

April 9, 1968

E. B. HUNT
CATALYTIC HEATER

3,376,932

Filed March 4, 1966

4 Sheets-Sheet 1

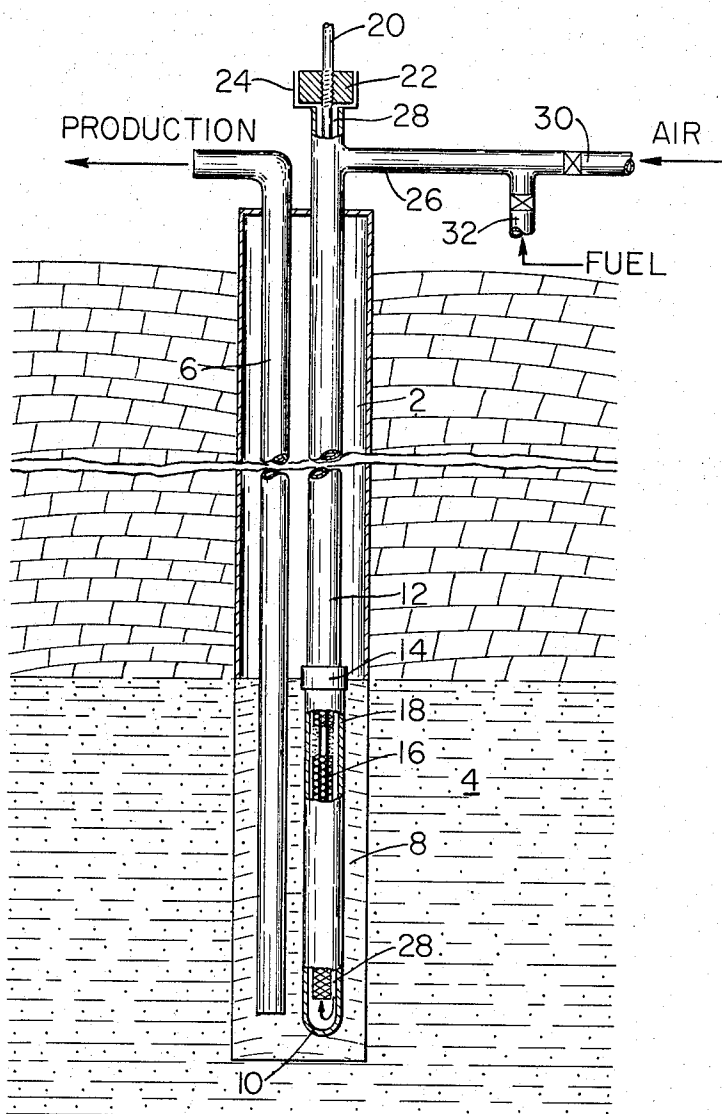


Fig. 1

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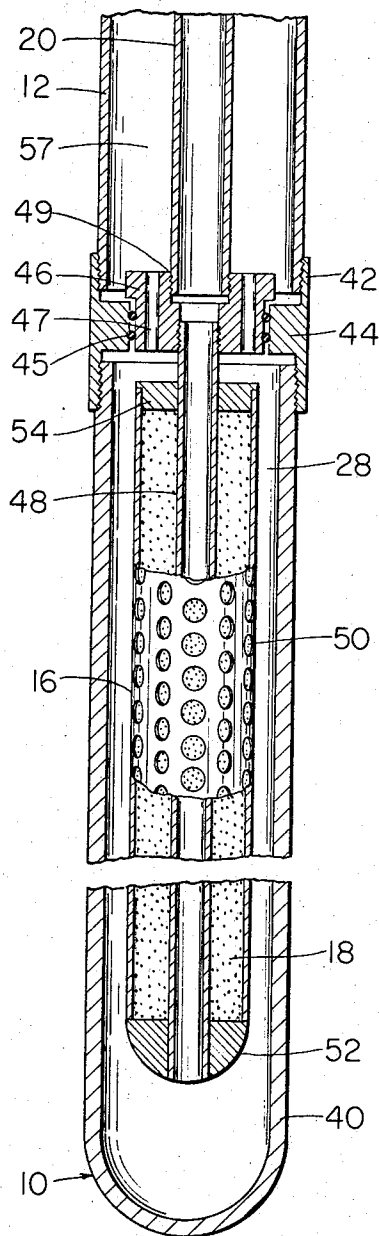


Fig. 2

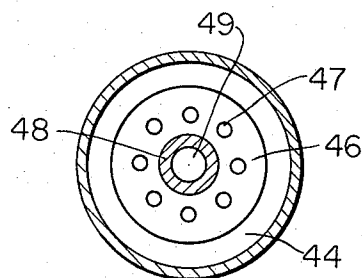


Fig. 3

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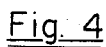
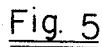
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CATALYTIC HEATER

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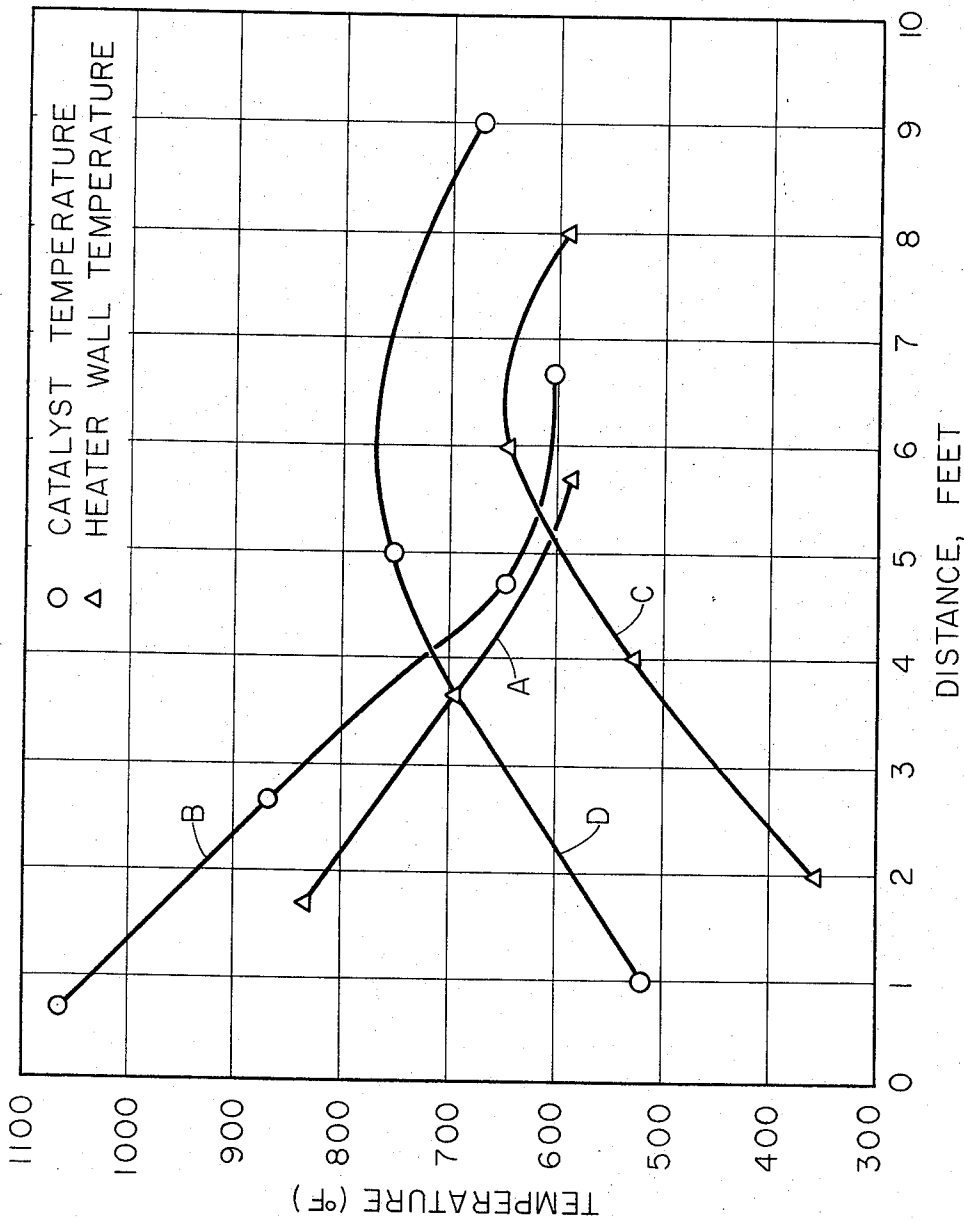


Fig. 6

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3,376,932

CATALYTIC HEATER

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4 Claims. (Cl. 166-59)

ABSTRACT OF THE DISCLOSURE

A catalyst-lined bottom-hole heater is proposed for low-temperature service, below about 400 or 500° F. The catalyst coating may be coated with a porous material to limit the reaction rate. However, by having the catalyst in intimate contact with the heater wall, good heat transfer may keep the temperature low enough so that the porous material may not be needed.

The present invention relates to a novel design for a catalytic oil well heater wherein the heat is derived by catalytic oxidation of a suitable fuel-air mixture. More particularly it is concerned with an apparatus suitable for heating formations containing viscous or relatively high pour point crudes difficult to produce by conventional means.

Briefly, the heater of my invention is designed so that all of the air-fuel mixture does not flow through all of the catalyst and the latter is placed within the heater so that it does not come into direct contact with the outer shell or heater housing. Heaters of this general design have a number of advantages, including (1) low pressure drop because the feed does not have to flow through the entire catalyst bed; (2) lower heater shell temperature at a given amount of excess air owing to the spreading out or diffusion of the reaction and to the catalyst being out of direct contact with the heater wall; (3) less excess air is required to keep the heater wall temperature at reasonable values which can greatly reduce air compression costs; (4) operation of the heater is less affected by conditions external of the heater because the catalyst is not in direct contact with the heater wall; and (5) higher catalyst temperature at a given wall temperature since the catalyst is not in contact with the heater wall. The advantage of this is that such condition permits the catalyst temperature to be high enough so that propane, LPG, and similar fuels may be used.

Many methods have been employed in the prior art for heating oil wells, e.g., by electrical means, by injecting heat transfer agents into the well such as steam, hot oil, etc., and by burning natural gas in the well bore. Considerable difficulty has been encountered in the application of electric well heating owing to the highly corrosive nature of oil field brine, sulfur compounds, and other components of the fluids produced through the well bore. These fluids penetrate the innermost parts of the well heater, and even traces of moisture cause short-circuiting of the apparatus necessitating shutdown, removal and repair. These difficulties materially reduce the operating efficiency of such heating processes. Well bore liquids also penetrate and permeate the customary insulating materials rendering them practically useless. The application of electrical heating means to deep wells, i.e., wells in excess of 3,000 ft., is difficult owing to the problems encountered in supplying adequate electrical power at such depths. These problems are peculiar to the well heating art and are not generally encountered in other applications of electrical heating.

One of the principal drawbacks of the gas or liquid fueled heaters is that it is extremely difficult to avoid damage to the casing and any well equipment present in

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the area where heat is being applied. This is due to the fact that the temperature at which heaters of this kind operate cannot be maintained at levels which such equipment can withstand. One of the difficulties with electrical heaters is their tendency to short out owing to hot spots developing through poor heat exchange, generally resulting from coke formation on the surface. With increasing thickness of the coke layer on the exterior of the heater, the temperature tends to build up until it exceeds the melting point of the heating elements causing the latter to fail.

Accordingly, it is an object of my invention to provide a catalytic heater suitable for stimulating the flow of viscous and high pour point wells from oil-bearing formations wherein the structure of the heater is such that the catalyst component is separated from the housing or outer shell of the heater by an annular or equivalent space. It is another object of my invention to provide apparatus whereby the catalyst itself is distributed within the heater so that the air (or oxygen) -fuel mixture employed is not forced to pass through the entire body of catalyst actively involved in generating heat to be transferred to the formation. It is still another object of my invention to provide a catalytic heater which can be employed effectively in deep (e.g., in excess of 3,000 to 4,000 ft.) wells. It is still another object of my invention to provide a catalytic heater in which the operation thereof is substantially not affected by external conditions.

My invention is further illustrated by the accompanying drawings in which:

FIGURE 1 is an over-all elevation view, primarily in section, showing the heater in place in a well and the position of the heater with respect to the formation and the production tubing.

FIGURE 2 is a detailed view of a heater design of my invention in which the heater shell or housing is lowered into position on a suitable tubing and the remainder of the apparatus, including catalyst container and landing nipple, are lowered on narrow diameter tubing or equivalent means into position.

FIGURE 3 is a plan view of the heater shown in FIGURE 2.

FIGURE 4 is a fragmentary sectional view of another embodiment of my invention similar to that shown in FIGURE 2 except for having a crossover arrangement in land nipple 55 to accommodate the flow of gas through the system.

FIGURE 5 is a plan view of the heater shown in FIGURE 4 illustrating in some detail the crossover construction in the landing nipple 55 of FIGURE 4.

FIGURE 6 shows two sets of curves illustrating the difference in both catalyst and heater wall temperatures and the extent such temperatures are spread over the entire heating unit when all the fuel-air mixture must pass through all of the catalyst—compared to operation of the catalytic heater of the type covered by my invention.

Referring now to FIGURE 1, a cased well 2 penetrates a formation 4 containing heavy viscous oil. Within well 2 production tubing 6 extends down to near the bottom of open hole section 8. The assembly of tubing and heater is placed alongside of production tubing 6 with the heater 10 placed opposite the oil-bearing zone. The outer shell of heater 10 is threadedly or otherwise removably mounted to tubing 12 at 14. Catalyst basket 16, filled with catalyst 18 is attached to macaroni string or tubing 20 and is placed at the enclosed base of heater 10. Basket 16 which is substantially the same length as heater 10 is suspended within the heater housing so as to define an annular space between the wall of said housing and the catalyst basket. Tubing 20 is held in position at the top of the well by means of hanger 22 resting on shoulders 24 at the

mouth of tubing 12. Below the mouth of tubing 12, line 26 is affixed thereto so as to be in direct communication with annular space 28. Valved air and feed supply lines 30 and 32, respectively, are tied into line 26.

FIGURE 2 is a detailed view of one embodiment of the heater shown generally in FIGURE 1 in which outer shell or housing 40, closed at its lower end is affixed to tubing 12 by means of coupling ring 42 equipped with an inwardly protruding seating ring or nipple 44 on which landing nipple 46 rests. Landing nipple 46 is equipped with channels 47 to permit the flow of gas during operation of the heater. To insure a gas-tight fit between landing nipple 46 and seating nipple 44, O-rings 45 are provided in the former. Threadedly connected to and suspended downwardly from nipple 46 is open-ended pipe or tube 48 which in turn carries catalyst basket 16 having perforations 50. These perforations may vary in size; however, I have found that in the majority of cases, holes of the order of $\frac{3}{16}$ " in diameter with about $\frac{1}{4}$ " spacing—thus providing about 50 percent open area—afforded adequate opportunity for the fuel-gas mixture to contact the catalyst. If desired, expanded metal structures may be substituted for the perforated basket 16. At the bottom of basket 16 is nose cap 52, forming a closure between the lower end of tube 48 and the walls of the basket. A cap 54 is fitted by friction, spot welding, or other means in the top of basket 16 to prevent loss of catalyst during installation of the heater. The combination of heater 10 and landing nipple 46 is carried by tubing 20 threadedly engaged to the upper portion of nipple 46 containing threaded socket 49.

FIGURE 4 is a variation of the heater design shown in FIGURE 2 in which a crossover is placed in landing nipple 55 for separately handling the gaseous feed mixture and products of catalytic combustion. Thus passageways 56 in landing nipple 55 serve to place annulus 57 and the interior of tube 48 into direct communication with one another. Passageways 58 provide communication between tubing 20 and annulus 28. In the event products of combustion generated by operation of the heater prove to be corrosive, the vent line handling such products may be coated with any of several plastic materials, such as, for example, a phenolic resin, to insure adequate protection of the line.

The device shown in FIGURE 2, for example, after being installed in the well is placed in operation by introducing an air-fuel mixture down annular space 57 through channels 47 and into heater 10 where said mixture contacts a portion of catalyst 18 exposed by perforations 50. Adequate contact of said mixture with the catalyst is obtained owing to the fact that a rather high degree of turbulence is produced in annulus 28. Depending on flow rates and composition of the air-fuel mixture temperatures at or near the catalyst surface may range from about 400 to about 1,000 degrees F. Higher temperatures are possible but ordinarily are not desirable because of the coking problems generally resulting therefrom. The hot products produced by catalytic oxidation of the air-fuel mixture are forced upwardly through tube 48 and directly into vent line 20.

Two features that I feel are primarily responsible for the outstanding performance of my heater are (1) no great pressure drop is experienced when the air-fuel mixture contacts the catalyst because said mixture is not required to flow through the entire catalyst bed and (2) the space between catalyst basket 16 and shell 40, i.e., annulus 28, prevents conditions external of the heater from materially affecting its operation. In this way the transfer of heat from shell 40 to the formation is continuous and uniform, with no difficulty being experienced in maintaining the catalyst but hot enough to promote rapid and complete oxidation of the fuel. In contrast I have observed that with heaters having the catalyst bed in direct contact with the heater wall, the transfer of heat to the formation is sometimes so rapid that the temperature of the

catalyst bed frequently falls below the level required to sustain satisfactory oxidation of the fuel.

Additional advantages of the heater of my invention will be realized by reference to FIGURE 6, showing two sets of curves showing temperature distribution through catalyst beds of two different types. Curves A and B were obtained by flowing a suitable air-methanol mixture through a bed of catalyst arranged so that all of the mixture had to pass through all of the catalyst. It will be seen that initially the temperature on the catalyst exceeded 1,000 degrees F. and that the heater wall temperatures rose to a level above 800 degrees F., indicating rapid reaction. As the mixture continued through the catalyst bed the temperatures decreased until at a distance between 6 and 7 feet through the bed, the catalyst wall temperature had fallen to about 600 degrees F.

A substantially different result is shown in curves C and D which were obtained by flowing an air-methanol mixture gas through a heater of the design covered by my invention. In the latter case all operating conditions, as well as the air-fuel mixture, were the same as previously used. In the second set of curves it will be seen that while the catalyst and wall temperatures initially were lower than in the first case, the temperatures further on down the catalyst bed increased and were maintained at a higher level for a greater distance through the bed, thus indicating a larger area from which heat could be transferred from the catalyst and heater wall to the formation.

While methanol at present is the preferred fuel to be used in the heater of my invention, other materials such as natural gas, propane, or LPG may be used. Care, of course, must be exercised to avoid the occurrence of explosive mixtures. In the case of methanol, explosive mixtures with air are encountered where the methanol content ranges from about 6.5 to about 36.5 volume percent.

The catalysts used may be selected from a wide list of materials and form no part of my invention. Typically, catalysts suitable for oxidation of the feeds contemplated herein include platinum, palladium, rhodium, etc. These materials are preferably used in very dilute concentrations, e.g., 0.05 to about 0.5 weight percent, and may be supported on materials having a large surface area, such as pumice, aluminum oxide, metal wool, for example, stainless steel wool, and the like. Supported platinum catalyst suitable for this purpose is manufactured by the Chemetron Corporation of Louisville, Ky., and is identified as catalyst G-43. This catalyst is available in $\frac{1}{4}$ " x $\frac{1}{4}$ " tablets which are well suited for use in the heater of my invention. In operation, the portion of catalyst apparently entering into the oxidation reaction is that with which the feed mixture first comes in contact.

To further illustrate the apparatus of my invention reference is made to the following example.

Example

The well in which the heater of my invention was tested was located in the Walker Hollow Field, Uintah County, Utah. When brought in this well produced 52 barrels/day of a crude oil having a pour point of from 100 degrees F. to 105 degrees F. Within five months after it had been completed, production had leveled off at about 7 barrels/day. Prior to the use of my invention the only means available for stimulating production involved the use of hot oil. In such treatments, oil is heated to 180 degrees F. to 200 degrees F., pumped down the annulus between the tubing and casing, and then brought back up the tubing. Immediately after a treatment of this sort the production increased to about 30 barrels/day, but within 24 hours thereafter, production began to decrease until after one week's time, it was back down to 7 barrels/day. Treatments of this kind usually cost about \$1,000 each. The heater of my invention was then installed by first running in the well a string of 2 $\frac{1}{2}$ " tubing, having affixed to the bottom thereof a closed-end heater shell of the same diameter and about 20 ft long. The bottom of the

heater shell was landed at 4828.3 ft., after which the catalyst basket packed with a platinum catalyst supported on alumina particles, together with a landing nipple above the basket, were lowered on 1" internally plastic-coated tubing until the assembly was in place on a seating nipple just above the basket, all as shown, for example, in FIGURES 2 and 4 of the drawings. The casing in this well was perforated at 4794 ft. and at 4828 ft.

The heater was started by pumping down the annulus an air-methanol mixture containing 1.82 mol percent methanol at a pressure ranging at about 120 to 130 p.s.i. The air rate was 2840 s.c.f.h. and methanol was introduced into the system at 0.683 gallon/hour. At these rates a reaction temperature of about 800 degrees F. was generated, resulting in a heat duty of 960,000 B.t.u./day. Within about 24 hours after the heater was placed in operation production had increased to 50 barrels/day, and four weeks thereafter, the well was still producing at this level.

Operating costs for heaters of the type contemplated herein typically range from about \$5/day for a heat duty of 200,000 B.t.u./day to about \$13/day for 1-million B.t.u./day.

Other dimensions of the apparatus used in the above example, referring specifically to the embodiment illustrated in FIGURE 4 were as follows: Tube 48, $\frac{3}{8}$ " I.D. x $1\frac{3}{4}$ "; tubing 12, $2\frac{1}{8}$ " I.D.; tubing 20, 1" I.D.; channels 58, $\frac{3}{8}$ " I.D.; and channels 56, $\frac{5}{16}$ " I.D.

The materials employed in fabricating the heater covered by the present invention are generally readily available. Ordinarily I prefer to use the heat resistant stainless steels, such as 304 stainless, or similar alloys for all parts of the heater except the housing which may be of ordinary low carbon steel, such as that used in oil field tubing.

I claim:

1. In a catalytic heater the combination comprising an elongated housing closed at one end, an elongated hollow body within said housing closed at least at the end of the closed end of said housing and spaced apart from the walls thereof to define an annulus between said body and said housing, said hollow body containing an oxidation catalyst and being perforated along the sides thereof thereby exposing said catalyst contained therein to contact with fluids in said annulus, a conduit carrying said body and extending from end of said hollow body with the end of said conduit adjacent the closed end of said housing communicating with the exterior of said body, means located above said body for conducting fluid reactants into the uppermost end of said conduit, and

separate means located above said body for withdrawing fluids from said annulus.

2. The catalytic heater of claim 1 in which said hollow body is closed at both ends.

3. In a catalytic heater the combination comprising an elongated housing closed at one end, a seating nipple within and affixed to the open end of said housing, a landing nipple resting on said seating nipple, a plurality of channels about the periphery of said landing nipple and passing therethrough, a channel extending through said landing nipple and located substantially centrally of said plurality of channels, an open-ended conduit extending from said central channel and into said housing, and a hollow elongated body closed at both ends thereof, said body containing an oxidation catalyst and carried by said conduit to define an annulus between said body and said housing, said hollow body being perforated along the sides thereof thereby exposing the catalyst contained therein to contact with fluids in said annulus.

4. In a catalytic heater the combination comprising an elongated housing closed at one end, a seating nipple within and affixed to the open end of said housing, a landing nipple resting on said seating nipple, a first open-ended conduit affixed to the under side of said landing nipple, a hollow elongated body closed at both ends, said body containing an oxidation catalyst and carried by said first conduit to define an annulus between said housing and said body, said hollow body being perforated along the sides thereof thereby exposing said catalyst contained therein to contact with fluids in said annulus, a plurality of spaced channels around the periphery of said landing nipple providing passageways to said first conduit from the top side of said landing nipple, a socket in said top side centrally located with respect to said plurality of said channels adapted to receive a second conduit, and a second group of channels in said landing nipple extending from the under side thereof communicating both with said second conduit and said annulus.

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CHARLES E. O'CONNELL, *Primary Examiner*.

DAVID H. BROWN, *Examiner*.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,376,932

April 9, 1968

Elton B. Hunt

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

Column 1, line 39, "temperature" should read -- temperatures --. Column 2, line 46, "land" should read -- landing --. Column 5, line 43, "perferated" should read -- perforated --; line 46, after "end" insert -- to end --.

Signed and sealed this 5th day of August 1969.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.

Commissioner of Patents