 10 may be arranged as close together as desired, and that a substantially con-

tinuous longitudinally extending primary combustion zone consisting of the several substantially contiguous primary combustion zones may be thus produced. A flame of such type provides a uniform source of heat throughout its transverse dimensions, and is well adapted for heat treating metal, such as steel, by flame hardening or softening, to obtain a case or treated zone of uniform depth and uniform hardness or softness.

The invention is disclosed in Fig. 1 in use in spalling the surface 43 of a block W of granite, or the like. In this use the blowpipe 10 is supported by the hand of the operator gripping the sleeve 23, while the head 20 rests on the surface 43 of the work W, the wear-resisting edge 38 being in direct contact with such surface. With the blowpipe in a position with respect to the work, as shown by Fig. 1, the blowpipe 10 is advanced slowly in the direction of the externally mixed flames produced thereby to accomplish the desired result. While the blowpipe 10 is highly successful for rock facing, it will be understood that its usefulness is not limited thereto, but may be used for any heating purpose including those set forth below.

Referring to Fig. 4, there is shown an externally mixed flame blowpipe tip T comprising a substantially cylindrical tapered solid metal body, such as copper plated with chromium, having two separate gas passages 44 and 45 approximately arranged in a common plane passing substantially through the longitudinal central axis of the body and including greatly reduced outlet portions 46 and 47 which are inclined inwardly at substantially equal angles to terminate in and intersect one another at a common outlet port or orifice 48 in the bottom wall of a small cylindrical recess 49 in the end face 50. The recess 49 is not absolutely necessary, but provides protection for the port 48. In either case, the longitudinal axes of the passages 46 and 47 meet at the center of the port 48 in the plane of the outer end of the port 48. The tip T is provided with any suitable means, not shown, for connection to the stem of a blowpipe having separate gas passages for communication with gas passages 44 and 45, respectively. The passages 44 and 45 may be supplied with oxygen and acetylene under suitable pressure, whereby the outlet portions 46 and 47 simultaneously and separately discharge oxygen and acetylene at substantially equal relatively high velocities into free space at an included angle such that a mixture is effected the combustion in air of which produces a substantially stable relatively flat flame characterized by a well-defined primary combustion zone of heart shape. Such primary combustion zone is of substantially elliptical transverse cross-section and substantially rectangular in central longitudinal cross-section with the pointed inner end spaced from the face 50 of the tip T. In operation the port 48 does not "carbon up" notwithstanding the fact that the ratio of oxygen to acetylene by volume is substantially less than that heretofore required for diffusion flames. The fact that the secondary combustion zone is non-luminous indicates the absence of free carbon, while the ratio of oxygen to acetylene is such that the flame is substantially non-oxidizing. The operation and use of the blowpipe tip T of Fig. 4 are substantially similar to those of the multiple flame blowpipe head of Figs. 1 to 3, except that they are, of course, limited to those requiring but a single flame, such as seam welding, and preheating for cutting and working ferrous metal members.

Referring to Figs. 5 to 12, inclusive, of the drawings there is illustrated a multiple flame externally mixed flame blowpipe device comprising a head 60 of any suitable metal, such as copper, in the form of a substantially rectangular block having a face 61, and a series of spaced parallel first and second passages or bores 62, 63, intersecting at an opening to said face 61 for discharging into free space a series of spaced relatively small oxidizing streams at a relatively high velocity, the bores 62, 63 being arranged in converging pairs with each bore at an included angle of about 45-60 degrees to the face 61. The head 60 is also provided with a series of spaced parallel third passages or bores 64 opening to the face 61 for simultaneously discharging into free space a series of spaced parallel relatively small fuel streams at right angles to the face 61 with one bore 64 disposed between each pair of the 45-60 degree bores 62, 63. In the illustrated embodiment, four groups of meeting or intersecting bores 62, 63 and 64 are provided, the size of the holes preferably being that formed by a No. 65 drill.

The head 60 is provided with a pair of spaced parallel substantially longitudinal bores 65, 65 and a cross bore 66 for distributing oxygen to the outlet passages 62 and 63, the oxygen being supplied to the head under suitable pressure through a conduit 67 the end of which is secured in a socket 68 provided with parallel bores 69, 69 leading to the cross bore 66. With this system of oxygen distribution an adequate supply of oxygen is provided for each of the passages 62 and 63. The ends of the bores 65 and 66 are sealed with suitable plugs 70 and 71, respectively.

For supplying the fuel outlet passages 64 with a suitable fuel, such as acetylene, under pressure, the head 60 is provided with a central longitudinal bore 72 to which the inner ends of the bores 64 open, the bore 72 being connected to an acetylene supply conduit 73 through a suitable inlet bore 74. The end of the acetylene distributing bore 72 is sealed by a suitable plug 75.

Although the elimination of water cooling is one of the features of the present invention, the head 60 may be provided with cooling means including an inlet conduit 76, an inlet bore 77, a longitudinal circulating bore 78, a cross circulating bore 79, a longitudinal circulating bore 80, an outlet bore 81 and an outlet conduit 82. The ends of the circulating bores 78, 79 and 80 are sealed with suitable plugs 83, 84 and 83. The inlet and outlet conduits 76 and 82 are connected to any suitable source of cooling fluid supply, such as water, which, in operation, when circulated through the passages 77 to 81, inclusive, of the head 60 maintains the latter at a comparatively low temperature. While water cooling is not required to eliminate flashback difficulties, in certain applications it becomes necessary to prevent the blowpipe from being damaged by the heat of the operation.

The operation of the multiple flame externally mixed flame blowpipe device illustrated in Figs. 5 to 12, inclusive, of the drawings is substantially similar to that described above in connection with Figs. 1 to 3, inclusive. However, in the modification of Figs. 5 to 12, inclusive, the bores 62, 63 and 64 are disposed for so directing the oxygen and acetylene gas streams that they converge at high velocity in substantially common spaced transverse planes at included angles of about 30-60 degrees such that their kinetic impact is effective to form a mixture the combustion of which produces a series of merging intense sub-

stantially non-luminous flames in the form of a single almost invisible tongue 85 of high temperature characterized by intense well-defined stable primary combustion zones 86 of substantially heart shape as shown by Fig. 12.

Referring to Fig. 13, there is shown a head 90 having a face 91 at the surface of which separate oxygen and acetylene discharge passages meet or intersect in outlet orifices or ports 92 of substantially flat rectangular cross-section which may be in line. A substantially continuous ribbon of flame may be produced by an arrangement of this character.

Among the advantages of the invention, wherein oxygen and acetylene are mixed externally, over the prior art wherein such gases were mixed internally of the blowpipe device, are the following:

(1) The blowpipe construction is simpler and cheaper.

(2) The blowpipe is free from popping and flashback difficulties.

(3) The resulting flame is comparatively constant and may be adjusted by eye approximately to a 1.2-1.3 ratio by volumes of oxygen to acetylene; this ratio actually being more favorable to heat transfer than a ratio of about 1.0, the apparent neutral for a premixed oxy-acetylene flame.

(4) The primary reaction zone is spread over a broader and more effective area and tends to give a more uniform heating performance than the needle-like inner cone produced by the combustion of premixed gases.

(5) There is no carbon formation on the tip, nor is carbon deposited on the workpiece under proper operating conditions.

(6) Since the flames operate at "blowoff" when burning in open air the head or tip remains comparatively cool, which, combined with freedom from flashbacks, permits the use of this type of flame in many cases without water cooling.

Items 3, 5 and 6, above, also distinguish the invention from diffusion flames of the prior art, which required an excessive ratio of oxidizing gas to acetylene for even incomplete combustion, indicated by a luminous zone or feather of secondary combustion and an unstable, weak and relatively soft zone of primary combustion, and rendering such flames unsuitable for many operations, such as working and flame treating ferrous metal, as pointed out above. Thus, the present invention has many of the advantages of both premixed gas flames and diffusion flames without the disadvantages and limitations of either one and in addition has new advantages, such as the shape and nature of the primary combustion zone of a single flame or a series of flames in line to provide a continuous ribbon, which render it particularly suitable for work, such as spalling rock and heat treating metal, where an intense uniform heating source is desired.

The field of use of the invention is, of course, quite broad, including the application of heat, such as flame hardening, flame softening, descaling, dehydrating, paint burning, rock surfacing, and general heating. The invention is also applicable for preheating in cutting and descaling, and for welding, soldering and brazing. As pointed out above, the blowpipe shown in Figs. 1 to 3, inclusive, has been used successfully to rough face granite. The invention may be used to process other materials, such as rock, ore, stone,

concrete, brick, cement, plaster, stucco, furnace lining, glass, quartzite, limestone, and similar natural and artificial minerals. Metal shapes, such as billets, bars, beams, and ingots of iron and steel may be processed by externally mixed flames produced according to the invention. Among the processes in which the invention is capable of use, may be listed: drilling, cutting, scraping, melting, breaking, fusing, pulverizing, mining, piercing, grooving, quarrying, sawing, disintegrating, cleaning, desurfacing, skinning, pulverizing, burning, lancing, boring, expanding, crumbling, slotting, spalling, hardening, softening, descaling, dehydrating, fabricating, facing and gouging.

One aspect of the present invention is particularly concerned with apparatus for and process of flame hardening, flame softening, descaling, dehydrating, paint burning, rock desurfacing, and preheating for cutting or descaling with externally mixed flames produced as set forth above. The advantages derived from the use of said externally mixed flames in certain of said uses include the advantage that they are not subject to popping or flashback difficulties caused by flying solid particles; and especially in the case of the spalling of rock for surfacing, grooving, or shaping the same, the more uniform, slightly lower temperature of the externally mixed flames compared to the temperature of internally mixed gas flames results in a better and more easily controlled spalling action. Further, since the oxygen and acetylene are not mixed within the blowpipe or tip, overheating of the apparatus of the invention cannot cause flashback; while the externally mixed flame provides protection from popping and flashback without any decrease in heat transfer efficiency.

Heretofore, the process of grooving or facing spallable rocks with premixed oxy-acetylene flames has met with considerable difficulty because of the high heat concentration and popping and flashbacks. The present invention overcomes these difficulties by virtue of the production of an almost invisible tongue of flame which is not only very "hard" and intense, but which has a stable and well-defined primary combustion zone which is highly suitable for facing or grooving spallable material, such as granite.

The externally mixed flame of the invention is effective for burning the paint from a wooden surface with little or no charring of the wood itself. Actual tests have also demonstrated that the invention is applicable for dehydrating and descaling steel surfaces. The performance of the invention has been found to be entirely satisfactory for such operations.

A seven flame head made in accordance with the invention with externally mixed flames has been employed for flame softening a piece of air hardened steel which had been flame cut. The flame cut surface had an original hardness of 55 to 60 Rockwell "C." By treatment with externally mixed flames of the invention, the hardness was reduced to 18 to 25 Rockwell "C" which values are within the range of machinability of steel. Said seven flame head was also used to flame harden the surface of a piece of S. A. E.-1045 steel. The surface hardness was increased from 13 to 55 Rockwell "C" in the treated zone by the externally mixed flame treatment of the invention, resulting in a case of notable uniformity across the treated surface.

The invention has also been used for preheating in oxygen cutting of steel $\frac{1}{4}$ inch thick, as

well as for preheating in hand oxygen descaling. Both of these operations have been successfully carried out with externally mixed flames in accordance with the invention.

While, as pointed out above, the preferred oxidizing stream is oxygen or air and the fuel stream is acetylene, it will be understood that any suitable combustible fuel, such as a gas rich in carbon or hydrogen, may be used with any suitable combustion-supporting fluid which mixes therewith to produce a combustible mixture in air. Also, while the terms "oxygen" and "acetylene" have been used in describing the invention, particularly in connection with the apparatus, it will be understood that such use of the terms is for convenience of description and not for purpose of limitation; for example, acetylene may be supplied to the passages 65, 65 instead of oxygen, and oxygen to the passage 72 instead of acetylene; and any suitable combustion-supporting fluid may be used instead of oxygen, and any suitable combustible fluid instead of acetylene.

The present invention is distinguishable from known forms of externally mixed or diffusion flames, such as illuminating flames and laboratory flames produced by a blast lamp having a central orifice for discharging compressed air or oxygen at relatively high velocity and surrounded by an annular orifice for the delivering of combustible gas, in that flames according to the invention are made up of separate combustible gas and combustion-supporting gas jets or streams impinging at an angle, whereas those of known blast lamp flames flow together at substantially zero angles; also, in flames of the invention, the separate streams of combustion gas and combustion-supporting gas intersect at substantially equal velocities, thus giving rise to extreme turbulence and thorough and rapid mixing, whereas in known blast lamp flames, the central jet of air or oxygen is of much higher velocity than that of the surrounding stream of combustible gas, which results in poor mixing which is accomplished to a certain extent by the aspirating action of the central air stream; further, the flames of the present invention are composed of separate streams of combustible gas and combustion-supporting gas which issue out of contact with each other from the face of the tip or head, whereas in known blast lamps outlets for the two streams are concentric.

While there have been described what are at present considered to be preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is therefore intended in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A blowpipe tip having outlet passages converging at an acute included angle, said passages being adapted to discharge at least two gas streams at substantially equal velocities, one of said passages being adapted to discharge a stream of fuel gas and the other of said passages being adapted to discharge a stream of oxidizing gas, the axes of said passages lying in the same plane and the discharge orifices of said passages coinciding in the plane of a surface of the tip to form a common discharge orifice, whereby such fuel gas stream and such oxidizing gas stream will collide in said common discharge orifice at the instant that both of said streams discharge from

their respective passages, to produce a single combustible gas stream immediately externally of said tip.

2. A blowpipe tip having an end face provided with a recess, said tip also having outlet passages converging at an acute angle, said passages being adapted to discharge two gas streams at substantially equal velocities, one of said passages being adapted to discharge a stream of fuel gas and the other of said passages being adapted to discharge a stream of oxidizing gas, the axes of said passages lying in the same plane and the discharge orifices of said passages coinciding in the plane of the bottom surface of said recess in the face of the tip to form a common discharge orifice, whereby such fuel gas stream and such oxidizing gas stream will collide in said common discharge orifice at the instant that both of said streams discharge from their respective passages, to produce a single combustible gas stream immediately externally of said tip.

3. A blowpipe tip having outlet passages converging at acute included angles, said passages being adapted to discharge three streams of oxidizing and fuel gases, one of said passages being adapted to discharge a stream of one of said gases and the other two of said passages being adapted to discharge a stream of the other one of said gases, the axes of said passages lying in the same plane and the discharge orifices of said passages coinciding in the plane of a surface of the tip to form a common discharge orifice, whereby such three gas streams will collide in said common discharge orifice at the instant that said three streams discharge from their respective passages, to produce a single combustible gas stream immediately externally of said tip.

4. A blowpipe tip having outlet passages converging at acute included angles, said passages being adapted to discharge three gas streams, the central one of said passages being adapted to discharge a stream of fuel gas and the other two of said passages being adapted to discharge streams of oxidizing gas, the axes of said three passages lying in the same plane and the discharge orifices of said passages coinciding in the plane of a surface of the tip to form a common discharge orifice, whereby such fuel stream and such oxidizing gas streams will collide in said common discharge orifice at the instant that all of said three streams discharge from their respective passages, to produce a single combustible gas stream immediately externally of said tip.

5. An externally mixed flame blowpipe device capable of producing in free space an intense flame substantially in the form of a ribbon of high temperature characterized by a row of closely spaced primary combustion zones, said device comprising a head having fuel gas and oxidizing gas distributing passages; a series of spaced parallel outlet passages leading from such oxidizing gas distributing passage, for discharging oxidizing gas streams at high velocity; and a series of spaced parallel outlet passages leading from such fuel gas distributing passage for simultaneously discharging fuel gas streams at high velocity, the discharge orifice of each of said fuel gas passages coinciding with the discharge orifice of an oxidizing gas passage in the plane of a surface of said head to form a common discharge orifice, whereby said outlet passages are adapted to discharge oxidizing and fuel gas streams which collide in such common discharge orifices, the

included angle between said coinciding outlet passages being such that the collision between said oxidizing and fuel gas streams is effective to form a series of combustible gas streams externally of said head, said combustible gas streams, when ignited, being adapted to produce a high temperature flame having a series of primary combustion zones, and means for supplying such oxidizing and fuel gas streams, respectively, in such proportions that a combustible mixture is produced in each of said primary combustion zones.

6. An externally mixed flame blowpipe device as defined by claim 5, in which two oxidizing stream discharge passages coincide with a central fuel stream discharge passage at each one of the common discharge orifices in said head.

7. An externally mixed flame blowpipe device capable of producing in free space an intense flame substantially in the form of a ribbon of high temperature characterized by a row of closely spaced primary combustion zones, said device comprising a head having a groove provided with a bottom wall, a series of spaced parallel outlet passages for discharging relatively

5 small oxidizing streams at high velocity, and a series of spaced parallel outlet passages for simultaneously discharging relatively small fuel streams at high velocity, each of said oxidizing stream outlet passages converging with one of said fuel stream outlet passages so that such outlet passages intersect in the bottom wall of said groove, the discharge orifices of such intersecting passages coinciding in the plane of such bottom wall to form a common discharge orifice, said outlet passages being disposed for so directing said oxidizing and fuel streams that said streams collide at the instant of discharge from their respective discharge passages, the longitudinal axes of said converging outlet passages lying in spaced parallel planes and said converging outlet passages intersecting at an acute included angle, and means for supplying such oxidizing and fuel streams, respectively, in such proportion that a single combustible gas stream is discharged from each of said common discharge orifices.

MALCOLM H. BARNES.
CHARLES J. BURCH.
WILLIAM G. EDWARDS.