Jan. 12, 1960 H. F. WEAVER ET AL 2,920,946

PROCESS FOR PROCESSING OF EXISTING AIR VAPOR MIXTURES

Filed May 17, 1954 3 Sheets-Sheet 1

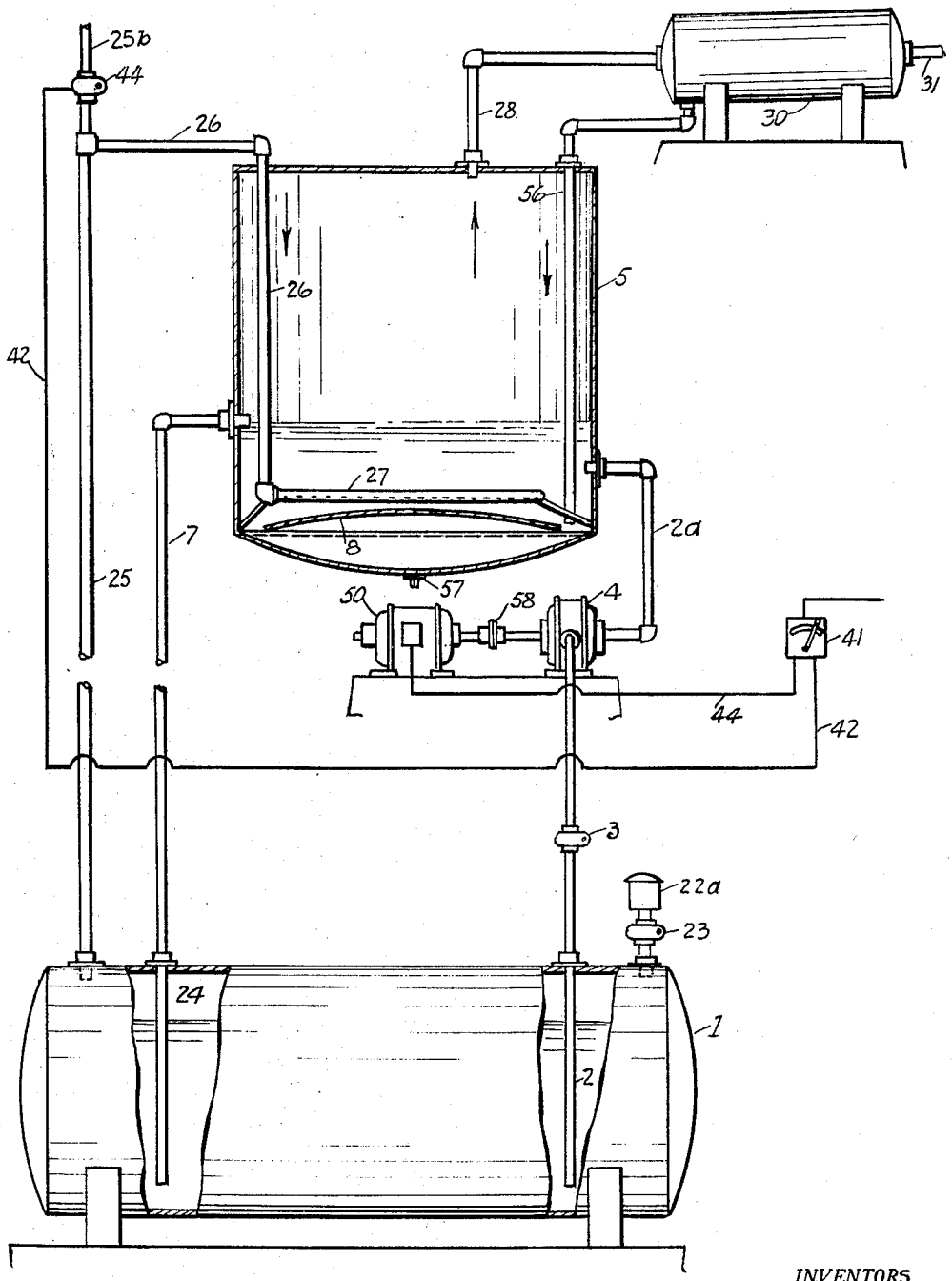


Fig 1

INVENTORS
Howard F. Weaver
Joseph Abelow
By Meyer & Berkin
Attorney

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PROCESS FOR PROCESSING OF EXISTING AIR VAPOR MIXTURES

Filed May 17, 1954 3 Sheets-Sheet 2

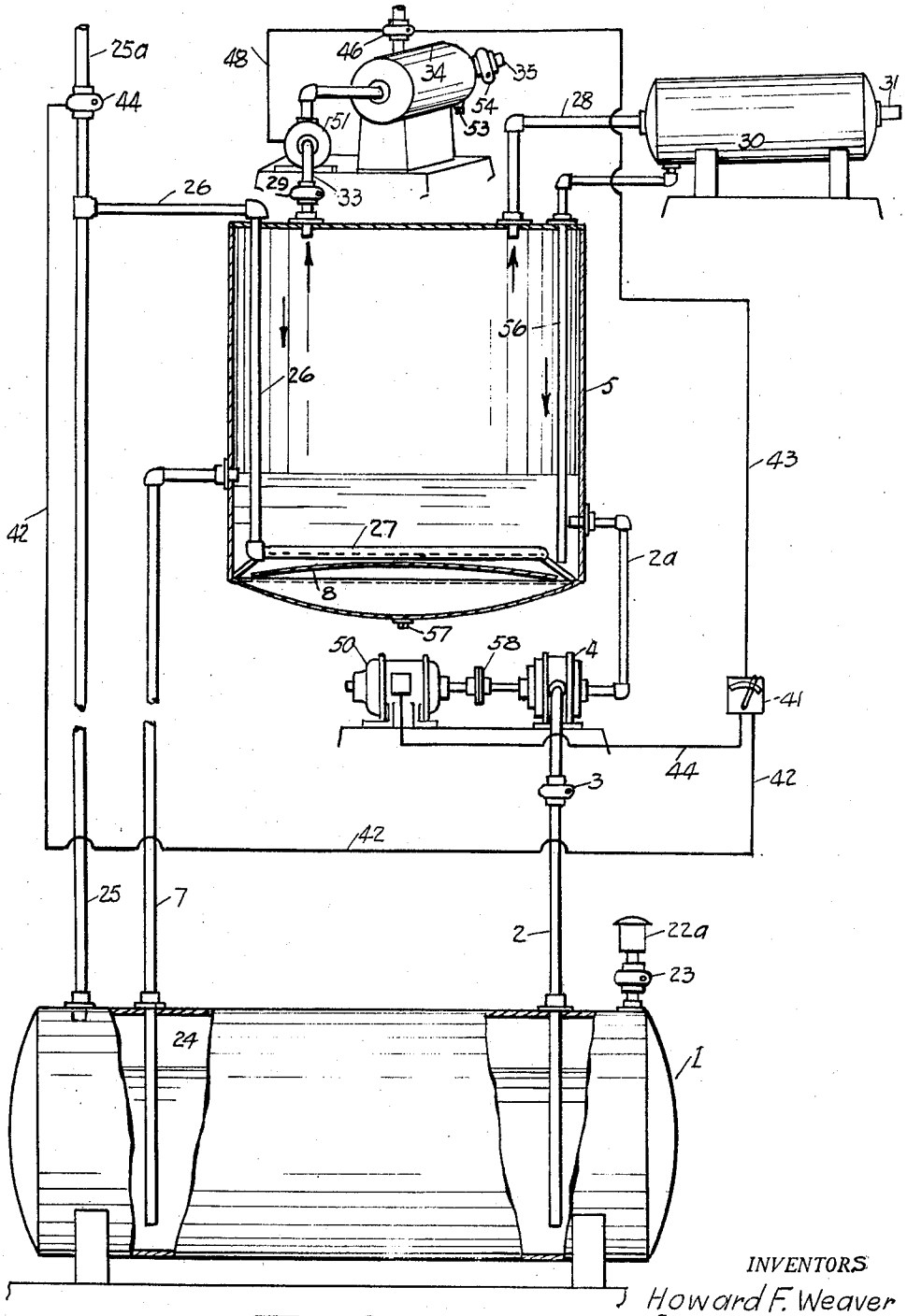


Fig 2

INVENTORS
Howard F. Weaver
Joseph Abelow
By Meyer & Baskin
Attorney

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PROCESS FOR PROCESSING OF EXISTING AIR VAPOR MIXTURES

Filed May 17, 1954 3 Sheets-Sheet 3

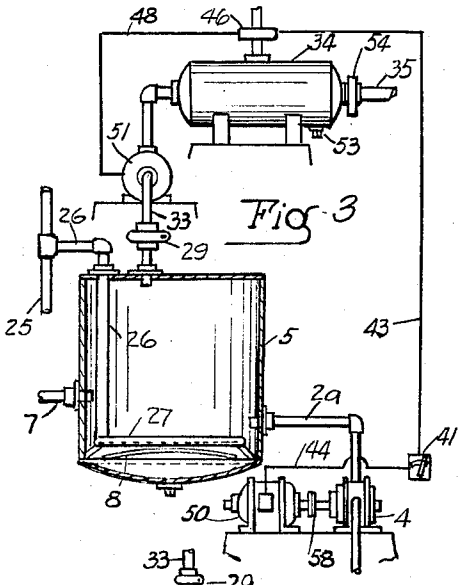


Fig 3

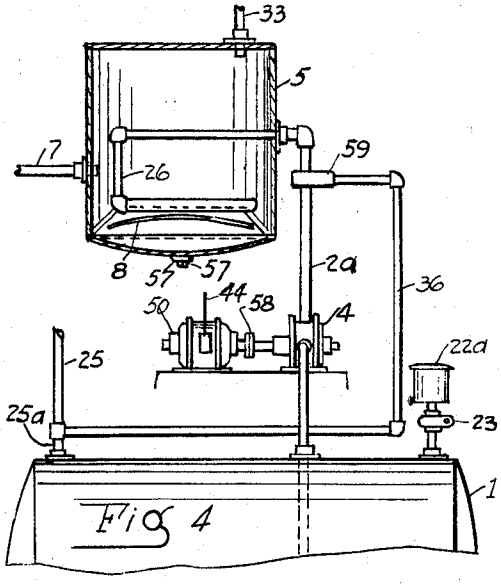


Fig 4

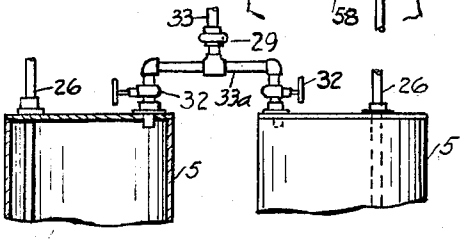


Fig 6

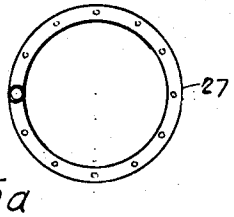


Fig 5a

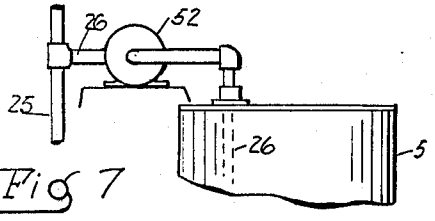


Fig 7

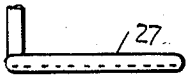


Fig 5

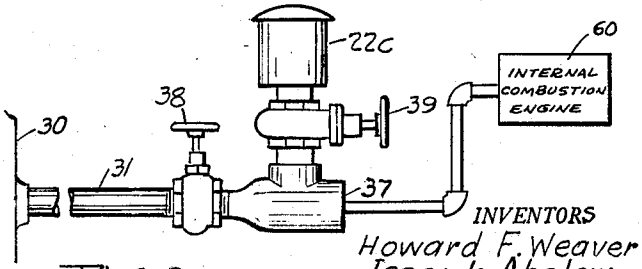


Fig 8

INVENTORS
Howard F. Weaver
Joseph Abelow
by Myers & Bailin
Attorney

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PROCESS FOR PROCESSING OF EXISTING AIR VAPOR MIXTURES

Howard F. Weaver, North Miami, Fla., and Joseph Abelow, Manila, Philippines

Application May 17, 1954, Serial No. 430,366

1 Claim. (Cl. 48—219)

This invention relates to a process of capturing, processing and utilizing the vapors of gasoline or other volatile liquids, and also some gases, which have previously been considered as waste and were released through ventilator tubes into the atmosphere as a safety measure to prevent the danger resulting from accumulation of such vapors or gases.

An object of this invention is to provide a simple, efficient, inexpensive, automatic, safe apparatus, economical in operation for the production of a superior and more uniform gaseous fuel from gasoline or other volatile liquid as compared to apparatus of the prior art. This apparatus is suitable for domestic as well as industrial or commercial and farm purposes, and requires a minimum of service for cleaning or repairing. The apparatus is versatile so as to meet a large variety of requirements for generating air-vapor mixtures.

An object of this invention is to provide an apparatus particularly suited for installation where there are large storage facilities for gasoline, such as filling stations, farms and large commercial or industrial users where this apparatus is designed to process hitherto wasted vapors using for this processing the lighter and more volatile ends of the gasoline in continuous circulation from a storage tank to a processing tank and back to said storage tank again.

Another object of this invention is to provide an apparatus that recovers the hitherto wasted gasoline vapors from the storage tank. The air-vapor mixture is drawn from the gasoline storage tank and is enriched by being passed through the liquid fuel circulating or dormant in the processing tank. As a result of this the air-vapor mixture from the storage tank will be brought up to a uniform heating value, as a gaseous fuel. This same procedure will also apply to the recovery of other waste gases such as methane gas from sewers and sewage disposal plants and to the treatment of other gases of low calorific value. The amount of enriched air-vapor mixture produced is automatically controlled by the amount of air-vapor needed by the installation consuming the gaseous fuel.

The processing tank has a cooling effect on the gasoline passing through it and being returned to the storage tank. This tends to lower the temperature of the gasoline in the storage tank which in turn helps to lower the rate of vaporization of all the gasoline in the storage tank.

When the apparatus is attached to a standard gasoline storage tank there is no interference with the normal or conventional usage of said storage tank by virtue of the attachment of this apparatus. The gasoline therein, used for said processing can be sold to the public with no appreciable loss in quality or utility and with only a small depletion in quantity.

Another object of this invention is to produce from the operation of the apparatus a gaseous fuel of uniform heating value suitable for use in internal combustion engines; and the amount of air-vapor produced is automatically controlled by the intake manifold vacuum of

the internal combustion engine. This apparatus will also produce a gaseous fuel of uniform heating value suitable for cooking, heating, refrigeration, etc., and for any other purpose for which a combustible gaseous fuel is used, and the amount of air-vapor mixture produced for that purpose will be controlled by the suction action of a compressor installed for that purpose.

If both these consuming facilities are mounted on one apparatus, both functions can be carried on simultaneously, or each facility on the apparatus can be operated separately at a different time, independently of the other; or either of these gas consuming facilities can be mounted alone on an apparatus, which will then produce enriched air-vapor mixture for only that purpose.

Prior art systems of air-vapor generation are, in general, unsatisfactory. In most systems the gaseous fuel is generated from small batches of volatile liquid resulting in a non-uniform fuel, but no known system makes any attempt to process waste fumes from storage tanks, using a continuous flow of gasoline, as in this invention.

An object of this invention is to have one apparatus that is so versatile it can function under almost any and all circumstances under which a vapor processing apparatus might be required and will provide air-vapor for almost any purpose that may be required whether for the operation of internal combustion engines or for cooking, heating, refrigeration, etc., or for any other purpose for which a combustible gaseous fuel is used. The apparatus will function when operating with a large storage tank such as used in filling stations. The apparatus will function when used with highly volatile hydrocarbons or whether used with ordinary gasoline or other hydrocarbons or other volatile liquids. It will also function when recovering waste vapors from gasoline storage tanks or when recovering other similar waste gases of low calorific value or of varying calorific value such as methane from sewers or sewage disposal plants, or other combustible gases of low calorific value which can be processed in the same manner as vapor from gasoline storage tanks, i.e. drawn through a processing tank to be uniformly enriched.

Other objects will be apparent from the following description. The invention consists in the novel features hereinafter described in detail, illustrated in the accompanying drawings, and more particularly pointed out in the appended claim.

Referring to the drawings:

Figure 1 is a general elevational view, partly cut away, of one form of the improved apparatus for processing vapors for use as a fuel for internal combustion engine.

Figure 2 is a general elevational view, partly cut away, similar to Figure 1 with the addition of facilities for utilizing the gaseous fuel for cooking, heating, refrigeration, etc., or for any other purpose for which a combustible gaseous fuel is used.

Figure 3 is an elevational view with tank, cut away, and attachments to show how the apparatus is installed if air-vapor mixture is required for burning, but not for consumption in an internal combustion engine.

Figure 4 is an elevational view, partly cut away, of another form of the apparatus to show how an aspirator can be attached to the liquid circulating system.

Figure 5 is an elevational view of one form of the agitator coil.

Figure 5*a* is a plan view of one form of the agitator coil.

Figure 6 is an elevational view to show how two or more processing tanks can be attached to provide a mixture of two or more volatile gases in any proportion.

Figure 7 is a side view to show how a blower can be attached to draw gasoline vapors from storage tanks when the addition of a blower is desirable.

Figure 8 is an elevational view of a regulator controlling the ratio of air to air-vapor mixture fed to the carburetor of the internal combustion engine.

The gasoline is circulated from the storage tank through the processing tank and back to the storage tank, in continuous circulation, as follows:

The gasoline is pumped from storage tank **1** through pipe **2** past check valve **3**, through pump **4** into pipe **2***a* which discharges into processing tank **5**. The liquid is in continuous motion in the processing tank **5** where it is maintained at a constant level and it is then discharged through outflow pipe **7** and back into storage tank **1**. The liquid thus makes a complete cycle. Where the return flow from processing tank to storage tank can be accomplished by gravity flow, no pump is needed on outflow side. If force of gravity is insufficient, a pump must be employed on pipe **7** to move the gasoline back to storage tank **1**.

Where there are several storage tanks and maximum utilization is desired, the gasoline circulated through the processing tank **5** can be drawn from the various storage tanks in rotation, using one storage tank for a stated period of time and then switching to another storage tank and so alternating the use of all the tanks.

In no way does the above interfere with the operation of the storage tank **1** in its conventional and ordinary uses prior to the attachment of this apparatus, or in the use of the gasoline as it would normally be used. The conventional means for removing gasoline from the storage tank **1** to a dispensing pump, for sale or ordinary use, is not here shown.

The various pieces of equipment mentioned above, such as pump, check valve, motor, etc., are conventional items for use in such situations in connection with the handling of volatile liquids such as gasoline.

When operated under normal conditions the level of gasoline in the processing tank **5** will automatically adjust itself to a preset level. One method of accomplishing this is by installing the opening for the outflow pipe **7** at the desired level. The same may also be accomplished by installing an adjustable standpipe, not shown, as the outflow pipe. The outflow pipe **7** being substantially larger than the inflow pipe **2**, also acts as an automatic safety device to prevent accidental flooding in the case of gravity controlled outflow. When a return pump is employed, however, a safety control device of conventional design should be installed to prevent accidental flooding.

The level of gasoline in the processing tank must be high enough to ensure adequate uniform enrichment of the air-vapor mixture and still allow enough air space above the liquid level to prevent the liquid from being entrained in the air-vapor stream. These factors above depend upon the size of the installation using this apparatus.

The air-vapor mixture is made richer by raising the level of gasoline in the processing tank and conversely is made leaner by lowering the level of the gasoline in the processing tank. The level is preset at time of installation of apparatus.

When the apparatus is near a large gasoline storage tank it can capture and utilize the gasoline vapors resulting from the natural vaporization of the gasoline, heretofore wasted and released into the atmosphere through the storage tank ventilator pipes. These vapors represent a considerable economic loss. Also, they contaminate the atmosphere and constitute a fire hazard. By means of this invention, they will be recaptured to serve virtually as a source of free power since they utilize vapors not otherwise normally used.

The gasoline vapors are drawn from the storage tank **1** by the partial vacuum in the intake manifold of the internal combustion engine, shown schematically in Fig. 8 and indicated by the numeral **60**, attached to regulator **T 37**. Air from the atmosphere is drawn through air

filter **22***a*, past one way check valve **23**, into storage tank **1** replacing vapors drawn from across space **24** above the top of the liquid gasoline. The air-vapor mixture is drawn through vent pipe **25**, through line **26**, through agitator coil **27**, through gasoline in processing tank **5** where the air-vapor mixture is uniformly enriched, through pipe **28**, into dampener tank **30**, through pipe **31**, through a flame arrester, not shown, of conventional design through air to air-vapor ratio regulator as shown in Figure 8, to internal combustion engine, not shown. The dampener tank **30** serves to homogenize the air-vapor mixture and also to settle out any liquid gasoline entrained in the air stream. A return line **56** to bottom of generating tank **5** returns this gasoline automatically.

As shown in Figure 8, the air to air-vapor ratio regulator consists of valve **38**, T-connection **37**, valve **39** and air filter **22***c*. By adjusting valves **38** and **39** the proportion of air to air-vapor mixture is regulated according to the needs of the internal combustion engine. From the air to air-vapor ratio regulator the mixture goes to the conventional carburetor of said engine. The purpose of using the carburetor is to enable the engine to be used with conventional liquid gasoline if desired, a petcock being used in the liquid gasoline fuel line of the internal combustion engine for this purpose although for purposes of this invention the conventional carburetor can be eliminated.

In Figure 2 and Figure 3 the uniformly enriched air-vapor mixture is also drawn through pipe **33**, past check valve **29**, through compressor **51**, into a conventional pressure storage tank **34**, through a gas pressure regulator **54** and pipe **35**, through a flame arrester, not shown, of conventional design, to the gas burning appliances, not shown.

Where gasoline vapors are available from several storage tanks, all the vent pipes **25** can be joined to pipe **26** so that the hitherto wasted gasoline vapors from all the storage tanks can be captured and utilized. Each storage tank, however, should have an installation similar to the one described herein for the storage tank **1** filler neck, with air filter **22***a* and check valve **23**, as shown in Figures 1 and 2.

The electrical system controlling the circulation of gasoline through the apparatus is the same in all of the figures and operates as follows:

Closing switch **41** activates motor **50** which drives pump **4**, circulating the gasoline through the generating tank **5**. At the same time valve **44** on vent pipe **25***a* is closed so that the gasoline vapors from storage tank **1** will be drawn through pipes **25** and **26**, through agitator coil **27** and generating tank **5** as described above. Opening switch **41** de-energizes motor **50** and opens valve **44** to permit dissipation of gasoline vapors in the normal manner.

If the apparatus is used intermittently, valve **44** on vent pipe **25***a* may be replaced with a one-way check valve that will retain fumes in storage tank **1**, so that all the fumes can be recaptured for processing.

The electrical system that controls the operation of compressor **51** and pressure storage tank **34**, shown in Figure 2 and Figure 3, operates as follows:

The action of compressor **51** creates a partial vacuum which draws the enriched air-vapor mixture from processing tank **5**, through pipe **33**, into pressure storage tank **34**. When the enriched air-vapor mixture is used it passes from pressure storage tank **34**, through gas regulator **54**, pipe **35**, through a conventional flame arrester, not shown, to an appliance, not shown, consuming this air-vapor mixture.

Pressure storage tank **34** has a pressure switch **46** that operates as follows: There is a high and low setting on pressure switch **46** on pressure tank **34**. When the pressure reaches the high setting on pressure switch **46**, the switch **46** opens the circuit, which de-energizes compressor **51**. The remainder of the apparatus, however,

continues to operate to supply enriched air-vapor mixture through pipe 28 to the internal combustion engine on a continuous basis regardless of whether the pressure storage tank 34 facilities are being operated continuously or intermittently.

When sufficient air-vapor mixture has been consumed from the pressure storage tank 34 to cause the pressure switch 46 to drop to the low pressure setting, contact is made which closes an electrical circuit. Compressor 51 is activated and enriched air-vapor mixture is again drawn from processing tank 5 and pumped into the pressure storage tank 34, through line 33. When the pressure in pressure storage tank 34 is built up to the high point again, the pressure switch 46 opens and the entire cycle repeats itself as described above. The above procedure holds true regardless of the source of electrical energy.

The electrical system derives its electricity either from an electric generator being driven by the internal combustion engine being driven by the enriched air-vapors from this apparatus, or from some other source of electrical energy not dependent upon this apparatus such as a public utility power supply or an independent electrical generating system.

Where the apparatus is installed only for the processing of air-vapors for cooking, etc., as shown in Figure 3, it is necessary to have an outside source of electricity to drive electric motor 50 and compressor 51. In such event, switch 41 is moved to automatic position so that pressure switch 46 automatically controls the operation of the entire electrical system, as follows: When pressure is low, switch 46 closes and contact is made which closes the electrical circuit. Motor 50 and compressor 51 are activated. When the pressure reaches the high point, switch 46 opens. Both motor 50 and compressor 51 are de-energized. The circulation of liquid gasoline ceases and the entire system is dormant. When the pressure reaches the low point again, switch 46 closes and the cycle repeats itself.

Where the apparatus processes air-vapors only for an internal combustion engine, motor 50 can be replaced by an electric motor to be run by the engine's battery or by a small gasoline engine, or pump 4 can be belt-driven by the internal combustion engine itself. This latter procedure offers several advantages and is particularly desirable when no source for electricity is readily available.

These variations are not described in detail because they do not affect the substance of the invention but are merely variations in application.

There are many areas where electricity is available but where gas is expensive. In such situations, it might be an economy to install an apparatus for processing of enriched air-vapor mixture only for cooking, heating, etc. It is also manifest that this system can be used to supply gas for pipeline distribution in small communities. It merely calls for the addition of conventional storage and distribution facilities.

The apparatus is versatile and can suit almost any situation with slight modifications, as shown in the various figures.

Figure 3 shows the modifications of the invention when the apparatus is used exclusively for the processing of enriched air-vapor mixture for burning purposes, such as cooking, heating, refrigeration, etc. For such installations, one motor can be used to drive both pump 4 and compressor 51, instead of using two motors, and the pressure switch 46 will automatically control the entire electrical system as described under electrical system.

Figure 4 shows how an aspirator 59 can be attached to the gasoline pipe 2 leading from storage tank 1 to processing tank 5. The vacuum developed by the flow of the gasoline in pipe 2 and aspirator 59 creates suction, drawing the fumes from top of storage tank 1 through pipe 25*a*, and pipe 36 and both liquid and air-vapor mixture then would be fed into pipe 26 leading to agitator 27 in processing tank 5. Under certain circumstances it could be used to replace compressor 51 shown in Figure 3, if requirements for air-vapor for burning are not heavy, and the apparatus serves only as described in Figure 3.

Figures 5 and 5*a* show elevation and plan views respectively of perforated agitator coil 27. The coil 27 can be of almost any shape or design provided that pipe 26 enters the processing tank 5 from above the level of the gasoline in the processing tank, to prevent gasoline leaking out pipe 26 or running back to storage tank 1. The same result might be accomplished by a check valve.

With this apparatus almost any type of agitator coil will give satisfactory results. Best results, however, will be obtained when the perforations are small and the total area of perforations is substantially greater than the area of opening of line 28 leading to internal combustion engine. Holes can be from about 1/32 inch in diameter up to about 1/8 inch in diameter, and should be evenly distributed along the coil so as to get even distribution of air.

Holes should be made chiefly along the bottom of the agitator coil to prevent the collection of sediment in the agitator coil. A diverting shield 8, under coil 27, attached to the bottom of the tank 5 serves to keep the liquid in the bottom of the processing tank tranquil. If there should be water or sediment in the gasoline, in the main storage tank 1, some of it will settle out under the diverting shield 8 in the processing tank. The processing tank can be cleaned by removing drain plug 57. In this way, the apparatus also serves to improve the gasoline in the storage tank 1.

Figure 6 shows how it is possible to mix two or more processing systems, if it should be desired to combine various types of air-vapor mixtures. A manifold 33*a*, with two or more branches, as needed, is attached to each processing tank 5 with valves 32 to control the proportion of each kind of air-vapor mixture entering the final mixture. If it is necessary to obtain a precise final mixture, then meters should be installed on the branches between valves 32 and manifold 33. If only a small proportion of a particular air-vapor is required for the final air-vapor mixture, it might be sufficient to use a simple processing tank containing only pipe 26, agitator 27, and a quantity of volatile liquid, with no provision for circulation of same. This system for mixing different air-vapor mixtures can be used in combination with any of the variations previously mentioned.

Figure 7 shows how a blower 52 could be installed on line 26 if desired. Although not required on standard installations, at times it would serve a useful purpose.

It is a feature of this invention that the quality of the enriched air-vapor mixture finally obtained is not affected by contaminated product in the liquid storage tank 1. Even if water and/or dirt are present in the storage tank 1 and are pumped into the processing tank 5, the enriched air-vapor mixture produced will be uncontaminated. As mentioned previously, the processing tank 5 will even serve to clean the gasoline and to remove water and sediment.

By adjusting the level of the gasoline in the processing tank the air-vapor mixture for burning can be regulated to any desired calorific value within the limits of the system. It will be advisable in most cases, to adjust the calorific value of the finished mixture to about 530 B.t.u. per cubic foot when producing air-vapor for cooking, heating, refrigeration, etc. This air-vapor will then be suitable for burning in standard appliances made by a large number of stove manufacturers which have already been adapted for highly efficient use with butane-air carbureted gas. The apparatus will deliver uniform calorific quality and the adjustment can be made at the stove to regulate the proper proportion of enriched air-vapor to air. It will be necessary to have a conventional pressure reducing regulator on the finished gas line before the point where the gas enters the appliance.

In this apparatus no pressure other than the vapor pressure of the gasoline or liquid fuel is carried in the standard storage tanks used as a source for fuel for this system. Therefore, it is a simple matter to replenish or remove gasoline from the storage tank, even when the apparatus is running. This is not the case with the majority of gas machines at the present time, as most of them carry a pressure on the liquid container, which must be released by shutting down the machine before additional fuel can be poured into the underground tank. In the case of large restaurants and semi-industrial users, this periodic interruption of gas service is a serious handicap, and for small customers it can be an annoyance.

Economies are effected by using air-vapor rather than liquid gasoline, even without recovery of hitherto wasted vapors, because the utilization is more complete when the fuel is in an air-vapor state as compared to the liquid state. To the extent that the hitherto wasted vapors are utilized, this apparatus actually provides free power. Accumulation of carbon in the engine is practically eliminated and the oil dilution is minimized, so that the oil remains clean and retains its lubricating qualities for a longer period compared to use of liquid gasoline.

The apparatus and method described herein can be applied to volatile liquids other than gasoline, which is constantly referred to herein because it is the most widely available volatile liquid, and it is desired to be understood that it is intended to employ this apparatus with any or all of the hydrocarbons and their mixtures, and this apparatus will also be employed for the recovery of waste fumes and gases such as methane, etc., hitherto lost into the atmosphere or processed by any other method, and to enrich other gases of insufficient calorific value to be combustible.

We claim:

A process for capturing and utilizing waste gasoline vapors from large storage tanks by uniformly enriching already existing air-vapor mixtures in said storage tanks comprising continuous circulation of volatile liquid from said storage tank, through a processing tank consisting of a single chamber having an unobstructed interior, and back to said storage tank while maintaining a constant liquid level in said processing tank and an unobstructed air vapor space above said liquid level said unobstructed air vapor space comprising about two-thirds of the total volume of said processing tank, drawing an air-vapor mixture from the top of said storage tank into the bottom of said processing tank through said liquid, forming a uniformly enriched air-vapor mixture, out the top of said processing tank into a homogenizing dampener tank with unobstructed interior containing a gravity flow liquid return line to said processing tank, through a T regulator controlling the proportion of air to air-vapor mixture, said regulator being joined to a stationary internal combustion engine, the vacuum produced by the said internal combustion engine serving to draw the air-vapor mixture through said vapor processing system.

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