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EPA Evaluation of the P.S.C.U. 01 Device Under Section 511 of the Motor Vehicle Information and Cost Savings Act

by

Stanley L. Syria

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Test and Evaluation Branch
Emission Control Technology Divison
Office of Mobile Sources
U.S. Environmental Protection Agency

EPA Evaluation of the P.S.C.U. 01 Device Under Section 511 of the Motor Vehicle Information and Cost Savings Act

The Motor Vehicle Information and Cost Savings Act requires that EPA evaluate fuel economy retrofit devices and publish a summary of each evaluation in the Federal Register.

EPA evaluations are originated upon the application of any manufacturer of a retrofit device, upon the request of the Federal Trade Commission, or upon the motion of the EPA Administrator. These studies are designed to determine whether the retrofit device increases fuel economy and to determine whether the representations made with respect to the device are accurate. The results of such studies are set forth in a series of reports, of which this is one.

The evaluation of the "P.S.C.U. 01" was conducted upon the application of Dutch Pacific, Incorporated. The device is comprised of several mechanical and electrical components and is intended to generate steam and deliver it to the combustion chamber via an inline catalyst. The device is claimed to improve fuel economy and to reduce exhaust emissions. The P.S.C.U. 01 is classified by EPA as a vapor bleed device.

1. Title:

Application for Evaluation of P.S.C.U. 01 under Section 511 of the Motor Vehicle Information and Cost Savings Act

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The information contained in Sections two through five which follow was supplied by the applicant.

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2. Identification Information:

a. Marketing Identification of the Product:

"The trade mark will be "P.S.C.U. 01" (Proportional Steam Control Unit). The model number for usage in passenger vehicles and light trucks is "01/12/2". A different number will be assigned to the model for use in diesels and other heavy-duty vehicles when such model has been fully developed."

b. Inventors and Patent Protection

(1) Inventor

Ben van Brakel
Bekerbaan 3
Schimmert, Netherlands; and
Mikko Kozarowitsky
Rijksweg Zuid 149
Sittard, Netherlands

(2) Patent

"A copy of an English translation of the Patent Application is attached as Exhibit 1". [See Attachment A of this evaluation]

c. Applicant:

(1) Dutch Pacific, Inc.
218 Main Street, Suite E
Huntington Beach, CA 92648

(2) Principals

Johannes P. M. Zwaans, President
Paulus H. M. Zwaans, Vice President/Chief Financial Officer

(3) "Each of the above is authorized to represent the organization in communication with EPA."

d. Manufacturer of the Product:

(1) KOZA Production B.V.
Industriestraat 2
Sittard, Netherlands

(2) Principals

"The principal owner of the manufacturer is Mikko Kozarowitzky."

3. Description of Product:

a. Purpose:

"The objective of the product is to economize on fuel consumption and to decrease harmful emission levels."

b. Theory of Operation:

"For a description of the theory of operation, please see Exhibit 2." [Attachment B]

c. Construction and Operation:

"For a description of the product itself, please see the drawings and schematics attached as Exhibit 3." [Attachment C]

d. Specific Claims for the Product:

"At this juncture we prefer not to make any claims whatsoever, and will await test results before doing so. See Exhibit 2, [Attachment B] pages 23 through 25 for the results heretofore obtained. A general claim of an increase in fuel economy and a substantial decrease in harmful emissions can be made at this time."

e. Cost And Marketing Information:

"The product is currently being produced in the Netherlands for limited distribution and further testing and evaluation. Full production has been projected to commence in or about January, 1983. The suggested retail price will be approximately $590.00. To date no investigation has been made as to intended methods for marketing the product."

4. Product Applicability Installation, Operation, Safety and Maintenance:

a. Applicability:

(1) "There is a beneficial effect on all internal combustion engines. However the P.S.C.U. 01 is designed for use on engines with a displacement of under five (5) liters or 5000 cubic centimeters and thus will not produce maximum results on larger engines. A unit for use on larger engines is currently being designed and tested in Holland. It has been ascertained that the unit is not compatible with the 2-stroke Detroit Diesel engines however it has been found compatible with all other diesel engines."

(2) "The unit is not recommended for use in temperatures below freezing. An additive for the water tank as well as other means of preventing the water from freezing are currently being investigated. The unit draws considerable current (approximately 22 amps.) and will occasionally turn itself off, when the battery voltage drops below approximately 11.8 volts."

b. Installation - Instructions, Equipment, and Skills Required:

"For complete installation instructions, see Exhibit 4 hereto [Attachment D]. No special tools or equipment are required to complete installation. Installation should be performed by an individual with a basic knowledge of auto mechanics. No adjustments are required of either the product or the vehicle prior to or after installation."

c. Operation:

"See Exhibit 5 [Attachment E] attached hereto for a copy of the operating instructions to be furnished to the consumer."

d. Effects on Vehicle Safety:

"The use of this product will in no way cause damage to or result in an unsafe condition for the vehicle, its occupants, or persons or property in close proximity. A lack of maintenance or any malfunction of the unit will cause the unit to shut itself off. At this point, the unit will cease to perform its functions until such time as the malfunction is cured or the maintenance provided."

e. Maintenance:

"The water tank attached to the unit must be filled at installation and whenever necessary thereafter. It is recommended that the water level be checked each time the automobile is refueled. The catalyst holder should be changed at 30,000 mile intervals. A screwdriver and an adjustable wrench will be sufficient for this operation and no specific skills are required."

5. Effects on Emissions and Fuel Economy:

a. Unregulated Emissions:

"In the event of a malfunction or failure mode, the beneficial effect of the catalyst on the emissions will gradually decrease and will eventually cease altogether. The only information available on pollutants other than those regulated by the EPA relates to sulphur compounds, the formation of which is also favorably affected."

b. Regulated Emissions and Fuel Economy:

"See the test result obtained in the Netherlands on pages 23 through 25 of Exhibit 2 hereto [Attachment B]. Further data will be submitted upon completion of required testing."

The following sections are EPA's analysis of this device.

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6. Analysis

a. Identification Information:

EPA knows of no problems with respect to the identification information.

b. Description:

(1) The primary purpose of the device, as given by the applicant, is to improve fuel economy and reduce exhaust emissions. Based on the information submitted, EPA judges the applicant's statement to be appropriate.

(2) The theory of operation given in Exhibit 2 (Attachment B) was adequate in that EPA was able to develop an understanding of how the device is supposed to function. It appears the device, which is comprised of several mechanical and electrical components, is intended to generate steam and deliver it to the combustion chamber via the air cleaner and an inline catalyst. The steam is claimed to carry catalyst material to the combustion chamber and therein causes an improvement in the combustion process.

Based upon the information provided, EPA is doubtful that the quantity of catalyst material introduced to the combustion chamber or the time it is exposed (approximately six to nine milliseconds at a cruise speed of 3000 RPM) to the high temperatures and pressures are sufficient to cause a signficant change in the combustion process. Additional information (including test data) is required to substantiate these aspects of the theory of operation.

The agency expects that any changes attributable to the device will likely be due to the introduction of water vapor to the engine rather than due to the catalyst material. Even then, in EPA's judgment there is considerable question that this device will produce all the benefits claimed by the applicant. The amount of water vapor introduced by this device is very small; too small to likely produce a significant effect on the combustion process. Some other devices that introduce larger amounts of "liquid" water in conjunction with adjustments in engine parameters have produced modest improvements in fuel economy. In that situation the larger amount of water lessens the engine's tendency to detonate and permits operation at a more advanced ignition timing setting, which results in improved fuel economy. Water injection at these higher rates lowers oxides of nitrogen emissions but when ignition timing is advanced to improve fuel economy, a major portion of the oxides of nitrogen reduction may be lost.

There are two generally accepted concepts as to why water injection reduces oxides of nitrogen and lowers the fuel octane requirement of the engine. One theory maintains that in the combustion process, the inert water molecules intersperse among the molecules of fuel and oxygen and make it more difficult for the fuel and oxygen to get together for combustion. The speed of the reaction is thereby decreased lowering the peak combustion temperature and lessening the tendency to detonate or form oxides of nitrogen. The second theory maintains that as the water vaporizes in the combustion chamber the fuel/air mixture is cooled which ultimately results in a lower peak combustion temperature. In any case, the end result is less detonation and lower oxides of nitrogen.

In a recent study, it was found that the addition of significant amounts of water as liquid caused essentially no change in fuel economy.[1] If the water is vaporized prior to entry into the combustion chamber, there will be even less benefit for two reasons. First, the vapor displaces some of the oxygen which decreases the volumetric efficiency. Second, because the water is already vaporized, there is little evaporative cooling of the fuel/air charge and there is little benefit from the cooling phenomenon discussed above. During World War II liquid water injection was used on aircraft to improve

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[1] Bruce D. Peters and Russell F. Stebar, "Water-Gasoline Fuels — Their Effect on Spark Ignition Engine Emissions and Performances", General Motors Corporation Research Labs, SAE Paper 760547, June 1976.

takeoff performance. In this situation a large amount of water lowered cylinder head temperatures, and thus permitted takeoffs at higher intake manifold boost pressures. The increased takeoff power was due to an increased quantity of fuel/air charge that resulted from the higher boost pressure, not due to the water injection itself.

There is a popular concept that introducing water in any quantity and any form is beneficial to the operation of an internal combustion engine. As a result many vapor injection or steam injection devices have been submitted to EPA for evaluation. In most cases the amount of water introduced is insignificantly small. Regrettably, none of the vapor devices produced significant benefits and only one water injection device produced fuel economy benefits and that was at the expense of increased emissions.

(3) The description of the P.S.C.U. 01 device in most respects was considered adequate. It was; however, not adequate with respect to stating the materials used, and the dimensions of the container housing the electrical heating elements. Because of this shortcoming, EPA was not able to determine whether the unit could produce the quantity of steam claimed for the device.

(4) The applicant does not make any specific claims for the device in the application, but instead makes a general claim that it will improve fuel economy and reduce emissions. Information submitted in support of the application (Attachment B) does contain statements that fuel savings of eight to fifteen percent are possible with the device. The only test data submitted in support of his claims are that data referred to in Attachment B. For the reasons given in Section 6.d.(2), the data were determined to be not sufficient for showing the benefits attributable to this device.

(5) The cost of the device as given by the applicant, is approximately $590. According to the installation instructions (Attachment D) the kit is not complete and EPA expects the purchaser may be required to spend as much as $15 more to purchase other materials needed to install the device. EPA estimates that installation time would be at least four hours and assuming a shop rate of $20 per hour, the installation cost would be an additional $80. Thus, total initial cost would be approximately $685. To calculate the mileage required to be driven to recover the cost of the device, one must also take into consideration

the replacement cost of the catalyst (every 30,000 miles). EPA asked for this information (Attachment F) however, the applicant did not respond to the request. Therefore, the following results are based on only the initial cost and should be viewed as the minimum mileage to be driven.

If use of the device did result in a 13 percent improvement in fuel economy as claimed in Attachment B (and assuming a initial cost of $685 and a cost of $1.40 per gallon of fuel) a vehicle averaging 20 mpg would have to be driven approximatey 85,000 miles to recover the cost. This means the vehicle would either be approaching the end of its useful life or would likely be traded off before the cost could be recovered.

The reader should also note that because the applicant states in section 4.a.(2) "the unit is not recommended for use in temperatures below freezing," for many purchasers, the device could only be used on a seasonal basis[1]. Thus, the total miles driven before the cost are recovered could increase significantly.

c. Applicability Installation, Operation, Safety and Maintenance:

(1) Applicability:

The applicability of the product as stated in the application seems appropriate.

(2) Installation - Instructions, Equipment and Skills Required:

The installation instructions (Attachment D) referred to by the applicant leaves EPA with several concerns. First, even though the list of contents includes a chamber for a catalyst, it is not clear whether the catalyst itself is included or is purchased separately. EPA asked the applicant (Attachment F) to clarify this point in question; however, he did not respond.

Second, the list of contents shows that the package is not complete enough to accomplish the installation of the device. This may cause an inconvenience for some purchasers because of the necessity to obtain the additional components, i.e., electrical wire and terminal connectors, insulation, sealant, bracket material, and water reservoir, elsewhere. Additionally, the list does not state what size water reservoir is required.

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[1] Although the applicant states antifreeze additives are being investigated, none are presently recommended.

Third, for many of the recent model vehicles with crowded engine compartments EPA expects it will be very difficult to find suitable locations for the several components which make up the device since they must be located at specified heights relative to one another.

Fourth, because of the limited space between the hood and air cleaner on some vehicles, the installation of the steam injection tube into the top of the air cleaner may be precluded in some instances.

Fifth, step number ten of the instructions, which addresses electrical lead connections, could be more detailed. The narrative instructions and the schematic drawing (No. 3 of Attachment 3) are too general to be applied effectively to the many different electrical circuits being used today.

EPA agrees with the applicant that only a basic knowledge of automobile mechanics is required and that common tools readily found in most homes is adequate for installing the device.

(3) Operation:

Based on the design of the device, EPA has judged that except for replenishing the fluid, action by the driver is not required in order for the device to function properly.

Considering that steam is being ported to the air cleaner, the device may interfere with the normal operation of the heated intake system and consequently, the driveability may be changed. However, for lack of sufficient data, EPA does not know if this is a real concern.

(4) Effects on Vehicle Safety:

Based on its understanding of the device, EPA judges the applicant's statement regarding vehicle safety to be appropriate.

(5) Maintenance:

On a short term basis, EPA judges the applicant's statement regarding maintenance to be reasonable. EPA, however, is concerned about the effect road vibrations and contaminants and temperature extremes will have on the device over a long term basis. No information on long term durability was provided.

d. Effects on Emissions and Fuel Economy:

(1) Unregulated Emissions:

Based on the design of the device, EPA does not expect the device to have an adverse effect on unregulated pollutants.

(2) Regulated Emissions and Fuel Economy:

The applicant did not submit test data in accordance with the Federal Test Procedure and the Highway Fuel Economy Test. These two test procedures are the primary ones recognized by EPA for evaluation of fuel economy and emissions for light duty vehicles.* The test results that were submitted by the applicant (Attachment B) were from the testing of a single engine on an engine dynamometer under steady-state conditions. Consequently, the data did not adequately represent the varying speed and load conditions of in-use vehicles nor did it provide for a statistically sound test program. EPA developed a test plan and requested the applicant to submit additional test data (Attachment F). However, the applicant did not respond. Eventually, the applicant notified the Agency (Attachment G) he wished to withdraw his application for evaluation.

e. Test Results Obtained by EPA:

EPA did not test the device for this evaluation because neither the information (theory of operation and description of the device) nor the test results adequately supported all the claims made for the device.

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*The requirement for test data following these procedures is stated in the policy documents that EPA sends to each potential applicant. EPA requires duplicate test sequences before and after installation of the device on a minimum of two vehicles. A test sequence consists of a cold start FTP plus a HFET or, as a simplified alternative, a hot start LA-4 plus a HFET. Other data which have been collected in accordance with other standardized procedures are acceptable as supplemental data in EPA's preliminary evaluation of a device.

7. Conclusions

EPA fully considered all of the information submitted by the applicant. The evaluation of the P.S.C.U. 01 device was based on that information and EPA's engineering judgment. The applicant failed to submit adequate data to substantiate his claims for the device. Additionally, considering the description of the device, EPA does not expect that it can significantly change the cleanliness, power, fuel economy, or emissions of an engine. Thus, there is no technical basis for EPA to support the claims made for the device, to perform confirmatory testing, or to continue the evaluation on its own.

FOR FURTHER INFORMATION CONTACT: Merrill W. Korth, Emission Control Technology Division, Office of Mobile Sources, Environmental Protection Agency, 2565 Plymouth Road, Ann Arbor, MI 48105, (313) 668-4299.

List of Attachments

Attachment A	A copy of an English Translation of the Patent Application (provided with 511 Application and designated Exhibit 1).
Attachment B	A copy of the theory of operation (designated Exhibit 2).
Attachment C	A copy of schematic drawings (designated Exhibit 3).
Attachment D	A copy of the installation instructions (designated Exhibit 4).
Attachment E	A copy of the operating instruction (designated Exhibit 5).
Attachment F	A copy of the letter from EPA to Dutch Pacific, Incorporated, November 26, 1982.
Attachment G	A copy of a letter from Dutch Pacific, Incorporated, to EPA, December 13, 1982.

Title: EPA Evaluation of the P.S.C.U. ol Device Under
Section 511 of the Motor Vehicle Information
and Cost Savings Act

ATTACHMENT A

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Not clearly reproducible from submitted document. Copy will be furnished upon request from the U. S. Environmental Protection Agency, Emission Control Technology Division, Test & Evaluation Branch, 2565 Plymouth Rd., Ann Arbor, MI 48105.

P.S.C.U.-01

KOZA PRODUCTION B.V.
THE NETHERLANDS

P.S.O.U. and the Rare Earths to save fuel and fight pollution.

Ing B. van Brakel,
Schimmert.
The Netherlands.

Translated by Technisch Vertaalbureau Eindhoven.
January 1982.

Contents

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1. Description of P.S.C.U.-01 for use in internal combustion engines

P.S.C.U. stands for Proportional Steam Control Unit.

The P.S.C.U. is made up of three main parts :

A. A closed steam generator (the vaporizer) where the water is evapora by means of electric heater elements.

B. An electrically driven feed pump to provide a regular supply of wat to the vaporizer.

C. An electronic control unit to give proportional steam production an control of the water level.
The electronic control unit comprises also :
- Overheating protection
- Water supply monitoring
- Check on accumulator voltage

Operation of the P.S.C.U.

The P.S.C.U. is activated by switching on the ignition key (which activates the fuel system and/or ignition system of the engine). An int relay of the P.S.C.U. is then energized, switching on the main circuit. As a result, about 10 seconds after starting the accumulator voltage is checked by another circuit : if the voltage is high enough (11.8 or 23.6 the vaporizer heater elements are switched on.

The water-level sensor is mounted near the heater elements. If there is sufficient water in the vaporizer a signal is generated that corresponds to the temperature of the water. When the water level drops owing to evaporation below the sensor, the latter is rapidly heated up by the radiation from the heater elements to a temperature about 15°C above the boiling point of the water. The sensor converts this rise in temperature into an electric signal, which is in turn converted by a comparator circu into a drive current for the water pump. The latter therefore pumps wat from an external reservoir into the vaporizer. As soon as the water level there reaches the sensor, the temperature of the sensor drops again to that of the water and the signal level to the comparator circuit is such that the pump is switched off.

The comparator circuit is so adjusted that it reacts to a change of the water level of about 4 mm. This means that only a small quantity of water is dosed each time to the vaporizer so that, because of the relatively large quantity of water present in the vaporizer, the boiling water suffers only a very small drop in temperature. The supply of steam is therefore not interrupted.

When the pump is switched on, a timer is also started ; if after about 35 sec the level sensor still gives no signal that the water is once more up to the normal level, the pump is switched off and a warning signal is sent to a signal lamp or a buzzer to indicate that the external water reservoir is empty.

The sensor for the proportional control of the steam is mounted directly under the steam outlet pipe. When there is a low underpressure at the inlet venturi of the engine, the temperature at the steam outlet will rise ; the sensor will then provide a signal to its comparator circuit which in turn causes some of the heater elements to be switched off. When, however, the temperature of the sensor drops owing to the lower steam production, the heater elements are switched on again.

When there is a large underpressure in the engine venturi, i.e. at high speeds or high acceleration (high speed of aspirated air) the underpressure in the vaporizer is almost equal to the pressure in the venturi. Owing to this underpressure, the boiling point of the water in the vaporizer is lowered so that the production of steam is increased. When the accelerator vane in the venturi is closed, the pressure in the vaporizer rises again to the normal atmospheric pressure so that the temperature of the sensor rises again ; the heating is then again

partly switched off until the demand for steam increases once more.

The comparator circuits should be so adjusted that a large operatin range can be covered by the set value. For extreme cases it is possible to adjust the P.S.O.U. for other applications ; your Regio can carry out the necessary adjustments.

Changes in the set value are to be recommended for the following ca

- Engine capacity is less than 1000 cc.
- Engines of capacity 1000-2000 cc fitted with supercharges (turbo compressor).
- Engines used where the air is rarefied, e.g. in trucks in mountai regions or in light aircraft.
- Specially tuned engines for top performance in rallies and races.

Your Dealer or the technical staff of KOZA PRODUCTION B.V. are alwa willing to help with advice.

In the event of a fault in the electrical system of the engine wher the accumulator voltage drops below a certain pre-set value (11.7 V for a 12 V system, 23.4 V for a 24 V system), the P.S.O.U. i switched off automatically.

If the water reservoir is not refilled in time, the P.S.O.U. will sw off a part of the heater system. This will be switched on again lat just for an instant, to check whether water has meanwhile been added. If the reservoir is refilled with water during a fuelling stop, the P.S.O.U. will switch on the heating of the vaporizer and refill it with water within about 3 minutes.

The P.S.O.U. of KOZA PRODUCTION B.V. has a vaporizer unit designed t produce steam continually, independently of the ambient temperature according to the demand, that is, directly proportional to the rate at which air is aspirated by the engine, while requiring a minimum of power from the engine.

The intensive physical, chemical, mechanical and electronic investigations of KOZA PRODUCTION B.V. have made it possible to operate conventional internal combustion engines such that they cause less pollution of the environment and yet also consume less fuel, simply by the use of a P.S.C.U. and a suitable catalyst.

2. Catalysts

As is well known, fuels for internal combustion engines such as Petrol, Paraffin (Kerosene), Diesel Oil and LPG (Propane) are obtaine by distillation from high-boiling fractions (gas and residue oils). In order to obtain the desired fuel products, these high-boiling oils are subjected to temperatures between 400 and 600°C and pressures between 5 and 20 atmospheres for reaction times of several minutes. The main difficulty lies in the necessity to suppress as far as possi the various side reactions, leading e.g. to the formation of the ligh hydrocarbons C_1 to C_4 and the formation of cokes. This is achieved m by allowing only a part (15-30%) of the raw material to react as it passes through the cracking furnace. The uncracked remainder is then separated from the light cracking products and passed through the cra furnace once more.

In practice various processes have been worked out in detail, such as e.g. the DUBBS cracking installation, with the aim of getting as larg as possible an output of petrol. Such an installation works at the high pressure of about 80 atmospheres. In this way it is possible largely to suppress the splitting off of the lighter hydrocarbons so that mainly substitution and dehydrogenation reactions take place. Such a process is still used to get low-knock (high octane) petrol for motor cars by the direct distillation of crude oil. (Knocking or pinking is the detonation or pre-ignition of a fuel-air mixture owing to the compression and high temperatures occurring in the combustion chambers of engines).

The paraffin hydrocarbons with straight chains have the highest tende to knock. The naphthas have much less tendency to knock. The olefins, the aromatic hydrocarbons and the strongly branched paraffins have the best anti-knock properties.

The best hydrocarbons for combustion in I.C. engines are obtained if the cracking and reformation processes take place over a catalyst, for example a natural day such as montmorillonite (contains large quantity of rare earths) The molecules then break largely in the middle so that fewer C_1 and C_2 hydrocarbons are formed (undesired gases). Moreover isomerisation, cyclisation and aromatisation reactions take place more readily.

From the foregoing it will be clear that petrol refining companies do everything possible to produce an optimum product for internal combustion engines and under ideal conditions, where the right mixture with free hydrogens and oxygen is possible, these fuels will yield an optimum efficiency. Because, however, these fuels pass through the carburettor or injection system to the combustion chamber mixed with atmospheric air containing hydrogens, oxygen and other gases aspirated via the venturi a combustion product results that is dependent on a large number of factors, e.g.

1. Fuel/air mixture ratio
2. Homogeneity of mixture
3. Temperature distribution in mixture
4. Compression
5. Existing contamination in combustion chamber
6. Composition of aspirated atmosphere and many other factors.

Nevertheless, as mentioned earlier, the combustion reaction can be improved by cracking and reformation in the presence of a catalyst. Such a reaction can be made to take place in the combustion chamber of the engine when it is at the right temperature and pressure, provided that the catalyst is present there.

To be suitable, the catalyst must have the following properties.

1. It must have the affinity to combine with hydrogen but also to release it at the right moment for reformation of the fuel and its residue.
2. It must be able to admit sufficient oxygen to the combustion process to burn the newly formed hydrocarbons.

3. The composition of the catalyst, e.g. CeH_4O_4 , must be such that it can form an aromatic compound (cracking process) which can decompose under certain conditions of temperature and pressure to form finally carbon dioxide and water and leave the other gases undisturbed.
4. After the catalyst has done its work in the fuel/air mixture (e.g. as CeH_4O_4), it must yield up its oxygen for the oxidation of CO to CO_2 and yield up its associated hydrogen and oxygen compounds in the form of water and itself leave the combustion chamber in the form of Ce, Ce_2, Ce_3, CeO_2, CeO_4 or in its native state $CePO_4$. $CePO_4$ is the preferred compound of cerium.

Most of the catalysts hitherto tested for this purpose are members of the rare earths series (lanthanides), such as cerium, mentioned in the foregoing example. Cerium has the atomic number 58 and can be extracted from monazite sand, which is cerium phosphate $CePO_4$, found in Brazil.

For fundamental reasons, not to be discussed further here, it can be shown that other substances possess the same properties and can quite certainly meet the conditions mentioned above.

Catalysts suitable for our purpose may consist of mixtures of elements or of their oxides or be combined in an organic molecular structure. It is not necessary to use the catalyst in the 100% pure form as long as care is tken that the contaminants are not reactive and do not become so under the influence of pressure or temperature. The best seems to be to use catalysts made up from a series of elements that al have a catalytic action..

KOZA PRODUCTION B.V. LTD has an extensive list of suitable elements and has the necessary know-how with regard to their combination to form catalysts suitable for a wide range of applications. Each of these elemental and/or oxidic catalysts are protected by world-wide patents.

Examples of KOZA PRODUCTION B.V. catalysts include :

- Cerium 50% and other rare earths
- Lanthanum 59% and other rare earths
- Aluminium oxide 55% and other rare earths
- Silicon hydrides Si_xH_y beginning with SiH and ending with Si_6H_{14} and lanthanum.
- The elements titanium, hafnium, vanadium, thorium and a series of organic and inorganic lanthanides or their oxides which, however, fall outside the scope of this paper.

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3. Operation of P.S.O.U. and catalysts

When an internal combustion engine is properly tuned, the hydrocarbons and the air will be ideally mixed yet, owing to secondary effects such as local fluctuations in composition, pressure and temperature, this ideal composition of the combustion mixture may not yield the highest possible efficiency. The maximum efficiency can be achieved only when the mixture is subjected during combustion to the action of a catalyst and any hydrogens or oxides of hydrogen associated with it.

As you have no doubt observed on your motor car, an internal combustion engine works considerably better and more smoothly when the relative humidity of the aspirated air and its temperature are high, for example during spring and autumn mists. The reason for this is that there are then relatively many hydrogen compounds in the air, which are thus aspirated by the engine. These hydrogen compounds, e.g. 2H, and/or H_2O vapour, have a favourable effect on the combustion reaction.

An unfavourable aspect, however, is that unburnt hydrocarbons and/or traces of nitric or sulphuric compounds can easily arise.

In 1965 a Japanese laboratory performed experiments on the injection of steam in the venturi and combustion chamber of an engine, to simulate the high relative humidity of misty air. The results with regard to the efficiency of the engine were very interesting but the side effects, namely the generation of carbon monoxide, nitrogen oxides and sulphuric oxides, were not predictable or measurable. At that time, also, the investment required to achieve a practical working devi was out of all proportion to the possible profits.

The injection of steam and/or water vapour with methanol has been known even longer in the world of aircraft engines. As far as we can ascertai the first application was in 1942, when it was used on the Mark I Spitfi of the Royal Air Force.

From the observations that a high relative humidity improves the combustion process but that the fixing of the extra supply of oxides of hydrogen must be properly under control and that the moment and nature of the reaction has to be controlled by a suitable catalyst, KOZA PRODUCTION B.V. has developed the P.S.C.U.-01 which ensures that the right quantity of hydrogen oxides is always combined with the catalyst.

KOZA PRODUCTION B.V. has also carried out a comprehensive investigation to find the most suitable catalyst and the right composition of oxides. The P.S.C.U.-01 developed by KOZA PRODUCTION B.V. is an intelligent electronically controlled device that produces steam at about 100 °C at a rate proportional to the rate at which air is aspirated by the engine.

The steam produced by the P.S.C.U.-01 is fed via the steam duct to the catalyst and from there mixed with the aspirated air in the specially formed exit pipe, see fig. 1.

The hydrogen oxides associated with the catalyst are released in the combustion chamber only when the temperature and pressure there provide for the necessary chemical potential for the relevant substitution reactions. At a temperature of about 500 °C and a pressure between 5 and 20 atmospheres there is substitution of the hydrogen oxides and oxygens associated with the catalyst provided that there is no more reaction between the hydrocarbons already present and the aspirated air in the combustion chamber. Owing to the hydrogen oxides associated with the catalyst, an extra heat of combustion of 58 cal/mole is added for each mole of H_2O.

Because of the controlled steam generation by the P.S.C.U.-01 and the association of hydrogen oxides to catalyst in the combustion chamber, a combustible mixture is created which regulates and reforms itself. A situation then arises whereby an extra 58 calories per unsaturated bond per mole of water associated to hydrocarbon compounds is made available instead of 34 calories per mole being lost in the formation of CO

In addition, in spite of the absence of the compound CO, no nitrogen oxides NO_x or sulphur oxides SO_x are formed and this also implies the saving of a further 62 calories per mole. Because also all carbon atoms involved in the combustion process are forced by the catalyst to take up such a position that they can be burnt or oxidized, a further 14 calories are made available per mole of bound carbon atoms.

Summarizing, when the right substitution reactions are conduced by the introduction of catalyst and with the controlled steam generation of the P.S.C.U.-01, the follwoing enhancements per mole of the thermal efficiency are theoretically attainable :

Added :	
2 H_2O	2 x 58 = 116 cal.
CeO_2	1 x 32 = 32 cal.
Not formed	
2 CO	2 x 34 = 68 cal.
NO_x and SO_x (approx)	1 x 62 = 62 cal.
Free O atoms	6 x 14 = 84 cal.
Total enhancement from cracking(approx)	362 cal.
Energy required for cracking (2 H_2O)	2 x 58 = 116 cal.
Net enhancement per mole	246 cal.

With a well-tuned engine, a cylinder charging efficiency of 90% and a mixture homogeneity of 90%, a thermal yield can be obtained of about 1000 cal/mole.

By introduction of the catalyst a thermal yield of 1000 + 246 = 1246 can thus be obtained.
The enhancement of the efficiency is therefore (1246 - 1000)/1000 = 24

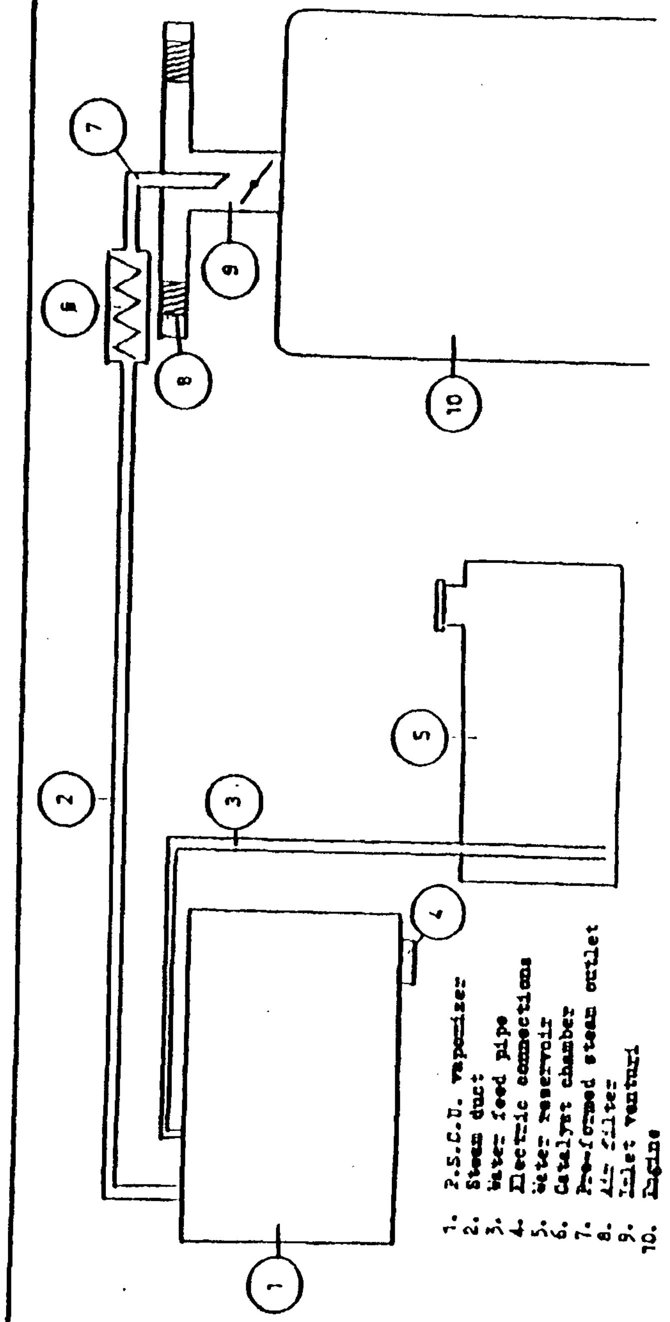
With a charging efficiency of 90% and a mixture homogeneity of only 70% the catalyst CeH_4O_4 from CeO_2 gives even more enhancement of the efficiency, estimated roughly at

$$24.6 \times \frac{100}{70} = 35\%$$

In practice, however, a filling efficiency of about 90% and a mixing homogeneity of about 90% are normally achieved so that the theoretical enhancement remains limited to about 24.6%. With very good mixing of hydrocarbon fuels the above result is approximately halved. The maximum enhancement is then found to be about 12%.

It will be evident that in order to achieve these improvements with the P.S.C.U. and a suitable catalyst, it is essential to have a well-tuned engine. It is also necessary that the operating range of the P.S.C.U. is sufficient for it to respond adequately to the working conditions obtaining. If the engine is tuned for too rich a mixture or if the steam temperature is too low or if too much steam is generated, the efficiency of the engine may decrease. Too many unburnt hydrocarbons may be formed which in turn extract too much energy from the combustion process and cause unnecessary emissions.

It is therefore recommended that you subject your engine to a tuning inspection before fitting the P.S.C.U. Fuel savings can then be obtained over the whole torque-speed range of your engine giving you all the advantages made possible by the catalyst.



1. P.S.C.U. vaporizer
2. Steam duct
3. Water feed pipe
4. Electric connections
5. Water reservoir
6. Catalyst chamber
7. Pre-formed steam outlet
8. Air filter
9. Inlet venturi
10. Engine

SCHEMATIC DIAGRAM OF P.S.C.U. AND CATALYST DISPENSER MOUNTED ON AN ENGINE.

FIG. 1.

Aims

he aims of KOZA PRODUCTION B.V. are as follows :

By means of the P.S.C.U., together with catalysts, to help the users of fossile fuels to get the most efficient possible conversion into energy while avoiding the production of polluting emissions or reducing the amount of existing emissions.

By means of minor modifications, to make the P.S.C.U. suitable for application to all existing hydrocarbon combustion systems such as
- Conventional internal combustion engines
- Gas generators
- Oil or natural gas burner systems for combustion purposes or heating installations
- Cracking installations for the combustion or refining of hydrocarbons.

To design the P.S.C.U./catalyst unit in such a way that it can be installed easily and rapidly in existing combustion systems.

By the application of modern fabrication techniques to produce a robust and reliable unit at a very low price having regard to the enhancement of the efficiency achieved, so that the P.S.C.U. will be used on the mass scale.

By way of lectures, technical information and guidance to make you familiar with the operation and applications of the P.S.C.U. and its catalysts.

5. Advantages

The advantages of using the P.S.C.U. catalyst unit in internal combustion engines are as follows.

1. Owing to the complete combustion of the aspirated fuel/air mixture, a higher efficiency is obtained, i.e. the same performance for less fuel.

2. The complete combustion of the fuel/air mixture implies the suppression of gaseous emissions such as carbon monoxide, nitrogen oxides, sulphar dioxide and unburnt hydrocarbons or at least a considerable reduction in these emissions.

3. Owing to the reduction of carbon monoxide, nitrogen oxides, sulphar dioxide and unburnt hydrocarbons, the combustion chamber and the exhaust pipe are no longer contaminated by soot or attacked by aggressive gases.

4. An engine that is coked up and dirty through long use is cleaned and rid of unburnt hydrocarbons by the use of the P.S.C.U./catalyst unit. (see attached graph, 01).

5. The temperatures of the exhaust ports and of the exhaust gases are considerably reduced because all the gases in the combustion chamber are fully burnt before the exhaust valves open ; no after-burning effects therefore take place in the exhaust pipe.

Summary of advantages for internal combustion engines

- Less fuel consumption for the same performance
- Considerable reduction of undesirable emissions
- No deposits of combustion residues in combustion chamber
- Longer life for the exhaust system
- Longer life for lubrication oil because it is much less contaminated and the working temperature is lower.
- Cleansing of engines long in use.
- Longer life for injection components, sparking plugs and exhaust valves owing to lower temperature and less contamination

- No major modifications to the engine are required to attain the foregoing advantages.
- Applicable to all types of I.C. engine.

Explanation of graph 01

The graph 01 shows the dependence of the fuel consumption and the composition of the exhaust gases on the running time or the distance covered.

It can be seen from the graph that the carbon monoxide concentration drops off slowly during the first 1000 km, due to the use of the P.S.C.U./catalyst. During the next 1000 km the amounts of carbon monoxide and unburnt hydrocarbons increase in engines that have previously been run without the P.S.C.U./catalyst, their combustion chambers being coked with unburnt hydrocarbons.

Hydrocarbons unburnt during the first period of fall-off of the carbon monoxide are bonded to the hydrogen oxides carried by the catalyst during the next combustion process so that after some time a somewhat combustible hydrocarbon mixture is obtained. After having first decreased, the carbon monoxide content increases again as a result of the combustion of the earlier mentioned newly formed hydrocarbon products. During the increase new combustible hydrocarbons are formed from the old combustible hydrocarbons which, in view of their composition, give rise to quite a lot of carbon monoxide.

After about 2000 km the carbon monoxide content drops again, now to very low values which stabilize at this level after about 4000 km. For engines running on petrol and LPG a CO value of about 0.2 to 0.1% can be achieved in practice.

At that moment (near 4000 km) all unburnt hydrocarbons that were present in the combustion chamber have been converted into combustible hydrocarbon compounds and the carbon monoxide concentration then

occurring depends on the tune of the engine.

It will be clear that the situation of the curves with respect to the time/distance scale depends entirely on the time that the engine has run before any steam/catalyst injection took place. The graph serves merely as an example and explanation of the observed and predictable effects.

It will probably also be clear that owing to the sharp decrease in the production of unburnt hydrocarbons, the formation of deposits especially in engines running on paraffin (kerosine) and diesel oil is considerably reduced. Also, the catalyst in the combustion chamber takes up and binds free oxygen and hydrogen atoms and so suppresses or at least reduces the formation of nitric or sulphuric gases.

Owing to the activating action of the catalyst on the combustion reaction and on the consequent acceleration of the combustion, the reaction proceeds uniformly in spite of the non-ideal mixing of the fuel/air charge, so that the charge yields up the maximum amount of energy availabl from the hydrocarbon/air mixture, with dissociation into CO_2, H_2O, O_xH_y and other aspirated gases.

In any case it can be said that with the right dosing of steam and catalyst, the reactions forming CO, NO_x, SO_x or CH_xO_x no longer take place.

6. Disadvantages

The disadvantages associated with the use of PSCU and catalyst are as follows.

1. Extra load on the electric circuit, about 450 W.
2. Water reservoir has to be checked and replenished.
3. Extra servicing necessary for the P.S.C. unit, mainly a check on the catalyst remaining in stock in the dispenser.

These disadvantages are quite insignificant compared to the advantages and results brought about by the P.S.C.U.

With regard to the extra load on the electric circuit, it can be shown that the power consumption for the P.S.C.U. is only a fraction of that yielded by the improvement in efficiency : only about 1% of the fuel consumed is used to operate the P.S.C.U. Thus if the effective saving of fuel was 10%, the real saving was 11% ; subtracting the 1% required to achieve this result we obtain the effective saving of 11 - 1 = 10%.

7. History of the most commonly used catalysts

The most commonly used and the most touted catalyst is based mainly on cerium, Ce, atomic number 58.

Cerium belongs to the series of rare earths (lanthanides), a group of 15 elements (atomic numbers 57-71) chemically related to aluminium (atomic number 13). In the periodic table they fall between barium and hafnium. The members of the rare earth series resemble each other more closely than is generally the case with most groups of elements. The reason for this lies in the similarity of their atomic structure.

Going from the inert gas xenon, via caesium and barium to lanthanum, the next element cerium begins with the build-up of the N-shell from 18 to 32 electrons (2×3^2 to 2×4^2). Hence between cerium in Group 2 and hafnium in Group 4 of the periodic table, there is a group of 15 elements whose outer shells (O and P) have identical structures. For this reason they are chemically similar, with only minor differences in their properties.

The most important mineral yielding rare earth elements is monazite sand, found in Brazil. Its main constituent is $CePO_4$.

The first publications on the use of the rare earths (lanthanides) as catalysts appeared in 1872 when the properties especially of cerium as an initiator of reactions for the formation of hydrogens and hydrogen oxides were discovered. Auer von Welsbach used these properties in 1891 in the gas mantle (about 1% cerium oxide and 99% thorium oxide) to give a brighter light in gas and oil lamps and to suppress the formation of soot. Since that time many investigations have been made into the use of cerium and other rare earths for a variety of purposes.

Apart from the experiments of Professor R. Volcher, which were very positive, no other *investigations* for the application of cerium or related elements to control the combustion process in internal combustion engines have been made since 1969. In 1981 KOZA PRODUCTION B.V. started anew on a comprehensive *programme* of investigations into the application of catalysts to promote the controlled combustion of hydrocarbons in the combustion chambers of engines.

These combined physical, chemical mechanical and electronic investigations has lead to the development by KOZA of a generally applicable P.S.C.U./ catalyst system which *effectively reduces emissions and saves fuel.* The system is unique and is protected by world-wide patents.

Ned. Patent pending : 8 105 682 , dated 17-12-1981.

8. Koza test set up and results obtained

The Koza test rig consists of a 2.3 litre motor coupled a 3-phase synchronous generator with a continuous load of 3 x 5000 VA, i.e. a total load of 15 kW.

Under constant conditions of

- Ambient temperature
- Relative humidity
- Shaft load
- Speed (r.p.m.)
- Aspirated air temperature,

the test equipment was used to investigate the effect of hydrogen compo carried by a catalyst containing cerium, thorium, silicon, titanium and other substances. In addition the effects of the composition of the mixture and the concentration of water vapour could be studied and an accurate measurement made of the temperature of the water vapour. In all further analysis of results, engine speed, shaft power and inlet manifold vacuum were taken as fixed standard values. In addition variab such as

- relative humidity of air in inlet manifold
- average temperature of the mixture
- pressure differences

were measured and recorded.

Furthermore, the temperatures of oil, exhaust *gases* and exhaust ports were measured and the fuel consumption accurately recorded.

Results and conclusions of tests

For clarity we *give* here once more a short summary of the reactions to be expected, the atomic transitions and the related results.

Cerium (Ce) is a metal belonging to the 15 elements of the rare earth series. Cerium melts at 795°C and its density is 6.64 kg/dm^3. It oxidis rapidly at room temperature and even *faster* when the air is humid and at higher temperatures. It is one of the most reactive of the rare earths and is completely oxidized in a hot atmosphere of water vapour.

As with several related elements, the electronic structure of cerium can assume various forms viz. it may have either two valencies, 3-valent or 4-valent, by exchange of electrons between the O and P shells or 4-valent according to the configuration of the (outer) N-shell. Depending on the way in which they are formed, the following molecules can then arise :

CeO_3 , CeO_2 and XO_2 (X is here some other catalyst element).

All these oxides dissolve in water and are very reactive with water. The oxide Ce_2O_3 melts at 1690°C and has the tendency to dissociate at 200°C. The oxide CeO_2 and other oxides investigated by us melt in the region of 2600°C and dissociate spontaneously at various temperatures in the range 490-600 °C.

The characteristic valency behaviour of these oxides give them their remarkable and useful catalytic properties. These catalysts have a large capacity to exchange oxygen atoms whereby it is possible to oxidize hydrogen and hydrocarbons.

This property is shared by all other rare-earth oxides and by some other oxides such as those of thorium, magnesium, tantalum, tin, copper, and several others.

Owing to this valency behaviour there is a constant exchange of oxygen atoms at the surface trying to establish an equilibrium, resulting in the catalytic oxidation of CO to CO_2 and in the conversion of the light hydrocarbons resulting from the combustion of oil products which in turn can be hydrogenated and oxidized to combustible hydrocarbon compounds and finally burnt to form CO_2 and H_2O.

The valency behaviour of the oxides are also responsible for the automatic cleaning of the combustion chamber since they form bonds with the unburnt carbonaceous matter to form hydrocarbons which can then later be oxidized (burnt). The formation of such hydrocarbon compounds depends on the temperature and pressure, e.g. between 250 and 500 °C.

The normal composition of the exhaust gases of an internal combustion engine includes the following :

- Unburnt hydrocarbons, CH
- Nitrogen oxides, NO_x
- Carbon monoxide, CO
- Carbon dioxide, CO_2
- Water vapour, H_2O
- Atmospheric gases aspirated by engine

On the basis of the foregoing, the composition of the exhaust gases may be expected to be :

- Carbon dioxide CO_2
- Water H_2O
- Atmospheric gases as aspirated

The <u>results of the test</u> were as follows.

Main constituents of exhaust gases :

- Carbon dioxide, CO_2
- Water, H_2O
- Components as given in graph C1 after a test duration of 50 running hours. (3-hour runs with stops of 2-3 hours).

In spite of the extra power consumption of 266 watts for the of the steam, a fuel saving of 13% was achieved compared w conventional engine without the PSCU/catalyst.

he composition of the exhaust gases after 50 running hours was as follows

<u>Conventional engine</u>		<u>Engine with catalyst</u>	
- Carbon monoxide CO	3.5%	- Carbon monoxide CO	0.1%
- Carbon dioxide CO_2	8.2%	- Carbon dioxide CO_2	11.5%
- Hydrocarbons CH	32 ppm	- Hydrocarbons CH	0.3 ppm
- Nitrogen oxides NO_x	0.2 ppm	- Nitrogen oxides NO_x	1.2 ppm

uel consumption :

Petrol :	8.0 l/hour	Petrol :	6.9 l/hour

haft power (energy per hour) :

$_1t$ = 15 000 x 3600 = 54 000 kJ $(P_1 + P_2)t$ = (15 000 + 266) 3600 = 54 957 kJ

eat content of fuel used per hour :

x 0.7 x 11 000 = 61 600 kcal = 256 666 kJ   6.9 x 0.7 x 11 000 = 53 130 kcal = 221 375 kJ

et efficiency of engines :

$\frac{54\ 000}{256\ 666} \times 100 = 21\%$ $\frac{54\ 957}{221\ 375} \times 100 = 25\%$

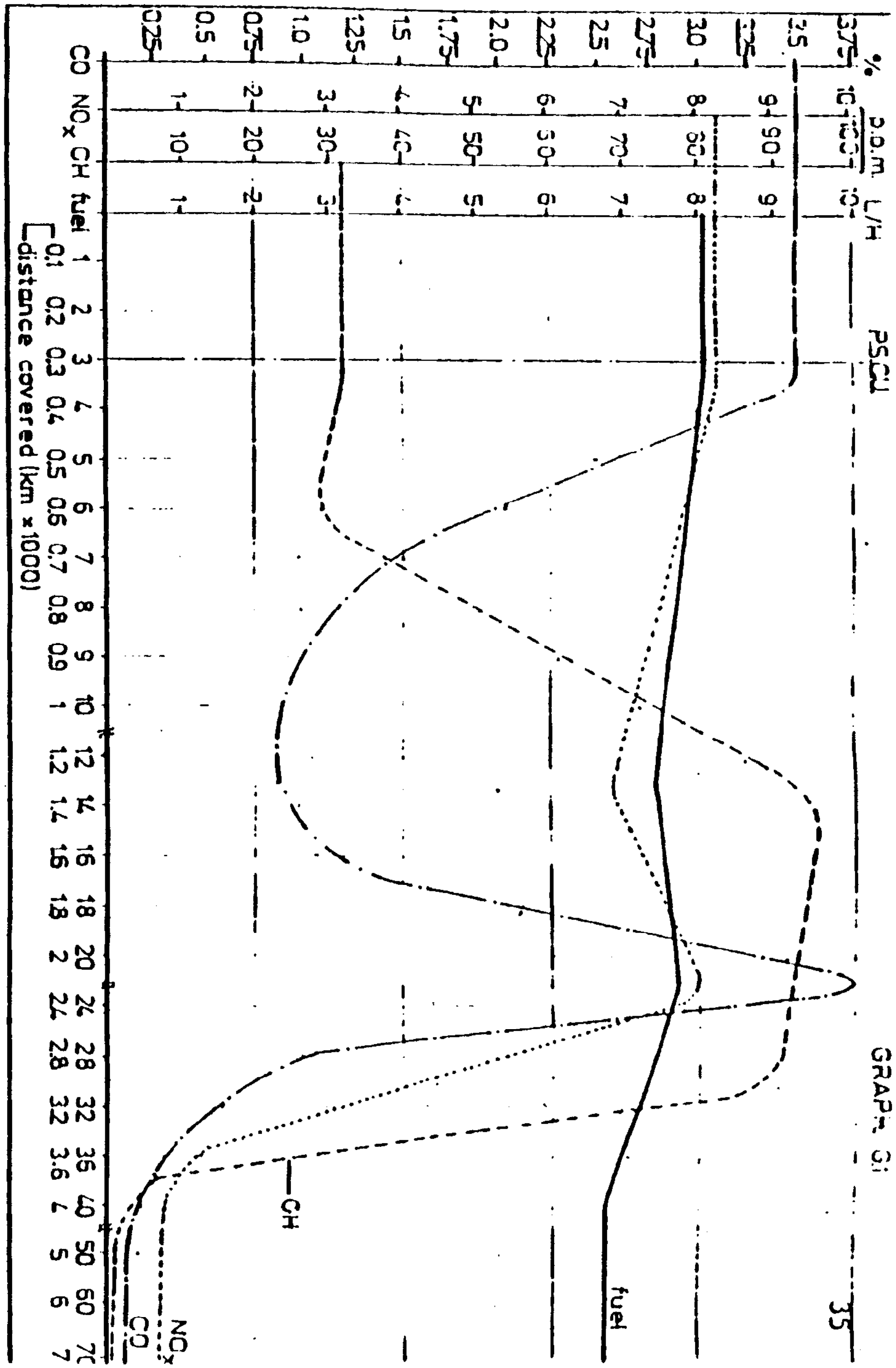
se of the catalyst thus brings about a net increase of 25 - 21 = 4% in
he efficiency and a saving in fuel of (8 - 6.9)/8 = 13.8%.

66 W is needed for to produce the steam in the PSCU. To generate this
ower with a heat engine of efficiency 25% and a generator of efficiency 95%,
he amount of heat required per hour is

$$266 \times 3600 \times 0.24 \times \frac{100}{25} \times \frac{100}{95} = 970\ 000 \text{ cal.} = 970 \text{ kcal.}$$

rom the calorific value of the fuel, 11 000 kcal/kg and its density 0.7 kg/l,
e find that 1 litre of fuel represents 0.7 x 11 000 = 7700 kcal.
ence, to generate 266 W for the steam production, 970/7700 = 0.126 litres
f fuel are required per hour.

ummarizing, the PSCU catalyst dispenser gives
- Improvement of engine efficiency by 4%
- Fuel saving of 13.8%
- Fuel consumption of 0.125 litres of fuel for PSCU itself.



9. Extracts from earlier tests

The extracts give brief summaries of the results of earlier tests on cerium as a catalyst in internal combustion engines.

1 - Test by Höhere Technische Lehranstalt des Staates Bern.
Ecole d'Ingénieurs Bienne, 11 April 1979.

Test carried out on a Toyota private car, type Corolla Liftback, distance on clock 30 150 km.
Measurements carried out in accordance with ECE Standards.
Results

Gas component	With catalyst	Without catalyst
CO	31.47	50.25
CH	3.64	7.40
NO_x	6.66	6.38

These tests were authorized by "ECOLE D'INGENIEURS BIENNE", Automobile Technique Dept., Mr P. Wittwer.

2 - Test by Höhere Technische Lehranstalt (HTL) Bienne, 4 September 1979.

Test carried out on BMW car, type 320, distance on clock 50 000 km.
Measurements in accordance with ECE Standards.
Results

CO	59.62	66.46
CH	3.50	4.86
NO_x	2.04	4.15
Fuel consumption	412.50	442.50

Total distance covered during test : 3440 km.

Test authorized by the above-mentioned institute and confirmed by Mr P. Wittwer.

3 - East-West Trading Company, Seoul, Korea. Report of results given in a letter dated 14 November 1979 :
Tests on a British-Leyland car, type PONY.

Results : CO concentration 0.1%, reduction in fuel consumption of 23%.

4 - Oscar Caponairo, expert at Automobiles de Luxembourg, 27 Jan. 1977.
Tests on a BMW car, type 2800, distance on clock 100 000 km.

Normal fuel consumption : 12.15 l/100 km.
Normal CO concentration : 6%

After catalyst injection for 2000 km, the CO concentration had droppe to 0.5% and the fuel consumption had been reduced by 12%.

Authorized by O. Camponairo, Expert judiciaire agréé et assermenté par la Haut Cour de Justice du Grand-Duché.

5 - Petroleos del Peru , 13 Aug. 1970.

Tests on a Toyota Car, type Sedan 1000, year 1974.
Tests carried out with fuel of octane number 04.

Fuel consumption reduced over the entire test period by 14% to 20%.
CO concentration reduced to 0.3%.

6 - Colegio de Quimicos del Peru, 10 Febr. 1970.

Tests on Toyota Car, type 1700, year 1972.

Fuel consumption reduced by 10%
CO concentration reduced from 5.5/6% to 0.3/0.1%.
Authorization for tests unknown.

It can be concluded from the foregoing extracts from the reports named th wherever tests were made, the results showed a reduction of fuel consumpt and a considerably lower CO concentration.

These results confirm our own conclusion that the use of a catalyst has a favourable effect on the combustion of hydrocarbon.

That the results do not conform entirely to the theoretical expectations may be attributed to the fact that insufficient attention has been paid hitherto to the generation of just the right quantity of water vapour at just the right temperature, to provide the most effective conversion of CeO_2 into CeH_4O_4.

10. Energy balance calculations

During the investigations of KOZA PRODUCTION B.V. the following chemical formulae have been used. They are given here, for clarity, sometimes in simplified forms as approximations more readily comprehensible to readers not entirely familiar with the subject.

1. Hydrogenation or substitution reaction under high temperature and pressure.

Chemical formulae for the first cracking reaction for oil products.

Average standard product $CH_3 - (CH_2)_8$ is transformed into

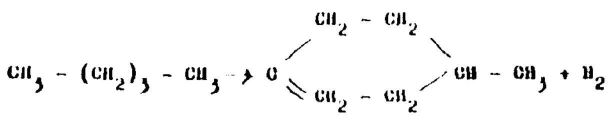
$$CH_3 - (CH_2)_2 - CH$$

This in turn transforms to

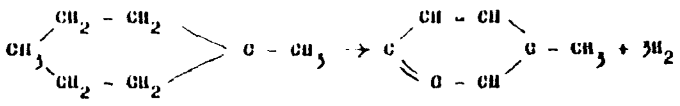
$$CH_2 + CH_3 - (CH_2)_3 - CH_3$$

This is essentially the splitting of paraffin hydrocarbons into olefins.

From this product naphthas (diesel oils) can be fabricated via a long but well-controlled route, using the substitution reaction :

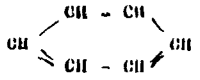


or anti-knock petrol by the reaction :



Further chemical explanation is given on the basis of the hydrocarbon compound benzene, C_6H_6.

A very low knock (high-octane) hexane compound is :



For the calculation of preferred compound outside the normal elementary series of potential compound we use the rules of KOPP concerning the surface free energies and the so-called Parachoor rules.

The Parachoor determines which compounds outside the elementary series will be produced and in what form, independent of the temperature.

The remaining atomic bonds necessary for our purpose can be calculated with the aid of the Lorentz-Lorenz formula .

$$R = \frac{M(n^2 - 1)}{\rho(n^2 + 2)} .$$

Further details concerning the calculations fall outside the scope of this paper.

Applying the rules of Kepp and Lorentz-Lorenz, the compounds being formed and the reactions can be calculated, using hydrogenated oxygens which can be formed by the intermediary of a suitable catalyst

If the compound C_6H_6 is to be completely broken down to CO_2 and H_2O, it first has to be reformed into $C_6H_6O_{15}$ which can then be burnt to $(CO_2)_6$ and $(H_2O)_3$.

To burn one molecule of C_6H_6 completely to carbon dioxide and water, therefore, it has to be combined with 15 atoms of oxygen. For each volume of gaseous hydrocarbon compounds therefore, 7.5 volumes of oxygen O_2 are required. Because oxygen forms about 21% of the atmospher about 35 volumes of other atmospheric gases (mainly N_2) will also be present in the charge.

In order to get complete combustion to carbon dioxide and water, it is necessary to have 100% homogeneous mixing of the components before combustion and to have oxygens and hydrogens available where necessary to burn any light hydrocarbons formed to carbon dioxide and water.

In practice the filling efficiency of internal combustion engines does not exceed 90% (residual gas from the previous cycle occupies about 10% of the volume). Also the mixture never attains a homogeneity of more than 90%. In such a far from ideal mixture, it will be clear that combustion will be incomplete, giving unburnt hydrocarbons and carbon monoxide. An example now follows by way of illustration.

An internal combustion engine with a displaced volume of 1500 cc , consumes 6 litres of fuel per hour when running at 2500 r.p.m. At this speed this engine aspirates roughly(1.5/2 x 2500 x 60 = 112 500 litres fuel-air/mixture per hour. As however a maximum filling efficiency of only 90% can be achieved, only about 112 500 x 90/100 = 101 250 litres are aspirated. Owing to turbulence and imperfect mixing not all the oxygen in the aspirated air takes part in the combustion process to give the maximum possible energy.

Now 6 l of fuel, which in gaseous form occupies a volume of very roughly 6000 litres, should be mixed (per hour) with about 101 250 - 6000 = 95 250 litres of air to obtain complete combustion and a maximum conversion into carbon dioxide (CO_2) and water (H_2O). As however only about 90% is properly mixed so as to have access to the oxygen in the aspirated air, combustion is incomplete and only 6000 x 90/100 = 5400 litres is fully converted to carbon dioxide and water, about 600 litres being converted (per hour) into CO, CH and NO_x or passes out unchanged into the exhaust.

The theoretical fuel consumption per hour of a 4-stroke internal combustion engine is given approximately by the expression

$$\frac{\text{Displacement volume}}{2} \times \text{r.p.m.} \times 60 \times \frac{1}{21 \times 10^3} \text{ litres/hour}$$

where the$(21 \times 10^3)^{-1}$ is a factor allowing for the fuel/air ratio, filling efficiency and the ratio of volumes of the fuel-mixture in liquid and gaseous form. The quantity of heat generated per hour is then the fuel consumption per hour times the density of the fuel (0.7 kg/l) and its calorific value (11 000 kcal/kg).

For the test motor used by KOZA (V = 2.3 l, r.p.m. = 2500), the fuel consumption is thus

$$\frac{2.3}{2} \times \frac{2500 \times 60}{21 \times 10^3} = 8.2 \text{ l/hour.}$$

and the heat generated is therefore

$$8.2 \times 0.7 \times 11 \times 10^3 = 63\ 250 \text{ kcal/hour}$$

To calculate the fuel consumption of an engine fitted with a catalyst--dispensing unit, one may assign a "new effective calorific value" to the fuel. To obtain this it is necessary to estimate the losses normally occurring owing to incomplete combustion, condensation losses and losses due to the formation of undesired combustion products.

If 1 gram of $C_6H_6O_{15}$ is completely burnt this yields about 11 000 calories of heat and the only combustion products are $(CO_2)_6$ and $(H_2O)_3$.

If a substance of composition $C_6H_6O_{13}$ were burnt, the combustion products would be $(CO_2)_4 + (H_2O)_3 + 2CO$. From each $C_6H_6O_{13}$ two molecules of CO are thus formed each of which remove 34 calories (per gram of $C_6H_6O_{13}$) from the heat of combustion. Also, instead of 6 molecules of CO_2, only 4 are formed giving a condensation loss for each CO_2 of 94 cal per gram of $C_6H_6O_{13}$.

The calorific value of the fuel is therefore reduced by (2 x 34) + (2 x 94) = 256 calories. The compound $C_6H_6O_{15}$ gave about 11 000 cal per gram. The substance $C_6H_6O_{13}$ there gives only

11 000 - 256 = 10 744 cal/g.

Each gram of the assumed inferior compound $C_6H_6O_{13}$ therefore reduces the calorific value by 256/11 000 = 2.3% while producing a new and undesired compound (CO).

We conclude that outside the normal thermal losses of about 70% of an internal combustion engine under ideal conditions and outside the 5% used for the generation of electric power required for the engine, a further loss of about 2.3% occurs due to incompletely burnt fuel.

The P.S.C.U. and catalyst helps to suppress incomplete combustion and accelerates the whole combustion process, giving a lower thermal loss.

Results from the Koza test rig (per hour).

	Conventional engine	Engine with catalyst
Cooling water temperature	95 °C	90 °C
Exhaust temperature	610 °C	500 °C
Oil temperature	105 °C	95 °C
Exhaust losses, CO and CH	2156 kcal	54 kcal
Electric power for engine	160 W	456 W
Total shaft power	15 kW	15 kW
Thermal energy consumed	61 600 kcal	53 130 kcal

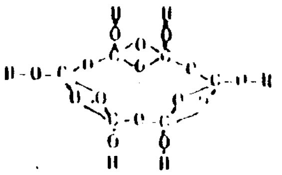
The thermal energy consumed can be broken down as follows :

Frictional losses	4 400 kcal	4 400 kcal
Cooling water	37 494 kcal	31 079 kcal
Radiation losses	3 500 kcal	3 400 kcal
Exhaust loss	2 156 kcal	54 kcal
Shaft power available	12 960 kcal	12 960 kcal
Oil cooling	952 kcal	861 kcal
Internal electric losses	130 kcal	360 kcal
Total	61 600 kcal	53 130 kcal

We see that in spite of the extra electrical power used to generate steam for the injection of catalyst, less heat is dissipated by the oil, the cooling water and especially by the exhaust.

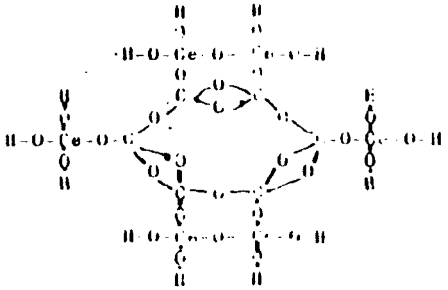
Because of constructional differences and differences in the proportion of materials used by the various engine manufacturers, the following formulas and calculations must be regarded only as rough guides. The results are certainly subject to variations of ± 20%.

In ideal circumstances, the compound C_6H_6 forms with $7.5(O_2)$ a fully combustible compound, burning to water H_2O and carbon dioxide CO_2 .



$(CO_2)_6 + (H_2O)_3$

The processes occurring during the combustion of C_6H_6 with oxygen in the presence of a catalyst are very complex and can take on many forms. An example of an intermediate product is



This may be written as $C_6H_{14}O_{31}Ce_6$; it burns to $(CO_2)_6 + (H_2O)_7 + (CeO_2)_6$.
$(CO_2)_6 + (H_2O)_7 + (CeO_2)_6$.

Because cerium can assume different valencies, it will be clear that instead of $(CeO_2)_6$ as combustion product, CeO and Ce can be formed and also CO_2 by the removal of an oxygen from the cerium compound.

Since the introduction of catalyst provides an extra eight hydrogen atoms and an extra sixteen oxygen atoms for the combustion process and since the catalyst is available and capable of bonding excess oxygens or hydrogens and also releasing them as required, a less critical mixture is formed than is normally formed from C_6H_6.

It can be stated that [illegible]

by the combustion of fuels based on C_6H_6 (benzene), C_7H_{14} (diesel oils) or C_7H_{12} (petrol) because of the presence of CeH_4O_4, then the maximum work can be extracted from the fuel.

From the foregoing Koza tests we had for the thermal energy content Q of the fuel :

Q = volume of fuel/hour x density x calorific value = 8 x 0.7 x 11 000 = 61 600 kcal.

The "new effective value" of the calorific value of the fuel resulting from the use of a catalytic unit can be obtained from the data concernin the faster burning and the reduced losses. From the tests the fuel consumption was a factor 0.06 less so that

"New effective calorific value" = 11 000/0.06
= 12 000 kcal

The catalytic unit has therefore given an improvement of
(12 800 - 11 000)/12 800 = approx. 14%.

In order to achive this improvement in the calorific value the right amount of catalyst must be carried by the steam into the fuel/air mixture aspirated by the engine.

The amount of steam required is about 420 g per hour (average value for the P.S.C.U.-01-2-12, see Section 12, p. 37, Provisional Technical Specification). To produce this quantity of steam 266 W are required and as shown earlier (p. 24) this requires the expenditure of about 0.126 litres of fuel per hour.

11. Summary and conclusions

- From earlier investigations and from the results of test carried out by Koza it can be concluded that the injection of catalyst into the combustion process has a positive effect on the efficiency of combustion.

- The results attainable are dependent on the amount of catalyst injected and this in turn depends on the amount of steam generated.

- The presence of the catalyst gives the engine a considerably flatter torque curve so that a high performance can be attained over a larger range of speeds.

- The results attainable can be calculated and the composition of the exhaust gases can be predicted on the basis of the foregoing ideas.

Final conclusions

The application of a catalyst injected by means of steam/water-vapour near 100 °C, when properly dosed, gives the following results :

1. The net efficiency of an internal combustion engine can be increased by at least 3%.
2. The fuel consumption can be reduced by 13% while maintaining the same performance.
3. Toxic gases in the exhaust can be reduced by a factor 30 and coking is suppressed.
4. The normal temperature of the exhaust port is reduced by about 5%, giving less thermal load and extending the life of the engine.
5. The temperature and the contamination of the lubricating oil is reduced very considerably so that the life of the lubricating oil increases by 50%.

6. The exhaust gases are much less corrosive because e.g. nitric and sulphuric components are absent. The life of the exhaust system is therefore determined only by the external corrosion ; this implies that its life is increased by at least 50%.
7. Owing to the breakdown of unburnt hydrocarbons already present in the combustion chamber, the latter is cleaned and because also there is no new formation of unburnt hydrocarbons, the life of injection systems and sparking plugs are greatly extended.

Use of the P.S.C.U.-01 makes possible –

- Fuel saving of 8 – 15%
- Use of normal (lower octane) petrol instead of super (premium grad
- Cleansing of the motor by automatic de-coking.
- Increase of life of
  - (a) Lubricating oil
  - (b) Engine
  - (c) Ignition system, injection system
  - (d) Exhaust system
- Drastic reduction of toxic emissions

12. Provisional Technical Specification

Type	PSCU-01/2/12	PSCU-01/2/24	PSCU-01/4/24
Number of heater elements	2	2	2
Supply voltage	12V D.C.	24V D.C.	24V D.C.
Maximum current	20 A	12 A	24 A
Max. power dissipation	240 W	200 W	576 W
Max. evaporation capacity	0.575 l /hour at 740 mbar	0.695 l/hour at 740 mbar	1.305 l /hour
Min. evaporation capacity	0.250 l /hour at 1040 mbar	0.305 l/hour at 1040 mbar	0.610 l /hour
Min. temp. of vapour (at 740 mbar)	92 °C	92 °C	92 °C
Max. temp. of vapour (at 1040 mbar)	104 °C	104 °C	104 °C
Min. vapour pressure	700 mbar	700 mbar	700 mbar
Max. vapour pressure	1040 mbar	1045 mbar	1050 mbar
Vapour pressure range	340 mbar	345 mbar	350 mbar
Max. pumping height for water pump	300 mm	400 mm	450 mm
Capacity of water pump	1 l/hour	1.1 /hour	1.6 l/hour
Max. hose length for pump	2 metres	2 metres	3 metres
Max. length of steam duct	600 mm	600 mm	1000 mm
Weight of catalyst charge	42 g	42 g	75 g
Consumption of catalyst per m³ aspirated air (approx.)	0.4 mg/m³	0.4 mg/m³	0.42 mg/m³
Life of catalyst (running hours)	500 hours	500 hours	750 hours
Suitable for engine capacities of l	1.8-5 litres	2-6 litres	5-12 litres

Subject to modification.
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Appendix 1

Emissions and pollution

There are many factors that contribute to the pollution of our environment. In this Appendix we discuss one of the most important of these factors, viz. that deriving from the use of hydrocarbon fuels lubricants. Air, water and the ground are all subject to the effects of pollution products from hydrocarbons.

Air pollution

The United States Council of Industrial Health was the following rule to define air pollution. Air pollution exists if the well-being of man is unfavourably affected or when damage is brought to his possessions.

Man is dependent for most of his needs on plants and animals so that there is also pollution when the environmentof plants and animals is unfavourably affected.

History of air pollution

Even in the stone age there was a certain degree of air pollution, for example by the incomplete burning of wood (especially in caves), producing soot and smoke. At that time however we can hardly speak of pollution in the American sense because the concentrations of hydrocarbons in the air were so small that man's environment and well-being were hardly affected. However air pollution as a result of the activities of man goes back at least 700 years. In 1257 a law was passed in London which aimed to limit pollution of the air by the burning of inferior fuels.

Air pollution by industry, power stations, motorised traffic and agriculture is, however, not more than 200 years old. Serious pollution of the air can be said to have begun with the industrial revolution and has increased with the years. Only in the last ten to twenty years have efforts been made to tackle the problem.

Air pollution due to motorised traffic

Over the whole world considered, nature produces more than ten times as much carbon monoxide as motorised traffic. The traffic pollutes the air, however, mainly in the towns where it produces a high concentration of carbon monoxide due to the high density of traffic.

In addition to carbon monoxide, the incomplete burning of hydrocarbons in the internal combustion engines used for road vehicles produces carbon (soot), carbon dioxide, water, and all sorts of partially oxidized hydrocarbons such as aldehydes, peroxides and carbon-based acids. There is also a certain percentage of the original unburnt hydrocarbons C_xH_y in the exhaust emissions.

Because engine fuels also contain, in general, a small percentage of sulphur, small quantities of SO_2, H_2SO_3 and H_2SO_4 are also formed.

When the burning temperature is high enough, the time of burning long enough and when there is sufficient oxygen, oxides of nitrogen will also be formed by the reaction between atmospheric oxygen and nitrogen. Examples of the nitrogen oxides formed are NO, NO_2 , and N_2O_4 . The general notation for these oxides is NO_x .

Measures to prevent air pollution by road vehicles

CO and C_xH_x can be converted into CO_2 and H_2O in an after-burning process, provided that oxygen is present and means to make the reaction proceed fast enough.

In one system air is forced by a pump into the exhaust gases at the moment that these leave the exhaust port of the cylinder, still aflame. The completion of the combustion then takes place in the exhaust pipe and the dissipation of the extra heat there represents a considerable problem. Moreover quite some energy is required to drive the pump.

Another possibility is catalytic after-burning in which the completion of the combustion takes place at a lower temperature with the aid of a catalyst. Apart from the technical complications, catalytic after-burning brings other problems.

1. Catalysts now available are all poisoned by the lead compounds in the exhaust gases, within a short time.
2. The macro-problem of producing sufficient catalyst for millions of vehicles.

The poisoning of the catalyst can be avoided by the use of lead-free petrol. Since it is not possible to produce a lead-free petrol having the high-octane values now commonly in use, it would only be possible to avoid pre-ignition (detonation, pinking, knocking) by lowering the compression ratio of engines. This however leads to a higher fuel consumption.

With these after-burner systems the NO_x concentration is not affected. A lowering of the NO_x concentration can be achieved by admitting a portion of the exhaust gases to the fresh fuel-air mixture. This reduces the combustion temperature at the expense, however of the thermal efficiency.

An alternative prime mover in the form of the Wankel engine, Stirling engine or gas turbine might satisfy the requirements of low fuel consumption and low emissions but the high development and production costs of such engines quite preclude their general application. Moreover, practically all existing road vehicles are propelled by conventional diesel and petrol engines.

An alternative solution is the application of the P.S.C.U.-01 with catalyst injection.

In this system a catalyst, which activates the reaction of hydrocarbon compounds, is injected into the fuel-air mixture right at the beginning of the combustion process.

The P.S.C.U. generates hot water vapour which carries catalyst into the engine at a controlled rate. As a result :

1. The combustion is considerably faster, although the burning temperature remains the same resulting in a much lower production of NO_x .
2. Extra oxygen and hydrogen associated with the catalyst is made available during the combustion process making possible the complete combustion of CO and C_xH_x to CO_2 and H_2O in the combustion chamber.
3. Owing to the characteristic properties of the catalyst the formation of sulphuric acid and sulphuric compounds and of nitric compounds is suppressed.
4. The thermal efficiency of the engine is improved considerably because the fuel is now burnt completely and converted to CO_2 and H_2O without the formation of toxic substances.

With the PSCU-CATALYST SYSTEM

- Engine consumes less fuel for the same performance
- Toxic emissions greatly reduced to values well below USA standards,

Economic aspects of the PSCU-Catalyst System

1. The investment in the PSCU-Catalyst System is earned back in a very short time from the reduced fuel consumption.
2. The suppression of toxic and agressive combustion products keeps the engine and exhaust system clean, with lower maintenance costs.
3. Very low toxic emissions, so much less pollution of the environment.

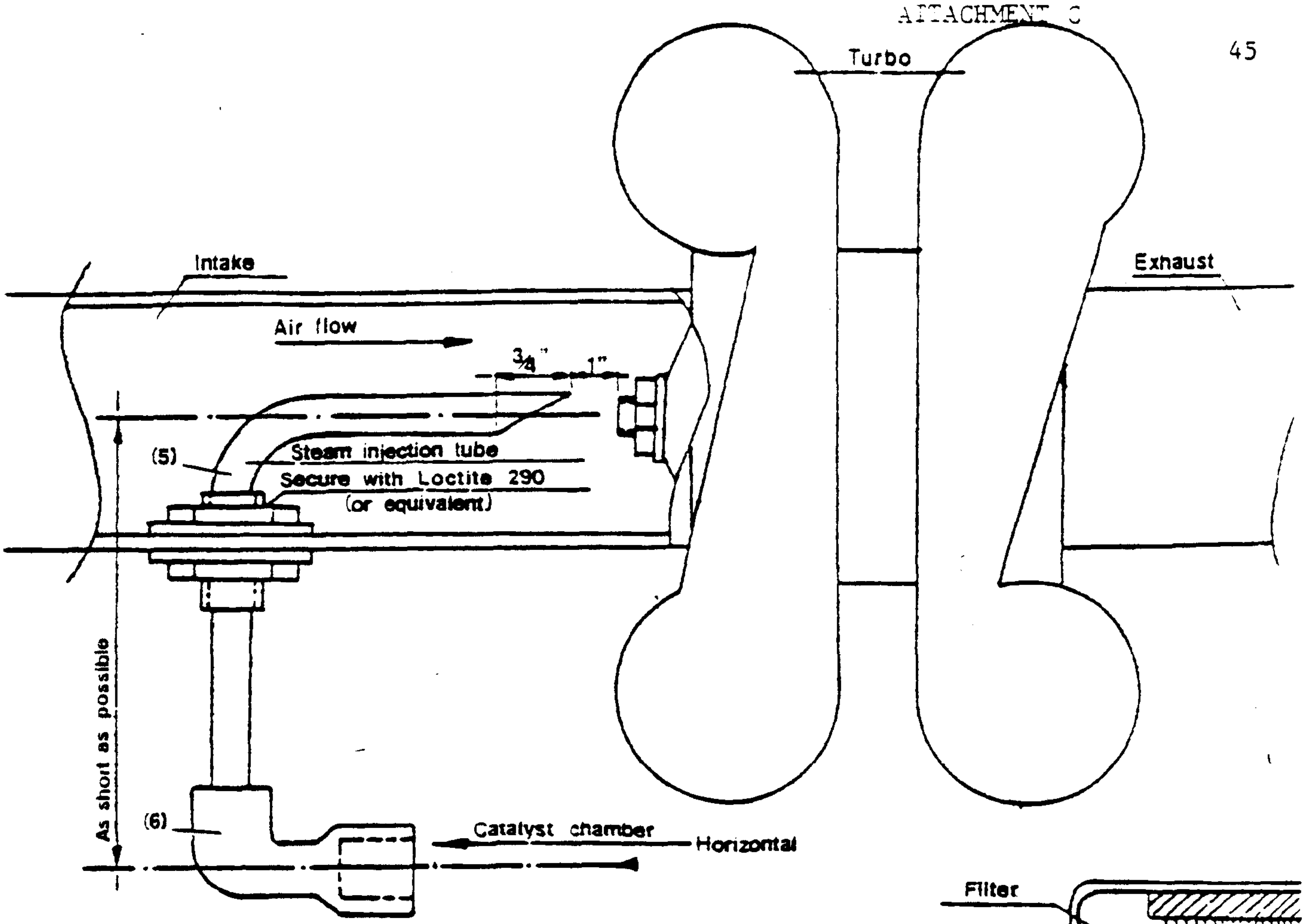
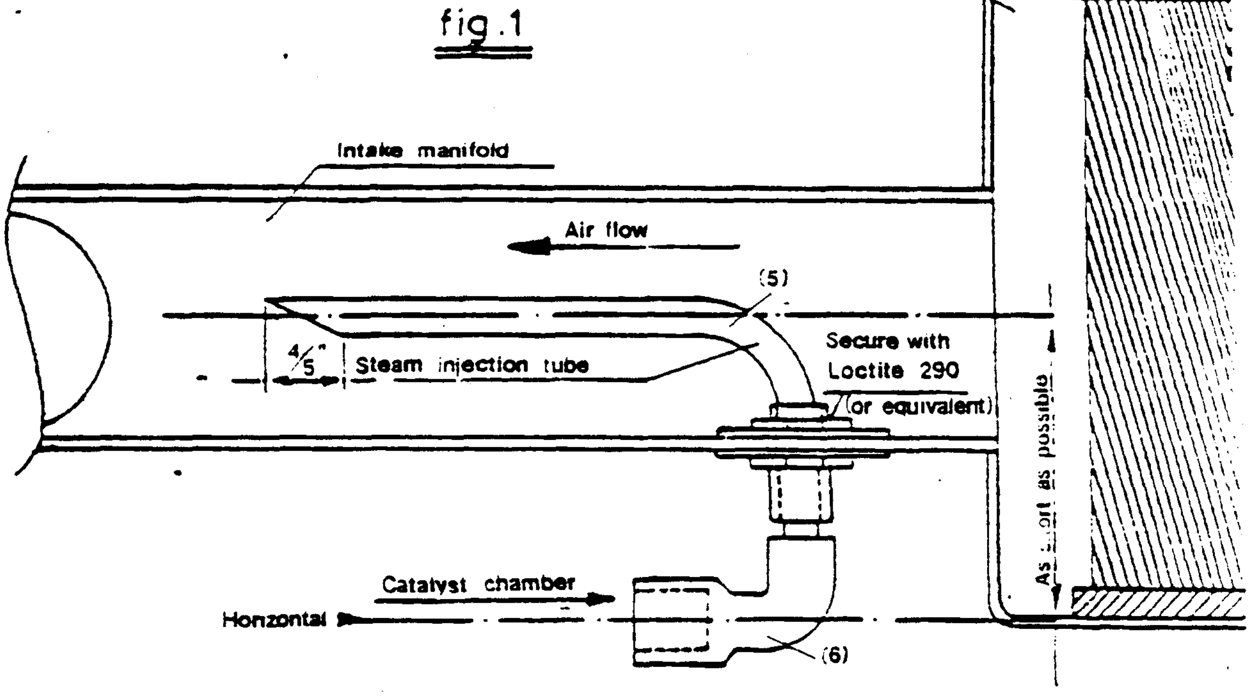


fig.1



TOP VIEW

fig.2

KOZA-PRODUCTION. B.V. SITTARD

P.S.C.U.-01

INSTALLATION INSTRUCTIONS

STEAM INJECTION TUBE

GETEK ING.V.BRAKEL

D.D 14-09-1982

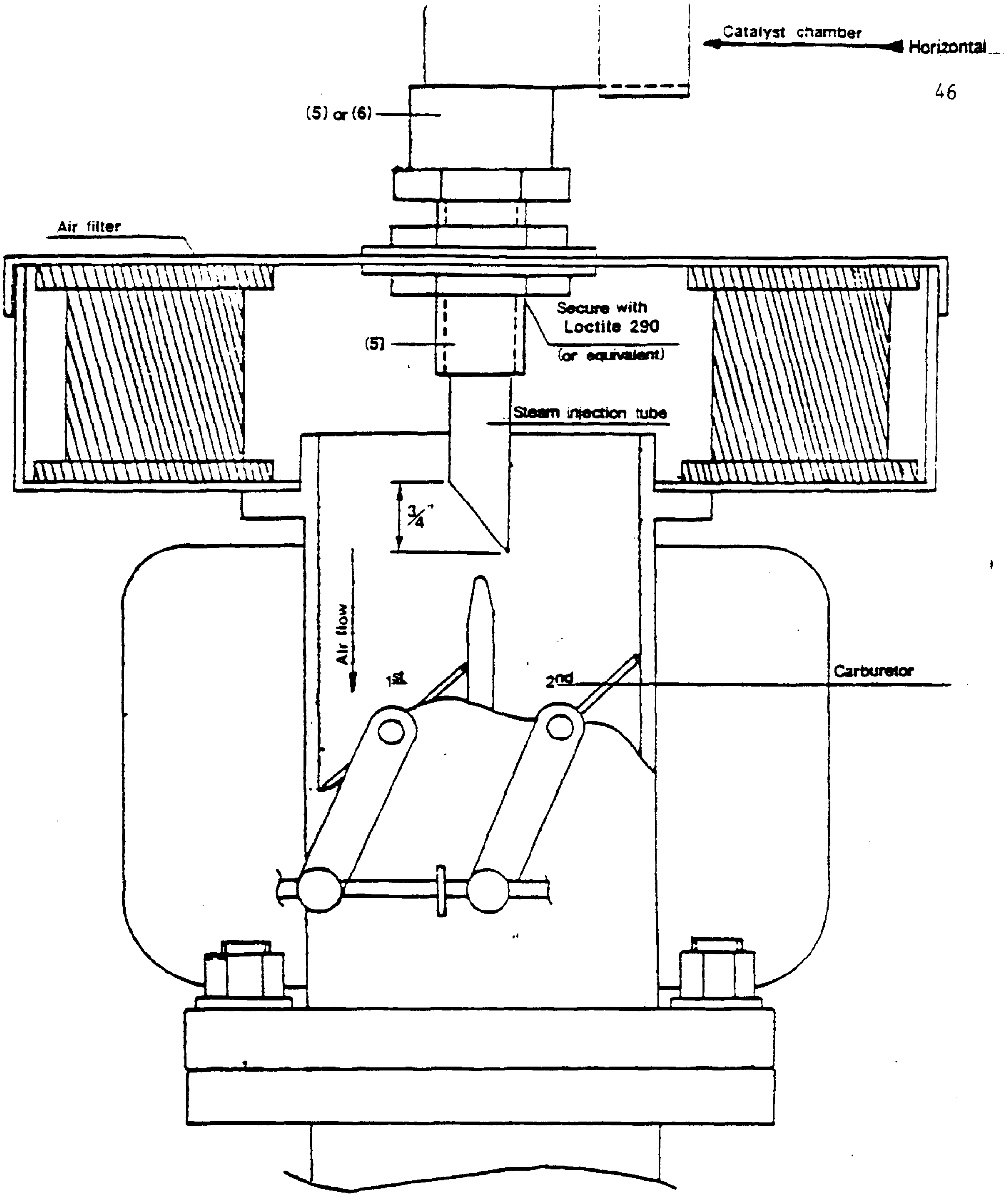


fig.3

KOZA-PRODUCTION.B.V. SITTARD
P.S.C.U.-01
2
GETEK
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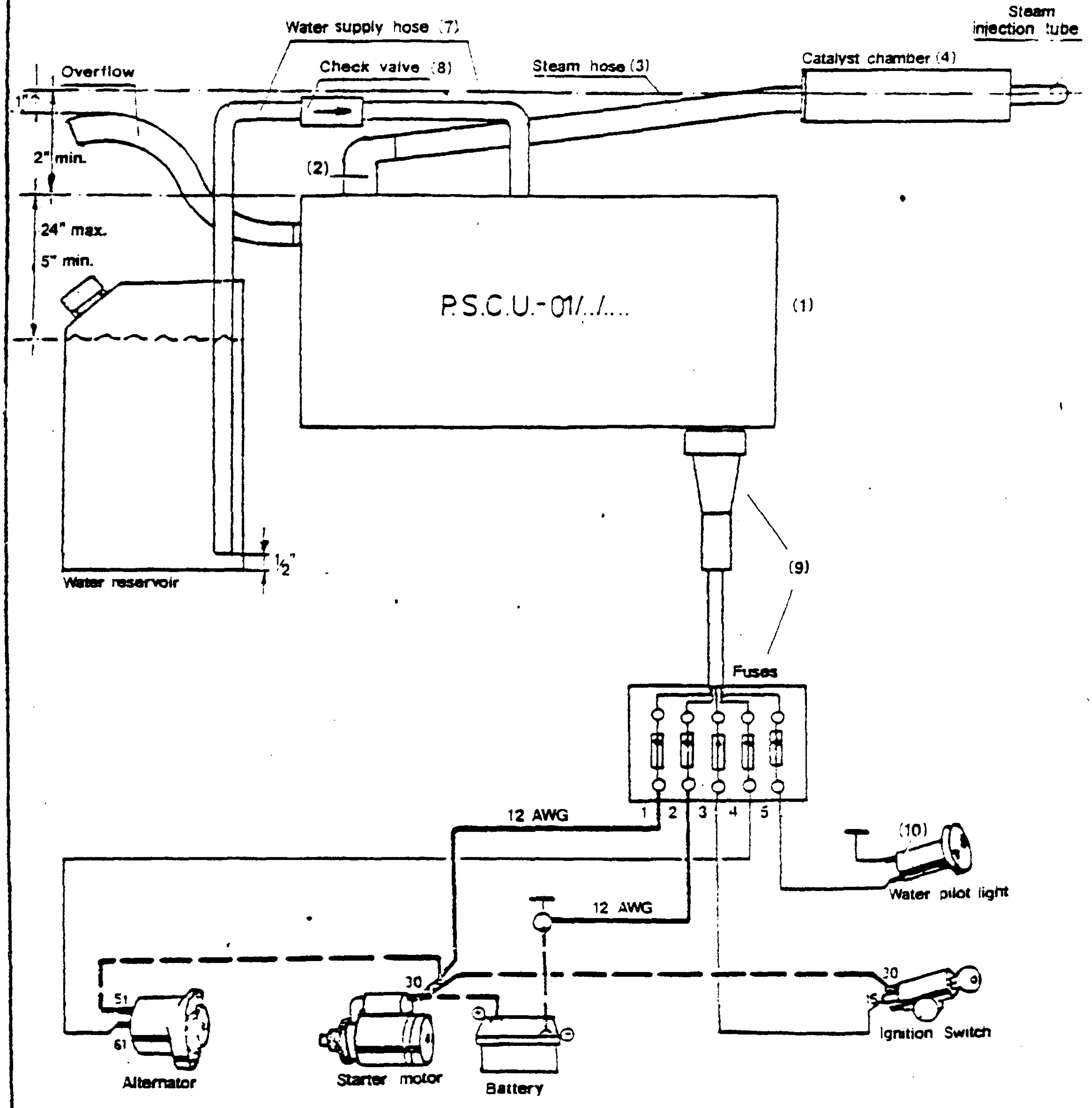
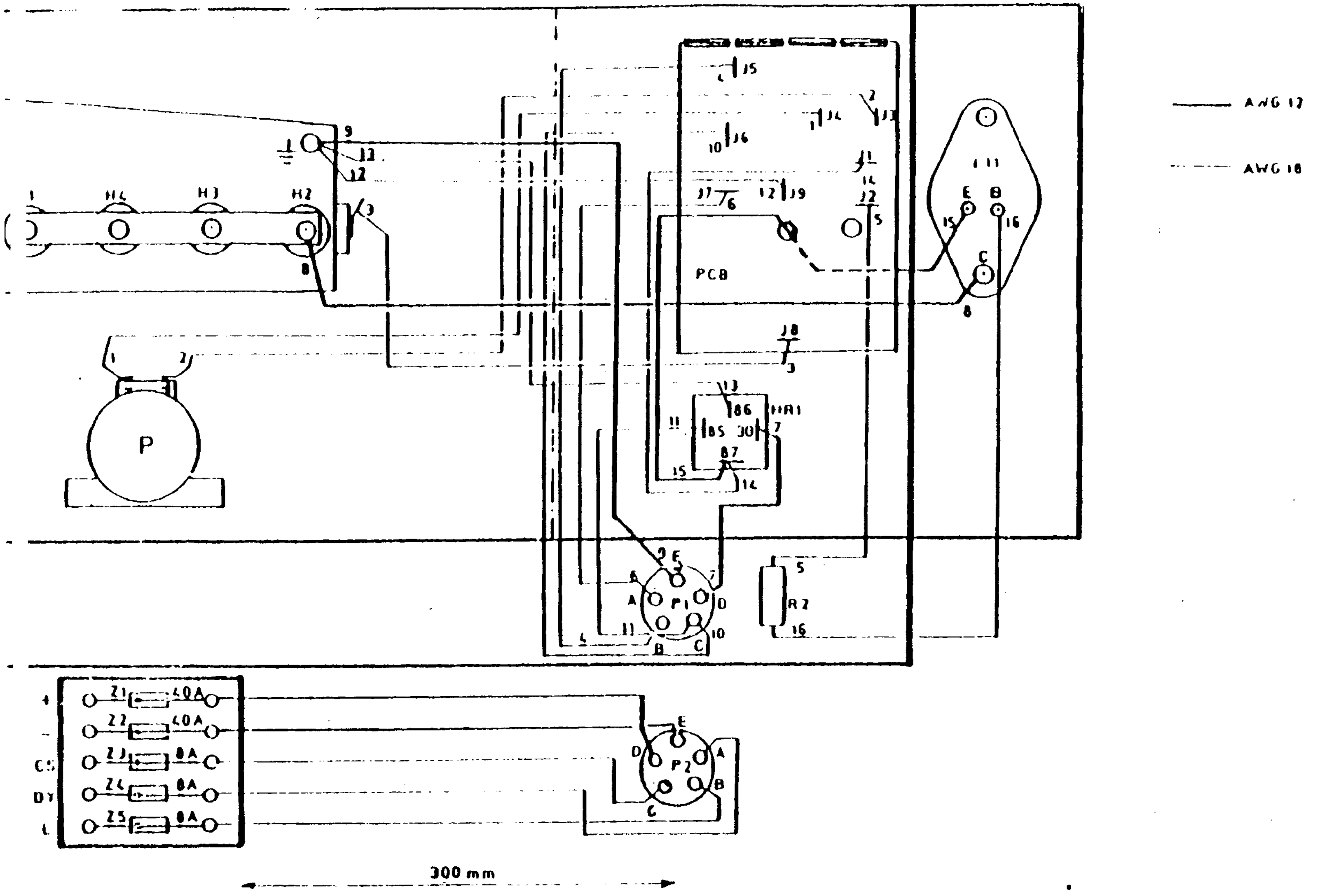
INSTALLATION INSTRUCTIONS



KOZA-PRODUCTION. B.V. SITTARD. | P.S.C.U.-01 | 3

GETEK. | ING.V.BRAKEL



KOZA-PRODUCTION.B.V. SITTARD

-P.S.C.U.-01

5

WIRING DIAGRAM

GETEK ING.V.BRAKEL

D.D. 30-08-108 2.

CONTR

INSTALLATION INSTRUCTIONS - P.S.C.U. 01/12/2

This package contains:

(1) P.S.C.U. 01/12/2
(2) 12 mm. Brass elbow joint with sleeve coupling and hose coupling
(3) 12 mm. Gray steam hose approx. 3 ft. long
(4) Brass catalyst chamber with 12 mm. sleeve coupling and hose coupling
(5) 12 mm. Injection tube with nuts and rings
(6) 12 mm. Brass elbow with sleeve coupling and internal thread
(7) 1/8" Silicone heat resistant water hose approx. 6' long
(8) 1/8" Plastic check valve
(9) Plug with attached fuse box
(10) Lampholder
(11) Lamp
(12) 5 solderless terminal connectors and tie wraps
(13) Mounting bracket with 2 bolts (8 mm), washers and lock washers
(14) 2 hose clamps
(15) 2 5/16" bolts, with washers, lockwashers and nuts
(16) Sheet metal screws 8 x 3/4"

Other materials needed:

- Various terminal connectors
- Electrical wire (12 AWG and 18 AWG)
- Insulation (flex tube insulation)
- Loctite 290 (or equivalent)
- Additional bracket material
- Water reservoir (minimum 1 gal.)

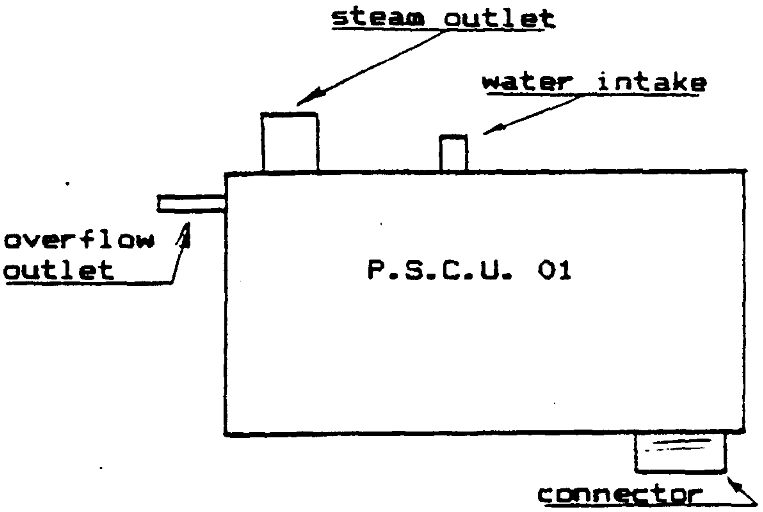
Tools Required for Installation:

- Basic tool set and electric drill
- 5/8" drill bit
- Crimping tool

EXHIBIT 4

READ THIS CAREFULLY BEFORE INSTALLATION

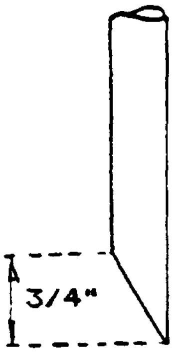
1. Find a suitable place, as close as possible to the air intake, where the P.S.C.U. 01 can be placed horizontally. Note that the steam outlet is at the top and the electrical connector is at the bottom of the unit.



2. Insert the steam injection tube (#5) in the air filter/air intake as shown in Figs. 1, 2 or 3 below:

   Fig. 1 - example of fitting to turbo charged engines.
   Fig. 2 - example of fitting to engines with fuel injection.
   Fig. 3 - example of fitting to engines with carburetor.

   Drill a 5/8" (16 mm) hole in the air filter/air intake as appropriate for your engine type. Saw off the end of the steam injection tube at an angle, as shown below:



Mount the steam injection tube in the air filter/air intake and secure with Loctite 290. It is preferable that the brass bend be used. If space is limited the brass bend should be cut off and the brass elbow used instead. The brass elbow should also be used when the bend is needed inside the air intake.

3. Connect catalyst chamber (#4) to steam injection tube with sleeve coupling.

4. Before mounting the P.S.C.U. 01, note the level difference between the catalyst chamber and the top of the unit, as shown in the "General Installation" drawing. Mount the P.S.C.U. 01, preferably using the bracket provided. An additional bracket may have to be used. Use the 8 mm bolts and washers to fasten the unit to the bracket. To fasten the bracket to the body, use the 5/16" bolts.

5. Connect the catalyst chamber to the steam outlet using steam hose (#3) and brass elbow (#2). Use hose clamps to secure hose. Insulate steam hose, catalyst chamber and visible portion of steam injection tube with flex tube insulation.

6. Place water reservoir in such a way that the maximum water level is not higher than 5" below the top of the P.S.C.U. 01 and the minimum level may not be lower than 24" from the top of the P.S.C.U. 01. (See General Installation drawing.) Place water supply hose (#7) approx. 1/2" above the bottom of the reservoir.

7. Place check valve (#8) close to the water intake of the unit, in the water supply hose (#7). The arrow on the check valve should point towards the P.S.C.U. 01. Cut off any excess and secure the water supply hose with tie-wraps.

8. Use the excess of the hose (#7) to connect to the overflow outlet of the P.S.C.U. 01 and position it in such a way that no part of the hose is less than 1" below the center line of the catalyst chamber.

9. Mount the water pilot light into the dashboard.

10. Before connecting the fuse box it is advisable to disconnect one of the cable terminals of the battery.

    Mount the fuse box (#9) in a suitable place and connect as follows:

    point 1 - with 12 AWG wire to point 30 of the starter motor or directly to the positive (+) terminal of the battery
    point 2 - with 12 AWG wire to the ground connection of the engine or directly to the negative (-) terminal of the battery
    point 3 - with 18 AWG wire to point 15 of the ignition switch, or to point 15 of the ignition coil (Series resistor cannot be connected. If in doubt, ask your dealer.)
    point 4 - with 18 AWG wire to point 61 of the alternator to ensure that the unit will only operate when the engine is running.
    point 5 - with 18 AWG wire to a connection point of the water pilot light. The other connection point of the light must be connected to a grounding point.

11. Put the lamp in the lampholder. Put the fuses in the fuse box as follows:

    point 1 and 2 - 40 amp. fuses
    point 3, 4 and 5 - 8 amp. fuses.

    Connect the cable terminal back to the battery. Prime the pump before use by forcing some water into the water intake and by filling the water supply hose. Fill the water reservoir, preferably with distilled water or soft, clean water.

The P.S.C.U. 01 is now ready for use. Read the operating instructions before use.

P.S.C.U. 01 OPERATING INSTRUCTIONS

The P.S.C.U. 01 consists of the following parts:

- Vaporizer
- Water supply pump
- Electrical control unit
- Catalyst chamber
- Steam injection tube

HOW THE P.S.C.U. 01 OPERATES:

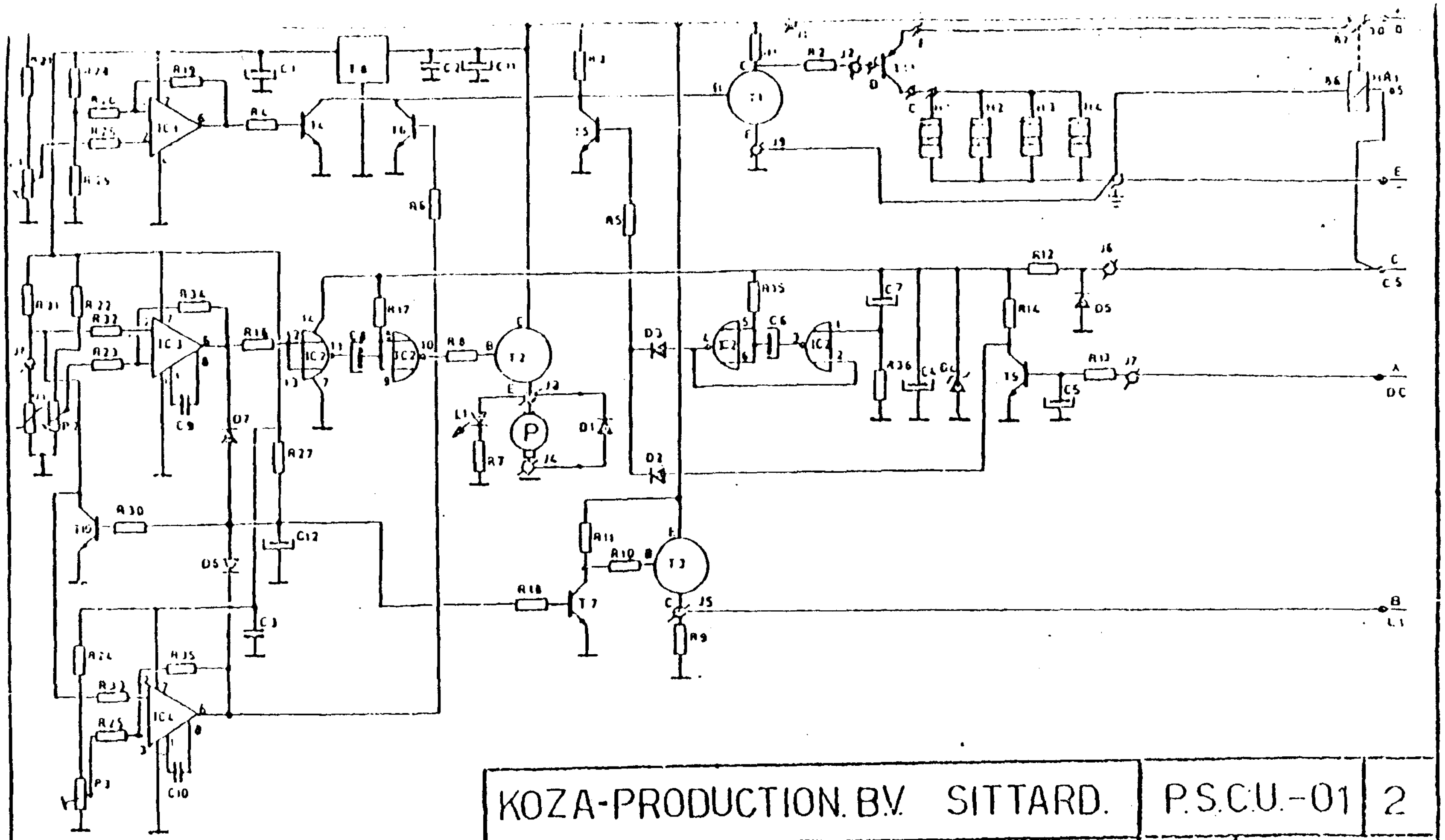
The unit will function when the ignition of the car is switched on and the engine is running. It will pump water from the reservoir to the vaporizer when needed. In the vaporizer steam is produced by means of electric heating elements. The vaporizer is connected to the air intake of the engine with a steam hose, the catalyst chamber and the steam injection tube.

When the engine is running there will be a partial vacuum in the air intake which will cause a partial vacuum in the evaporator via the steam injection tube, the catalyst chamber and the steam hose. The faster the engine runs, the larger the vacuum will be. The vacuum will cause more water to vaporize to steam. The steam will pick up a certain amount of catalyst while flowing through the catalyst chamber. Steam containing some catalyst will then enter into the engine. The catalyst will now regulate the combustion process in such a way that the engine will run more efficiently and less harmful exhaust gasses will be produced.

During the first period of operation of the P.S.C.U. 01 the catalyst performs a cleaning function in the engine. The beneficial effects of the unit will not be fully evident during this period. The duration of this cleaning process varies depending on the carbon build-up in the engine, averaging approximately 2,000 miles.

The electronic control unit will:

- check the water level in the vaporizer, and turn on the water supply pump when the level is too low. In the event no water is available the control unit will switch off the heating elements and turn on the red light.
- check the temperature in the vaporizer and switch off the heating elements when the temperature is too high.
- check the voltage of the car battery. The P.S.C.U. draws a relatively high current and there might be occasions when the available power is too low (e.g. when the battery is bad). The P.S.C.U. 01 will switch itself off when the battery voltage is below approximately 11.7 volts, so that enough charge will always be left to start the engine. After the battery is recharged to approximately 12.3 volts the unit will be switched on again.



KOZA-PRODUCTION. B.V. SITTARD.	P.S.C.U.-01	2
ELECTRICAL CIRCUIT	GETEK	ING V BRAKEL
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WHAT YOU MUST DO TO GET THE FULL BENEFIT FROM THE P.S.C.U. 01

- check the water level in the water reservoir regularly and refill when needed. The level must always be high enough so that the unit can operate until your next check-up. It is recommended that the reservoir be filled at each refueling.
- the catalyst chamber must be replaced every 30,000 miles.
- if you notice that no water is being used, check the fuses in the fusebox and replace if necessary. Check to see if the check valve is blocked. If both the fuses and the valve are in good shape consult your dealer.
- if reservoir has been allowed to run dry (red lamp is lit) the water supply hose must be filled to ensure that the pump will prime.

ATTACHMENT F

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

November 26, 1982

OFFICE OF
AIR, NOISE AND RADIATION

Mr. Johannes P.M. Zwaans, President
Dutch Pacific, Incorporated
218 Main Street, Suite E
Huntington Beach, CA 92648

Dear Mr. Zwaans:

We have performed a preliminary review of your November 9, 1982 application for an EPA evaluation of the P.S.C.U.-01 retrofit device. Based upon our preliminary review, we have noted the following concerns:

1. The installation instructions provides a list of those components included in the package. Although the list includes a brass catalyst chamber (item 4), no mention is made of the catalyst itself. Is it also included or is it purchased separately?
2. How did you determine the 30,000 mile interval for replacement of the catalyst?
3. How will replacement catalysts be available and at what cost?

Enclosed is a set of test plans. As a minimum for your device, we recommend Test Plan C and Testing Sequence 4. We also recommend that you test two late model vehicles and that they be driven 2500 miles at each point where mileage accumulation is indicated. Although the operating instructions (Exhibit 5 of your application) state that 2000 miles are required, the 2500 miles were chosen because the test data (Graph 1 in Exhibit 2 of your application) indicates that optimum benefits are achieved after 2500 to 3000 miles. Other details with respect to testing, test vehicle selection, and test facilities were furnished to you previously. However, should you have any questions or require further information, please contact me. So that we may evaluate your device in a timely manner, I ask that the required information and test data be submitted by January 15.

Sincerely,

Merrill W. Korth
Device Evaluation Coordinator
Test and Evaluation Branch

Enclosure

ATTACHMENT G

DUTCH PACIFIC, INC.
218 Main Street, Suite E
Huntington Beach, California 92648
(714) 960-5456

December 13, 1982

Mr. Merrill W. Korth
Device Evaluation Coordinator
Emission Control Technology Division
United States Environmental Protection Agency
Motor Vehicle Emission Laboratory
2565 Plymouth Road
Ann Arbor, Michigan 48105

Dear Mr. Korth:

We have been advised that the manufacturer/producer of the P.S.C.U. 01 device has encountered serious financial problems in Holland and might be dissolving their corporation. We would therefore like to withdraw our application, previously submitted on November 9, 1982, until such time as the company recovers financially or finds another manufacturer/producer to undertake production.

We appreciate your prompt response to our application and request that you put it in abeyance until we notify you that the above problems have been resolved.

Very truly yours,

Johannes P.M. Zwaans
President