

[54] HEAT GUN

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[*] Notice: The portion of the term of this patent subsequent to Dec. 18, 1990, has been disclaimed.

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[21] Appl. No.: **351,359**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 197,207, Nov. 10, 1971, Pat. No. 3,779,694.

[52] U.S. Cl. **431/351; 431/352; 432/222**

[51] Int. Cl.² **F23D 15/00**

[58] Field of Search 431/347, 351, 158, 352, 431/344; 432/222

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Primary Examiner—John J. Camby

[57] **ABSTRACT**

Aimable hand held shrink gun for plastic film producing heated air in 250° to 1000°F range employs high performance internal combustion burner discharging

exhaust gas at velocity above 4000 feet per minute and temperature on order of stoichiometric burning temperature, i.e. 3,450°F for propane fuel. High velocity exhaust gases enter mixing zone preferably in a divergent manner and with perimeter of gas flow cross-section at least 25% greater than the perimeter of a circle of equal area, to provide an extended gas-air interface. The exhaust gas propels and heats a large volume of ambient air, producing in a practical small distance a useful flow of shrinking air at the desired temperature. Preferably the burner outlet is of elongated form with decreasing cross-section towards outlet, e.g. a multiple legged outlet cross-section. Preferably a positioning means set a minimum distance between work piece and outlet. Where the exhaust gas stream is exposed to admission of increasing air along the length, the length of the positioning means sets the working temperature. Preferably a shield extends about the exhaust gas stream, preferably in the form of a tube with space for ambient air. With apertures along the tube length, the mass of air increases and decreases rapidly in temperature therealong. With a closed wall tube its smallest cross-section defines the amount of ambient air entrained and thereby sets the discharge temperature. Burners useful in this heat gun are of high capacity type with jet pump feed, pressure recovery passage and flame holder positioned at entry of fuel mixture into the burner chamber. By combining an ignition chamber upstream of the burner outlet with a flameholder having thin blades and limited bluff-body effect, an increase in performance is achievable.

37 Claims, 11 Drawing Figures

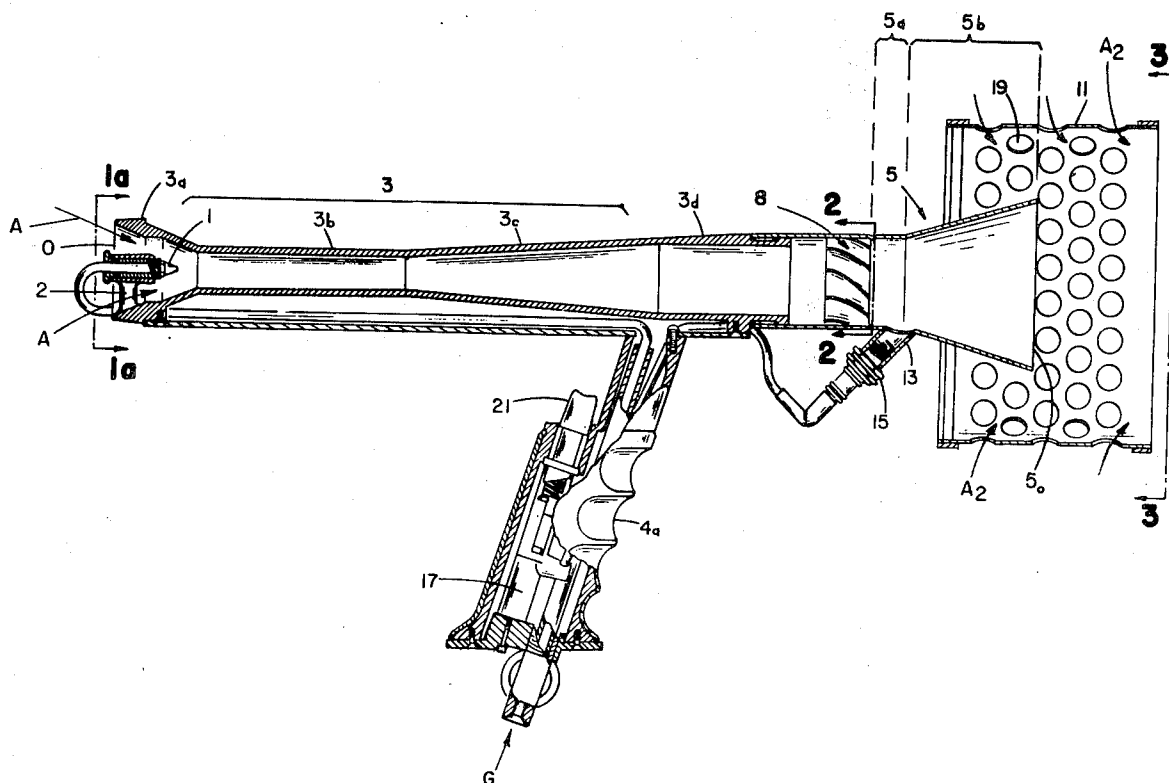


FIG 7

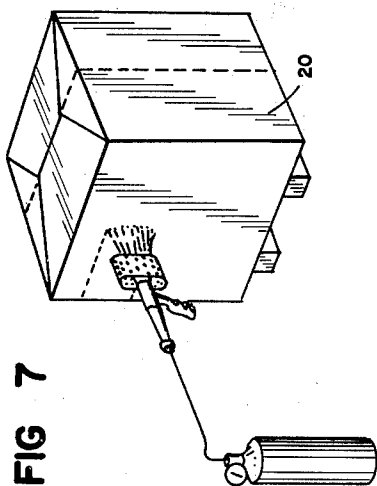


FIG 1

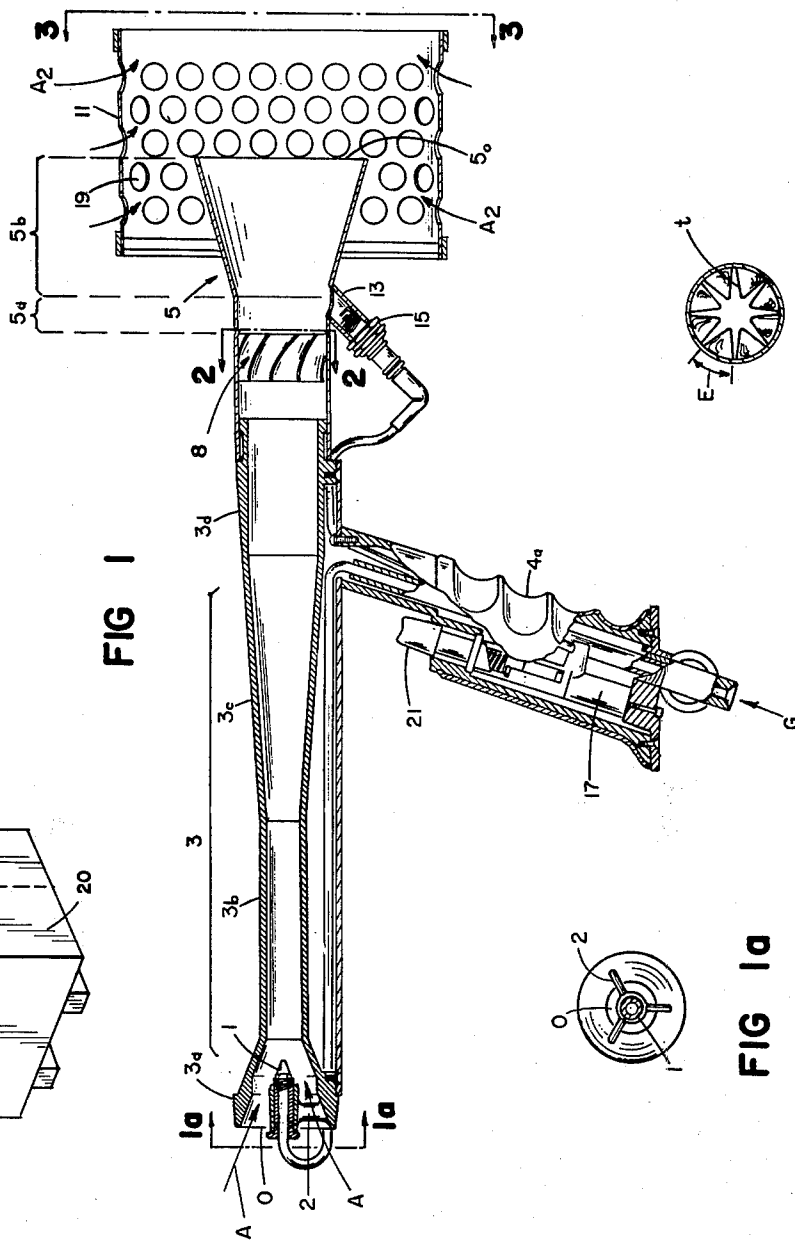


FIG 1a

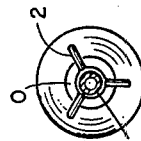
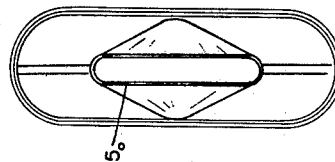


FIG 2



FIG 3



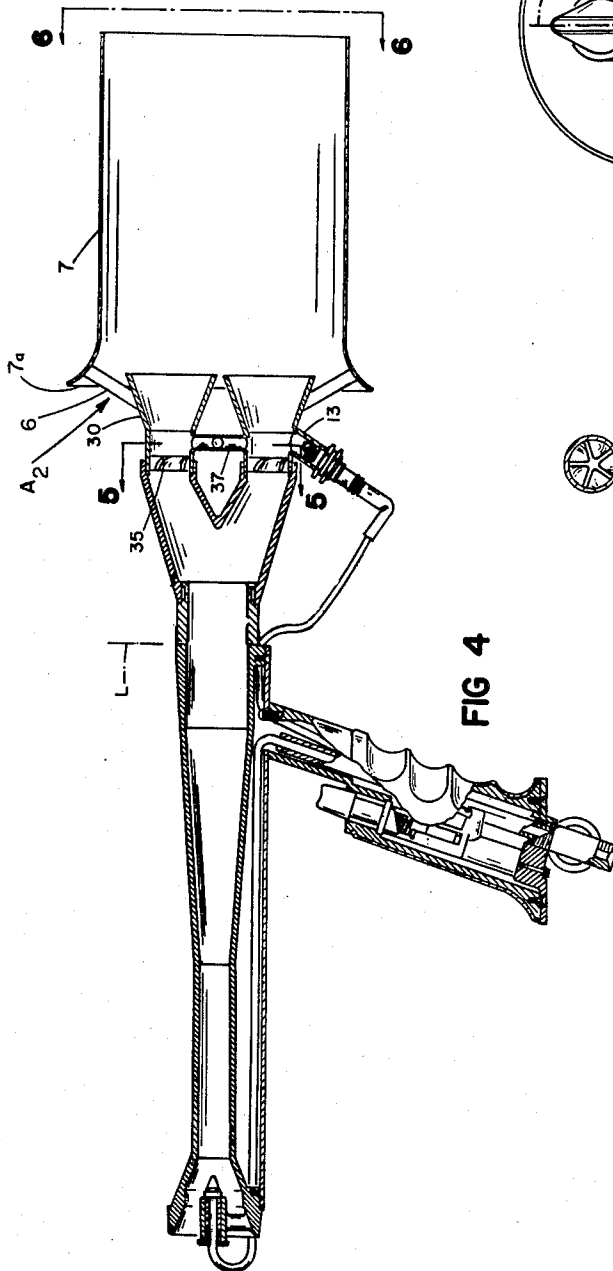


FIG 4

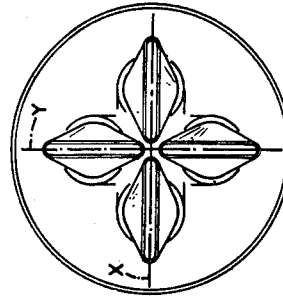


FIG 6

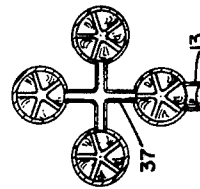


FIG 5

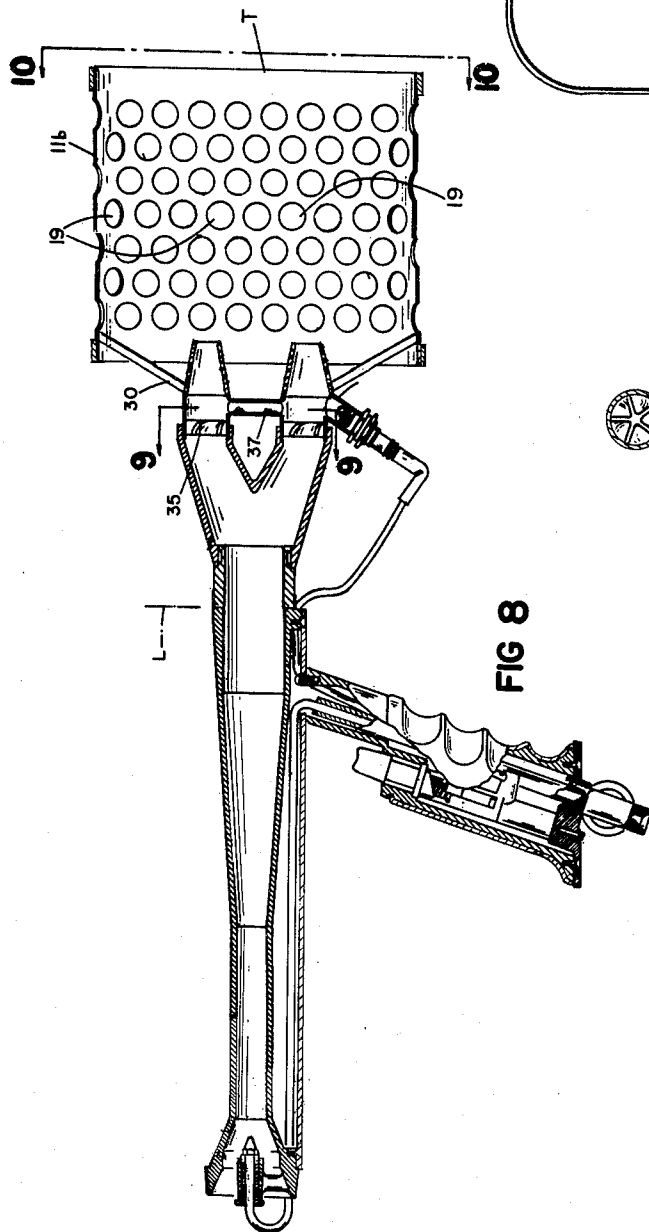


FIG 8

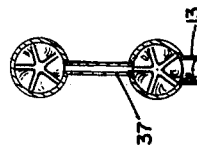


FIG 9

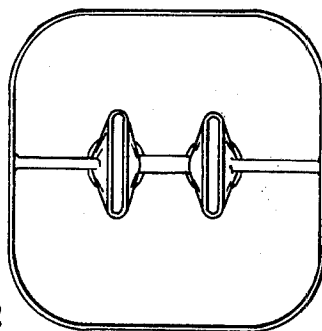


FIG 10

HEAT GUN

This is a continuation-in-part of U.S. Pat. Application Ser. No. 197,207, filed Nov. 10, 1971, now U.S. Pat. No. 3,779,694.

Numerous applications in industry and home require low temperature heating, in particular heating of plastic film to shrink it about various objects to form secure, water-proof covers about the objects, etc. Low temperature in the range of 250° about 1000°F is extremely important since higher temperatures lead to blistering, cracking and charring of inherently low temperature materials. One tool used for this purpose is the electric heat gun. An electric blower passes cold air over a resistance heating element, and the hot air is directed at the work piece. Two disadvantages are that the power (hence flow-rate of heated air) is limited to 3 kw using common electric outlets rated for 30 amp fuses and the tool is not usable in the field where electricity is not available.

To get around the first limitation, units have been built in which a gas flame supplies the heat and a blower is used to mix in tempering air. These units, incorporating two different power systems, are relatively complicated, bulky, and expensive. A typical 25 kw unit intended for hand held use weighs about 12 lbs.

Units that rely on fuel alone, such as hand held torches have the problem that the flame temperature of common fuels such as natural gas or propane are quite high, above 3000°F, many more times the desired temperature. In an attempt to avoid overheating the product, efforts have been made to slow down the flame being applied to the work piece by means such as spreaders, or by employing fuel rich, so-called yellow flames, but still hot spots, overheating, scorching and charring problems persist.

According to the present invention, it is discovered that a much more satisfactory low temperature heating device for use as a shrink gun can be provided. A jet of fuel gas first entrains by jet pump action a quantity of atmospheric air for combustion, followed by recovery of the velocity head to produce a pressure exceeding atmospheric, followed by a combustion chamber whose outlet directs high velocity, high temperature air into a propelling zone. In the propelling zone the combustion gases propel relatively larger quantities of ambient air in the same direction with attendant moderate heating thereof. The invention employs an intentionally high velocity, intense burning action rather than the common low velocity, diffused burning pattern. This appears at first sight contradictory. Commonly, higher velocity burners are employed to achieve faster, more intense heating rates. Such behavior can be illustrated by plotting the time needed to heat the end of e.g. a copper piece held at the burner outlet, using the same energy input but varying the exhaust gas velocity directed against the copper. The higher the velocity, the sooner the copper will be heated, and at high velocities the copper will melt. The inference here is that when more gentle heating is sought, lower velocities should be employed. The prior art gas torches described above attempted to employ this principle to achieve gentle heating.

But according to the present invention, using the high velocity, intense burning, the work piece is held some distance away from the burner, quite beyond the flame. A jet pump effect then is employed to entrain, propel

and mix with large quantities of ambient air. A high velocity burner according to the present invention can thus produce a large air flow of desired low temperature (consisting mainly of ambient air which is propelled in the same direction and heated by the combustion gases) within a short distance.

These good results are attributable, it is believed, to a combination of factors. The much higher velocity (for a burner of given fuel consumption) leads to a smaller area outlet aperture, which leads to a larger ratio of cross-section perimeter to cross-section area of the stream, which leads to a more effective air entrainment interface, i.e. higher pumping rate and mixing rate for a given length of the mixing zone. This can be enhanced by flattening the burner outlet area or otherwise shaping to get an extended perimeter of gas-to-air interface. As more and more cold air is drawn in, the momentum of the exhaust gas from the combustion chamber is spread over a much greater air mass; however, the velocity at the work piece remains sufficiently high to achieve good heat transfer.

Furthermore the short time it takes for the exhaust gases according to the present invention to reach desired low treating temperature means that they are not subject to detrimental buoyancy forces. Note that for slower burner output velocities, and slower cooling found in prior devices, the stream of gaseous products is exposed for a quite long time to the effects of the general surroundings as it moves to the work piece and it thus starts curving upwards due to buoyancy forces and becomes seriously prone to being deflected by drafts of air, becoming uncontrollable.

According to the present invention, it is thus proposed to construct a heat gun with a high velocity burner and to entrain air with a jet of the high velocity exhaust gases to produce an air blast of intermediate or low temperature. In one preferred embodiment the air entrainment can take place as in a free jet with a predetermined distance between burner and work piece. The pumping or entrainment zone preferably is within an open metal cage, one function of which is to space the burner predictably from the work piece to assure a predetermined blast temperature delivered to the work piece and another function is the admission of additional air along the length. The peak gas product temperature is a predictable function of spacing to the work piece, thus an adjustable cage or other standoff or positioning means can be present and precalibrated for different output temperature requirements.

Another preferred embodiment employs a closed mixing tube of bigger (by at least 5 times) cross-sectional area than the burner outlet area. Given a sufficient length of mixing tube, generally 3 to 7 diameters, or shorter where highly dispersive burner outlets are used, this construction assures complete mixing of the burner products with the entrained air resulting in high uniformity in temperature of the resulting stream. The degree of temperature attenuation (or mixing ratio) is here governed by the ratio of the mixing tube and burner outlet cross-sectional area, and thus a desired temperature can be reproduced repeatedly by the predetermined sizing.

In preferred embodiments the outlet of the combustion chamber is shaped such that the outlet cross-sectional area and the downstream cross-section assumes a shape with a perimeter substantially greater than the radius of a single circle of the same area. Such outlets typically take the shape of slits, or multiple rounds. By

this means the mixing length to achieve a desired temperature attenuation is reduced in direct proportion to the ambient-to-exhaust gas (jet pump) interface, defined by the exposed perimeter of the stream cross-section. This behaviour can be illustrated by comparing the mixing length of two burners having the same fuel-burning capacity and same exhaust gas velocity but different combustion chamber outlet configurations. An outlet that has at least 25 percent more flow perimeter than a round outlet achieves a desired temperature such as 600°F in 12 inches, contrasted with 30 percent more length for the circular outlet.

Further reduction in mixing length can be achieved if the combustion chamber is shaped such that the streamlines of the exhaust gases assume a divergent pattern from the centerline, so that the perimeter of the stream cross-section downstream of the outlet is greater than at the outlet and to separate the exhaust gas molecules from each other as much as possible to maximize exposure to and mixing with ambient air. In the case of multiple outlets such a pattern can be achieved by inclining the axes of the flow paths away from the center line. In the case of slits, such a pattern can be achieved by tapering the walls of the combustion chamber away from the center line but maintaining a constantly decreasing cross-sectional area of the chamber in the region immediately upstream of the outlet to avoid diffusion or separation of the flow inside the chamber.

Accordingly to another feature, different outlet sections associated with different combustion chambers receive fuel-air mixture from a common primary jet pump activated only by a jet of gaseous fuel.

A further feature of the invention which enhances the velocity of the exhaust gases from the combustion chamber—and hence the secondary pumping effect on ambient air—also has independent significance in general for burners powered by liquid gas fuel sources or other pressure-limited devices. This feature comprises the use of bluff body flame holders of known types, and particularly those which swirl the fuel-air mixture entering the combustion chamber and produce eddy effects for stabilizing the combustion process in the wakes of the blades. In such prior constructions the trailing portions have been intentionally very blunt, for producing a so-called “bluff body” effect, enabling significant recirculation of portions of the gases in the combustion chamber. While such bluff bodies have enabled successful combustion, it is realized that they introduce a significant pressure loss, so that much of the pressure in the upstream recovery passage fails to be usefully converted to velocity of the gas. According to a feature of the invention, it was hypothesized that much of the recirculation heretofore felt necessary was really only necessary during the initial stages of ignition, for carrying the flame back from the outlet to the inlet of the combustion chamber. According to the invention an igniting recess is provided adjacent the flame holder, upstream of the combustion chamber outlet. Also, the ignition recess is positioned out of the mainstream of gases flowing from the flame holder means but in communication therewith, this recess being provided with a spark means for initially igniting the gas fuel mixture. With this construction smaller or thinner bluff bodies with smaller pressure drop can be employed, with reduced bluff body effect. Such flame holders have insufficient eddy effects to produce recirculation of gas from the outlet of the combustion cham-

ber, but sufficient to produce recirculation of gas from the vicinity of the ignition recess. It is found that such a construction successfully initiates as well as sustains combustion, while the pressure loss across the flame holder is greatly reduced, and a corresponding increase in gas velocity effects can be achieved.

FIG. 1 is a partially diagrammatic verical cross-sectional view of a preferred embodiment having a shrouded propelling and mixing zone and a flattened and diverging burner outlet. FIGS. 1a, 2 and 3 are transverse views taken on lines 1a, 2 and 3 respectively in FIG. 1.

FIG. 4 is a view similar to FIG. 1 of a second preferred embodiment; FIGS. 5 and 6 are transverse views taken on lines 5 and 6 respectively of FIG. 4;

FIG. 7 illustrates a pallet carrying an object about which is shrunk a plastic film bay by use of a shrink gun according to the invention.

FIG. 8 is a view similar to FIG. 1 of another preferred embodiment and FIGS. 9 and 10 are transverse views taken on the respective lines of FIG. 8.

Referring to FIGS. 1–3 and FIG. 7 pressurized gas G passes through nozzle 1. The nozzle aims into a duct 3. The nozzle-duct combination is commonly known as a jet pump and its function is to entrain atmospheric air A from openings O around the nozzle, between struts 2, see FIG. 1a. The duct comprises a first inlet section of gradually converging form 3a, then a straight section 3b followed by divergent section 3c and then a short length of straight, pressure recovery section 3d. The pump formed by the inlet, and subsequent straight, divergent and straight sections provides a fuel-air mixture in section 3d at as high a pressure as possible, typically 2 inches water column, up to 4 inches water column, assuming a pumping pressure of 20 psi for gas G, as from propane source S.

The mixture is directed into the burner. The burner consists of an internal combustion chamber 5 and the bluff body flameholder 8. Gas is burned in the combustion chamber. Flame is prevented from flashing back into the jet pump because of the design of the flameholder. Passages, dimension *e*, are so small that the gas velocity therethrough is greater than the burning velocity so the flame simply cannot travel upstream.

At cross-sectional view FIG. 2 the combustion chamber is cylindrical, and then flattens out, FIG. 3. In this embodiment, with a spreading flow of the exhaust gases it is important that in the latter part of the burner, after combustion has occurred, the passage has equal, or as shown, decreasing cross-sectional area while, to extend the wetted perimeter, it fans out in one direction. The flow cross-section area upstream is larger than the outlet 5_o, FIG. 3. The gases are thus accelerated as they come out of the burner. The geometry is particularly important in this latter half of the burner, to maintain velocity and avoid separation of the stream from the diverging walls.

In this particular burner embodiment there is first a cylindrical section 5a less than one diameter in length from the flameholder and then a transition section 5b. In operation combustion initiates at the flameholder and spreads downstream.

The air enters the inlet 3a at a slow velocity and speeds up to a very high velocity inside pump 3 reaching, in a typical embodiment, a maximum around 8,800 fpm in section 3b. In the diffuser 3c it slows, the velocity energy converting to static pressure head, reaching a velocity of 2,200 fpm in pressure recovery section 3d.

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When the gas enters the burner 5 and is heated it tends to expand and it increases in velocity again to a maximum in the outlet 5_o of the burner around 14,570 fpm. From then on the gas starts to entrain large quantities of ambient air A₂ and the mixture slows down.

In a typical embodiment according to FIG. 1, the following conditions can be measured:

distance from outlet 5 _o in inches	Output Temp. °F	gas velocity feet per minute	mass flow rate pounds per minute
0	3450	14,750	1.5
4	2100	4,400	3.4
6	1450	2,800	5.3
8	1100	2,100	7.3
10	900	1,635	9.3
12	770	1,375	11.2
14	660	1,175	13.4
16	590	1,025	15.4
18	530	920	17.5
20	475	830	20
22	435	760	22.3
24	400	690	24.7

In this embodiment the mixing process is obtained in what is called a free jet in which air can enter the mixing stream at any point downstream, entering through the series of apertures 19 distributed along the length of tube or shroud 11. This mixing is very length-dependent. As can be seen from the foregoing table the further downstream from the burner the more air is drawn in, the lower the temperature has dropped. This temperature attenuation curve is very predictable for each size of outlet and velocity through it. Due to the fact that there is an ever decreasing temperature, one can select the temperature wanted. To assure constant spacing, a device such as cage 11 serves to position the burner relative to the workpiece and still admit air for mixing.

In the embodiment of FIG. 1 for different temperatures at the end of shroud 11 one needs only to position its end in the appropriate location. It thus sets a maximum temperature deliverable to the workpiece and by moving away one can obtain lower temperatures.

The embodiment of FIG. 1 has other details. At the entry to the combustion chamber 5 the flame holder 8, as seen in FIG. 2, has a plurality of helical blades set about a center, with thin trailing edges *t*. Adjacent this flame holder is a recess 13 out of the mainstream but in communication therewith. In this recess is spark plug 15 which is actuated by a hammer blow upon piezo crystal 17 located in the handle, actuated by plunger 21.

This unit can readily be made to have for instance a rating of 30 kw (100,000 BTU per hour) with outlet velocities for instance of 1500 ft/min, at output temperatures of 1000°F, or with suitable shortening or lengthening of member 11, respectively higher and lower velocities and temperatures.

The unit is light-weight and can be readily aimed at a plastic film bag 20 of 5 feet dimension on each side, see FIG. 7 pulled over an article on a pallet. By holding the unit of FIG. 1 one or two feet away from the film, and progressively sweeping the output across, up and down and around the object, the plastic film (e.g. polyethylene of 0.006 inch thickness) rapidly shrinks until it tightly hugs the article, providing a weather proof covering therefor.

The embodiment of FIGS. 4-6 is identical to that of FIG. 1 up to line L. From there the gas passage

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branches to a number of small combustion chambers 30 each of which has its own helically bladed flame holder 35 having thin trailing edges. One of the combustion chambers has an ignition recess as described for FIG. 1, and another has a passageway 37 communicating with the first, to be ignited thereby.

The outlet sections of each combustion chamber diverge as described above, terminating in an elongated outlet slit, these slits being in an array with axes X and Y of the long dimensions intersecting at the center of the array. These individual outlets and the array are effective to produce a very large jet-to-air interface for effective pumping and entrainment of air, as in duct 7.

The duct 7a is open at its ends and has imperforate walls along its length.

In effect the hot gases from the burners 30 drive a second jet pump, mix and heat ambient air A. Duct 7 of this second jet pump has a cross section area, shown in FIG. 6, which is substantially larger than the outlet area of the burner, with an order of magnitude from 5 to 50. The air inlet 7a to duct 7 is of corresponding size, due to its flare form, positioned by struts 6 concentrically about the burner. The velocity of the hot gases entrains cold air, and this stream mixes in the duct, the function of the duct being to equalize the velocities and the temperature of the mixture. If the duct were cut too short a hot core and a cold outside would be found. Complete mixing occurs so that after a length of more than about 3 diameters up to 7 depending upon design, equal temperature and equal velocity come out. The amount of air entrained is governed primarily by the area ration of duct 7 to the burner outlet area. Typically, to achieve the same low temperature with same burner design, the length of shroud 11 of FIG. 1 beyond the burner will be less than the length of tube 7 of FIG. 14, and hence FIG. 1 may be more convenient for certain applications. Where the uniformity of the temperature of all air emitted from the outlet is important, one may choose however the embodiment of FIG. 4 over that of FIG. 1. Another advantage of FIG. 4 is that it is windproof in high cross winds, useful for instance around airports and railroads.

Referring to the embodiment of FIGS. 8-10, it is identical in principle to FIG. 4 up to flameholders 35, the exception being that the end of the single pressure recovery passage discharges into twin branches passages and combustion chambers instead of into four of them. In this particular embodiment the slit-form outlets of the combustion chambers are spaced apart with their long dimensions parallel, and side by side. The pair of outlets discharge into a perforated shroud 11b, similar in its apertures to the shroud of FIG. 1, but being of generally square cross-section, see FIG. 10. In a preferred embodiment the shroud is 6 inches long measured from the outlet of the combustion chamber and 8 inches wide and high. In an embodiment identical to FIG. 1 up to line L, at its outlet T there is observable a temperature of 750°F, peak velocity of 1340 fpm and a mass flow rate of 11.6 pounds per minute. This compares most closely to the 12 inch distance for the embodiment of FIG. 1 and thus demonstrates that the same output can be got over much shorter propelling and mixing distances using multiple outlet arrangements.

In typical use, in shrinking plastic pallet wrap about objects on pallets, the operator will take into account how fast he moves the gun and the thickness and nature of the plastic film when determining the particular dis-

tance he employs between the gun and the thermoplastic film. For instance using a 0.006 thick polyethylene film and a shrink gun according to FIG. 1 rated at 120,000 BTU per hour a film section of 1 foot height can be shrunk at a speed of travel of the gun of 32 feet per minute, at a spacing of 1 foot away, measured from the combustor outlet. Also, where tears in the film occur, he may patch them simply by moving the gun closer, softening the area of the tear and then applying a patching piece of similar thermoplastic film.

It will be understood that numerous variations in the specific construction are possible within the spirit and scope of the following claims.

I claim:

1. A hand held aimable shrink gun plastic film capable of providing a shrink-producing flow of heated air in the 250°F to 1000°F range against plastic film lying over an object to be covered, the shrink gun relying upon fuel along without assistance of blowers or compressors, said shrink gun comprising a gas jet adapted for connection to a conventional fuel gas source such as propane having a stoichiometric burning temperature substantially exceeding 3000°F, a jet pump activated by said gas jet and having an opening for drawing atmospheric air for combustion into a subatmospheric pressure region produced by said jet, said jet pump constructed to impart velocity to said combustion air by mixing, an enlarged pressure recovery passage into which the mixture of gaseous fuel and combustion air proceeds, said recovery passage constructed to convert velocity head of said gases to a pressure head exceeding atmospheric pressure, an internal combustion chamber having an entry into which said pressure recovery passage discharges, said internal combustion chamber having a flame holding means at said entry and an outlet discharging into an ambient air propelling and mixing zone preceding said work object, the respective parts of said shrink gun constructed to introduce and burn said fuel in substantially stoichiometric conditions and discharge combustion gases into said propelling zone at a temperature exceeding 3000°F and a velocity in excess of 4000 feet per minute in a manner to propel relatively larger quantities of ambient air in the same direction with attendant heating thereof by said combustion gases, thereby to produce a flow against said plastic film at temperature in the 250°F to 1000°F range, consisting in major part of ambient air propelled and heated by said combustion gases.

2. The shrink gun of claim 1 including positioning means setting a minimum length of said propelling and mixing zone between said work piece and combustion chamber outlet, ensuring a flow of heated air below a predetermined maximum temperature upon the work piece.

3. the shrink gun of claim 2 wherein the combustion gases are exposed during their travel through said propelling and mixing zone to admission of increasing quantities of air.

4. The shrink gun of claim 2 wherein said positioning means comprises a shield member extending at least partly about the stream of combustion gases, said member providing air flow space whereby ambient air can flow from surroundings into contact with said combustion gases.

5. The shrink gun of claim 4 wherein said shield member has openings along its length exposing the traveling gases to admission of additional air therealong.

6. The shrink gun of claim 1 wherein said combustion chamber outlet has a cross-section perimeter greater by at least 25% than the perimeter of a single circle of identical cross-sectional area.

7. The shrink gun of claim 6 wherein said combustion chamber has a constant or decreasing flow cross-section area leading to said outlet.

8. The shrink gun of claim 7 wherein said outlet comprises an elongated outlet aperture, said combustion chamber having walls diverging in the direction of elongation of said aperture.

9. The shrink gun of claim 6 wherein the outlet cross-section comprises a multiplicity of elongated slits.

10. The shrink gun of claim 1 wherein said outlet has portions directed in divergent outward directions.

11. The shrink gun of claim 10 wherein said outlet comprises a multiplicity of outlet apertures, axes of some of said apertures diverging relative to other of said apertures.

12. The shrink gun of claim 1 wherein said combustion chamber has a restricted entry connected to said recovery passage, said entry being of substantially smaller cross-section than said passage and than the combustion chamber downstream thereof, said entry adapted to produce an inlet velocity to said combustion chamber greater than the flame velocity of said gas.

13. The shrink gun of claim 12 including a tubular member surrounding the outlet of said combustion chamber, said tubular member providing an air inlet flow cross-section in the vicinity of said outlet which is greater than 5 times the flow area of said combustion chamber outlet, said tubular member having a length longer than said combustion chamber.

14. The shrink gun of claim 13 wherein said tubular member has air inlet openings along its length, for adding air to the stream flowing through said tubular member.

15. The shrink gun of claim 13 constructed to produce a predetermined outlet temperature wherein walls along the length of said tubular member are imperforate, the inlet for ambient air to said tubular member positioned in the vicinity of said combustion chamber outlet, and being in the range of 5 to 50 times the volume of combustion gases, said outlet and said tubular member cooperating to provide a jet pump for ambient air.

16. The shrink gun of claim 1 wherein said combustion chamber has an exhaust outlet flow cross-section of extended perimeter, preferably the outlet formed as an elongated slit, said outlet defining a propelling means having an extended jet-air interface effective to propel and mix with large quantities of ambient air over a short distance before reaching said object to be heated.

17. The shrink gun of claim 16 wherein said combustion chamber in the region immediately preceding said outlet has walls arranged so that the flow cross-section does not increase leading to said outlet, said walls cooperating to achieve a high exit velocity at said outlet for propelling said ambient air.

18. The shrink gun of claim 17 wherein said flow cross-section of said combustion chamber decreases leading toward said outlet while one pair of walls diverge from each other in the direction of said outlet to produce a high velocity, divergent jet having a progressively enlarging jet-air pumping interface, for increased entrainment of air.

19. The shrink gun of claim 16 wherein there are a plurality of outlet sections for said high velocity gas,

preferably these outlet sections being set at angles to one another, providing a large jet-air pumping interface for increased entrainment of air.

20. The shrink gun according to claim 19 wherein a single combustion chamber has angled walls defining gradually diverging streams, the ends of the walls defining said plurality of combustion chamber outlet sections.

21. The shrink gun of claim 19 wherein certain outlet sections are associated with different combustion chambers, all of said combustion chambers receiving fuel-air mixture from a common mixing chamber comprising a primary jet pump activated only by a jet of gaseous fuel.

22. The shrink gun of claim 1 having a bluff body flame holder means in the path of air-fuel mixture entering said combustion chamber, producing eddy effects for stabilizing the combustion process, known per se, and characterized in that said combustion chamber has an ignition recess adjacent said flame holder means and well upstream of the outlet of said combustion chamber, said ignition recess being out of the mainstream of gases flowing from said flame holder means but in communication therewith and having spark means known per se for initially igniting the air fuel mixture, and the said flame holder having insufficient eddy effects to produce recirculation of gas from the outlet of said combustion chamber, but sufficient to produce recirculation of gas from said ignition recess whereby ignition can be initiated while said flame holder introduces only a small pressure loss to gas entering said combustion chamber.

23. The shrink gun according to claim 22 characterized in that said bluff body flame holder comprises a series of helical blades (known per se), the end of said blades being tapered producing only a limited bluff body effect.

24. A hand held aimable shrink gun for plastic film capable of providing a shrink-producing flow of heated air in the 250°F to 1000°F range against plastic film lying over an object to be covered, the shrink gun relying upon fuel alone without assistance of blowers or compressors, said shrink gun comprising a gas jet adapted for connection to a conventional fuel gas source such as propane having a stoichiometric burning temperature substantially exceeding 3000°F, a jet pump activated by said gas jet and having an opening for drawing atmospheric air for combustion into a subatmospheric pressure region produced by said jet, said jet pump constructed to impart velocity to said combustion air by mixing, an enlarged pressure recovery passage into which the mixture of gaseous fuel and combustion air proceeds, said recovery passage constructed to convert velocity head of said gases to a pressure head exceeding atmospheric pressure, a plurality of internal combustion chambers each having an entry into which said pressure recovery passage discharges, each of said internal combustion chambers having a flame holding means at its said entry and an outlet discharging into an ambient air propelling and mixing zone preceding said work object, the respective parts of said shrink gun constructed to introduce and burn said fuel in substantially stoichiometric conditions and discharge combustion gases into said propelling zone at a temperature exceeding 3000°F and a velocity in excess of 4000 feet per minute in a manner to propel relatively larger quantities of ambient air in the same direction with attendant heating thereof by said combustion

gases, the outlets of said plurality of combustion chambers combining to produce a flow against said plastic film at temperature in the 250°F to 1000°F range, consisting in major part of ambient air propelled and heated by said combustion gases.

25. In a burner for gaseous fuel activated only by the ambient pressure of a liquid gas fuel source, suitable for use in heat guns and torches, and comprising a mixing chamber directing air fuel mixture into a combustion chamber, the mixing chamber in the form of a primary jet pump activated only by a jet of fuel from said source which jet entrains air from the atmosphere and forms a fuel-air mixture, a pressure recovery passage of increased cross-section wherein velocity head produced by said jet pump is converted to pressure head, said combustion chamber having a restricted entry connected to said recovery passage, said entry being of substantially smaller cross-section than said passage and than the burner chamber adjacent thereto, said entry adapted to produce an inlet velocity greater than the flame velocity of said gas, and a bluff body flame holder means at said entry, said flame holder means in the path of air fuel mixture entering said combustion chamber, producing eddy effects for stabilizing the combustion process, known per se, that improvement wherein said combustion chamber has an ignition recess adjacent said flame holder means and well upstream of the outlet of said combustion chamber, said ignition recess being out of the mainstream of gases flowing from said flame holder means but in communication therewith and having spark means known per se for initially igniting the air fuel mixture, and the said flame holder having insufficient eddy effects to produce recirculation of gas from the outlet of said combustion chamber, but sufficient to produce recirculation of gas from said ignition recess whereby ignition can be initiated while said flame holder introduces only a small pressure loss to gas entering said combustion chamber.

26. The burner according to claim 25 wherein said bluff body flame holder comprises a series of helical blades (known per se) the end of said blades being tapered producing only a limited bluff body effect.

27. The burner of claim 25 wherein there are a plurality of parallel combustion chambers, said ignition recess communicating directly or indirectly with each of said combustion chambers.

28. A hand held gun for directing a flow of heated air against a work object, relying upon fuel alone without assistance of blowers or compressors, said gun comprising the combination of

- a gaseous fuel jet adapted for connection to a conventional fuel gas source,
- a jet pump activated by said gas jet and having an opening for drawing atmospheric air for combustion into a subatmospheric pressure region produced by said jet, said jet pump constructed to impart velocity to said combustion air by mixing,
- an enlarged pressure recovery passage into which the mixture of gaseous fuel and combustion air proceeds, said recovery passage constructed to convert velocity head of said gases to a pressure head exceeding atmospheric pressure, and
- an internal combustion chamber arranged to receive for combustion said gases discharging from said pressure recovery passage, said chamber having walls arranged to cooperate with said pressure head to convey combustion-

related gaseous expansion into velocity head of the combustion products,
 said chamber having an outlet constructed and arranged to discharge said combustion products into an air entrainment zone for mixing said products with, and transferring heat to, ambient air to produce at the downstream end of said zone a flow of heated gases at a selected temperature,
 said outlet having an effective wetted perimeter at least 25% longer than that of a single circle of identical cross-sectional area, thereby providing an extended interface between combustion products discharging from said outlet and ambient air, enhancing said mixing, and reducing the necessary length of said entrainment zone by comparison with a similar gun having a circular combustion chamber outlet.

29. A hand held gun for directing a flow of heated air against a work object, relying upon fuel alone without assistance of blowers or compressors, said gun comprising the combination of

- aa gaseous fuel jet adapted for connection to a conventional fuel gas source,
- a jet pump activated by said gas jet and having an opening for drawing atmospheric air for combustion into a subatmospheric pressure region produced by said jet, said jet pump constructed to impart velocity to said combustion air by mixing,
- an enlarged pressure recovery passage into which the mixture of gaseous fuel and combustion air proceeds, said recovery passage constructed to convert velocity head of said gases to a pressure head exceeding atmospheric pressure, and
- an internal combustion chamber arranged to receive for combustion said gases discharging from said pressure recovery passage,
- said chamber having walls arranged to cooperate with said pressure head to convert combustion-related gaseous expansion into velocity head of the combustion products,
- said chamber having an outlet constructed and arranged to discharge said combustion products into an air entrainment zone for mixing said products with, and transferring heat to, ambient air to produce at the downstream end of said zone a flow of heated gases at a selected temperature,
- said outlet being constructed and arranged to cause said combustion products to discharge into said zone in divergent outward directions, thereby providing an extending interface between said discharging products and ambient air, enhancing said mixing, and reducing the necessary length of said entrainment zone by comparison with a similar gun having a combustion chamber arranged for straight-ahead discharge.

30. the gun of claim 29 wherein said combustion chamber has at least one outwardly flaring wall at said outlet.

31. The gun of claim 30 wherein said outlet is an elongated slit and said combustion chamber has outwardly flaring walls extending along the major dimension of said slit.

32. The gun of claim 29 wherein said combustion chamber has a constant or decreasing flow cross-sectional area leading to said outlet.

33. A hand held gun for directing a flow of heated air against a work object, relying upon fuel alone without assistance of blowers or compressors, said gun comprising the combination of

- a gaseous fuel jet adapted for connection to a conventional fuel gas source,
- a jet pump activated by said gas jet and having an opening for drawing atmospheric air for combustion into a subatmospheric pressure region produced by said jet, said jet pump constructed to impart velocity to said combustion air by mixing,
- an enlarged pressure recovery passage into which the mixture of gaseous fuel and combustion air proceeds, said recovery passage constructed to convert velocity head of said gases to a pressure head exceeding atmospheric pressure,
- an internal combustion chamber arranged to receive for combustion said gases discharging from said pressure recovery passage,
- said chamber having walls arranged to cooperate with said pressure head to convert combustion-related gaseous expansion into velocity head of the combustion products,
- said chamber having an outlet constructed and arranged to discharge said combustion products into an air entrainment zone for mixing said products with, and transferring heat to, ambient air to produce at the downstream end of said zone a flow of heated gases at a selected temperature, and
- a temperature limiting structure extending downstream from said combustion chamber along said entrainment zone to prevent direct access of the work object to said combustion chamber outlet.

34. The gun of claim 28 wherein said pressure recovery passage is part of an elongated passage which is effectively closed to the atmosphere between said jet pump and said outlet.

35. The gun of claim 33 wherein said temperature limiting structure is a tubular member having an air inlet flow cross section in the vicinity of said outlet which is greater than five times the flow area of said outlet.

36. The gun of claim 35 wherein said tubular member has imperforate walls extending along its length and has an effective flow capacity such that the ratio of said flow capacity to that of said outlet determines the temperature of the resultant flow at the downstream end of said zone.

37. The gun of claim 36 wherein said tubular member has an outlet in the form of an elongated slit.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

Page 1 of 2

PATENT NO. : 3,917,442

DATED : November 4, 1975

INVENTOR(S) : Dimiter S. Zagoroff

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 11, "about" should be --to--.

Col. 2, lines 10 and 11, "ration" should be
--ratio--;

line 18, "momenntum" should be --momentum--;

line 48, "present" should be --preset--.

Col. 3, line 36, "pumpting" should be --pumping--

Col. 4, line 7, "verical" should be --vertical--;

line 17, "bay" should be --bag--;

line 66, "In the diffuser 3c" should not be in
italics.

Col. 6, line 5, "passageway" should be --passage--;

line 17, after "jet pump," insert --to pump--;

line 22, "flare" should be --flared--;

line 32, "ration" should be --ratio--;

line 46, "branches" should be --branched--.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION Page 2 of 2

PATENT NO. : 3,917,442

DATED : November 4, 1975

INVENTOR(S) : Dimiter S. Zagoroff

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 7, line 15, after "gun" insert --for--.

Col. 8, line 30, "vincity" should be --vicinity--.

Col. 9, line 53, "coon-" should be --con- --.

Col. 10, line 68, "convery" should be --convert--.

Col. 11, line 23, "aa" should be --a--;

line 52, "extending" should be --extended--.

Signed and Sealed this

first Day of June 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks