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E. BERL

2,560,152

STORAGE OF LIQUID FUELS

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Fig. 1

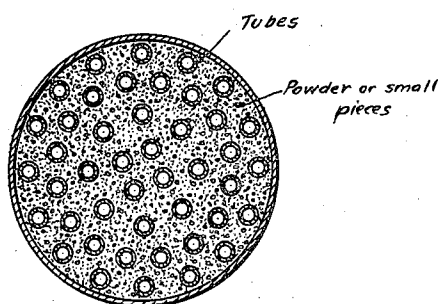
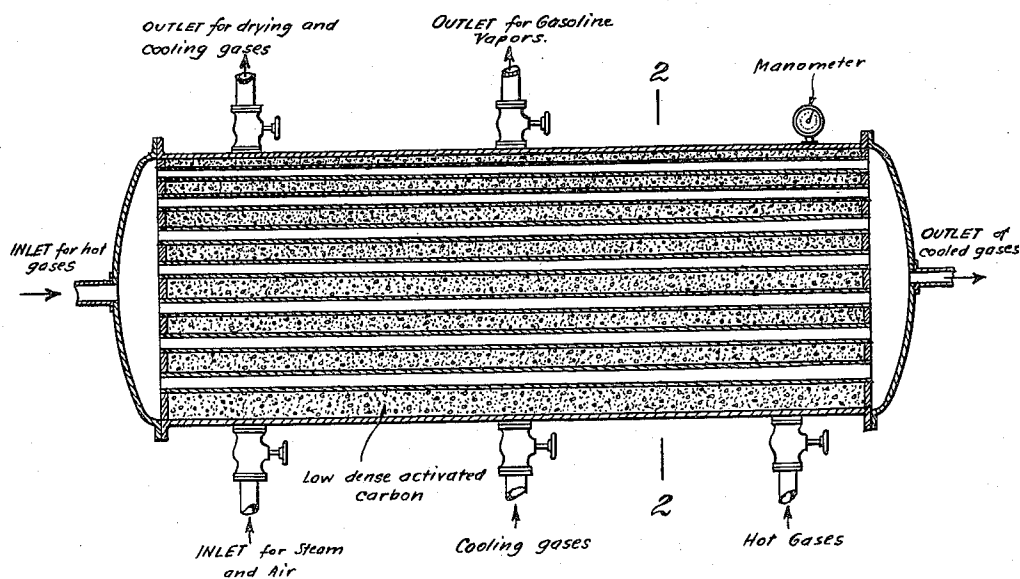


Fig. 2

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2,560,152

STORAGE OF LIQUID FUELS

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6 Claims. (Cl. 123-122)

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It is known that the use of volatile gasoline or other low-boiling fuels, like benzene and homologues, alcohols, naphthenes, and mixtures thereof represent a rather great danger, not only for the use of these fuels in automobiles, but especially for their use in aeroplanes. These rather high volatile materials ignite very easily in case of accidents. They can be ignited also by bullets. A container which by any accident is hit or destroyed loses more or less of this liquid fuel which, intentionally or unintentionally, can be ignited and burns with large and hot flames.

Several propositions have been made to decrease the danger which is connected with this high volatility of liquid fuels. Most of these proposals, for instance their complete solidification by the use of cold, are too complicated and too expensive so that actually no means are used to decrease the danger which is connected with this high volatility of those liquid fuels.

It is, therefore, an object of this invention to provide an internal combustion engine fuel which is explosion-proof even at higher temperatures or under the impact of a sudden shock.

Another object of the invention is a fuel having the above properties and at the same time having little weight and taking up little space as compared with its calorific content.

Another object of the invention is the provision of an aeroplane engine fuel which will not explode in a crash or when its container is hit by an ordinary or incendiary projectile.

Still another object of the invention is the disclosure of such a safety fuel as is easy to produce, economical in storage, and convenient to feed to the engine.

Other objects of the invention will become readily apparent from the specification.

It has been found by the inventor that many of the difficulties pointed out above can be avoided by absorbing the volatile liquid fuels on substances with highly developed internal surface and which possess a very low apparent density, such as silica gel or activated carbon. Certain qualities of activated carbon are especially suitable for these purposes. It is known that one can absorb liquid fuels by activated carbon. U. S. Patent 832,826 of C. G. Coleman uses for the filling of safety reservoirs for explosive fluids, for instance liquified acetylene, according to page 1, line 99, charcoal formed from the shell of cocoanuts. The same inventor, according to U. S. Patent 1,175,607, page 1, line 81, for a similar case protects a granular material, for instance cocoanut shell charcoal, also.

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The same inventor in his U. S. Patent 1,080,263, page 1, line 78, uses some absorbent solid, such as for example baked, porous-like pipe clay. According to U. S. Patent 1,816,825 of A. E. Ray a solidified fuel can be made by using a combustible, but not violently combustible, filler, for instance wood fiber, wood pulp, wood flour, etc., charcoal and carbon (page 2, line 33).

A typical gas mash coal which is characterized by its high apparent density should, according to views prevailing until now, adsorb much more of volatile fuel than a typical decolorization coal. The researches of the inventor have proved that these views are wrong. The gas mash coal adsorbs less liquid fuel than certain decolorizing carbons. The very astonishing fact has been found by the inventor that the apparent density of active carbon is a most important factor. This apparent density is characteristic for every kind of activated carbon. It cannot be changed fundamentally by converting coarse material into a fine powder by intensive grinding. Up to now activated carbons with low apparent densities (.07-.20) which, according to this invention, are especially suitable for the storage of volatile liquid fuels have not been used for this purpose. This density of activated carbons depends upon the raw material which has been used, and depends to a lesser extent on the chosen process of carbonization. Activated carbons with low apparent density can be produced according to my U. S. Patents 1,851,888 and 1,812,316. My last-named patent, No. 1,812,316, particularly deals with an activated carbon having an active surface of more than 700 sq. m./g. According to Table I the low apparent density is necessary for the right effect.

Table I shows the fundamental difference between different activated carbons. Table II shows how many times more carbon M (No. 1) with the lowest apparent density adsorbs benzene, iso-octane, and alcohols than the other five carbon qualities. One part in weight of activated carbon M with the low apparent density of .071 takes up 9.25-10.92 times its weight of those different volatile fuels. Carbons with high apparent density (ATC 500 and W, No. 5 and 6) adsorb under the same conditions only 1.40-2.05 parts of weight of the same fuels. The typical cocoanut shell coal C (No. 4) under the same conditions adsorbs 1.2 to 2.8 parts of those fuels. One can press out those combinations of activated carbon and liquid fuel until no liquid fuel flows any more. Carbon M (No. 1) retains then 6.66-7.18 parts of fuel per one part in weight of

carbon. Carbons ATC 500 and W (No. 5 and 6) under the same conditions adsorb only 1.01-1.64 parts of fuel per one part (in weight) of carbon. Between carbon M (No. 1) and ATC 500 and W (No. 5 and 6) stays coconut shell carbon C. It adsorbs, in pressed state, .78-2.39 parts in weight of those liquid fuels.

Table II gives the relative figures which show how many more times carbon M (No. 1) with the lowest apparent density adsorbs different fuels than the other carbon qualities 2 to 5. For instance, it absorbs 2.87 times more benzene than the next best carbon A (No. 2) and 6 times more benzene than the carbon ATC (No. 5). Table III compares Carbon MB No. 710 with kapok.

It seems, therefore, that the capacity to take up larger amounts of liquid fuel and to retain this rather strongly is a function of the apparent density of the adsorbing activated carbon. Columns E, F, and G (Table 1) show that the apparent density (column B) multiplied by the weight of the adsorbed liquid (columns Ca, Cb, Da, Db, Ea, Eb) is fairly constant, especially for the carbons with lower apparent density. Carbons No. 5 and 6 show a rather strong deviation from this rule which means that the adsorbing capacity with increasing apparent density becomes much weaker.

Those activated carbons with low apparent density have not been used until now to a large extent. In all those cases where as raw material for the production of activated carbon dense material like wood, coconut shells, peat, brown coal, or bituminous coal is used, activated carbons with rather high apparent densities (.2 to .65) result. The two-mentioned American Patents 1,851,888 and 1,812,316, especially the first-mentioned, allow the production of those very important carbons with low apparent density which possess this unexpected effect concerning the high and strong adsorption of these liquid fuels.

Activated carbons of low apparent density which are charged with volatile liquid fuels do not lose any liquid if the container is damaged. The liquid fuel adsorbed by these activated carbon does not ignite easily, and, if ignited, then the fuel burns very slowly so that there is no danger that through a quick burning of larger amounts of liquid fuels or through violent explosions persons may be hurt. Volatile liquid fuels which are adsorbed on this activated carbon with low apparent density will not be ignited if bullets with high speed perforate the container.

The liquid volatile fuels are taken up by this activated carbon with low apparent density with rather strong development of heat. Carbon M (No. 1) and carbons A and B (No. 2 and 3) give practically the same heat of absorption. Nevertheless, carbon M is much superior to A and B due to its low apparent density.

Volatile liquid fuels adsorbed on activated carbon with low apparent density show a lower vapor pressure than the pure form. They get, so to speak, the quality of a high boiling fuel, for example Diesel oil.

To desorb, i. e. free the adsorbed volatile liquid fuel from this low dense activated carbon, the system must be heated whereby normal or reduced pressure has to be used. Addition of steam and/or a neutral gas like air facilitates the removal of the liquid fuel from the adsorbents. The system: activated carbon with low apparent density plus adsorbed liquid fuel, has to be put in a suitable apparatus, for instance a tubular cooler. The activated carbon may be stored, for

example in the space between the tubes. Hot gases, for instance exhaust gases from the motor, have to be sent through the tubes in indirect heat exchange with the fuel. For starting, heat from an outside source may be used. At temperatures above the boiling temperature of the liquid fuel, this will be separated from the activated carbon. With the necessary air without or with a certain amount of water, or steam, the vapors of the now gaseous fuel enter the combustion cylinder where they burn after their ignition.

When the adsorbed liquid fuel has been partly or completely eliminated from the active carbon, the necessary cooling before new liquid fuel can be added has to be performed. This can be carried out by sending cool air or cool water through those tubes where before hot gases are introduced. One can cool the heated activated carbon with cool air directly in those cases where practically all adsorbed liquid fuel has been removed. It has been found advantageous to put the activated carbon in rather thin layers between perforated sieves so that no mechanical losses result. When the active carbon has again reached lower temperatures, it can be charged with new amounts of liquid fuel whereby during this operation cool air or cool water has to be sent advantageously through the cooling tubes, this to remove the heat of adsorption. This process of charging and removing the liquid fuel can be carried out many times without changing the qualities of the adsorbing material.

After a great number of charging and discharging operations the adsorbents may be steamed with dry steam. During this steaming, if it is carried out in the same storage apparatus, hot gases may advantageously be introduced in the tubes of this tubular apparatus. During the former use high boiling fractions of these liquid fuels may have been accumulated and certain condensation reactions of fuel components under formation of larger molecules may have occurred. They decrease the adsorption capacity of the adsorbents. Steaming, heating from the outside, and carrying out this operation advantageously in vacuum removes those injurious substances practically completely.

In the drawings,

Fig. 1 shows a longitudinal and

Fig. 2 shows a transverse section through a fuel storage apparatus according to my invention.

The apparatus consists of a tank, inside of which is arranged a plurality of tubes substantially parallel to its longitudinal axis. Interstices between the tubes are filled with activated carbon of low apparent density, in powdered form, or in small pieces. The carbon is charged with liquid fuel in the above-described manner. In operation, the fuel is liberated in vapor form through an outlet connected directly or indirectly with the engine by heating the system above the boiling point of the fuel. The heat may be furnished by exhaust gases introduced into the tubes at one end of the apparatus; they are discharged, somewhat cooled, into the atmosphere at the other end of the apparatus. Inlets and outlets for steam, air, hot gases and cooling gases are provided for direct communication with the fuel-adsorbing carbon, in order to control the operation of the apparatus at will. A manometer and other control instruments may also be connected.

The use of low density activated carbon and the adsorption of liquid fuels in appropriate storage apparatus and its removal represent no difficulties. The safety of aeroplanes or automobiles or

any other construction which uses these volatile materials is greatly improved by this invention.

This application is a substitute for my prior application Serial No. 304,720, filed November 16, 1939 and now forfeited.

Having now fully described the invention, without however limiting it to the examples disclosed in said description, and intending to limit the scope of the invention solely by the appended claims,

Table I

No.	A Carbon quality	B Apparent density	C		D		E		F		G		H	
			Benzene		Iso-octane		Ethanol		Apparent density B multiplied by—		Apparent density B multiplied by—		Apparent density B multiplied by—	
			wet	pressed	wet	pressed	wet	pressed	Ca wet	Cb pressed	Da wet	Db pressed	Ea wet	Eb pressed
			a	b	a	b	a	b						
1	M, MB No. 710.....	.071	10.92	7.18	9.25	7.04	10.9	6.66	.773	.510	.657	.500	.773	.473
2	A, MB No. 800.....	.144	5.03	4.48	4.80	4.40	4.48	3.77	.725	.645	.692	.663	.645	.543
3	B, MB No. 700.....	.162	4.92	4.43	4.50	4.32	-----	-----	.797	.717	.676	.700	-----	-----
4	Cocoanut shell carbon, C, MB No. 150.....	.281	2.8	2.39	2.41	2.19	1.2	.78	.787	.670	.728	.614	3.37	2.19
5	ATC 500, MB No. 70....	.37	1.82	1.30	1.40	1.01	-----	-----	.665	.48	.52	.372	-----	-----
6	W Wood charcoal MB No. 30.....	.31	2.05	1.64	1.66	1.23	-----	-----	.635	.52	.515	.382	-----	-----

MB No. = mg. methylene blue adsorbed by 1 gram of carbon.

The figures under C, D, E represent gram adsorbed material per 1 gram of dry carbon.

Table II

C1a=2.17	C1a=2.22	C1a=3.9	C1a=6.0	C1a=5.34
C2a	C3a	C4a	C5a	C6a
C1b=1.60	C1b=1.63	C1b=3.0	C1b=5.5	C1b=4.4
C2b	C3b	C4b	C5b	C6b
D1a=1.93	D1a=2.06	D1a=3.84	D1a=6.6	D1a=5.6
D2a	D3a	D4a	D5a	D6a
D1b=1.6	D1b=1.63	D1b=3.21	D1b=7	D1b=5.7
D2b	D3b	D4b	D5b	D6b
E1a=2.44	E1a=9.1	E1b=8.55	E4a	E4b
E2a	E3a	E3b	E4b	E5b
E1b=1.77	E1b=8.55	E4b	E5b	E6b
E2b	E3b	E4b	E5b	E6b

Table III

No.	A Adsorbing material	B Apparent density	C		D	
			Iso-octane		Ethanol	
			wet	pressed	wet	pressed
No. 1	MB No. 710.....	.071	9.25	7.04	10.9	6.66
No. 7	Kapok.....	4.07	.505	4.47	.99	

ratios:

$$\frac{D.1.a}{D.7.a} = \frac{2.26}{1} \text{ and } \frac{D.1.b}{D.7.b} = \frac{14.0}{1}$$

$$\frac{E.1.a}{E.7.a} = \frac{2.27}{1} \text{ and } \frac{E.1.b}{E.7.b} = \frac{6.7}{1}$$

What is claimed is:

1. A fuel storage and liberating system for use with an internal combustion engine, comprising a tank, a plurality of parallel tubes traversing said tank, an activated adsorbent carbon stored in said tank between said tubes, said activated carbon having an active internal surface of at least 700 square meters per gram and an appar-

ent density not exceeding .2, an inlet to said tank for supplying a volatile liquid fuel to be adsorbed by said carbon, an outlet in said tank passing to an internal combustion engine for the passage of desorbed fuel vapors, and means connected to the exhaust manifold of said internal combustion engine for conducting exhaust gases through said tubes.

2. A fuel storage and liberating system according to claim 1, wherein the apparent density of

30 said activated adsorbent carbon is between .071 and .162.

3. A method of storing and liberating a liquid fuel for use in an internal combustion engine, comprising the steps of adsorbing a liquid fuel in activated carbon having an active internal surface of at least 700 square meters per gram and an apparent density not exceeding .2, liberating said adsorbed fuel and passing the resulting fuel vapors to an internal combustion engine by passing the hot exhaust gases from the internal combustion engine in indirect heat exchange with the adsorbed fuel.

4. The method according to claim 3, wherein the apparent density of said activated adsorbent carbon is between .071 and .162.

5. In the method, according to claim 3, the step of admitting a hot neutral gas to said adsorbed fuel.

6. In the method, according to claim 3, the step of admitting steam to said adsorbed fuel.

WALTER G. BERL,

Executor of the Estate of Ernst Berl, Deceased.

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55 The following references are of record in the file of this patent:

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65 1,851,888	Berl	Mar. 29, 1932
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2,234,734	Maude	Mar. 11, 1941
2,273,350	Fry et al.	Feb. 17, 1942