The 1903-1911 Selden patent case [1]

The 1906 Arthur C. KREBS Testimony

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U.S.Circuit Court, Southern District of New York
Equity Case 8616: Electric Vehicle Co. & George B. Selden vs S.A. des Anciens Établissements Panhard & Levassor and André Massenat
Arthur Constantin Krebs Testimony

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Summary

Annotations are mainly referring to the following documents:

- **Judge Hough** Selden decision, from THE HORSELESS AGE, September 22, **1909**, p. 327.
- **Judge Noyes** Selden appeal decision, from the FEDERAL REPORTER, March-April, **1911**.
- **1924** - A. C. Krebs autobiographic letter (Krebs archives).
- **Greenleaf William**, *Monopoly on wheels. Henry Ford and the Selden automobile patent*, Wayne state university press, Detroit, **1961**, 302 p.; ISBN 0-7581-0626-2
- **Bishop Charles W.**, *La France et l'automobile, contribution française au développement économique et technique de l'automobilisme des origines à la Deuxième Guerre mondiale*, Génin, Paris, **1971**, 447 p. This American historian begins analyzing the Krebs testimony on p.163.

[1] **1961**, **Greenleaf**, p.275:" *The Selden patent case consisted of five separate suits in equity commenced in **1903** and **1904** by the Electric Vehicle Company as principal complainant and continued in and after **1909** by its corporate successor, the Columbia Motor Car Company. Of the five actions, three were informally designed "**Ford suits**", and the remaining two as "**Panhard suits**." The issues and proceedings in each suit were essentially the same. **To a considerable degree, the testimony in the Panhard group was directly stipulated from the Ford cases**. At the hearing on appeal, all of the cases were argued from a single printed record*.".

A. C. Krebs.
Oct. 31, 1906.

CIRCUIT COURT OF THE UNITED STATES[2]
SOUTHERN DISTRICT OF NEW YORK.

ELECTRIC VEHICLE COMPANY and GEORGE B. SELDEN[3],	Complainants.
against	
SOCIETE ANONYME DES ANCIENS ETAB-LISSEMSNTS PANHARD ET LEVASSOR and ANDRE MASSENAT,	Defendants.

Proofs for final hearing on behalf of the defendants in the above entitled cause taken de bene esse[4] pursuant to due notice before John A. Shields, Esquire, a Standing Examiner, at the office of Coudert Brothers[5], No. 71 Broadway, New York City, beginning on the 31st day of October, 1906,[6] at 11 o'clock in the forenoon.

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[2] **1961**, **Greenleaf**, p.131: "*The judiciary act of **1793** provided for a single court of appeals in all cases, but when the volume of business that came before the Supreme Court dictated the need for relieving the pressures on the high bench, the act of **1891** created the circuit courts of appeals. These intermediary tribunals brought relief and general satisfaction except in patent causes*."

[3] George Baldwin Selden (1846-1922). **1961**, **Greenleaf**, p.132: "*Some of this testimony, as well as many of the numerous exhibits, made the Selden case record an invaluable source for the history of the internal combustion engine and the automobile. The massive record holds a wide range and variety of materials, such as patent publications, motor car catalogues, advertisements, newspaper and magazine articles, agreements and contacts, account books, journals, charts, diagrams, drawings, and photographs. Together with the briefs and printed oral arguments, the entire record contains more than 14,000 pages and 5,000,000 words. A large part of it is dull and prolix except for the specialist with a consuming interest in **the mechanical details** of **early motor cars**. Imbedded in this stream of verbiage, however, are portions of testimony and evidence which for the automotive historian are **matchless both for their intrinsic value and their availability in a consolidated source***."

[4] "De bene esse".

[5] **1961**, **Greenleaf**, p.128: "*In a patent suit undertaken before **1913**, the method of taking testimony abetted delay and the piling up of mountainous legal records. The proceedings were not held in open court. Witnesses were interrogated before a standing examiner of the court or a notary public in law offices, hotels, or other places.* […] *There was no effective way of excluding irrelevant matter. The standing examiner, whose duties were nominal and non-discretionary, was powerless to control or limit the line of inquiry. He merely maintained order during the taking of testimony and supervised the transcription of the stenographic record. From three to five years were ordinarily required for collecting depositions and evidence.*" **1961**, **Greenleaf**, p.132: "*In the Ford cases, forty-two witnesses were called for the complainants and forty for the defendants. In the two Panhard suits, eleven witnesses were called for the complainants and thirty-nine for the defendants*."

[6] **A. C. Krebs letters to his wife**: "*Paquebot "La Provence", le 24 octobre **1906**. Ton* [fils] *Louis a fait connaissance complète avec Melle Yvonne Davignon qui est une petite blonde gaie et réjouie. Il faut te dire que dès samedi, Louis et moi, nous avions fait connaissance avec des américains, Mr et Mme Montant, riches américains auxquels m'avait recommandé Mr Cachard de la Maison Coudert notre avocat à New-York dans l'affaire Selden. J'ai trouvé en Mr et Mme Montant des gens charmants, Mr une 60aine d'années et Mme une 50aine environ. Ils viennent tous les ans en France où ils passent 4 à 5 mois ; possèdent une voiture automobile de chez nous avec laquelle ils ont déjà fait plus de 25000 kilomètres sans pannes.* [...] *New-York, le 30 octobre **1906** : Sur les conseils de Mr Montant nous sommes descendus à l'hôtel Manhattan (42° rue) un peu plus haut dans la ville que l'hôtel Waldorf. Il est moins grand mais aussi moins caravansérail. Nos chambres, qui communiquent, sont au 12° étage avec vue sur tout New-York. De nos fenêtres nous voyons à gauche East-River avec les deux grands ponts suspendus ; puis les grands Buildings jusqu'au sud de New-York et à droite l'Hudson. Le matin la vue est admirable comme étendue.*

Appearances:

Messrs. BETTS, SHEFFIELD & BETTS[7],

by S. R. Betts[8], for Complainants,

Messrs. Coudert Brothers[9],

by John P. Murray, for Defendants.

Thereupon Arthur Constantin Krebs, of the City of Paris, being first duly sworn by the Examiner in behalf of the Defendants to testify to the truth, the whole truth and nothing but the truth did testify as follows:

DIRECT EXAMINATION BY MR. MURRAY:

Q1. Please state what is your name, age, residence and occupation?

A. Arthur Constantin[10] Krebs; 55 years old[11]; residence Paris, 19 Ave. d'Ivry[12]; Directeur of the Societe Anonyme des Anciens Etablissements Panhard et Levassor.[13]

Q2. State what has been your mechanical experience; what led you to studies, and what education have you received on this subject?

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*Samedi la journée a été consacrée à notre agence et à voir la Maison Coudert ; ces deux points sont l'un dans le bas de Broadway l'autre près de Central Park à environ 10 kilomètres l'un de l'autre. Mais avec le subway qui a des trains express (c'est un métropolitain à 4 voies) la distance est franchie en 15 minutes. Les moyens de communication sont vraiment ici merveilleux ; tramways, chemin de fer en-dessus, chemin de fer en-dessous fonctionnent simultanément dans la même avenue à des vitesses vertigineuses mais avec un bruit à vous rendre cent fois sourd. La circulation des piétons et des voitures est très intense et je trouve que depuis mon voyage de **1895** la différence est beaucoup plus grande que celle éprouvée pendant la même période de temps de **1885** à **1895**. Les immenses constructions se sont développées aussi d'une telle façon que l'aspect des rues et surtout des avenues est complètement changé. À l'arrivée on trouve cela atroce ; puis on s'y fait et maintenant ça ne me paraît plus extraordinaire. Hier et aujourd'hui j'ai été occupé toute la journée par **l'affaire Selden** qui en est à la période des expertises. Nous avons parmi nos experts Mr Smith que Charles [de Fréminville] connaît et que nous avions vus à Detroit en **1885**. C'est un homme très aimable et parlant français.*" (Underlined by us).

[7] **1961**, **Greenleaf**, p.133: "*Among the counsel in the case were some of the most distinguished members of the American patent bar. The Electric Vehicle Company was represented by the New York law firms of Betts, Betts, Sheffield & Betts, and Redding, Greeley & Austin. The major part of the case for the complainants was handled by Samuel R. Betts and William A. Redding, the latter a veteran of many years of bicycle patent litigation for the Pope interests.*"

[8] **1961**, **Greenleaf**, p.138: "*Under cross-examination by Samuel R. Betts, Ford freely acknowledged his borrowings from the automotive art. He cheerfully admitted that his experimental engines had been patterned after the Otto gasoline engine. This was in keeping with the defense argument that the automobile had been evolved through a rearrangement of well-known mechanical elements, and that it was open to any experimenter to substitute an improved power plant for an inferior one in a familiar combination.*"

[9] **1961**, **Greenleaf**, p.133: "*The Panhard and Neubauer interests retained the New York law firm of Coudert Brothers. While the interrogation of witnesses in the Panhard suits was handled by John P. Murray, a handsome young attorney on the Coudert staff, the member of the firm who was destined to play an important role in the case was Frederic R. Coudert. He was not a patent attorney. Descended from a French grandfather who had settled in the United States in **1823**, Coudert had a fluent command of the French language. His mastery of that tongue, and his excellent relations with Panhard & Levassor, were to serve in good stead all of the opponents of the Selden patent.*" **1961**, **Greenleaf**, p.134: "*Parker* [the Ford counsel] *worked in close concert with the Panhard lawyers. He often visited the Coudert offices on Rector Street and maintained a correspondence with Murray.*"

[10] Arthur C. Krebs gets his second first name – "Constantin" – from his grandfather who stayed two years at the service of the Grand Duc Constantin, brother of the Russian Tzar in St Petersburg, as preceptor of his daughter.

[11] Arthur C. Krebs is born the November 16, of **1850**, in Vesoul (France). He will be 56 during this stay in New York.

[12] Arthur C. Krebs lives, with his family, in the Panhard & Levassor factory, in the house formerly occupied by Émile Levassor.

[13] The contract between the newly constituted Panhard & Levassor Company and Arthur C. Krebs is dated **1897**-08-01, at the time of the creation of the company after the death of Levassor.

Objected to[14], in so far as it calls for testimony by witness of work done in foreign countries, as incompetent, irrelevant and immaterial, such work being no defense to this suit on the Selden patent, and evidence of such work being incompetent to invalidate the patent in suit or to affect or limit its scope.

A.[15] In 1870 I entered the army as an officer[16]. In 1877 I was assigned to the engineer corps at the aeronautic station[17] where I studied for six years the construction of dirigible balloons. During that period I studied and worked on internal combustion engines.[18] It seemed to me this type of motor might afford a solution of the question of the dirigible balloon. Thereafter I occupied myself trying to propel vehicles by means of motors.[19] It is thus that about 1884 I followed with great interest the construction of the small petrol motors of Monsieur Daimler[20]. In 1889 in the shop of Panhard-Levassor was made the first application of this Daimler engine to a vehicle. This firm had also made gas engines of the Otto type and Benz type[21] which they abandoned to give their entire attention to the Daimler motor. Impressed with the satisfactory operation of this small engine, in 1894 I worked at and built a carriage with [electro-magnetic …] clutches.[22] This vehicle pleased Monsieur Levassor very much and I reached an understanding with him to establish their manufacture in the shops Panhard and Levassor.[23] Upon the death of Mr. Levassor in 1897 I

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[14] **1909**, **Judge Hough**: "*In many parts of the record, there are not 5 consecutive pages of testimony to be found without encountering objections stated at outrageous length, which may serve to annoy and disconcert the witness, but are not of enough vitality to merit discussion in 2,000 pages of briefs*."

[15] Arthur C. Krebs testifies in French "*before the stenographer*". It is said below XQ172: "*Complainants' counsel calls attention to the fact that this witness is being examined and cross-examined in the French language involving the translating of all questions and answers from English into French and back into English in order to make a record*." Krebs answers are probably translated in live after being taken down in shorthand by stenography.

[16] Arthur C. Krebs entered the French Army during the **1870-1871** Franco-Prussian war, as Sub-Lieutenant by regard of his admissibility to the military St-Cyr special school.

[17] Arthur C. Krebs refers here to the Chalais-Meudon aerostatic park which was managed by the captain Charles Renard (1847-1905).

[18] This mention is the only one we get from our sources regarding Krebs petrol engines experiments during his aerostatic period. We will see below that **1878** is the date when Krebs buys "a two horse power Otto four cycle engine" for his sewing shop at the Périn-Panhard workshops in Paris, and probably inspired him for the hydrogen motor he says below he studied in **1882**. **1884** is the date when Krebs is interested in the Daimler motor. **1894** is the date when Krebs built a carriage using a Daimler engine, he bought at the Panhard-Levassor workshops. He patented this car in **1896**.

[19] A. C. Krebs refers here to fire engines vehicles. He started to design vehicles adapted to speed with fire vehicles. He designed an electric fire engine (See below).

[20] Gottlieb Daimler (1834-1900).

[21] **1886** - La Nature: Moteur à gaz système Benz.

[22] The result of this work is the **1896** Krebs automobile patent: FR256344, GB189619774A.

[23] **Panhard archives** owns the license letter taken by Levassor on the Krebs patent, dated September the 3rd, **1896**: "*3 Septembre 1896. Monsieur Krebs, 9, Boulevard du Palais, Paris. En suite de votre visite de ce jour, et M. Levassor devant partir en voyage samedi matin, nous nous empressons de vous relater ci-après les conditions arrêtées : Vous nous donnez le droit exclusif de construction, en France et en Belgique, du dispositif de transmission de mouvement avec intermédiaire par roues folles et cliquet, comme il est décrit dans votre*

resigned my commission as Major[24] and thereupon became connected with the new company Panhard & Levassor as technical director.[25] From then I have continuously followed and directed the construction of engines and petrol vehicles. It was from that time on that the methods of ignition for motors underwent great modifications. The electric ignition system, which until then had been abandoned as not giving complete reliability, was taken up again when the new small secondary battery afforded means of producing electricity under better conditions[26]. Prior to that direct flame ignition had been preferred[27],

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brevet, et aussi ce qui est relatif à la direction [i.e. the caster angle]. *Nous vous paierions par chaque application de votre système les primes suivantes : Pour voitures avec moteur de 2 chx, frs. 100 ; 4chx, frs 150 ; 6 chx, frs. 200 ; 8 chx, frs 225 ; 10 chx, et au-dessus, frs. 250. Le compte de primes serait arrêté tous les 6 mois. Si, pour la troisième année et les suivantes, la somme par nous payée annuellement n'arrivait pas à 5.000 frs, nous vous reconnaîtrions le droit d'agir au mieux ce vos intérêts. Vous auriez à nous fournir les dessins de construction de la partie mécanique de la voiture que vous avez construite et des diverses particularités électriques ; vous nous donneriez en outre toutes les indications nécessaires que l'expérience de la première voiture a déjà pu vous indiquer. Vous nous autoriseriez gracieusement à employer votre système de moyeux de roues* [the Krebs metallic wheel hub, belongs to the "artillery wheel" type] *pour lequel, puisque vous dites qu'il est très bon, il pourrait être intéressant de prendre un brevet. Pensant avoir bien relaté ce qui a été dit, et espérant vous lire favorablement par prochain courrier, nous vous prions d'agréer, Monsieur, l'assurance de notre parfaite considération.* [Signed:] *Panhard-Levassor. P-S. Nous avons ajouté la Belgique parce que nous exploitons le brevet du moteur Daimler en Belgique*." **Levassor's letter to his patent agent in Belgium**: "*7 Septembre **1896**. Monsieur Biebuyck Ingr, 52 Rue de Spa, Bruxelles. J'ai l'avantage de vous adresser ci-joint : 1° Le mémoire descriptif d'un brevet de voiture automobile pris en France par M. A. Krebs le 13 mai 96 sous le n° 256344. 2° Le dessin de la voiture à l'échelle de 1/10. Veuillez faire le nécessaire pour prendre au plus tôt le brevet belge, préparez les descriptions et les dessins et envoyez-moi le pouvoir pour que je fasse signer par M. Krebs. Je tiendrai à ce que le tout soit déposé mercredi prochain. Vous m'enverrez également la note de frais et vous noterez le paiement des annuités comme vous le faites déjà avec les brevets Daimler. Agréez, Monsieur, mes sincères salutations.* [Signed:] *Émile Levassor*." **Levassor's letter to Gottlieb Daimler**: "*2 Décembre **1896**. Mon cher Monsieur Daimler. Je possède votre lettre du 30 Novembre. C'est une faute de n'avoir pas pris un brevet en Belgique pour le carburateur, mais comme dans ce pays on peut prendre des brevets d'importation, il est urgent de le faire de suite sans vous occuper de ce que peut en penser Mr Biébuyck, le prix du reste étant très faible. Si vous ne voulez vous charger de l'affaire, veuillez m'envoyer les pièces ; je ferai le nécessaire et je vous enverrai un pouvoir pour que Mr Maybach veuille bien le signer. Je vous remercie beaucoup de l'intérêt que vous prenez à ma santé : je vais maintenant tout à fait bien* [ie. After his accident in October during the Paris-Marseille race]. *Et au sujet de **la voiture avec changement de vitesses électriques**, une voiture a déjà été faite avec un moteur Daimler à cylindres obliques de 3 chx. Nous construisons actuellement un coupé et une victoria avec ce système et moteur à cylindres parallèles de 4 chx ; j'espère que tout ira bien. Mais ce n'est qu'après l'essai de ces voitures que je pourrai vous donner mon opinion motivée ; il faudra donc attendre, mais je suis à peu près certain d'avoir un bon résultat et j'ai tout lieu de croire qu'il y a dans ce mode de changement de vitesses, surtout pour des voitures devant circuler dans les grandes villes : comme les fiacres par exemple, une très grande facilité et très grande simplicité de manœuvre. La question doit donc vous préoccuper et si vous avez occasion de venir prochainement à Paris je vous conduirai dans la voiture qui fonctionne déjà. Vous jugerez et vous verrez quelle suite vous voulez donner à cette affaire. Quant aux brevets, ils ont été pris en France, en Angleterre* [by Krebs] *et en Belgique* [by Levassor]. *J'apprends avec peine la mort de Mr Steinway, j'espère qu'elle n'arrêtera pas le développement de la Daimler Motor Company en Amérique. Dans l'attente de vos bonnes nouvelles, Veuillez agréer, Cher Monsieur, mes cordiales salutations. Émile Levassor*." **Levassor's letter to Gottlieb Daimler**: "*22 Décembre **1896**. Mon cher Monsieur Daimler. Je possède votre lettre du 19 courant et vous accuse réception du titre du brevet français du carburateur* [Maybach]. *Je vais envoyer les pièces à Mr Biebuyck pour qu'il fasse le nécessaire en Belgique. Vous trouverez ci-joint la réponse à la Daimler Motoren Geselschaft. Nous avons ici à Paris une Exposition de vélocipèdes dans laquelle il y a aussi des voitures automobiles ; nous y faisons quelques affaires. Pour **la voiture avec changements de vitesses électrique**, je vous assure que c'est une chose à examiner et il est fâcheux qu'à votre dernier voyage vous n'ayez pu avoir le temps nécessaire pour cet examen. Nous pensons que vous pourriez traiter avec l'inventeur en donnant une somme fixe et en payant une Royalty par voiture. C'est ainsi que nous avons traité. J'espère que vous trouverez une occasion de venir à Paris pour établir votre jugement et **en voyant cette seule voiture vous pouvez être certain que vous en verrez beaucoup plus que ce que vous avez pu voir en Angleterre dans vos différents voyages**. Veuillez agréer, Mon cher Monsieur, mes bien cordiales salutations*."

[24] Arthur C. Krebs was Major-engineer in the Paris (military) fire department.

[25] Beginning as "Technical director", A. C. Krebs became officially "General manager" in **1903**.

[26] **1902** - Krebs patent US708053A: "APPARATUS FOR DISTRIBUTING THE PRIMARY CURRENT FOR ELECTRIC IGNITION BY COILS AND IGNITERS IN EXPLOSIVE-ENGINES".

[27] **1891**-08-21: Levassor patent **FR215695** for his improved hot-tube ignition system designed with Pr Arsène d'Arsonval.

although this did not permit high speed.[28] Then, with the incandescent tube ignition, Monsieur Daimler succeeded in getting 700 revolutions per minute with a view of applying then to automobile[29] vehicles.

Q4. What is your personal experience with carburetters[30]?

Objected to as immaterial and incompetent for the reason that it calls for testimony of use in a foreign country.

A. The first carburetter[31] in use was based on the principle of causing air to pass over surfaces saturated with petroleum distillate in order to produce the combustible gas by evaporation. This arrangement required a constant regulation owing to variable temperature of the air and the degree of volatilization of the fuel.[32] In order that the mixture be explosive, it is necessary that the relation between the weight of air and the weight of fuel be very nearly constant. To accomplish this pumps have been designed with the object of supplying the liquid fuel at the same proportion as the volume of air corresponding to the displacement by the piston in the cylinder.[33] The pump was next replaced by an orifice located in the air induction pipe in such a manner that air and liquid would flow in by orifices having a constant area under the same vacuum[34]. The uniformity of the power of internal combustion engines was regulated entirely by suppressing completely the suction, and therefore power strokes, when the speed exceeded the predetermined limit[35]. In that way one effected regulation by the system called "hit or miss."[36] This

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[28] **1909**, **Judge Hough**: "*Both flame and electric ignition had been used and were well known to gas engineers of the day, although in 1879 it seems to me that the flame method was by far more successful than the electric as applied to compression machines."* **1911**, **Judge Noyes**: *"Electric ignition was considered impracticable. But when the electric art had developed it was seen that the electric ignition could be made superior to flame ignition and it would permit much higher speed. But the change was not indicated by the Selden patent, which refers only to flame ignition*."

[29] **1971**, **Bishop**, p.7:" The *word "automobile" is a French word*."

[30] Sic.

[31] Before the era of petrol engines, the "carburetor" was a device intended to produce gas for various uses.

[32] **1971**, **Bishop**, p.236: "*Winton semblait être affligé d'ennuis de carburation dès qu'il quittait les États-Unis; il est tout à fait possible qu'il lui ait été alors impossible d'obtenir le type exact d'essence que nécessitait son vieux modèle de carburateur à léchage, dont la sensibilité inhérente au degré de volatilité du carburant est bien connue. (Par exemple, il était nécessaire de vider le carburateur si le moteur n'avait pas fonctionné pendant plus de quelques heures : comme la contenance était de quatre litres, on imagine le coût de l'opération !). "*

[33] **1911**, **Judge Noyes**: *"With respect to the second type, the constant pressure compression engine, Mr. Clerk says (page 31): "In it the engine is provided with two cylinders of unequal capacity. The smaller serves as a pump for receiving the charge and compressing it; the larger is the motor cylinder, in which the charge is expended during ignition and subsequent to it. The pump piston, in moving forward, takes in the charge at atmospheric pressure; in returning compresses it into an intermediate receiver, from which it passes into the motor cylinder in a compressed state. A contrivance similar to the wire gauze in a Davy lamp commands the passage between the receiver and the cylinder, and permits the mixture to be ignited on the cylinder side as it flows in without the flame passing back into the receiver."* "

[34] The "Maybach carburetor" belongs to this type.

[35] This mode of regulation is said "regulation on the exhaust" and is operated via a "Centrifugal governor".

[36] "Hit or miss" is the English translation for the French: "Tout ou rien".

method of control necessitated the inconvenience of a large fly-wheel in order to maintain uniform speed. In a vehicle the engine should be as light as possible. It was therefore desirable to reduce the weight of fly-wheel in proportion to the power strokes[37] and the work to be performed.[38] That is to say to reduce the volume of mixture introduced in order to obtain less powerful strokes.[39] It is in view of this that I have made a study of the theory[40] upon

[37] "Power stroke" seems to be the English translation for the Krebs expression: "coup moteur".

[38] Reduction of motor weight is an aerostatic affair, which was outlined by Santos-Dumont who used an automobile petrol engine for his **1901** events. On that issue A. C. Krebs is much experienced and concerned. **La Justice**, **1901**-08-07, 4pp, p3: **« *Les Ballons dirigeables* - *M. Santos-Dumont* -** *Le mauvais temps a encore empêché hier matin M. Santos-Dumont de tenter l'expérience du prix Deutsch. À six heures, le jeune aéronaute a sorti son ballon du hangar et, dans le parc aérostatique, il a renouvelé ses essais à la corde. Malheureusement quelques gouttes de pluie sont venues interrompre les manœuvres et la tentative a été reportée à un autre jour.* **- *Le commandant Krebs* -** *Un de nos confrères annonce que le commandant Krebs, qui fut le collaborateur des frères Renard dans leurs premières recherches relatives à la direction des ballons, serait à la veille de produire "un moteur extra-léger destiné aux organes spéciaux de la navigation aérienne". Le commandant Krebs qui, depuis plusieurs années, est rentré dans la vie civile, appartient en qualité d'ingénieur à un établissement de constructions mécaniques. Il est, en ce moment, et pour plusieurs semaines, absent de Paris, mais l'un de ses collaborateurs a fait à l'un de nos confrères les déclarations suivantes : "M. Krebs a complètement cessé de s'occuper de navigation aérienne. Il a, comme tout le monde, suivi les expériences de M. Santos-Dumont, mais, en ce qui le concerne, il s'est désintéressé de la question des ballons dirigeables. Ses recherches ne sont plus dirigées de ce côté. S'il a étudié la création d'un moteur extrêmement léger, ce n'est pas en vue de trouver la solution du problème de la direction des aérostats. Le moteur auquel votre confère fait allusion existe ; nous l'utilisons même déjà. Il est bien évident que les aéronautes pourront, s'ils le veulent, l'employer comme pourront l'employer les automobilistes. Le moteur dont s'est servi M. Santos-Dumont n'était pas autre chose qu'un moteur de voiture. On se tromperait donc si l'on croyait que le commandant Krebs qui, d'ailleurs, ne sera pas de retour à Paris avant le mois de septembre, a l'intention de se mêler aux discussions soulevées par les essais de M. Santos-Dumont et de prendre parti à la lutte ouverte entre différents aéronautes professionnels ou amateurs qui travaillent à découvrir la direction des ballons."* » **Note sur l'origine de la Société Anonyme des Anciens Établissements Panhard et Levassor** (Salon automobile **1902**-12, Panhard archives) : « *La Société Panhard et Levassor ne concevait l'application d'un moteur de grande puissance à une voiture de course qu'à la condition que ce moteur fut tout particulièrement léger, aussi a-t-elle été conduite la première à employer des cylindres en acier forgé avec enveloppe d'eau en laiton. Elle a ainsi obtenu des moteurs de 60 chevaux nominaux (70 CV effectifs), pesant seulement 4 kg par cheval effectif et des moteurs de 24 chevaux nominaux (30 CV effectifs), pesant seulement 5 kg par cheval effectif. Les moteurs de ce type qui ont eu un si brillant succès en **1902** entre Paris et Belfort étaient commandés à la Maison Holtzer, en ce qui concerne les cylindres, dès le 31 octobre **1901**. La construction de ces cylindres fait l'objet d'un brevet déposé le 23 octobre **1901**.* ".

[39] That conclusion adopted by Krebs is somewhat dared as the regulation on exhaust rather than admission will be still disputed in **1913** (Bishop p. 214). This conclusion constitutes the premises of the A. C. Krebs reasoning and states the beginning of his search for an automatic carburetor. He wishes reducing the volume of mixture admitted in order to reduce the weight of the fly wheel, the latter allowing a "uniform speed" of the engine. In fact, he succeeded in reducing the engine speed in maintaining constant the "power stroke" by insuring a "perfect mixture" at all engine speeds, and finally reducing the flywheel weight. Doing that, he allowed the engine varying progressively its speed and power from idle to its maximum possible. **Comptes-rendus du comité de direction Panhard & Levassor** [written by Charles de Fréminville, (Panhard archives)] : "**1913**-06-18 : […] *M. Krebs fait du reste remarquer que toutes les dispositions* [brevetées] *contenues dans les carburateurs relèvent des trois types suivants : Carburateur Maybach, réglé pour l'allure normale ; Carburateur automatique* [the Krebs' carburetor], *agissant sur l'entrée de l'air pour doser convenablement le mélange au ralenti ; Carburateur Baverey* [The Société du carburateur Zénith was created in **1909** to exploit François Baverey's patents concerning the compensator jet carburetor system.], *agissant sur le liquide. Enfin certaines dispositions ont fait usage de plusieurs carburateurs* [Krebs Double-barrel carburetor]. […]. **1919** - Motor truck and automobile motors and mechanism: "*In the early days of the 20th century, "Krebs", a French engineer, invented what may be termed "the first automatic carbureter" in which the mixture was regulated automatically by the speed of the engine ; "flexibility" being thus obtained to an extent hitherto undreamed of. This invention paved the way for, and inspired, a vast number of others of greater or less merit* [...] *The Krebs type can today be considered the simplest form of carbureter which operates satisfactorily" and there are several different models now manufactured based on the principle of the auxiliary air valve only. In these the problem is worked out in different ways.* [...] *While they all differ in the details of working out the design they are, nevertheless, based on the basic principle of the auxiliary air valve as originally worked out by Krebs*."

[40] Arthur C. Krebs exposes his theory of the "automatic carburetor" before the **French Academy des sciences** on the **1902**-11-24.

which I have constructed the automatic carburetter[41] which affords a means of supplying the motor with a perfect mixture.

Q5. Say when you saw the first time a self-propelled vehicle and what was your personal experience in connection with automobiles?[42]

Same objection as to Q4.

A. In 1867 I saw for the first time the automobile vehicle of Lotz[43]. Thereafter in 1878 the vehicle of Bollee.[44] Since then I have seen first steam vehicle in operation, and since 1891[45] vehicles of various types propelled by petrol. Since 1894[46] I have been occupied with construction of vehicles having explosion engines.

Q6. Will you please describe briefly the vehicle of Lotz of 1867, and the vehicle of Bollee of 1878?

Objected to as calling for incompetent testimony, the witness not having been qualified as one familiar with the so-called Lotz & Bollee vehicles, and as immaterial in that the alleged vehicles, if they existed, were propelled by steam and not by gas engines of any description, and for the further reason that the question calls for testimony of uses of alleged mechanisms in a foreign country, such testimony being incompetent in this suit.

A. The vehicle of Lotz consisted essentially of a steam generator carried on a forecarriage[47] with fifth wheel with a coupling (king bolt) pin and with a trailer consisting of an axle and two wheels, one of which wheels could be connected or disconnected from the axle in order to permit endless screw gearing with a sector connected by chains to the ends of the front axle. The

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[41] **1971**, **Bishop**, p.187: *"L'une des premières choses que fit Krebs, lorsqu'il succéda à Levassor, fut d'adopter un nouveau carburateur qui porta son nom pendant des années. Le carburateur Krebs jouit d'une très belle vogue dans les cercles automobiles, et l'on alla jusqu'à payer de fortes sommes pour le faire installer sur des machines qui ne le possédaient pas*."

[42] **1909**, **Judge Hough**: "*No one in the United States has passed, or even caught up with, Selden, while foreign efforts have been fairly and attractively told by Mr. Krebs, of the Panhard Company. He quite fully depicts the history of meritorious and successful efforts in road locomotion, apparently as ingenious as Selden's and more vigorously pursued*."

[43] The **1867** Lotz vehicle.

[44] These mentions are unique in our sources. In **1867**, A. C. Krebs is 17 years old, and lives with his parents in Besançon (France). He will detail below the Lotz vehicle. In **1868**, Krebs designs an amazing "Projet de voiture automobile", fitted with a very inclined wheel steering giving it a real sense of speed. In **1878**, Krebs belongs to the Chalais-Meudon aerostatic park. **1878** - Amédée Bollée senior's "La Mancelle" steam car.

[45] **1891** seems referring to an important event in the Krebs' memory, but he does not give it. Maybe it was the first Panhard & Levassor commercial vehicle appeared.

[46] **1894** refers to the first self-propelled vehicle race from Paris to Rouen. That event determined the Paris counsel to give to Arthur C. Krebs the funds necessary to experiment fire vehicles using petrol engines as motive power.

[47] Sic.

Bollee vehicle of 1878 was exhibited at the Champ de Mars in Paris,[48] to which place it had been propelled under its own power from Le Mans. One of the distinctive features of this vehicle consisted in the articulation of the front wheels which involved the individual pivoting of each wheel[49]. This is the same arrangement which we find today in the steering mechanism of practically every automobile vehicle.[50] The boiler was vertical[51] and the engine drove the rear wheels by means of chains.

Q7. If you know say what kind of an engine was used on the Lotz vehicle and if you saw it operating and, if so, where and when?

Same objection as to Q6.

A. It was a steam engine and transmitted its power to the wheels by means of gearing. I saw this vehicle running at Lons le Saulnier[52], in view of a trial made with this machine under the direction of Mr. Lotz when he made a trip for advertising purposes[53] in 1867, if I remember rightly.

Q8. Please state what engine was used on the Bollee vehicle and describe it, and state whether or no you have seen it operating. In case you have, where and when?

Same objection as to Q6.

A. I only saw the Bollee vehicle[54] at the Exposition of 1878. I did not see it operating, but I was impressed with some of the mechanical features of it, among others, the steering wheels[55].

Q9. Please state where and when, for the first time you saw a vehicle propelled by a Benz engine[56]?

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[48] Arthur C. Krebs refers here to the 1878 Exposition universelle in Paris.

[49] **1899**-09-09, Le Génie Civil : The Bollée steering system.

[50] This A. C. Krebs mention of the "Ackerman steering geometry" needs to be compared with his **1896** automobile patent (FR256344, GB189619774A) where he describes a king bolt steering mechanism bearing his "positive castor angle". The industrial version of that patent will be known as the "Voiture Clément-Panhard" (VCP), built at 500 ex. between **1898** and **1902**, and sold in many countries (FR284596, GB189902960A). About 15 are remaining today in France, the United States, England, Brazil, South Africa, Leetonia, etc. On the Panhard cars, A. C. Krebs will introduce the external quadrilateral steering which allows the connecting rods to work in tension rather than in compression.

[51] A. C. Krebs designed his own vertical steam engine and boiler in **1882** for the purpose of his aerostatic steam winch (see below). He used this steam engine for his **1888** "Durenne & Krebs fire steam engine" design. The latter had been patented FR189962. This patent was ceded to the Weyher & Richemond Company in **1891**.

[52] Lons-le-Saulnier is a town not far from Besançon where A. C. Krebs resided.

[53] As A. C. Krebs is here associating mechanical "trial" and "trip for advertising purposes", he gives one of the contexts of automotive experiments in France in that time. Another context is given just after, with the reference to the "Exposition of 1878".

[54] **1878 -** "La Mancelle" by Amédée Bollée senior : "the Bollée steam carriage".

[55] See above the reference to the "Ackerman steering geometry".

[56] The **1886** Benz car patent DE37435C.

Objected to as incompetent in that it calls for testimony of use in a foreign country, and as indefinite for the reason that it appears of record that Benz engines were of various kinds and it does not appear to which kind reference is made.

A. I saw a Benz vehicle[57] operated in Paris about 1891 or 1892. The transmission was effected from the engine to a shaft, by means of belts which shaft drove the driving wheels by chains. I never had the opportunity of closely examining a Benz vehicle until 1894.

Q10. Tell whether or no the Benz vehicle had a body, and if so describe it briefly?

Objected as to indefinite, for the reason that it does not appear what particular vehicle is being referred to, and as incompetent for the reason that it calls for testimony of use in a foreign country.

A. It is difficult for me to describe the Benz vehicle which I first saw because I confuse it in my mind with the one which I examined more in detail in 1894.

Q11. Please state what is the relation between the number of revolutions of the crank shaft and the number of revolutions of the wheels in the Benz vehicle?

Same objection as to Q10.

A11. I do not know what relation, but it appears to me that the motor always revolved faster than the wheels.

Q12. State whether or no there was a clutch or a disconnecting device permitting the motor to rotate free, and if so, for what purpose?

Same objection as to Q10.

A12. I am not certain of the means but there was some means permitting the motor to run free. This was operated when the vehicle stood still. The purpose was to permit the motor to be started while the vehicle was at rest.

Q13. Please give all details regarding your mechanical experience as far as you remember, year by year. Describe also as fully as possible the various subjects on which you have been engaged since you began your mechanical work?

Objected to as calling for incompetent testimony in so far as it calls for testimony by the witness of work done in foreign countries.

[57] **1899** - Baudry de Saunier : The Benz voiturette.

A13. Previous to 1870 my education had been particularly directed to preparation for L'Ecole Polytechnic[58]; but owing to the war with Germany, and my being in Besançon on the frontier, I was not able to take the entrance examinations, because they did not take place. I entered an artillery regiment and about November, 1870, as sub-lieutenant in an infantry regiment[59]. After the war I was transferred to St. Cyr School[60], where I remained for one year in order to complete my military education.[61] Since then I have continually been occupied with mechanical matters, and I applied myself to studies to equip myself as engineer,[62] by my own efforts, keeping myself in close touch with new developments in the mechanical arts.[63]

In view of this, in 1877 I was detailed to the Engineer Corps Staff in order to study and investigate the utility of balloons in warfare. From 1877 to 1885[64] I cooperated in all of the work on construction of captive balloons for military purposes and for their use in warfare. This work comprised, in addition to the construction of balloons proper, the study and construction of materials for readily producing hydrogen gas[65], and also of vehicles with steam windlass for handling balloons[66], etc. All the mechanical work has been the subject of special study by me, and to accomplish this I constructed and organized a shop located in the Park of Chalais-Meudon, which shop is still in existence.[67] At the same time I collaborated in the study and in the construction of the dirigible "La France"[68] the first balloon equipped with a motor which rose in the air and maneuvered successfully and returned to the starting point[69]. The first ideas entertained for the propulsion of balloons involved the idea of a gas engine[70] but the study of the subject soon showed

[58] Sic. The French Polytechnic special military school.
[59] **1871**-01 - Sub-lieutenant Arthur Constantin Krebs stationed at Villefranche-sur-mer near Nice (France).
[60] The Special military school of Saint-Cyr is located today in Brittany (France).
[61] Speaking of "military education" A. C. Krebs suggests he will have to complete his scientific education by himself.
[62] Saying his aim was to become an engineer, A. C. Krebs suggests that his entry in the infantry was due to the war, not to a personal choice.
[63] This insistence for Arthur C. Krebs in saying that he greatly got his technical knowledge by himself is exceptional here and tends to present him as a "self-made man".
[64] A. C. Krebs left the Chalais-Meudon Park in May **1884**. Charles Renard never mentioned a Krebs' participation to his **1885** flights with the "La France" dirigible balloon modified after **1884**.
[65] **1882** - The C. Renard & A. C. Krebs hydrogen generator car for inflating captive balloons in the field.
[66] **1882** - The A. C. Krebs steam winch for maneuvering captive balloons in the field.
[67] The Krebs interest for workshops is constant all along his career.
[68] The "La France" airship.
[69] The four trips of the airship "La France" with A. C. Krebs.
[70] A. C. Krebs will say below that he experienced **hydrogen engines**. This mention of "gas engines" seems referring to petrol and hydrogen engines.

me that in view of the actual conditions of the construction of these motors they were much too heavy.[71]

It was then that I selected an electric motor operated by a very light battery. Electricity was then undergoing great development[72] and I was therefore led to its study in order to solve the problem of the dirigible balloon[73]. It was suggested to the Minister of Marine[74] that this same method of an electric motor be employed for propelling sub-marine which is the propulsion of a floating body capable of diving below the surface of the water. I was then detailed on naval construction service from 1886 to 1890[75] to collaborate in the construction of the submarine "Gymnote"[76], which has been the model type for the construction of a number of submarines for the navy, until it became possible to displace the electric motor by the petrol motor.[77]

About 1890 I was instructed to study for the fire brigade of Paris vehicles for salvage apparatus, and at that time I attempted to follow up the work that was being done to adapt the small petrol engine of Daimler to automobile vehicles. In 1894[78] I commenced work on a vehicle equipped with a Daimler motor driving the wheels by means of a speed changing gear controlled by magnetic clutches[79]. The result of these studies was my securing a patent on the thirteenth of May, 1896[80], which resulted in my consummating connection with the firm Panhard & Levassor. In 1897 upon the death of Mr. Levassor I tendered my resignation as Major and became technical director of the Société Anonyme des Anciens Etablissements Panhard et Levassor. Since then I devoted all my time to the general management of that firm and the development of engines and

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[71] A. C. Krebs details below: "I bought and accepted [in **1878**], at the shops of that firm [Panhard & Levassor], a two horse power Otto four cycle engine for installation at the balloon sewing shop."

[72] The choice of an electric engine has been made by Krebs & Renard after the 1881 International Exposition of Electricity in Paris, where Gaston Tissandier demonstrated his electric dirigible model, and where international industrial units of electrical measures were defined.

[73] **1884** - The A. C. Krebs electric motor for the "La France" airship.

[74] Henri Dupuy de Lôme made that suggestion to the Minister of Marine after the demonstration by A. C. Krebs of his electric boat "l'Ampère" the **1883**-03-24 on the pond of the Chalais-Meudon Park.

[75] During this period, A. C. Krebs stayed officer in the Paris fire department.

[76] **1888** - The A. C. Krebs electric motor for the "Gymnote" submarine.

[77] A. C. Krebs will detail below his participation to that construction of **benzol engines** for French military submarines.

[78] This date of **1894** is confirmed by the Paris counsel reports (see above).

[79] **1896** - A. C. Krebs at the handlebar of his car with an electromagnetic gearbox in the Bois de Boulogne near Paris.

[80] **1896** A. C. Krebs patent (FR256344, GB189619774A) claims are 1° The Krebs three-point suspension system generalized (engine and chassis) 2nd The electromagnetic constant mesh gear box 3° The speed shifting on the steering device 4° The damped steering and the rack and pinion steering gear 5° The forward (positive) caster angle on the steering axle. Many connections can be found between the **1896** Krebs patent or the **1898** Voiture Clement-Panhard (VCP) patent (FR284596, GB189902960A) with the Ford three-point suspension principle and other features of the **1908** FORD T car. We saw above that Levassor filed a Belgian patent of the Krebs patent in order to give it international scope.

mechanical parts of vehicles and especially to the study of carburetters. This study has resulted in giving the petrol motor the flexibility and range of power requisite for the driving of vehicles. The first difficulty which I met in the working out of a carburetter was the maintenance under all conditions of a constant ratio between the weight of air and fuel. It was after a very precise theoretical study[81] of all the constituent elements which are involved in carburation that I designed the automatic carburetter as it exists today[82]. The results I desired to accomplish materialized upon the first trial and without it being necessary to modify by experiment the dimensions predetermined for the construction of the apparatus.[83] With this carburetter it is possible to vary either the speed of the engine under constant load, or the power at varying speed, or both the power and the speed at the same time. Immediately after that study I was led to recommend the use of a petrol engine, thus rendered very flexible for driving submarine boats. The construction of 22 boats[84] was started in 1902, driven by 60 horse power engines, which were constructed in our shops. At present I am also constructing petrol engines of the same power for dirigible balloons for the War Department,[85] which are still lighter than those for the submarines. I may therefore say that all the work that I have undertaken equipped me especially to be very thoroughly informed on the question of internal combustion motors. I may add that my carburetter, known as the Krebs carburetter,[86] is the only one actually used on all Panhard et Levassor vehicles, and there is great demand for its use on other makes of vehicles.[87]

Q14. Please state when Panhard et Levassor commenced the construction of automobiles and engines for such, and in reply thereto produce, if you have them, letters or documents authenticating these dates and the first actual operation of automobiles of the Societe Panhard et Levassor.

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[81] For his theoretical studies on carburetors, A. C. Krebs used the laboratory of his friend the academician and physicist Pr Arsène d'Arsonval in the Collège de France, in Paris.
[82] The **1902** Krebs "Automatic carburetor" patents: FR325241A, GB190222655A, US734421A etc.
[83] A. C. Krebs answers here to abroad critics that said he used wrong calculations, his correct result being due to post-calculations from his experiments. See below.
[84] A. C. Krebs refers here to the "Naïade" submarine series designed by his friend Gaston Romazzotti, the same who constructed the "Gymnote" submarine in Toulon in **1888**-**1889**.
[85] Arthur C. Krebs refers here to the Lebaudy semi-rigid dirigibles acquired by the French War department from **1904**.
[86] This claim by A. C. Krebs of naming "Krebs carburetter" his invention is unique in our sources.
[87] Arthur C. Krebs can assert here a kind of triumphal success pointing the apogee of his career. Next year the international industrial crisis following the financial crisis in the United States (said "Panic of 1907") will begin a period giving Panhard much more disputed results.

Objected to as irrelevant, immaterial and incompetent, for the reason that it calls for testimony by the witness of work done by the Defendant Company, a foreign corporation, in foreign countries, such work having no bearing on the scope or validity of the patent in suit or on any issues raised by the pleadings herein.

A14. Panhard et Levassor commenced the construction of automobile vehicles engines as early as 1889[88]; at the same time the firm of Peugeot, who was constructing quadricycles[89], made arrangements with the firm of Panhard et Levassor to purchase their light engines in order to use them on their quadricycles. Up to 1895 these two firms were in intimate relations, as shown by letters from Peugeot firm from December 30, 1889 to January, 1895. From that time on the Peugeot firm decided to construct their own engines. Among other letters there is one of March 17, 1890, in which Peugeot states the satisfactory result obtained with a Daimler engine, and wishes to know if a so-called 5 horse power engine does not really give more than 5 horse power; in one dated July 30, 1890, it is stated that the operation of a quadricycle equipped with an engine is not satisfactory.

There is also mention of two other vehicles which shortly would be completed, and if the engines operate satisfactorily they are to serve as a type[90]; in another letter, dated October 3, 1890, is mention of the question of the Peugeot firm, constructing petrol vehicles equipped with Daimler engines, the operation of which has been more satisfactory than anything of the kind. In another letter, October 25, 1890, the Peugeot firm placed an order for 20 engines of 2 horse power each, of the same type which had already been delivered. In 1891 the firm Panhard et Levassor made the first vehicle equipped with its Daimler engine[91], which first vehicle was soon followed by several others, which worked sufficiently well to offer them for sale. A leaflet of testimonials shows that as early as October, 1892, the vehicles sold to various customers had given entire satisfaction. A price list of January, 1892[92], lists petrol vehicles. In 1894, at the trials of the Petit

[88] **1889** - First Panhard & Levassor experimental car: "Première voiture de course".
[89] The **1890** Peugeot quadricycle Type 2.
[90] Catalogue Panhard & Levassor 1892.
[91] **1890-1891** - Panhard & Levassor mid-engined prototype automobile.
[92] **1892** – Panhard & Levassor advertising poster.

Journal[93] the Panhard et Levassor carried off the first prize (2 Panhard and Levassor vehicles, 2 Peugeot vehicles, equipped with Daimler engines furnished by Panhard et Levassor). Paris-Bordeaux-Paris, June, 1895[94], Carriage no. 5, equipped with Daimler engine, made the run there and back without stop. The Peugeot vehicle equipped with Daimler motor, and another vehicle of the firm Panhard et Levassor, were also among the first.

Q15. Can you produce any of the first catalogues and price list of the Panhard et Levassor firm?

A15. One of January, 1892, another of October, 1892[95], and a third of the 1st of December, 1895[96].

Q16. Can you give a description of the engine embodied in the vehicle of the Panhard et Levassor firm made before 1895?

The question is objected to as calling for testimony of use in a foreign country.

A16. The first engines constructed up to 1893[97] had one or two cylinders with the connecting rods acting in one plane on the same crank located between two fly wheels. The motors with two cylinders had their cylinders in the same plane and inclined with their axes disposed V shape. The inlet valves were automatic. The exhaust valves were controlled by stems, the movement of which was effected by cams sliding in a spiral groove in one of the fly wheels. The ignition was effected by means of a small platinum tube in communication with the interior of the cylinder and heated externally by the flame of a burner supplied by petrol under pressure of about 30 centimeters of water (3/100 of an atmosphere). The engine operated on the four cycle principle, that is, that the charge drawn in by the piston was compressed by it in the upper part of the cylinder previous to its ignition. The ignition resulting from this very compression which had the effect of driving the gas in the cylinder into the platinum tube. The location of the hot part of the platinum tube was so

[93] The 1894 Paris-Rouen race.
[94] **1961**, **Greenleaf**, p.34: "*No longer was the automobile regarded as a toy in France,* […] *In Paris at this time a horseless carriage, driven by a petroleum engine, is so common a sight that it attracts no comment," reported Harper's Weekly in* ***1895.*** "*It is not unlikely that this may also soon be the case in New York*." **1971**, **Bishop**:" *Le triomphe de Levassor fut purement transcendantal: nous sommes convaincus qu'il reste la plus haute performance solitaire dans l'histoire du sport automobile. Que cette victoire ait eu aussi des aspects commerciaux, cela est sans conteste. Que ces aspects n'aient pas été prévus en France, cela est vrai aussi*."
[95] Catalogue Panhard & Levassor 1892.
[96] Catalogue Panhard & Levassor 1895.
[97] The **1889** - Daimler V shape engine.

arranged that the gas driven into it reached the incandescent part at the moment the piston reached the upper part of its stroke. If ignition took place sooner the engine gave less power; the regulation of the motor consisting in carefully determining the position of the burner in order to properly heat the platinum tube. The engine was provided with a ball governor suppressing the exhaust of the burned gases as soon as the engine ran at too high a speed. The burned gases not being allowed to escape the cylinder remained filled and did not draw in a fresh mixture. Therefore no power stroke took place as long as the governor prevented the exhaust valve opening. In 1894[98] a new type was substituted in place of the model which has just been described. This consisted of two parallel cylinders[99] in which moved two pistons each acting by their connecting rod on the crank shaft carried in a casing which supported the cylinder, one fly wheel being fastened at the end of the shaft. The inlet valves were still automatic; the exhaust valves were operated by cams mounted on a special shaft located parallel to the crank shaft and operated by the latter by means of a set of gears causing the cam shaft to rotate at one-half the speed of the motor shaft. A ball governor mounted on the cam shaft determined the speed of the motor by preventing the opening of the exhaust valve. This arrangement slightly differing from one used on the previous engines, produces the same result, that is, the suppression of the in-take until such time as the engine speed slowed down below the normal. This type of motor was constructed until 1897. In both of these engines ignition was effected as I have described it above, that is by means of a platinum tube brought to incandescence. The combustible mixture was generated in the same manner in these engines. Carburetion was effected as follows: the inlet valves were connected by a pipe with the tank containing a volatile liquid hydrocarbon. During the suction stroke fresh air was led to the tank by a pipe bringing it in close proximity to the surface of the hydrocarbon whereby it became charged with combustible vapors before it reached the cylinders by the

[98] This new parallel cylinder engine was designed by Maybach and it will take the name of Phenix engine at Panhard & Levassor.

[99] **1971**, **Bishop**, p.183:" *Il n'est pas sûr qu'il y ait existé un brevet pour ce nouveau moteur.* […] *Si Daimler avait été l'inventeur du moteur Phénix, pourquoi celui-ci fut-il monté si longtemps sur des véhicules Panhard & Levassor avant de faire son apparition sur les voitures Daimler ?* […] [Krebs] *ne lui donne pas le nom de Phénix, bien que la description qu'il en fait ne laisse aucun doute, mais il ne lui donne pas non plus le nom de Daimler*." In the letters exchanged between Levassor and Daimler, the vertical cylinder engine is designated as being designed by "M". There is no doubt today that it is Maybach, Daimler's assistant, who designed the Phenix engine, as well as its carburetor. Levassor did not have the capacity to design such an engine.

pipe connecting the tank to the inlet valve. The combustible mixture thus generated being too rich, an opening communicating directly with the air, and easily closed by a valve, allowed the introduction into the pipe, connecting the tank to the inlet valve, of a quantity of pure air the amount of which could be easily controlled by the valve. This device, however, required a new setting of the regulating valve whenever the temperature of the tank and of the liquid hydro-carbon varied, or when the hydro-carbon became poorer in volatile parts after having been in the tank for some time. In order to remedy this cause of trouble Mr. Daimler invented in 1893 his atomizing carburetter[100]. This device operates as follows: in the pipe conducting the air to the inlet valve there is located a very small pipe through which liquid hydro-carbon can flow. Owing to the suction caused by the engine a partial vacuum is produced in the inlet pipe which, drawing air on the one hand and the liquid hydro-carbon on the other hand, causes them to flow simultaneously through their respective orifices. The liquid flowing through its narrow aperture falls in with a very swift stream of air which causes its atomization. This breaking up of the fuel has the effect of increasing greatly its surface of contact offered to the air, and it transforms itself almost instantly into vapor, this causing a great lowering of the temperature of the air, and mixing with it forms the combustible mixture which is carried into the cylinder. It may be noticed[101] that by means of this device the two fluids[102] are caused to flow through orifices the area of which has been previously determined in order to give the most suitable proportion of weight of fuel and that of air. That ratio is independent of the vacuum which causes the flow of the fluids. It can therefore be understood that in such condition the gaseous mixture remains the same whatever the speed of the engine. The engine will therefore be able to operate in the best possible condition independently of its speed.

Q17. Please describe the means employed for transmitting the power of the motor to the wheels in the Panhard vehicles constructed before 1895?

Same objection as to Q16.

[100] This carburetor is known as "Maybach carburetor".
[101] A. C. Krebs adopts here the professorial tone he likes to, reminiscence of the military training sessions he gave. We will periodically see below that change of tone.
[102] See the note below regarding the Carnot's vision of heat.

A17. As early as 1890 the transmission of the power of the engine to the driving wheels of the vehicle was accomplished in the following manner[103] generally speaking: the engine shaft was prolonged at one end by a shaft capable of being connected or disconnected to the engine shaft by means of a clutch [operated] by the foot or hand by properly disposed levers. The extension of the engine shaft carried a sleeve which could slid on it. This sleeve carried generally three gear wheels having different diameters and adapted to engage respectively with three gears carried by a third shaft located parallel to the first one. By shifting the sleeve any one of the gears could be brought into mesh with the complementary gear by means of the third shaft. This operation was accomplished by means of a lever shifted by hand, which caused the sleeve to slide and to stop in any one of the three positions of gear mesh. In order to shift the sleeve it was necessary to disconnect the motor shaft by actuating the clutch. A locking arrangement was provided with the object of preventing the shifting of the sleeve so long as the motor shaft was not disconnected. At one end of the third shaft was mounted a bevel gear inmeshing[104] with a bevel pinion keyed to the balance gear[105], the axis of the latter being placed parallel to the axle of the driving wheels. On the outer ends of the balance gear shafts were keyed sprockets driving sprockets on the rear wheels by means of chains.

In the first vehicles built up to 1893-1894, the driving axle was driven by a single chain[106], in which arrangement the balance gear was mounted on the axle instead of the counter-shaft driven by the bevel pinion of the third shaft. The driving wheels were then keyed at the outer ends of the shafts of the differential, which thus constituted the axle. The slackening of speed of the vehicle or its stopping was accomplished by a drum on the chain shaft, which could be retarded by a brake operated by a foot pedal. In order not to be compelled to stop the engine when the vehicle was stopped, the braking action on the drum could only take place after the motor had been disconnected by operating the brake pedal, effecting at the same time the disconnecting

[103] The "Panhard type gearbox".
[104] Sic.
[105] Balance gear: differential.
[106] The 1894 Paris-Rouen race: the four-seated vehicle with a central chain.

clutch. Thus this unclutching was automatically accomplished when the speed of the carriage was slackened or when it was stopped.

Q18. State whether or not a clutch mechanism or some means of disconnecting the motor from the speed changing gear was in use on the Panhard vehicle before 1895, and if so, what was the object of such device?

Objected to for the same reasons as for Q16, and for the additional reason that the question is leading and suggestive.

A18. Ever since the Panhard Company began to build petrol engines the motor shaft has always been connected to the speed changing mechanism by a clutch. This clutch is necessary to allow the passing from one speed to another, that is, to disengage the gears in mesh and bring into mesh the gears corresponding to the speed wanted. Such an operation can only be performed by reducing in the desired ratio the speed of the two shafts carrying the gear wheels. As the shaft connected to the driving wheel cannot change its speed, owing to the inertia of the vehicle, it is therefore the speed of the shaft, interposed between the engine shaft and the one just mentioned, which must be modified. As the speed of the engine is regulated by its governor, it may be readily understood[107] that it becomes indispensable to disconnect it from the shaft, which must undergo a change in speed. Moreover, the clutching action must be progressive, that is, it must allow for a certain slip in order to impart without shock to the vehicle the power of the engine. While the clutch is being applied, both the vehicle and the engine modify their speed until they correspond to the gear ratio selected[108]. Clutching mechanisms are well known and are numerous, but in practice, however, the friction cone, leather covered, has been adopted.

Q19. Please state the ratio between the number of revolutions of the crank shaft and the driving wheels in the Panhard vehicles built previous to 1895?

Objected to as immaterial and incompetent, in calling for testimony of use in a foreign country.

A19. The speed ratio was about as follows: for the first speed 20, for the second speed from 12 to 13 and for the high speed from 6 to 7. That is to

[107] Note the Krebs professorial tone.
[108] "slected" in the original text.

say at the first speed the engine was turning about 20 times faster than the driving wheels, at the second speed about 12 times as fast, and at the high speed about 6 times as fast.

Q20. Please specify the location of the engine in the Panhard vehicle built before 1895?

Same objection as to Q19.

A20. In the first 4 or 5 vehicles the engine was located near the middle part of the vehicle between the axle[109], but almost immediately thereafter it was decided to locate the engine at the front of the vehicle above the axle supporting the steering wheels[110], the axis of the engine being located longitudinally, that is, at right angle to the axle. In the Peugeot vehicle equipped with Daimler engine furnished by the firm Panhard & Levassor, the engine was placed at the rear of the vehicle the axis of its shaft being located at right angle to the axle.

Q21. Kindly examine the exhibit of the defendant, No. 165 and please say whether you know what it is?

A21. This document is an illustrated catalogue of the firm Panhard & Levassor describing the petrol engine but more especially the two seated vehicle constructed and offered for sale as early as 1891[111]. The picture shows clearly the forward location of the engine; the driving of the rear axle by means of a chain; the speed changing levers, and the clutch levers that I have just described. The description inserted in the catalogue gives some information regarding the engine, the steering of the vehicle, the possible speeds which may be reached, and finally all information relative to the starting of the engine and the vehicle and their stopping.

Q22. Please say whether or not the defendant's exhibit No. 165 comprising the catalogue of January 1892, the catalogue of October 1892, and the catalogue of December 1, 1895, describing the vehicle sold by Panhard & Levassor at these respective dates?

Objected to as leading and suggestive.

A22. The three documents above mentioned are actually catalogues of the firm Panhard & Levassor. Those of 1892 describe the same vehicle two seated

[109] **1890-1891** - Panhard & Levassor mid-engined prototype automobile.
[110] The Panhard system: front-engine, rear-wheel-drive layout.
[111] The Panhard catalogue **1891**: unidentified.

or four seated. The catalogue of 1891[112] describes only two seated vehicles but gives the information that four seated vehicle would be built next year, and states the price of this vehicle. The catalogue of 1895 illustrates a vehicle equipped with a motor developing 4 horse power. In this type of motor the axis of both cylinders are parallel instead of forming a V as said previously in the description given of these different types.

Q23. Kindly state what was the object of printing the catalogues mentioned in the preceding question?

A23. These catalogues were sent to customers who wished information from the firm Panhard & Levassor concerning these vehicles. They were also distributed to the public at the cycle shows which took place yearly, lately at the Palace of Industry[113]. It was at this show that the first small Daimler motor constructed by Panhard & Levassor appeared first, and the first automobile vehicles were shown afterwards. After every automobile race the vehicles which had covered the course were also exhibited at the Palais de l'Industrie to be shown to the public, and the catalogues were distributed on such occasions.

Q24. Please state if you know at what date the paper marked "Attestation" was printed, and for what object?

This sheet was printed in 1894 in order to be distributed to the public at the exhibition of vehicles which had taken part in the race "Concours du Petit Journal", 1894[114].

Q25. Please state how many copies of the paper marked "Attestation" were placed in circulation?

A25. I cannot give you any figure about it.

Q26. Please tell me what is the book I am showing you now. It seems that it is dated at the foot of the fifth page, Paris, July, 1895?

A26. This book is the catalogue that the firm of Panhard & Levassor[115] wrote and published immediately after the Paris-Bordeaux Race and return, where one of its vehicles driven by Mr. Levassor himself, showed how great was the reliability of the vehicle constructed by the firm. Monsieur Levassor

[112] Panhard & Levassor catalogue **1891**: unidentified.
[113] The "Palais de l'Industrie".
[114] The 1894 Paris-Rouen race.
[115] Catalogue Panhard & Levassor 1895.

drove his vehicle in both directions without any stops but those required for taking on petrol and water. This catalogue shows also that the manufacturing of the vehicle had already reached a vast extension, the number of different types of vehicles constructed by the firm reaching 19[116].

Q27. State why this catalogue was printed, what date, and how many copies were placed in circulation?

Objected as immaterial and irrelevant.

A27. The object was to let the public know that automobile vehicles could be applied to all sorts of uses. It was printed immediately after the Paris-Bordeaux race. I do not know how many were distributed.

Q28. State whether or not it described the vehicle sold by Panhard & Levassor in July, 1895, if any were sold at all?

Objected as incompetent, for the reason that it calls for testimony of use in a foreign country.

A28. It describes completely the vehicle sold by Societe Panhard & Levassor in July, 1895. Quite a number of these vehicles very sold, and few of them have come back during the eight years to our shops to be repaired. I even noticed that the motors, especially, were still working quite well. The owners were very well pleased, and I have seen one of them about this matter, in my office a few days before my departure for New York. His vehicle will be in a parade organized by the Automobile Club of Paris[117], where the oldest type of automobile vehicle used, or having seen service, will be exhibited.

Q29. State, if you can, the number of vehicles constructed to run on roads appearing in the catalogue I hand you, which were sold by the Societe Panhard & Levassor previous to November 1, 1895?

Same objection as to Q28.

A29. At least one sample of each of the vehicles described in this catalogue was constructed. As a matter of fact, no new model was studied and constructed before receiving a formal order from a customer. But I find it impossible to state the exact number of each type sold, as I have never given any attention to this question before now. I must state, however, that by the

[116] **1898** - Panhard & Levassor: numerous car types. **1899** - Panhard generator with Phenix engine.
[117] **1891-1911** - La voiture de l'abbé Gavois.

month of July, 1897, more than 600 vehicles had been constructed and sold.[118] At the time I became manager of the firm the number of the engines exceeded 700, and I started the numbering, in the name of the new company at 1000 in order to simplify the book-keeping. I am therefore in position to state that the number of carriages sold by Panhard & Levassor on the first of November, 1895, was certainly in excess of 100[119].

Q30. In your answer to question 23 you mention shows at which catalogues were distributed. Kindly specify where, when and what was the object of those exhibitions?

Objected as incompetent, in that it calls for testimony of use in a foreign country.

A30. I have said that the petrol engine built by the firm were at first exhibited in the Cycle shows, which took place every year, in the fall months, at Paris, at Palace de l'Industrie. At these shows the petrol engine was exhibited as applied in various industries[120], for boat propulsion […] that the first vehicles were exhibited in 1892, but as early as 1891 catalogues of small engines, describing various purposes to which they could be applied were distributed at those cycle shows. These exhibitions still take place annually in Paris, but after every automobile race there has always a special exhibition of the vehicles having taken part in the race. It is at these various exhibitions that these different catalogues were distributed.

Q31. Can you state if before January 1, 1895, there existed any parties in France who were constructing and selling self-propelled vehicles, capable of being driven over ordinary roads?

Objected to as irrelevant, immaterial and incompetent, for the reason that the question specifically calls testimony of use in Paris, France. Evidence of this use is incompetent.

A31. In 1894 the three largest constructors of automobile were the firm of Panhard & Levassor, who were manufacturing under the French Daimler patents; the firm of Peugeot of Valentigney, who bought their engines from Panhard &

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[118] **1961**, **Greenleaf**, p.55: "*The use of the automobile for public transportation in the Unites States began in January 1897, when the Electric Carriage and Wagon Company placed its motorized hansom* [electric] *cabs on the streets of New York City." P. 56: "Despite the proved superiority of the internal combustion engine as the power unit of the motor car, the electric vehicle held public favor until shortly after 1900*."

[119] The increase in sales between **1895** and **1897** is enormous!

[120] **1898** - Revue industrielle.

Levassor, and the firm of Roger[121], who constructed vehicles equipped with motors of the Benz Company. Several other constructors, such as Lebrun and Vacheron[122], also built a small number of vehicles equipped with Daimler engines. All these types of vehicles took part in the races organized by Le Petit Journal[123] over the Paris-Rouen course[124], on the [?] Panhard & Levassor vehicle and the Peugeot vehicle. These automobiles showed themselves greatly superior to the steam automobiles[125], which were also entered in this race (see the publication La Nature[126], July 20 an August 27, 1894).

Q31. State if you have seen automobiles races prior to January, 1895, and if so where and when?

A31. I was present on the 18th of July, 1894,[127] in the morning[128], at the starting of the automobile vehicles entered in the race of Le Petit Journal. The starting took place at La Porte Maillot. At least 20 vehicles reported to start.

A32. State if the Panhard & Levassor Company had entered vehicles in these races, and if so describe them?

Same objection as to Q31[129].

The firm Panhard & Levassor had entered two types of vehicles: a two-seated with a top[130], the motor being placed at the front of the vehicle; a four-seated vehicle[131], with a canopy top,[132] the motor being also located at the front of the carriage. These two vehicles won the first prize in their classes. The two-seated carriage was equipped with two chains, each one driving one of the rear wheels, as I have described in my answer to question No.

The four-seated vehicle had only one chain, driving the rear axle carrying the differential, as I have also described in my answer to the same question.

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[121] Émile Roger started constructing three wheeled cars with Benz engines in 1885.
[122] Lebrun and Vacheron provided their car from **1894** with an inclined steering wheel.
[123] Le Petit Journal.
[124] The **1894** Paris-Rouen race.
[125] **1894** - L'ingénieur civil :Steam car builders in **1894**
[126] **1894** - La Nature: "VOITURES AUTOMOBILES".
[127] This mention is unique in our sources.
[128] **1894** - La Nature: very early in the morning.
[129] Sic.
[130] The **1894** Paris-Rouen race: the two-seated vehicle with a top..
[131] The **1894** Paris-Rouen race: the four-seated vehicle with a canopy top..
[132] A. C. Krebs seems intending here that that four-seated carriage was not supposed to be a race car.

The wheels of these vehicles were made of wood and had plain, solid rubber tires. (See La [Nature[133] …]

Q33. I show you a copy of La Nature of August 25, 1894. State what is the subject of the article commencing page 198?[134]

A33. This article illustrates and summarizes and briefly describes the arrangement of the different types of vehicles which took part in the race of the Petit Journal, run from Paris to Rouen the 18th to 19th of July, 1894[135]. They are there set forth in order in which the awards were made. The two first prizes (for two and four passenger vehicles) were given to Panhard & Levassor, and the two other prizes went to Messrs. Peugeot for their petrol vehicle equipped with a Daimler engine made by Panhard & Levassor.

Q34. State whether or not the illustrations forming part of this article correctly represent the vehicles as you remember them?

A34. These illustrations were made from photographs actually representing the vehicles at the time of their starting. I recognize in the two passenger Panhard & Levassor vehicle Monsieur Levassor[136] holding in his hand the steering lever. Likewise the four passenger Panhard & Levassor vehicle is driven by Monsieur Mayade[137], superintendent at that time of the Panhard & Levassor firm, who can be readily recognized in the illustration. Both of these persons have since died as a result of automobile accidents.[138] I also recognize readily the petrol vehicle of Monsieur Roger[139] with its motor in the rear. That motor was the Benz type driving the jack shaft by means of belts.

Q35. Were you at one or more automobile races in 1895?

Objected as immaterial and irrelevant.

A35. Yes, I recall well in the Paris-Bordeaux-Paris race the return of the two passenger vehicle which was driven by Monsieur Levassor. That vehicle and its driver had made the trip there and return, 1175 kilometers, without

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[133] **1894** - La Nature: "VOITURES AUTOMOBILES".
[134] Arthur C. Krebs is one of the proofreaders of the La Nature periodical. As a famous aeronaut he knows well the manager Gaston Tissandier.
[135] Photos of the vehicles that took part in the race **1894** Paris-Rouen.
[136] Émile Levassor.
[137] M. Mayade.
[138] The link between the death of Mr. Levassor in **1897** and his accident in the Paris-Marseille race in **1896**, 6 months before, is not firmly established (see « Les Panhard-Levassor, une aventure collective », Claude-Alain Sarre, ed. ETAI, **2000**).A. C. Krebs states he believes in this thesis, and it may be the reason why he introduced the pneumatics, the steering wheel and the irreversible steering as soon as he entered the Company. Mayade as well, died in **1898** in a road accident.
[139] **1894** - La Nature: Voiture à pétrole de M. Roger.

stops other than those necessary to replenish with fuel, in about 48 hours. Unfortunately the first prize for the performance could not be given to it because it could not be awarded a vehicle with two passengers. Nevertheless the performance of this vehicle was considered most successful.

Q36. Say if the Panhard & Levassor Company had entered vehicles in all of these trials?

Same objection as to Q35.

A36. The Panhard firm never lost any opportunity to show their vehicles. They never failed to enter them in trials or other exhibitions, and unless I am mistaken the first prizes were always taken by them until 1900. Prior to 1895 and during that year the type of vehicles entered were in all cases built according to the arrangement I have described in answer to question No. 17. The seating capacity was either 2, 4, 5 or 6, depending upon the dimensions and shape of the body. The engines were always placed in the front, that arrangement having been adopted by the Panhard & Levassor Company after the very first trials because it offered facility for inspecting the engine and permitted while running to oil and to regulate the carburetter if needed.[140]

Q37. I show you a copy of La Nature[141] dated July 6, 1895. Please state the subject of the article beginning on page 84?[142]

A37. This article relates to the Paris-Bordeaux-Paris race. It gives a brief description of the vehicles which finished the run within the time limit. The cuts which illustrate the article represent the vehicles in the order in their class in which they had finished the run. In the lead we find the two passenger Panhard & Levassor.

Q38. What is the publication La Nature, and when and how many times does it appear, and what is the extent of its circulation?

A38. La Nature[143] is a review of sciences and their application to arts and industries. It is edited in Paris by Mason, Boulevard St. Germain No. 120. It appears weekly. Its circulation as near as I can remember is about 40,000. It is on file all over the world in the principal libraries. Besides it is

[140] These reasons justifying the "Panhard system" with the engine in front had never been mentioned before.
[141] **1895** - La Nature: "COURSE DES VOITURES AUTOMOBILES".
[142] Sic.
[143] La Nature: **1906** Title page.

received at all public libraries. The Scientific American[144] often reproduces articles which have appeared in La Nature, and vice versa.[145]

Q39. Please state what is represented in the illustration in the defendant's exhibit 172?

A39. The exhibit before me is a number of the Scientific American Supplement[146] October 6, 1894, on pages 15648 and 15649 of which I find illustrations and descriptions which appeared in issues of La Nature of August 25, 1894, in reference to the Petit Journal race. In comparing these two documents I see that the illustrations are identically the same.

Q40. State if you can what the illustrations in defendant's exhibit 173 represent?

A40. This exhibit is an issue of the Scientific American Supplement August 10, 1895, on the first page of which I find reproduced the article and illustrations given in La Nature in the number dated July 6, 1895, referring to the Paris-Bordeaux-Paris race. The illustrations of that article are the same of those in the journal "La Nature."

Q41. I show you a paper entitled "Quadricycle Peugeot 1891[147]." Please say if you know what it is?

A41. This paper is an illustrated catalogue of the quadricycle built by the Peugeot firm with Daimler petrol engines bought from the firm Panhard & Levassor. The trials and purchase of this engine resulted in negociations between the two firms as early as 1889. During 1890, as is shown by the correspondence to which I have referred in answer to question NO. 14, the trials were made jointly by both companies. As early as 1891 the Peugeot firm was in position to deliver this quadricycle which appeared at shows and trials and in different races. We see in the description in this catalogue under the heading MOTOR that it is of the Daimler system as manufactured by the firm of Panhard & Levassor, 19 Avenue d'Ivry, Paris.[148]

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[144] The **1903**-02-21 article in La Nature related to the Krebs carburetor is a good example of these circulations of information from France to America in that time: Scientific American dated **1903**-02-14.

[145] This mention by A. C. Krebs of the existence of circulations from America to France is not a fact of courtesy. He is very well informed of the American and British technological novelties by his anglophile brother-in-law Charles de Fréminville, he recruited in **1899** as technical director of the Panhard & Levassor Co.

[146] Scientific American supplement.

[147] La Nature: **1890** Quadricycle Peugeot.

[148] **Daimler letter to Levassor** (Panhard archives): "*Cannstadt, 16 février **1893**. Mon cher Monsieur Levassor, Rentré de mon voyage pour Berlin, Dresden et Leipzig, dont je vous ai fait part par la lettre de Mr L. du 23 écoulé, j'ai trouvé à mon retour vos estimées du 24 janvier, 6 et 6 courant contenant vos diverses observations au sujet desquelles je me permets de vous répondre le suivant : Vos lettres du 13 janvier*

Q42. I show you a book bearing the name Panhard & Levassor, and dated on the 5th page, "Paris, July, 1896." State if you know what it is?

A42. This document is a catalogue of automobile vehicles of the Panhard & Levassor firm[149].

Q43. When for the first time did you see the Unites States Letters Patent No. 549.160[150], in the name of Georg B. Selden?

A43. In 1903, I believe[151].

Q44. Please state whether or not the construction or manner of operation of Panhard & Levassor vehicles has been changed in any manner whatever in view of the details contained in that patent.

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*et du 6 courant m'informent que suivant le contenu de la dernière, Mr Peugeot est reculé de son intention de vendre des voitures Daimler hors de la France, (et hors de la Belgique), en suite de quoi la proposition de la première lettre a ainsi trouvé sa solution la plus convenable, car je suis tout de votre avis de ce que vous y remarquez dans votre lettre du 6 courant. Outre cela, il est bien entendu que Mr Peugeot terminera les affaires actuellement en négociation en Alsace comme nous y sommes convenus, et qu'il vende encore à ses amis autant qu'il peut. Dans le prospectus de Mr Peugeot, la voiture est appelée "quadricycle Peugeot". Ce n'est pas juste ; tant que cet établissement emploie le moteur Daimler, l'engrenage Daimler, etc. c'est-à-dire les éléments capitaux brevetés de ma voiture ; il reste toujours la "voiture Daimler" et non celle du fabricant ; car les autres fournitures faites par le dernier çà et là ne doivent pas renverser le droit, le caractère et le nom d'origine ; il ne suffit pas se borner de dire dans le prospectus de Mr Peugeot : "Moteur - Le moteur est du système Daimler". C'est bien moins que rien ; de cette manière nous perdrons tous les avantages des applications spéciales de mon moteur, que j'ai inventé surtout pour l'emploi spécifique aux véhicules à pétrole modernes, dont j'ai commencé déjà en **1884** et **85** par la création de "l'Einspur" (une ornière) comme embryon des voitures, bateaux, suivants. Il est bien entendu que je ne voulais pas vendre non seulement le moteur, mais aussi les applications créées par l'invention du moteur. Je pense que ce point de vue est aussi le vôtre, il a la même actualité pour vous puisque vous avez la propriété en France et en Belgique. Cette prétention de ma part est analogue au procédé d'autres inventeurs qui se sont essayés après moi dans la construction de petits véhicules à moteur ; par exemple Benz appelant sa voiture : "Patent Motor Wagon Benz" ; ainsi comme Serpollet et d'autres, donnant leur nom à leur invention, qui ne livrent pas leurs éléments brevetés pour que chaque autre fabricant puisse rebaptiser avec son nom les produits résultant sur la base de l'invention des autres. Quant à nous nous n'avons pas un motif d'être plus modeste que ceux-ci, car nous avons ici déjà les indices que peut-être les "voitures Benz" disparaitront de la plaine vis-à-vis de nos véhicules ; j'espère de pouvoir vous y communiquer le motif en peu de temps. D'autre part, j'espère que vous êtes d'accord avec moi, comme nous sommes convenus plus tôt, que tous les perfectionnements de la voiture et des autres applications faites en combinaison avec le moteur Daimler, perfectionnements faits par vous et vos licenciés, seront déférés au nom de Daimler. C'est une question très importante, surtout vis-à-vis de la concurrence, et pour garder l'unité et le perfectionnement de l'invention. Si vous jugez donc devoir faire une application, pour être brevetée, je vous prie de bien vouloir me faire parvenir les propositions au but de nous y consulte ensemble.* [Signed:] *Daimler"* (Underlined by Daimler) **Levassor letter to Peugeot**: "*20 février **1893**. Mon cher Monsieur Peugeot, Je vous adresse ci-joint le duplicata d'une lettre que je viens de recevoir de Monsieur Daimler. Vous verrez ses observations au sujet du titre "Quadricycle Peugeot" qui figure sur votre prospectus. Vous pourriez mettre par exemple : "Quadricycle avec moteur à pétrole système Daimler", ou "Quadricycle à pétrole, avec moteur Daimler" ; de cette façon la susceptibilité de l'inventeur n'aurait plus raison de s'alarmer. En réalité c'est Mr Daimler qui le premier a fait des quadricycles avec moteur à pétrole, c'est d'après lui que nous travaillons tous les deux, il est donc équitable de ne pas l'oublier sur les prospectus. Je vous prie d'agréer, mon cher Peugeot, mes bien* […] *salutations.* [Signed:] *Levassor."* **Levassor letter to Peugeot***: "22 février **1893**. J'ai votre lettre du 21 courant. Je comprends parfaitement que vous vouliez être maître de faire ce qui vous semble le mieux pour vos intérêts et que l'immixtion de notre ami, dans vos affaires, vous agace. Je n'ai donc pas à insister et je prends note que dans vos nouveaux catalogues vous mettrez, comme vous le promettez, un peu plus en relief le nom de "Mr Daimler". Je ne vais pas transmettre d'un coup vos observations à Mr Daimler, cela le mettrait sens dessus dessous ; mais, petit à petit, je pense pouvoir l'amener à envisager l'affaire d'une façon plus libérale. Agréez, mon cher Monsieur, l'expression de mes meilleurs sentiments.* [Signed:] *Levassor*." (Underlined by Levassor)

[149] Catalogue Panhard & Levassor **1897**.

[150] The Selden patent.

[151] **1903** is the date of the beginning of Selden suits in the US.

A44. When I first saw the drawings of Mr. Selden's invention the arrangement seemed to me so very antediluvian that I did not attach to it any importance.[152]

Q45. Please state whether or no the examination of this patent by you gave information which assisted you in the construction of Panhard automobiles?

Objected to as immaterial and irrelevant, for the reason that the Panhard Co. and not the witness is the defendant in this suit, and for the additional reason that the witness has testified that he was not connected with the defendant Company until the year 1897.

A45. To be franck, when I glanced at this document for the first time the appearance of the drawing showed to me that there was nothing in such an arrangement which could be retained for a matter of this sort. It is only about a year ago that I have been led to more carefully examine this document, when it was brought to our attention as being an anticipation[153] which had some value with reference to the construction of automobile vehicles.

Q46. Please describe the different changes which have been made in Panhard vehicles from November 1, 1895, to the present time?

Objected to as immaterial.

A46. These changes amount to the following: 1897, the motors were constructed up to 4 cylinders[154] in order to obtain a power greater than 7 horse, and to uniformly distribute the torque on the shaft.[155] In this way we got a power stroke for every half revolution. Besides the proper setting of the 4 cranks resulted in a reduction of vibration of the motor which was caused by the inertia of reciprocating parts.[156] 1898--, the steering which had been effected by means of a lever operated by a steering handle was changed, so that an endless screw was used to deflect the steering wheels.[157] Until 1901

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[152] **1961**, **Greenleaf**, p.49: *"One night in **1896** Charles E. Duryea was routed out of his bed in the Grand Union Hotel in New York by one of his stockholders in the Duryea Motor Wagon Company. The investor was limp with anxiety over the Selden patent, but Duryea did not share his feelings. "If I had seen mention of the patent before that time," said Duryea in his account of the incident, "it produced so little impression that I am unable to recall it."* […] *Like any other automotive pioneer, he did not believe it was possible to engross an invention that was in the public domain*."

[153] « Anticipation » : « antériorité » in French.

[154] In fact, Levassor built a four-cylinder engine he used in his **1896** Paris-Marseille-Paris race. It was a twin Phenix engine. When A. C. Krebs arrived in the factory in **1897**, he did the enhancements he explains here.

[155] A. C. Krebs refers here to the "balanced crank shaft."

[156] A. C. Krebs refers here to the balance of engines using bulks: **1901**-01-08 patent: FR306968A, GB190114881A, US778542A.

[157] A. C. Krebs refers here to his introduction of the steering wheel and his "irreversible steering" using an endless screw, in the Panhard & Levassor cars in the 1898 Paris-Amsterdam race. C S Rolls said he *"introduced the first car in Britain fitted with wheel steering*" when he imported a 6 hp Panhard et Levassor **1898** race car from France.

there were no important changes either […] aspect to the power of the motor. In 1901[158] the cylinders of the motor were slightly changed so as to cast in one piece the cylinder and the head with its valves. There was also introduced in the carburetter a throttle arranged in the mixture in-take pipe in order to vary the power of the motor without cutting out impulses.[159] In the change speed box the reverse which had been obtained by shifting the differential so as to mesh with one or the other of the bevel gears at the right or left, the bevel driving pinion was changed in the following manner: the differential was always driven in the same direction as the driving pinion, the reverse being obtained by bringing in an idle gear when on first speed, to engage with the two gears which produced that speed.[160] In 1902 the carburetter of 1901 was replaced by my automatic carburetter.[161] In 1904 the power of the motor used for propelling vehicles having been greatly increased, owing to the adoption of the automatic carburetter, which permitted the variation of the power from 0 to the maximum output of the engine, the clutch arrangement, consisting of friction cone became insufficient, and was replaced for powers exceeding 25 horse by a multiple disc clutch running in a bath of oil.[162] The pressure exerted by means of a spring on the discs results in sufficient friction between them so that the total friction becomes more than the power of the engine[163]. In 1904 also the speed changing gear embodied a combination of gears which permitted direct driving from the […]ing through a countershaft. This arrangement is called the "direct-drive."[164] At the same time that the power of the motor increased the wheels of vehicles were equipped with pneumatics similar to those which had already been used on bicycles.[165] Thanks to this important improvement in wheels, the speed of vehicles which previously had not been practically in excess of 20 to 25 kilometers now made it possible to run at 40, 50 or even 60 kilometers as early as the end of 1899.[166] In 1900 the

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[158] In **1901** appears the Krebs « Centaure engine »: Scientific American **1901**, **1902** - Wikipedia Moteur Centaure, Moteur Centaure allégé.
[159] This feature is known as the "Centaure carburetor" (**1899**-12-30 patent: FR295792, GB190000471A).
[160] This feature was known in that time as the "Panhard type gearbox".
[161] The **1902**-10-11 **automatic carburetor patent** : FR325241A, GB190222655A, US734421A.
[162] A. C. Krebs will claim below his paternity of this feature (**1904**-02-04 patent: FR340185A).
[163] The Krebs multi-plate clutch: FR340185A.
[164] The "Direct-drive" have been patented by Renault in **1902**. Krebs will explain below his proper system.
[165] The bicycle technology seems to have inspired A. C. Krebs a lot. He could have borrowed from it his "caster angle" steering system for his **1896** carriage patent. In **1911** he gave the shape of a pneumatic to his second elastomeric flexible coupling patent, which is known today as "Tire coupling." (**1911**-09-04 patent: FR445494, GB191217174A, US1107315A)
[166] A. C. Krebs imposed the pneumatics to all the Panhard & Levassor models from the **1898** Paris-Amsterdam race.

advent of the larger diameter pneumatic tire permitted vehicles having motors of 25 to 30 horse power, to reach speeds of 80 to 90 kilometers[167]. As a matter of fact, the only obstacle to realizing in practice these great speeds is the condition of the roads. To summarize, we have in the vehicles of 1892 and those of the present day very little difference,[168] as far as the general arrangement of elements is concerned. The engine is still placed in the front, the change speed gear is on the extension of the motor shaft and operates a differential the axis of which is parallel to the axle of the rear wheels or placed on the rear axle itself. In the first case the power of the differential shaft is transmitted by chains, in the second case the driving wheels are driven by the shafts of the differential. As far as concerns the engine the improvements have consisted in increasing the power by increasing the number of cylinders to 4 and increasing the diameter of these cylinders; in improving the carburetter, to insure in all cases a carburetion, or a combustible mixture as uniform as possible; in placing in the hands of the operator[169] the essential means for regulating the power of the motor and its speed; in controlling the water circulation and insuring its cooling by passing it through radiators. As for the change speed mechanism, in proportioning it for strength and solidity to the power of the motor; in enclosing in a tightly closed casing all the parts of the transmission. As for the vehicle, providing the wheels with elastic tires (pneumatics) enables the overcoming of obstacles which are encountered on roads at such a high speed so as not to result in shocks too severs for the essential parts of the vehicle.[170]

Q47. Have you made any special study of internal combustion engines; if so, when and for what purpose?

A47. In 1882, for the purpose of driving a dirigible balloon, which was then being investigated by the Ministry of War, I undertook the development of an internal combustion engine which was to use as a fuel the hydrogen which inflated the balloon[171]. It was on this occasion that for the first time I

[167] This mention is unique in our sources.
[168] A. C. Krebs here minimizes the role of the invention in the automobile advent. It seems not being a strategy regarding the present case, but the fruit of his personal thinking. We will see below he believes the automobile is mostly a mechanical engineer affair, incidentally an inventor one.
[169] Krebs pays attention to the steering and driver safety conditions.
[170] The **1906**-01-15 A. C. Krebs present before **the French Académie des sciences** his "Friction disk shock absorber": **1905** - FR356801, US859822A.
[171] This mention is unique in our sources.

thoroughly attacked the complete study of internal combustion engines.[172] At that time these engines could be divided in two general classes: The engines in which combustion took place under constant pressure and those engines in which combustion took place under constant volume.[173] In the first class we find engines, so-called "hot air", using any fuels solid, liquid or gaseous; in the second class we find all the engines which use a charge of fuel first introduced into the cylinder and then ignited in order to raise the pressure. It is these last named engines which are called explosion engines.[174] In fact it has been suggested to construct engines in which the charge consisted of some kind of powder, such as is employed in fire arms.[175] Those who proposed this solution hoped to be able to produce extremely light engines. This was a gross mistake, because they had not taken into account the weight of the charge, which consisted not only of the fuel, but also the weight of the oxygen which was necessary to support combustion. The weight of the latter is proportionately large as compared with the fuel. In engines in which combustion takes place under constant pressure the mechanical parts are subjected to regular strains, but this involves the evolution of heat during a relatively longer period of time; the ignition of the mixture is effected once for all at the time of starting the engines, in view of which it is possible to use heavier fuel because its combustion need not take place as instantaneously and as accurately as in explosion engines. The pressures reached are not as high as in the latter case, therefore on the other hand the expansion is not as great. For this reason this type of engine at its advent had appeared so attractive to the constructor in view of its ease of construction, was abandoned when the explosion engine appeared, that is to say, combustion under

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[172] This phrase suggests that the choice of an electric motor for the dirigible was not yet decided just after the **1881** Paris electric exposition.
[173] These classes are referring to the thermodynamics principles which Sadi Carnot stated in "Réflexions sur la puissance motrice du feu et sur les machines propres à développer cette puissance", Paris, **1824**, 188 pp., p 46: "*La différence entre la chaleur spécifique sous pression constante et la chaleur spécifique sous volume constant est la même pour tous les gaz.*"
[174] **1911**, **Judge Noyes**: "*The two types are called respectively the "constant pressure type" and the "constant volume type". Although these terms may have originated since the date of the invention, they correctly describe the types or classes of compression engines then in existence.* […] *It is apparent from the descriptions in this work* [of Dugald Clerk] *that a "constant pressure engine" is one in which the cylinder pressure remains the same during the outward travel of the piston while the volume of flame increases. The pressure is applied continuously and not spasmodically. This mode of operation is also called "slow combustion", and "nonexplosion". A constant volume engine operates in a different manner from a constant pressure engine. The volume during ignition theoretically remains constant; the pressure increases. The action is spasmodic. The piston moves by explosive action and is kept in motion by a series of explosions."* See below the detailed discussion about the "constant pressure" and "constant volume" types of engines.
[175] The A. C. Krebs friend, Gustave Zédé, did himself systematic experiences regarding the powder engine. The **1878**-11-12 he had been injured by the unexpected effect of a new exploding combination. He gave a torpedo shape to the experimental submarine "Gymnote", whose design of all electric and mechanical parts he asked to Krebs in **1888** (see below).

constant volume, in which the mixture is previously raised to high pressure. It was Beau de Rochas[176] who embodies in much detail, in a patent granted in France, in 1860, all the features of importance of increasing the pressures of the gas before their explosion. The arrangement indicated by him was only put into practice about 1875 in the Otto engines, so-called Four-cycle. Prior to that, attempts had been made to compress the explosive mixture by means of pumps previous to its introduction into the cylinder of the engine. The failure to succeed was primarily due to the complication of the mechanical parts and also to the very great negative work; and also to the heat losses through the walls when compressing the gaseous mixture and to the loss of pressure in the charge in the passing of the mixture from the pump to the working cylinder. In combining the operations of suction, compression, ignition and expansion, and exhaust of the gas[177], all in the same cylinder, a part of the heat stored in the walls during the suction of the mixture is regained. During compression the heat generated could not be dissipated by the walls of the cylinder since they are at a higher temperature.[178] At the time of ignition a temperature as high as possible is obtained and as a result a very high pressure. The energy resulting from expansion is therefore very high. In 1882 no one had dared to undertake the construction of explosion motors of high speed.[179] The ignition of the charge had always been a difficulty in the construction of these motors. Ignition by electric sparks, used from the very first by Lenoir in his engines had only given mediocre results[180], owing to the lack of constancy in the source of electricity. Therefore after him, this method of ignition was replaced in

[176] **1909**, **Judge Hough**: "*In **1861** Million, and a year later* [in **1862**] *Beau de Rochas* [FR52593], *Siemens, and others, pointed out the advantage of compressing the gaseous fuel before ignition, in order that the expansion should be both greater and quicker, with the greatest possible pressure at the beginning of the expansive movement; and in **1872** Brayton in America, and in **1876** Otto* [US178023A] *in Europe, introduced compression engines, the latter with great commercial success*." **Francisque Million** engine patents : 08/06/**1857** - FR32348, 04/11/**1858** - FR38566, 27/06/**1860** – FR45740, 08/03/**1861** - FR48755.

[177] The four-cycle system.

[178] That insistence of Krebs in studying the flow of heat within the explosion engine, sounds very close to the Carnot's vision of the heat as a fluid: "*Peut-on concevoir les phénomènes de la chaleur et de l'électricité comme dus à autre chose qu'à des mouvements quelconques de corps, et comme tels ne doivent-ils pas être soumis aux lois générales de la mécanique ?*" (Op. Cit., p. 21).

[179] **1909**, **Judge Hough**:" *When he was ready to file his application, he had completed and experimentally operated one cylinder of a three-cylinder engine of the general type Brayton had patented in **1872** and **1874**. He intentionally built a plurality of cylinders, to obviate or minimize the necessity for a fly wheel. He produced an inclosed crank case (which immediately reduced weight to an enormous extent), and used a small piston with a short stroke (which made possible the speed that would compensate for the loss of piston head area).*"

[180] **1961**, **Greenleaf**, p.28: "*Lenoir had in **1860*** [FR43624A, US31722A, ES2140H1] *constructed a road wagon driven by his engine* [using gaseous fuel]. […] *In **1863** he built a vehicle with a lighter non-compression engine operating on a petroleum derivative. Employing an unspecified means of carburetion, this motor developed one horsepower and a speed of 400 r.p.m.* [...] *Lenoir abandoned his experiments with road vehicles, although this lighter motor continued to be used for propelling boats.* […] *The case of Marcus* [US286030A, US306339A, US503611A], *like that of Lenoir and many another automotive experimenter, illustrates how a pioneer may break off his efforts in the absence of a prevailing social need for his technological contribution*."

the motors of Hugon, Otto and Langen and Otto four-cycle, by flame ignition. On this account I was led to abandon the idea of using these engines for dirigible balloons[181]. It was about this time that incandescent tube ignition in four-cycle engines was introduced in these engines. An iron tube fastened to the wall of the cylinder was heated externally by means of an open flame to red heat. At the time of the compression the gas in the cylinder is driven into the tube, pressing ahead of it the inert gas of the previous explosion and at the moment when the gas comes into contact with the red hot walls of the tube it ignites and communicates the ignition to the whole charge. Daimler, by adopting this method of ignition, constructed small engines which now could be run at 600 revolutions and above. By thus increasing the speed of rotation, he thus succeeded in producing in the same time a greater number of power strokes, and consequently, succeeded in increasing the power produced for a given weight. In this way it had been through the combustion under constant volume that light and powerful engines have been realized, which it was possible to forthwith apply successfully to the construction of automobile vehicles. This result was accomplished as early as 1889. The engines with combustion under constant pressure on the other hand never gave any result until the appearance of the Diesel engine. In this engine the fuel is introduced as in the past, during a fraction of the power stroke of the piston, but to realize the great expansion indispensable for a great efficiency, Diesel was led to carry the pressure of the air, in which the combustion takes place to a pressure of 30 to 35 atmospheres. This pressure obtained directly in the cylinder raises the air to such a temperature that the fuel burns immediately upon introduction into the cylinder. Thus there was eliminated the little flame which Brayton required all the time in his engine in order to ignite his mixture as it entered the cylinder, which little flame was at the base of the cylinder.[182] Although the Diesel engine fulfills all the conditions requisite for a good engine it has not been possible to construct such an engine of small power and efficiently light weight to be utilized on automobile

[181] A. C. Krebs is here thinking of the danger of placing a flame under a balloon inflated with hydrogen. Several explosions injured people in the Chalais-Meudon aerostatic park.

[182] **1911**, **Judge Noyes**:" *This constantly burning flame (or other continuous ignition) was necessary to the operation of the Brayton constant pressure engine. It was the "living torch at the entrance of the cylinder" referred to in the Brayton patent. Its existence was not essential to the timed explosion operation of the Otto* [US178023A] *engine.*"

vehicles.[183] It can therefore be stated that with our present day knowledge that the constant pressure engine will always be inferior to the constant volume engine for the construction of light engines.[184] As early as 1875 the latter was already superior for the same reason to the constant pressure engine.[185]

Q48. Please state to what extent electric ignition was known in 1880?

Objected to as incompetent, it not appearing that the witness has made a careful investigation of the […].

A48. Lenoir had employed this type of ignition in his gas engine[186], but electricity was difficult and expensive to generate. Generally batteries were used. Bunsen cells involved objectionable care and generated noxious gases. For this reason it gave way to the use of ignition by pocketed flame (motor of Otto-Langen, etc.)

Q49. Was there in 1880 an electric ignition system which it was known to be practically used in a vehicle on an internal combustion engine running at 200 to 250 revolutions a minute?

Objected to as incompetent for the reason specified in the objection to Q48.

A49. No the ignition used by Lenoir had been abandoned. The source of electric supply was defective. All the internal combustion engines used flame, or hot tube heated exteriorly by a flame. The latter mode of ignition could only be used in four-cycle engines with combustion at constant volume.[187]

Q50. When did the Panhard & Levassor Co. begin to use electric ignition.

A50. The Panhard & Levassor Company commenced to use electric ignition in 1899[188].

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[183] On that occasion A. C. Krebs gives here his definition of the motor adapted to the automobile engine, he searched during so many years. The "*small power*" is never mentioned in the literature as a condition of the automobile success. See below the Krebs other mentions to the Diesel engine.

[184] That time A. C. Krebs states scientific truth in his testimony.

[185] A. C. Krebs refers here to his above mention: "*the Otto engines, so-called Four-cycle*."

[186] **1860** Gas engine Lenoir with electric ignition.

[187] This is another difference, never mentioned elsewhere, between constant pressure and constant volume engines.

[188] **1961**, **Greenleaf**, p.71: "*Shortly after **1900**, advances in factory technology improved the construction and performance of the gasoline engine. Sturdier cylinder castings became available when American foundries abandoned the cupola for the reverberatory furnace and produced a better quality of foundry iron. Automobile makers began to insist on a higher grade of craftsmanship in engine components. Unreliable "hot-tube" ignition became outmoded when the improvement of coils, spark plugs, and other appliances enabled a general shift to electric ignition. These and like developments contributed to the ascendancy of the gasoline automobile over those powered by steam or electricity*."

Q51. Was there a reason why the Panhard & Levassor Co. did not use electric ignition before that time?

A51. Apparatus for electric ignition did not afford a practical ignition for more than one cylinder at that time. It was necessary to find a distributor[189] with which a number of cylinders could be ignited from the same source of electricity. In all vehicles of Panhard & Levassor Co. operating with 2 or 4 cylinder engines, the distributing apparatus was very thoroughly tried before their final adoption for igniting the vehicle engines.[190]

Q52. Have you examined the electric ignition system used in the 3-cylinder Selden engine, and offered as exhibit 89[191] in the Ford suit? If so, state whether or no that system was known in 1880?

A52. I have examined the electric ignition system used in the 3-cylinder Selden engine, it did not exist in 1880.

Q53. Can the engines used in the Panhard & Levassor vehicles be operated with illuminating gas from the city mains?

A53. Yes, the engines run well that way. They have actually been used as stationary engines by supplying them with illuminating gas taken from the city mains[192].

Q54. What is the object of the carburetter in the Panhard vehicle?

A54. Its object is to produce from liquid hydrocarbon the quantity of combustible gas necessary to form with the quantity of air drawn in by the

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[189] A. C. Krebs patented his ignition distributor: GB190200452A, US708053A.

[190] **1900** - At the **Paris Exposition Universelle** A. C. Krebs, as an experienced electrician, remarks the Lohner-Porsche "Semper vivus" hybrid car and acquire for Panhard & Levassor the wheel hub electric motor patent (GB190018099) license for France, Great-Britain and Italy.**1903** - **Automotor-Journal**: "A 15-HP Lohner-Porsche petrol-electric car" fitted with Panhard & Levassor engine and the "*Electromagnetic regulator for admission-valves*" (patent **US**691638) designed by A. C. Krebs.

[191] **1909**, **Judge Hough**: "*The one-cylinder engine built by Selden on the three-cylinder casting in **1877-78** was put in evidence as Exhibit 47. Thereafter the cylinders of Exhibit 47 were all bored out or rebored, new working parts fitted to them, and the engine put into a vehicle, the whole called Exhibit 89, completed in the winter of **1905-06**, and constituting the first physical embodiment of Selden's patent. The complainant licensee, Electric Vehicle Company, also constructed a new engine from the patent drawings (Exhibit 132) and a complete vehicle (Exhibit 157). Defendants aver that neither of these vehicles is a Chinese reproduction of Selden's drawings, and have devoted volumes of print to recording and arguing about the performances of Exhibit 89. In my opinion Exhibit 89 as constructed was such Chinese reproduction. Exhibit 157 was not; complainants having changed the water cooling device, used only electric ignition and made some other departures from the mechanical details shown in the drawings.* […] *Whether in **1905** Exhibit 47 was any better than scrap, whether Exhibit 89 would start on flame ignition, whether Exhibit 132 showed diagrams revealing volume or pressure constant, were perhaps interesting, but unimportant questions. They raised a false issue, over which months of time and volumes of print have been expended*."

[192] The possibility for a Panhard & Levassor engine to run on city gas is not mentioned anywhere else.

cylinder, an explosive mixture such as gotten in gas engines using city gas[193] or water gas[194].

Q55. Have you been in the habit of consulting and studying mechanical drawings?

A55. Yes, this specialty is to me indispensable in directing the work and investigations which are being made under my direction at the Panhard-Levassor factory.[195]

Q56. Please examine the Letters Patent in suit and say whether or no you see a valve between the chamber marked 'T' and the smaller chamber at the left of it?[196]

A56. No, the line in the drawing which defines the limit of that small chamber at the left cannot represent a valve.[197]

Q57. In the patent it states on page 2, lines 1 to 10 that compressed air is admitted to the working cylinder with a definite quantity of liquid hydrocarbon injected by a pump into the combustion chamber 'T'. Please examine the patent and say whether or not a homogeneous mixture could be obtained by that method?

A57. Examining the drawing in figure 3, the liquid is injected right into the lower part of the chamber 'T', while air is supplied through the vertical wall at the back. Part of the liquid will certainly remain in contact with the lower wall of said chamber, another part might be projected into the current of air, but it is doubtful if the mixture so formed would be sufficiently

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[193] The Bisschop atmospheric gas engine (FR88488, US178121) is said "Bischoff" by Dugald Clerk, **1886**: "*The two most successful engines of the "engines igniting at constant volume but without previous compression" type were **Lenoir**'s and, later, **Hugon**'s* [US49346A] *for very small powers ranging from one man to half-horse. Simple forms of this type are still in extensive use. The most widely known of these is the **Bisschoff**, a French invention*." GAS, OIL, AND AIR ENGINES, **1896**, P. 50: "*An extremely useful little engine was introduced by Alexis de Bisschop, and also exhibited at Paris in **1878**. Patents dated **1870**,**1872**,**1874**. It resembles an atmospheric engine in principle, but the piston is not free.*" Les moteurs modernes, **1881**: city gas engine. **1870** Gas engine patented by Alexis de Bisschop of Paris: Some 2,000 engines were built in England before production ceased in **1894**.

[194] "Water gas". La Nature, **1907**: le "Le gaz à l'eau" ou "gaz pauvre".

[195] A. C. Krebs is an excellent designer. His drawings are reputed to get a photographic precision. He says in his **1924 autobiographic letter**: "*This brought me naturally to draw with precision and was, later, of great help for me. A diagram well-made translates better, for others, the thinking of the author, than all descriptions or explanations that can be given, when a construction or any machine is concerned. That practice of translating my thinking into a drawing had developed in me the ability of well seeing in the space, and I remember that, in the Special Mathematics class, my teacher was always sending me to the blackboard for the mathematic descriptive drawings executions in which he was often becoming confused*."

[196] The Selden patent.

[197] **1909**, **Judge Hough**: "*It may also be noted here that in my opinion Selden's original drawings indicate the existence of a check—or wicket-valve in the appropriate place.*" **1911**, **Judge Noyes**: *"Although no description is given in the specifications, any one familiar with Brayton engines can see the air pump of smaller capacity than the motor cylinder; the air reservoir containing air compressed by the pump, and the inlet valve admitting air to the cylinder. *** Altogether I have no difficulty in seeing that the intention of the inventor is to operate by the constant pressure method, although he does not say so specifically*."

homogeneous, and that the proportion by weight of the liquid vaporized and the air forming the mixture would constitute a gas readily and always combustible.

Q58. Is a homogeneous mixture necessary in Panhard vehicles, and if so, say why?

A58. A homogeneous mixture and one in which the gaseous fuel and air have a constant ratio is absolutely necessary for good running of the engine. If the mixture is not so obtained, it cannot be ignited or would be delayed, resulting in incomplete combustion and the deposit of carbonaceous material which would coat the cylinder and valves and soon stop the engine.

Q59. When did you see the Selden machine exhibit 49 in the Ford suit?

A59. I saw the machine for the first time Oct. 29th, 1906[198].

Q60. State whether upon seeing that machine it was completely dismantled and if sketches of the different parts were made at the time?

A60. I attended the complete dismantling of the engine. Sketches of different parts were made at the time with mention of the principal dimensions of parts in a way that they could be exactly represented in their relation to the machine.

Q61. Can you describe that machine which you saw?

A61. This engine[199] consists of three horizontal cylinders side by side having parallel axis. On one side are located the three cylinders forming air pumps; on the other side the three working cylinders. The piston of one of the motors and that of corresponding pump form a rigid part, both […] pistons supporting a yoke perpendicular to the axis of the pistons, in which yoke the crank pin of the shaft is located transverse to the three cylinders, its axis being at right angles to the axis the three cylinders and located in the same plane. The angles between the cranks are equal. On the pump side the cylinders are closed by heads in which the suction valves and delivery valves are located. The delivery valves are connected together by suitable pipes to a compressed air reservoir. On the working cylinder side the cylinders are closed by heads containing chambers as follows: opening into the cylinder is found a large cylindrical chamber the bottom of which joins a small chamber called 'T'. This small chamber is provided with a valve opening from the inside

[198] **1906** - A. C. Krebs probably spoke with Henry Ford on the occasion of that Selden exhibit in New-York.
[199] The Selden patent.

outward by means of a cam which is mounted on a shaft placed in the rear and below the cylinder heads, its axis being parallel to the crank shaft. The communication from small chamber 'T' with the large cylindrical chamber is closed by a very thin valve provided with steel leaves forming a spring. This valve is guided in the opening that it closes, by four small pins on the valve. A metal bushing of same diameter as the large chamber presses on the ends of the leaves forming the valve spring and maintain the latter on its seat. On this bushing are maintained ten metal gauze discs kept in place by a sort of sleeve fitting the large chamber and fastened by screws. The valve closing the opening to chamber 'T' and which, as said, opens from inside outwards, was provided with a small hole in the case of the right hand cylinder only. In the small hole was screwed a screw drilled axillary with a very small hole the size of pin of ordinary dimensions. In the case of the other two cylinders this same valve was not provided with similar holes and when on their seats there was no communication from the interior to the exterior as has been described for the right cylinder. Each cylinder head carried besides an exhaust valve opening inwardly actuated by a cam mounted on the cam shaft already described. The three valves closing outward by the chambers 'T' communicated by suitable pipes with the end of the compressed air reservoir to which we have already referred. These valves were moreover separated from the small chambers 'T' by pieces of wire gauze arranged in the chambers; besides in the common pipe connection between the valves and compressed air reservoir were thirteen pieces of wire gauze. The air on its way from the compressed air tank to the cylinders, when the valve closing the small chamber 'T' was open, had to pass through first the thirteen pieces of wire gauze in the air pipe, second the wire gauze located below the valve in the small chamber 'T', third after having finally raised the valve giving access to the cylindrical chamber it had to pass through the ten pieces of wire gauze which covered it. The head of the right hand cylinder was equipped with three small pumps the rods of which […] mounted on an extension of the cam shaft already described. These pumps drove the liquid hydrocarbon from the tank containing it, by means of a pipe leading to the suction valves of these pumps. The delivery valves of these pumps were respectively connected by means of pipes to their corresponding cylinders. These pipes lead into the small chamber 'T'. A small

check valve is located at the termination of the pipe at chambers 'T'. Every one of the large cylindrical chambers was provided with orifices leading outward and closed by means of plugs, one per cylinder. This plug consisted of an electric spark plug such as is actually found on motor vehicles.[200] The cam shaft was operated on the side opposite to the oil pumps by a train of three gears, causing it to turn at the same speed as the crank shaft. At the gear end the crank shaft supports an electric distributor permitting sending to each spark plug at the desired moment the secondary current of an induction coil actuated by a small storage cell. This induction coil provided with a trembler as well as the storage cell, are of comparatively recent type, being employed for causing the ignition of explosion engines in the ordinary type of automobiles.

Q63. Can you explain why wire netting or gauze was located in the pipe connecting the so called tank to the cylinders?

A63. This netting or wire gauze was placed for no other purpose than to prevent the combustion which sometimes propagates itself past the inlet valves, to reach the tank and cause it to burst.

Q64. Would the presence of wire gauze in the pipe be required if the so called tank did not contain anything else but air?

Objected to as leading.

A64. It would be useless, since pure air cannot be ignited.

Q65. Have you noticed iron wires on the piston heads of the working cylinders?

Objected to as leading.

A65. I noticed that nuts protruding above the piston and drilled to receive cotter pins were traversed by iron wires connecting them two by two; the appearance of the wire showed that it had been brought to a high degree of heat.

Q66. What is your opinion the reason for the presence of these iron wires?

A66. In the case of a four-cycle engine, compression preceding explosions, these wires, if brought to red heat, would cause pre-ignition, but in case of the motor in question, the mixture must be ignited as soon as it is introduced

[200] A. C. Krebs notes here the adjunct of an electric ignition by the complainants to the original design.

into the cylinder and these iron wires did materially assist the ignition of the gaseous mixture at the proper time.[201]

Q67. Can an engine vibrating to such an extent that the vibrations cause it to move itself bodily on the ground, be of any practical use in the case of an automobile?

A67. It is often more difficult to hold an engine rigid than to mount the same motor on a vehicle frame equipped with springs interposed between the frame and the axles. Many of the engines installed on the first automobile vehicles were unbalanced[202] and the vehicles were shaken by the vibrations of the engine. These motions of the vehicle, which were very apparent when the vehicle was standing still, disappeared, or rather became neutralized or reduced, by the vibrations resulting from the running of the vehicle on the road. There are cases of trip hammers mounted on elastic foundations, which do not show signs of strains, although they are constantly vibrating. It would be next to impossible to attempt to maintain them rigidly fastened to the […] vehicle, regardless of its vibrations.[203]

Q68. Would an engine rotating at the rate of one hundred revolutions per minute, then stopping, be of any practical value in the case of an automobile vehicle?

Objected to as immaterial.

A68. No. What is required above all of an automobile engine is the capacity to run indefinitely, so to speak, without stopping, and to be always ready to deliver the power necessary to overcome resistances met.[204]

Q69. Can an engine running for 20 minutes and then stopping be considered practical for an automobile?

Objected to as immaterial.

A69. No. At the time of stopping one may have to cover a certain distance to avoid accident. The driver must therefore in running an automobile always

[201] This fact which differentiates the two classes of engine is never mentioned elsewhere.
[202] A. C. Krebs patented a balanced engine: FR306968A, GB190114881A, US778542A.
[203] A. C. Krebs has always paid attention to vibrations in the construction of his cars. He patented several times (patents: FR30714, US700950A) the feature known as the "*three-point suspension system*" of the engine. Henry Ford patented as well this feature in the US. Krebs used extensively this system in his 1896 and 1898 patents (on engine and frame suspension). Ford used extensively this system in his Model N, before his Model T in 1907.
[204] A. C. Krebs defines here what he intends under the term of "*practical*", in such a way it can be understood as complementary to his above automobile definition. See above notes.

be able to count upon the engine to deliver the work required by circumstances.[205]

Q70. What is the power developed by the Panhard engine constructed for automobile uses?

Objected to as indefinite, for the reason that no particular automobiles are referred to, and for the additional reason that whatever the defendant may have done since this suit was commenced is immaterial.

A70. Their power varies from 10 to 130 horse-power.

Q71. What is the weight of the 130 horse-power motor?

A71. Its weight, including the fly-wheel, but without accessories, such as the water circulating pump, carburetter and magneto reaches about 230 kilograms.

Q72. Have you ever seen an Otto-Langen engine, and if so when did you see one for the last time?

A72. The Societe Panhard & Levassor owns one of these engines and I saw it about two months ago.[206]

Q73. Have you ever operated an Otto-Langen engine? If so, when have you done so?

A73. Two years ago, I operated an Otto-Langen engine owned by Panhard & Levassor Co. It is the last one in the series of engines which had been constructed by Panhard & Levassor Co. some 20 years ago[207].

Q74. Do you know the construction and the principle of operation of the Otto-Langen engine?

A74. Yes, all the necessary documents concerning their construction are kept in the files P. & L. I have examined them some two years ago, when I ran the engine still in possession of P. & L.

[205] A. C Krebs is a very good driver. He exhorted his crews to drive safely when they were making trials in the streets outside the factory. He says here that the engine power is at the same time a factor of danger and a factor of safety. That duality of the automobile behavior is plainly understood by the engineer. Next year he will patent a motor brake: FR376040A, GB190802328A, US934547.
[206] It seems that the A. C. Krebs recent interest given to this ancient motor been motivated by the Selden case.
[207] Otto-Langen engine constructed by Panhard & Levassor Co. some 20 years ago.

Q75. Please examine the French patent No. 116,871, granted to Rosenwald, under the date of February 3, 1877[208], and state whether or not you understand it?

A75. This patent describes a system of locomotion, in which a gas engine mounted on a vehicle transmits its power to the rear wheels of the vehicle. The drawing annexed to the patent represents very clearly an Otto-Langen engine, placed forward of the carriage body and back of the driver's seat. This engine transmits its power by means of mechanical devices so arranged that there can be no doubt left, as to the possibility of their satisfactory operation.

Q76. Kindly state whether or no the Rosenwald patent, as described and illustrated by the drawing, leads to the belief that such a vehicle could be operated, and give the reasons upon which you base your opinion?

A76. The examination that I have just made of this document permits me to certify that this vehicle should operate. The engine is of a known type, having been proven successful, and the mechanical arrangements adopted to transmit its power to the driving wheels are of a nature to obtain the results sought. As far as the engine is concerned, its supply of gas is assured by a tank in which it is stored. The cooling of the cylinder is provided for. The driver has close at hand a clutching and unclutching mechanism, as well as a braking device combined with the unclutching mechanism. Finally, the steering of the vehicle is effected by moving the fifth wheel, by means of a lever placed in the hand of the driver.

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[208] **1909**, **Judge Hough**: "*Rosenwald 208 (French 116,871) made a picture of a brougham having an Otto free piston engine perched in an apparently insecure position between passenger and driver. His is a paper patent only, and is in my opinion clearly shown to be inoperative for reasons of which one only may be mentioned: The most improved type of Otto engine then known weighed over half a ton per horse power. He did not use the most improved type, and did not propose any improvement or modification which would have prevented his brougham from going to pieces at the first jar of his motor.* […] *The inventive act is shown by comparing Selden and Rosenwald. If the latter's brougham had actually carried its engine, and traveled even a little, he might nevertheless (on defendant's own argument) have found his patent invalid by American law, because each part of his vehicle was doing just what it had always done, without any new "co-operative law," while his engine in particular was the same motor which, before it was applied to the brougham, had perchance driven a lathe and might to-morrow do something else. Rosenwald might have been held a mere aggregator (however successful); but Selden's combination cannot be taken apart, and each element recognized as something that had done the same thing or sort of thing before*." **1911**, **Judge Noyes**: "*The Rosenwald French patent of **1877** was for a carriage propelled by a non-compression gas engine. This vehicle had reducing gears and a clutch or "disentangler." The engine described was of the free piston type and was poorly adapted for use in a road locomotive*." **1961**, **Greenleaf**, p.28: "*That such components were available to contemporary inventors is demonstrated by Rosenwald patent granted by French government in **1877**. The Rosenwald road carriage, specifying an Otto and Langen motor, included every basic feature of an automobile except a compression gas engine. Anxious to secure a comprehensive patent, the inventor claimed "the exclusive exploitation of any system of locomotion by gas". Had Rosenwald built this vehicle, its engine probably would have made the carriage unfit for road travel*."

DIRECT EXAMINATION FINISHED AT 2:40.

Counsel for plaintiff states that he does not understand that the direct examination is closed and will not be closed until the same has been translated into English language and desires the witness […] beginning the cross-examination.

Counsel for defendant states that the deposition was taken in the French language which he does not understand contrary to his request solely at the request of Mr. S. R. Betts, and further that he will produce the witness for examination at 10:30 tomorrow and if complainant will not the proceed he will request the examiner to close the deposition.

Counsel for complainant calls attention to the fact that what had been taken down is not in fact a deposition, was not commenced as a deposition should be commenced, and in fact was not intended to be a deposition.

ADJOURNED till Saturday November 4, 1906, same place at 10:30 A. M.

NOVEMBER 5TH, 1906.

Met today pursuant to adjournment November 3rd, 1906.

PRESENT:

Commissioner Shields,

Messrs. Murray and Parker[209] for the defendants,

Messrs. Betts and Peters for the complainants.

Counsel for the defendants offers in evidence the following exhibits:

Defendants' counsel offers in evidence letter from L. F. de Peugeot to Panhard & Levassor, dated 17th of March, 1890. Same is marked defendants exhibit No. 178, Nov. 3, 1906, J. A. S. Exr.

Letter from L. F. de Peugeot to Panhard & Levassor, dated July 30, 1890, and the same is marked defendants exhibit No. 179, Nov. 3, 1906, J. A. S. Exr.

Letter from A. Peugeot to Levassor, dated October 3, 1890, and same is marked defendants' exhibit No. 180, Nov. 3, 1906, J. A. S. Exr.

Letter from L. F. de Peugeot to Panhard & Levassor, dated 1890, and the same is marked defendants' exhibit No. 181, Nov. 3, 1906, J. A. S. Exr.

Paper entitled "attestations", and the same is marked defendants' exhibit No. 183, NOV. 3, 1906, J. A. S. Exr.

Catalogue of Panhard & Levassor, dated January 1892,[210] and same is marked defendants exhibit No. 183, Nov. 3, 1906, J. A. S. Exr.

[…] and the same is marked defendants exhibit No. 184, Nov. 3, 1906, J. A. S. Exr.

Catalogue of Panhard & Levassor, dated December 1, 1895, and same is marked defendants' exhibit No. 185, Nov. 3, 1906, J. A. S. Exr.

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[209] **1961**, **Greenleaf**, p.133: "*The defense of the three Ford suits was shouldered almost completely by Ralzemond A. Parker. With his rumpled clothes, wide-brimmed hat, and open Midwestern manner, Parker had a rural air that was in sharp contrast to the poise and polish of his Eastern adversaries. According to a friendly New York attorney who made his close acquaintance, Parker "knew more about the case than anyone connected with it."* " P.134: "*Parker stressed that the example of Winton's surrender must not be followed by any of the defendants. "We expect this fight to be fought out to a complete finish," he wrote to his [Panhard] French allies, "and in the event that you will join us to this extent in affording us aid requested against the common enemy we assure you that no arrangements will be made whereby your confidence will be betrayed or wherein you will be left to yourselves in any fight of your own."* " P.182: "*For a time it seemed that Ford might stand alone in opposing the A.L.A.M. In January, 1905, the independents were taken aback by the announcement that Panhard & Levassor had capitulated. André Massénat, manager of the New York branch of the French firm, acknowledged the validity of the Selden patent and agreed to the entering of a consent decree. The settlement provided for an adjustment on back royalties and payments on future importations. The unqualified surrender brought high elation in the A.L.A.M., which informed the trade that Panhard cars might "now be purchased with license tags affixed, and without liability to prosecution." But victory was short-lived. The French manufacturers, denying that Massénat had authority to act in their behalf, repudiated the settlement. The A.L.A.M. promptly renewed the suits against Panhard & Levassor, and unity of purpose and action was restored in the unlicensed camp*."

[210] Catalogue Panhard & Levassor **1892**.

Article entitled "Voitures automobiles", commencing at page 198 of La Nature of August 25, 1894,[211] and same is marked defendants' exhibit No. 186, Nov. 3, 1906, J. A. S. Exr.

Catalogue of Panhard & Levassor, dated July 1895,[212] and same is marked defendants' exhibit No. 187, Nov. 3, 1906, J. A. S. Exr.

Article entitled "Course des Voitures automobiles", commencing at page 84 of La Nature, dated July 6, 1895,[213] and same is marked defendants' exhibit No. 188, Nov. 3, 1906, J. A. S. Exr.

Catalogue of Panhard & Levassor, dated 1891,[214] and same is marked defendants' exhibit No. 189, Nov. 3, 1906, J. A. S. Exr.

Catalogue of Panhard & Levassor, dated July 1896,[215] and same is marked defendants' exhibit No. 190, Nov. 3, 1906, J. A. S. Exr.

Counsel for the defendants states that he will give a translation of the testimony so far given, it being understood that the same is subject to correction and an agreement between counsel as to a correct translation. If they cannot agree then the Commissioner shall appoint a translator to decide the questions which may arise.

The cross-examination of the witness is adjourned to this office at 2 o'clock Monday, November 5, 1906.

[211] **1894-08-25** - *La Nature*, ed. Masson, Paris: "VOITURES AUTOMOBILES".
[212] Catalogue Panhard & Levassor **1895**.
[213] *La Nature*, 06/07/1895, ed. Masson, Paris, **1895**: "COURSE DES VOITURES AUTOMOBILES".
[214] Panhard & Levassor catalogue **1891**: unidentified.
[215] Catalogue Panhard & Levassor 1892. Catalogue Panhard & Levassor 1897. Catalogue of the new Panhard & Levassor Co 1898. Catalogue of the new Panhard & Levassor Co 1908. Catalogue of the new Panhard & Levassor Co 1909. Catalogue of the new Panhard & Levassor Co 1914.

November 5th, 1906.

MET PURSUANT TO ADJOURNMENT.

PARTIES PRESENT AS BEFORE.

CROSS-EXAMINATION BY MR. BETTS.[216]

XQ77. When did you arrive in this country?

A77. On the 26th day of October last.

XQ78. What was the object of your coming here?

A78. I came to answer the questions which I may be asked about the Selden case.

XQ79. Did you come over from Europe specially[217] for that purpose?

A79. It has been the cause of my trip.

XQ80. What conferences have you had in Europe about your testimony before coming here?

A80. No discussion whatever.

XQ81. Who asked you to come here?

A81. The firm taking care of our interests in New-York – Coudert Brothers.

XQ82. When was that request made?

A82. Several months ago.

XQ83. Tell me just when?

A83. I do not remember when, as I only studied this case shortly before leaving.

XQ84. Did Coudert Brothers write you on the subject of your testimony?

A84. Messrs. Coudert Bros. wrote to the firm of Panhard & Levassor asking them to send to America some member of the firm as well posted as possible on the subject, for the purpose of testifying.

XQ85. Did you see the letters written by them?

A85. No, I have not seen these letters.

XQ86. Have you read before testifying any of the evidence concerning the Selden patent?

A86. I believe that I saw for the first time the Selden patent in 1903. I have not seen any description, evidence or testimony relative to this suit.

XQ87. Has a resume of the evidence been given to you?

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[216] See above notes regarding counsels involved in this case.
[217] Sic.

A87. I have only been told of its substance since I have been under examination.

XQ88. Who have you consulted about your testimony here?

A88. The firm of Coudert Brothers.

XQ89. Have you had conversations with Mr. Jesse Smith[218] or Professor Carpenter[219]?

A89. I saw these gentlemen for the first time on the 29th of October last, but as I do not understand the English language I was only able to watch as a spectator the taking apart of the Selden motor which these gentlemen were having done.[220]

XQ90. Have you read or been told of then testimony given by Dugald Clerk?

A90. No. This is the first time that I am told about it.

XQ91. Have you ever seen or read a book written by Dugald Clerk on the subject of gas engines?

A91. No, I have never seen or read this work.[221]

XQ92. Can you read books written in English language?

A92. No. I cannot.[222]

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[218] See above the A. C. Krebs letter where he speaks of Mr. Smith, Jesse M., he met with his brother-in-law Charles de Fréminville during his first travel to America in 1885, for the Paris fire brigade purpose. "**Voyages de Charles de Fréminville aux États-Unis (1885, 1898, 1913, 1919) - Lettres à son épouse Rachel**" (Textes transcrits et rassemblés par Yves Le Quesne", non édité, **2001**), p.26: "*Mercredi 21 octobre* [**1885**]. *[…] vers 8h1/2 nous allons trouver Mr Jean Smith, ingénieur ancien élève de l'École Centrale* [as de Fréminville was]. *Nous avons reçu de lui un excellent accueil. Il a paru un peu désappointé quand il sut qu'Arthur ne parlait pas anglais. Il a été obligé d'aller chercher son français dans les profondeurs où il avait dû sommeiller pendant bien longtemps. Il nous a conduits à une fabrique de wagons très bien montée et où j'ai fait une visite très intéressante. J'en ai rapporté beaucoup de renseignements et de photographies. Il nous a ensuite fait dîner et nous a conduits à ses machines électriques, qui ont beaucoup intéressé Arthur [A. C. Krebs]. Pendant toute cette journée nous avons beaucoup causé sur Détroit et ses habitants, ses industries. Ses principales industries sont la fabrication des meubles, des poêles, des wagons [aim of the de Charles de Fréminville travel], enfin le commerce du grain y est très important. Depuis notre arrivée à New-York nous ne cessons de nous extasier sur la manière dont les Américains travaillent le bois. Dans toutes les chambres on a des jalousies qui sont de vraies merveilles. Les voitures* [à cheval] *sont d'une légèreté et d'une élégance incroyable, même les voitures de campagne.* " Note that Panhard & Levassor before being an automobile builder was a wood sawing machine builder from **1855**, under the name of Périn-Panhard Co. So, A. C. Krebs, when general manager of the company, patented many improvements in sawing machines and the firm will continue to sell saw blades in the US after WWI.

[219] **1961**, **Greenleaf**, p.132: "*Professor Rolla C. Carpenter of Cornell University, a leading authority on the internal combustion engine, appeared as an expert witness for the defense.*" **1961**, **Greenleaf**, p.141: "*He offered an illuminating analysis of the prior art and showed that in some respects Selden had less to offer than his predecessors. Carpenter devoted much of his testimony to the basic differences between the Selden engine and the Otto-type motor of the Ford car. He presented a concise comparison indicating that in at least fifteen particulars the Otto-type engine bore no resemblance to the modified Brayton motor shown in the Selden patent. In contrast with the weak performance of Bentley, the testimony of Carpenter was closely reasoned and supported by an abundance of factual reference. To the opposition lawyers, it posed anew the necessity for a vigorous rebuttal*."

[220] A. C. Krebs says in his above letter that Mr. Smith can speak French.

[221] We will see below that it is the truth.

[222] We will see below that it is not the plain truth.

XQ93. Did you ever hear of Dugald Clerk[223] of England as an authority on gas engines?

A93. Yes, vaguely.

XQ94. Did you ever hear of what is termed the Clerk Cycle for gas engine?

A94. I do not remember.

XQ95. Who do you consider as an authority on gas engines?

A95. I have always considered that in gas engine matters the men who have succeeded in making a step forward were practical men -- not theoretical men -- with the exception of Beau de Rochas. The theoretical men have built theories that have not been confirmed by actual practice.[224]

XQ96. You have mentioned only the name of Beau de Rochas. Are there other authorities that you recognize?

A96. Every one of the men who study this subject with the view of establishing its theory are interesting, but at the present time we are not sufficiently in possession of the factors that would enable us to fully understand the reasons why it is possible to transform into work only a very small part of the heat developed in the combustion from which we are trying to realize work.[225]

XQ97. I ask you if you know the names of any others than Beau de Rochas, whom you recognize as authorities or experts on the subject of gas engines?

A97. I cannot cite the name of any one in preference to the other, each has contributed his stone in the up-building, of the edifice.

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[223] **Clerk**, **Dugald**, **THE GAS AND OIL ENGINE** (6th edition, Longmans, Green Ed., London, **1896**): "*The Daimler motor carriage has come into considerable prominence in connection with the recent trials of horseless carriages in France. The author has carefully examined one of these carriages.* [...] *In the author's opinion this carriage, ingenious as it is, will not find much use in England. A carriage, however, using heavy oils and overcoming the difficulties would probably be very successful.*" **1961**, **Greenleaf**, p.67: "[…] *William B. Greeley, who in December, **1899**, sailed for London to consult* Dugald Clerk, *widely respected as the most eminent living authority on the internal combustion engine. At length Clerk announced that the patent was valid, basic, and controlling in the art.*" **1961**, **Greenleaf**, p.145: "*Clerk is said to have received a retainer of $20,000 and a liberal allowance for expenses.*" **1961**, **Greenleaf**, p.147: "*More than this, the Scottish expert placed the stamp of his authority upon a sweeping classification of all compression internal combustion engines under a single rubric. Selden, he said, had "appreciated the advantage of the compression cycle, adapted it to the purpose of a motor vehicle, showed one form of engine which was powerful in proportion to its weight, and thereby disclosed to the world for the first time an effective combination of a liquid hydrocarbon gas engine of the compression type with the other elements mentioned in his combination."* " **1961**, **Greenleaf**, p.148: "*Toward the close of his testimony, Clerk more than once expressed unfamiliarity with American patent law. He was concerned that he had made contradictory and untenable statements*."

[224] See above his explanation about his study of his automatic carburetor, and our notes. This phrase is a profession of faith. A. C. Krebs considers himself as a "practical man" experiencing theories.

[225] Clearly, A. C. Krebs considers himself as an authority on gas engines, and we will see below he represents the French firms in America in that trial specifically for that reason. So, he does not want to admit he acknowledges another authority than him. Nevertheless, his derivative argument states his present technical research of far reaching extend as efficiency is still the main purpose of petrol engine research today.

XQ98. Do you consider yourself an authority on gas engines, or only as a stone-carrier?

A98. No; I believe that I have carefully studied the subject and know it well enough to enable me to appreciate the direction in which work can be done to effect successful improvement.

XQ99. Do you consider that Beau de Rochas and your-self are only ones you can mention?

A99. Such has never been my intention. Beau de Rochas has been a pioneer, who had foreseen without being able to realize a method of operation, which was only brought to light in practice about 15 years later. From that point of view there can be no question as to how my personality figures in this matter.[226]

XQ100. Do you recognize any American as an expert and authority on the subject of gas engines?

A100. In principle, in order to explain phenomena, hypotheses are advanced upon which theories are built. Such theories may be used as a guide in practice until they are disproved by results.[227] Those initiating the establishment of

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[226] This reference by A. C. Krebs to his "personality" is very rare. He states that his contribution in the history of the petrol engine is that of a "practical man".

[227] The Automotor Journal (January 10, **1903**) p.43: "*THE KREBS CARBURETTOR.* […] *In his paper before the Académie des Sciences, Commandant Krebs introduces a lot of calculations and formulæ to show how he obtains the form of the additional air apertures. It is noticeable that in these calculations he omits to allow for increasing tangential friction of air at increased velocity, and also assumes that the amount of petrol spayed from the nozzle is directly proportional to the speed of the air current around it. His calculations, however, give a practically satisfactory result, because the above errors are counteracted by another mistake. When an engine runs at one time at twice the speed at which it does at another, each piston stroke takes place in half the time at the higher speed. Consequently, the rate at which the fuel issues from the nozzle of the sprayer must be twice what it is at the lower speed to supply the same amount of fuel. This consideration seems also to have been omitted from his calculations by Commandant Krebs. The result of the two errors appears to have been compensate one another, as he appears to have given the right shape to his apertures, since, as we understand,* ***the carburettor works admirably in practice****. We think it very likely that the shape given to the apertures was arrived at by repeated experiments, and that the calculations were an afterthought introduced for the benefit of the Academy of Sciences.* […] ***The results obtained with this carburettor are of very considerable importance from a practical point of view****. In the first place,* ***it enables the carburation to be kept at its lowest possible limits****. The driver does not need to trouble in any way about the carburation, either when starting or running, and* ***it is independent of variations of temperature in the atmosphere****. The carburation is always good, and if the ignition is in proper condition the motor always starts at the first turn of the starting handle. It enables the adjustment for additional air, usually mounted on the dash-board, and the feed of hot air to be completely suppressed, together with* ***the resulting complications which even the most experienced driver can never succeed in adjusting except more or less approximately****. The temperature at which the mixture is made is constant, as the mixing chamber is water-jacketed, as may be seen in the illustrations, and the water in its jackets takes part in the general circulation, and does not form simply a pocket off it. Freezing up is also rendered impossible.* ***All these details form a very important improvement, obtained by very simple means****, and this makes it of still greater value. In the second place,* ***the constant degree of the carburation at all speed enables the motor to be run at a very small number of revolutions without losing the power of each stroke****. For instance, if the change-speed lever be put on the third speed, which might give under ordinary circumstances a speed of 50 kiloms. an hour, and it is desired to run only at 10 kiloms. this can be effected by reducing the speed of the motor from 1,000 down to 200. The power of the motor when the speed is reduced from 1,000 down to 200 is, of course, diminished, since it is proportional to the number of revolutions, but t****he power of each stroke remains the same****, and this may verified by means of a Prony brake.* ***A considerable increase of flexibility consequently results****. The new carburettor* ***may be applied to every size of motor****. The dimensions, of course, will necessarily be varied according to the power of the motor.* […] *Applying the new carburettor to a motor requires no structural alteration. The valve for the additional air will when working be observed*

a theory may be looked upon as authorities, in the case of all apparatus which confirms their hypotheses. This is just what has taken place in the history of gas engine. At the present time these engines are divided into two types of operation, the motors in which combustion takes place at constant pressure, and those in which combustion takes place at constant volume. The former which at first were in favor with constructors have been greatly surpassed at the present day by the second. Eminent Americans have been paying attention to these different motors and their principles of operation, and therefore can be consulted to advantage.

XQ101. Give me the names of Americans whom you recognize as authorities on the subject of internal combustion engine?

A101. I cannot give the name of any one who was such when he was practically working on the subject. Thus Brayton did devise and construct an engine which for his time and for the object intended was of interest.

XQ102. Did you see the three Brayton engines in a garage in New York October 29, 1906?

A102. Yes, I saw three old engines which appeared not to have run for a long time.

XQ103. When did you see for the first time an internal combustion engine of the Brayton compression type?

A103. October 29th last at an automobile garage.

XQ104. Do you think that the three Brayton engines which you saw 29th, 1906, would be capable of propelling a vehicle on ordinary roads in the condition as they then were?

A104. It does not appear that these motors were constructed for the purpose of being put on a vehicle to propel it.[228] They are engine too heavy per horse power and constructed for quite a different purpose than for propelling vehicles.

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to rise and descend behind the apertures, according to the number of revolutions the motor is making. If it is desired to employ carburettors for alcohol instead of petrol, it is sufficient to change the sprayer nozzle and replace it by a somewhat large one." See above the phrase where A. C. Krebs says he calculated first the theory of his automatic carburetor before experimenting it.

Note: **1913**-05-26 - Panhard & Levassor Management Committee**:** "A. C. Krebs: *"The United States is asking to purchase our **1903** carburetor patent, which is still valid for 5 years. We send 2 proposals: 1° Sale of the patent for $ 10,000, 2nd License for cash $ 2000, plus $ 1 per carburetor"*."

[228] A. C. Krebs says here that the adaptation of the Brayton engine for automobile purpose was a question of "construction", that is to say an engineering question, not an inventing question. This appears to be consistent with what he said above, regarding the usefulness of theories in respect to practices.

XQ105. For What kind of work do you think that these three Brayton engines, as far as you know were built?

A105. It would seem that one was intended for a shop motor, while in the two others from the arrangement for effecting the two directions of the drive of the power shaft it would seem they were constructed to be put in boats.[229]

Adjourned until Wednesday morning at 10:30, same place.

[229] A. C. Krebs is very aware on boat propulsion as he designed "in **1882** an electric boat at Chalais-Meudon" for his aerodynamics studies. In **1886** he designed an electric trial boat for the "Gymnote" submarine project. He designed in **1888** a steamboat fitted with his fire steam engine. In **1895** he convinced Panhard & Levassor to equip a boat for the Paris races on the Seine with one of their petrol engines: "A. C. Krebs has been the main promoter of motorboating in Europe as soon as **1895**", etc.

NOVEMBER 7TH, 1906.

PARTIES PRESENT AS BEFORE.

CROSS-EXAMINATION BY MR. BETTS.

XQ106. Is the Brayton engine which you referred to in answer to question 101 an internal combustion engine of the compression type?

A106. As this question is put it does not define the method of operation of the Brayton engine unless one knows it.

XQ107. Can you describe the principle of operation of the Brayton engine[230] referred to by you in question 101 and state if this engine is a compression engine or a non-compression engine?

A107. In reply to question 100 I have stated that engines may be divided into two main classes. At the time Brayton made his engine it was known that engines of either class should be operated with previous compression. The Brayton engine as I know it is a compression engine included in the class of constant pressure combustion engines.

XQ108. Are the Panhard and Renault engines, which are involved in the present suit, compression engines?

A108. These engines, like all engines of to-day, are compression engines, but to completely define them one must add that combustion takes place at constant volume.

XQ109. […] in suit a compression engine?

A109[231]. In the specification of the Selden patent it states in line 105 et seq. that the engine used is of the compression type, but this phrase is absolutely vague and would not define the type of engine used if not supplemented by the brief description that follows, and by the annexed drawings.[232] In studying closely that description and consulting the drawings

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[230] **1961**, **Greenleaf**, p.15: "*The Brayton* [US125166A] *was indubitably a constant pressure engine. The burning mixture increased in volume, but the pressure in the working cylinder never exceeded that in the external compressor. In operation the Brayton resembled a steam engine, and contemporary observers were quick to draw the comparison. The converted Brayton favorably impressed experts who weighed its merits against those of the clattering Otto and Langen. Its smooth action, and its capacity to run on petroleum fuel, soon brought the motor into use in many shops. Made and marketed in the United States and Great Britain, the Brayton, although inferior to the Otto and Langen in operating economy and efficiency, was free from excessive vibration. Some of the larger Brayton motors yielded as much as forty horsepower*."

[231] Noted "XQ109." In the original text.

[232] **1909**, **Judge Hough**: "*I have already tried to show that Brayton's petroleum engine, Lenoir's illuminating gas engine, and an Otto machine driven by gasoline, are now, and were in **1879**, not only "gas engines" in the sense that they all operate on the same scientific principles, but they were known as and called "gas engines," by those best qualified to speak* [ie. Dugald Clerk]. […] *The force of these objections, based on the face of the drawings and specifications, as compared with the claims, depends on whether the patent is viewed as*

one recognized quite clearly that the Selden engine belongs to that type of combustion engine under constant pressure.

XQ110. Do you recognize a type of internal combustion engine which is a non-compression type?

A110. Pressure and compression are only relative. For instance, the Lenoir engine, in which admission was at atmospheric pressure, was said to have no compression, but there were always the atmospheric pressure[233]. In certain cases the pressure at which combustion takes place may be below atmospheric pressure.[234] This happens in some cases when regulating the power. It is on this account that the term "internal combustion engine of compression type" is a very vague term and does not determine a type of engine.[235]

XQ111. In the Lenoir engine does not combustion take place at constant pressure or constant volume?

A111. Combustion takes place at constant volume.

XQ112. Why do you use a Lenoir engine on your Panhard […]?

A112. We actually do use a Lenoir type[236] of engine, a type improved according to the theories of Beau de Rochas. That is to say an engine in which the pressure of the gaseous mixture is raised as high as possible at the time of ignition. Combustion takes place at constant volume, and very quickly on account of the high pressure at which it takes place.

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a primary or pioneer one […]." **1911**, **Judge Noyes**:" *It is true that in the specification and drawings he described and showed a particular type of engine* […] *So without any expert opinion we should have no difficulty in determining that the engine of the patent is of the Brayton two-cylinder constant pressure type. And the testimony even of the complainants 'expert is to the same effect. Mr. Clerk said in his testimony that the reference in the patent to existing well-known engines was to the Brayton constant pressure engines*."

[233] **1909**, **Judge Hough**: "*Compression is a relative word. Men can for short periods live and work in a caisson where the air is compressed; but a Lenoir engine, if it could operate in the caisson would be a non-compression engine still, though using the air of its immediate environment. It is density of fuel, as compared with the air into which the engine exhausts, that determines and defines compression. This seems overlooked in some of defendants' cross-examination (Clerk, x-Q, 156-163), and neglected in some portions of their argument*."

[234] The fact that pressure inside the cylinder at the time of ignition can fall below atmospheric pressure seems not known by other experts at the trial. A.C. Krebs will be asked below for more explanation on that matter, and this issue will be discussed until the very end of this testimony. **Clerk**, **Dugald**, **THE GAS AND OIL ENGINE** (6th edition, Longmans, Green Ed., London, **1896**): "*To carry it out in a perfect manner, the mechanism must be so arranged that during the charging, the pressure of the gases in the cylinder does not fall below atmosphere; there must be no throttling of the entering gases*." In **1896** Clerk seems not a regulation on admission partisan. In his **1913** edition of his book, he mentions many cases he explains this way: "*The piston while moving from the point 1 to the point 2 takes in the charge; the pressure in the cylinder falls below atmosphere as the piston approaches the end of its stroke. This is due to the resistance of the valve port to the entering air and gas*."

[235] **1909**, **Judge Hough**: "*The change from a gaseous fuel burning at atmospheric pressure to the same fuel burned under compression was a change of kind; for, though formed of the same chemical elements, the compressed fuel possessed a power, when used by men who live by breathing atmospheric air, that uncompressed and commercially possible gases did not and could not exert in any non-compression engine even as yet imagined. It therefore seems clear that the phrase "compression type," as applied to internal combustion engines, is reasonably indicative of a class, and appropriately describes an unmistakable and invariable species of the genus gas engine*." **1911**, **Judge Noyes**: "*In our opinion the statement in the patent that any form of compression engine may be employed is inconsistent with the intention disclosed by the patentee in the patent as a whole and should not have too much stress laid upon it*."

[236] Underlined in the original text.

XQ113. Did Beau de Rochas ever make an engine in accordance with the theories you mention?

A113. I stated in answer to question 99 what Beau de Rochas has done. He enunciated a theory which had never put into practice until fifteen years after his death.

XQ114. Who first made an operative engine based on the Beau de Rochas theory?

A114. The Otto "four cycle" engine.

XQ115. Who was Otto? Can you say where and when he made and operated the first four-cycle engine you refer to?

A115. Otto was, I think, a German whose work on gas engines is very important. After the Lenoir engine had proven to be so mediocre, he built with Langen the engine called "Otto and Langen", which had a great expansion. Later, by applying the Beau de Rochas theory, he built about 1873 the engine bearing his name and operating on the four cycle principle.[237] It is since that time that engines operating with gas or petrol or liquid hydro-carbon have given results capable, in respect to efficiency, of comparison with the best steam engines.[238]

XQ116. You give 1873 as the date that Otto actually constructed his four cycle engine. Is it not rather in 1876 that he built that engine?

A116. Otto's work on this question dates back to 1870. I cannot, therefore, give an exact date to the appearance of his engine. To be definite on the subject it suffices to refer to the date of his patent. But of this I am certain, that in France their commercial production was entrusted to the Panhard et Levassor firm before the exposition of 1878. During that year while at the aeronautic station I bought and accepted, at the shops of that firm, a two horse power Otto four cycle engine for installation at the balloon sewing shop, which installation I referred to at the beginning of these interrogatories.[239]

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[237] **1961**, **Greenleaf**, p.31: "*Between **1874** and **1886** the Otto factory at Deutz, enjoying the protection of German patent rights, enforced a monopoly over this type of engine. But other makers challenged the Otto claims, holding that they could not rightfully cover the principle originated by Beau de Rochas* [FR52593] [in **1862**]. *After a four-year legal battle before the courts of six European countries, the scope of the patent was reduced. In **1886** Otto was forced to vacate the controverted claim*."

[238] This comparison of efficiency between steam and petrol engines is rarely mentioned in that time.

[239] See notes above referring to A. C. Krebs experiments on explosion engines during his aerostatic period. Note that speaking of the "balloon sewing shop" Krebs keeps in mind the wood sawing as well (see notes above). Actually, he designed in **1880** a sawmill dedicated to the silk cloth cutting of gores for balloons envelopes.

XQ117. What is the weight complete of the Otto four cycle engine which you state you purchased from the Panhard et Levassor Company in 1878?

A117. That engine was a shop engine. It's[240] base was heavy. I cannot remember its weight.

XQ118. Give as nearly as possible the weight of this Otto engine of 1878, including its base, cooling system, and all parts necessary for its operation.

A118[241]. I said that this engine was intended to be stationary in a shop. Consequently as for the cooling system the only object was to have it capable of running all day without replenishing water. The weight of that water and tank was therefore very great, and it is quite impossible for me to give even approximately the weight of the complete apparatus. The same may be said of the base or bed plate on which the engine proper is mounted.[242]

XQ119. Give the weight of this Otto engine of 1878 without including the weight of tank, water or base.

A119. It is impossible for me to give it. I want to repeat that this engine was for a shop and not intended to be a light engine. The weight under the circumstances was therefore an advantage.

XQ120. Has the Panhard Company ever built an Otto four-cycle engine like that of 1878 and mounted it on an automobile or a wagon intended for ordinary road use before 1891, the time you say the Panhard et Levassor firm made their first automobile vehicle equipped with their Daimler engine, as you have stated in reply to question 14?

A120. The first trial of this kind which the Panhard et Levassor firm attempted dates prior to 1891. In 1891 we delivered to a customer the first automobile vehicle. The Otto engine was adapted by Daimler about 1882 for use on vehicles.

XQ121. Do you know at what date a Daimler engine was mounted on a road vehicle and seen in public, so far as you know?

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[240] Sic.

[241] Noted "XQ118." In the original text.

[242] See above notes. **1911**, **Judge Noyes**: "*When the inventors began to adapt the Otto engine to the purposes of a road engine, the desirability of lightness was apparent, and changes were made in the bed and castings so that the engine could be supported upon a steel frame instead of upon the heavy foundations used in stationary work. Other changes in the direction of decreasing weight and bulk and increasing speed were made. But these inventors were actually taught nothing in these matters by the Selden patent, and if it had been before them they would, as we have seen, have learned nothing definite from it*."

A121. As far as I remember the first Daimler trials can be carried back to 1883; as for the application of his small engines for vehicle propulsion Daimler's patents on this subject can be consulted to advantage.

XQ122. What is your authority for this statement?

A122. I have known Mr. Daimler in 1897, when I went to visit him at Cannstadt, Germany, in October. In the house he lived in he showed me the laboratory and shop where he had studied and first built his little engine, then the first vehicle on which he made his first trials.[243]

ADJOURNED UNTIL 2 P. M. SAME DAY.

SAME PARTIES PRESENT.

XQ123. Why was the work of Daimler necessary to make it possible to adapt the Otto four cycle engine of 1878, for the propulsion of vehicles on roads?

A123. Daimler, who had been working for many years in the Otto works tried to produce an engine sufficiently reduced in weight and dimensions with the object of adapting the Otto engine to automobile vehicles, to boats, and in general for all uses requiring as small bulk as possible on the part of the engine.

XQ124. Was there not even in 1878 a desirable advantage in reducing the weight per horse-power of the 4-cycle Otto engine?

A124. Upon the first appearance of the Otto gas engine there was such a public demand for it as a stationary engine, that it seems that they were above all occupied at that time in meeting that demand. As soon as they were confronted with the question of using it for vehicle propulsion it was immediately studied and constructed for that purpose.[244] A very few years sufficed for that as shown by the above dates.

XQ125. Do you know if Otto himself ever adapted his 4-cycle engine for the propulsion of a road vehicle?

A125. I know nothing on that subject.

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[243] This mention is unique in our sources. Daimler's first vehicles.

[244] **1961**, **Greenleaf**, p.21: " *"It required a severe struggle on my part to arrive at the idea that an engine of any kind could be built without a frame," said Selden years later.*" **1961**, **Greenleaf**, p.32: "*"Clearly this was not an engine for a motor car," wrote Duryea long afterward* [seeing the Otto engine in **1885** at the Ohio State Fair at Columbus], *"but even more clearly it had all the elements needed for a successful motor car. It only needed to have each element refined, lightened and increased in capability. Here was the future of the motor car."* "

XQ126. Have you ever heard, or seen, or known that Otto adapted his 4-cycle engine for the propulsion of a road vehicle?

A126. I know nothing about such having been done.

XQ127. In 1878 you had a heavy Otto 4-cycle engine; at the same time you were working on the development of an internal combustion engine which should be lighter per horse-power developed; - why did you not succeed then in constructing an Otto engine of the type constructed later by Daimler[245]?

A127. The engine which I studied at that time was not a 4-cycle engine, but an engine with combustion at constant pressure.

XQ128. In reply to Q116 you state you purchased and accepted from the Panhard et Levassor Co. a 4-cycle Otto engine in 1878, and that you yourself were working on an internal combustion engine light in proportion to its power, - why did you not then develop the 4-cycle Otto engine into the motor later produced by Daimler and applicable to road vehicles?

A128. I said that in 1878 I purchased an Otto shop engine for use in our balloon factory, while studying later on light engines I had neither the experience nor above all the genius of Daimler.[246] I was evidently following on the wrong track, and succeeded ultimately in the object I had in view (steering balloons), by using an electric motor.

XQ129. What were the particular difficulties that had to be overcome in the construction of the heavy 4-cycle Otto engine of 1878 which required "the experience and the genius of Daimler" in order to develop this engine and convert it into an engine capable of driving vehicles on roads?

A129. Above all it was necessary to realize the accurate and certain ignition of the gaseous mixture introduced into the cylinder.[247] It was this special point in particular that Daimler succeeded in solving in an almost perfect manner. Besides it was necessary to reduce as much as possible the weight of the reciprocating parts in order to increase the speed at least 600

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[245] **1961**, **Greenleaf**, p.32: "*It was Gottlied Daimler, the former manager of the Otto Gas Engine at Deutz, who created the light, compact and powerful gasoline motor that became the prime mover of the modern automobile. Between **1882** and **1883** Daimler reduced the weight of the Otto motor and increased its speed more than fourfold to 900 r.p.m.* […] *Aware of the far-reaching implications of his achievement, Daimler was confident that he had "created the basis for a new industry*." "

[246] A. C. Krebs shows here he accepts to refer himself to "genius" instead of "authority".

[247] **1911**, **Judge Noyes**: "*The Otto engine, on the other hand, was a constant volume compression engine. Although the leading idea of compression and ignition at constant volume had been suggested before the time of this engine, Otto seems to have first successfully applied it, and his engine came into general use. This engine was operated by a series of timed explosions and, as we shall later see, was the prototype of the modern automobile engine. It is clear from this examination that the statement heretofore made that the Brayton and Otto engines differed in being respectively constant pressure and constant volume engines is sustained by the record*."

or 700 revolutions per minute; finally the reduction as much as possible of the number of parts composing the motor.

XQ130. Then Otto himself did not solve these difficulties you mention as solved by Daimler?

A130. Otto succeeded in producing a good ignition for engines which he built. These engines, as I have already said, were especially adapted for stationary purposes, the number of revolutions practically not exceeding 200 per minute.

XQ131. But Otto himself did not solve in his 4-cycle engine of 1878 the difficulties involved of making it applicable to road vehicles, but left it for another to solve?

A131. Otto, as I have already stated, does not appear to have devoted himself to the application of his engine for the propulsion of vehicles. Had he been confronted with the necessity of doing it, there can be no doubt he would have succeeded in constructing an automobile vehicle propelled by his engine. As far as Daimler is concerned, he has from the very first effected an almost complete solution of the problem with regard to the adoption of the Otto engine to a vehicle. The present engines differ only from that devised by Daimler in details of secondary importance.

XQ132. What fuel has been used by the Panhard and Renault automobile engines?

A132. They chiefly used the petroleum derivative "benzine", products of coal distillation, and pure alcohol more or less carburetted with "benzine".

XQ133. Are these fuels as used known by the general term of liquid hydro-carbon?

A133. Yes. These are the liquids which are generally termed liquid hydrocarbon, except alcohol, which is a liquid hydro-carbon combined with its equivalent of water, and which, on that account, generates less heat during combustion per unit of weight.

XQ134. Do the engines of the Panhard and Renault automobiles compress the charge before ignition?

A134. These engines which are 4-cycle engines, with combustion at constant volume draw the explosive mixture in without compression, then compress it

prior to ignition. These operations are effected in the cylinder of the engine itself.

XQ135. What is mixed with air to make the explosive charge in the engines of the Panhard and Renault automobiles?

A135. In these engines, like engines which employ gas or liquid hydro-carbons, the combustible mixture is composed of a mixture of air with the vapor of the liquid hydro-carbons employed, combining these two fluids[248] in a proper ratio by weight. This ratio must be substantially constant in order to get complete combustion.

XQ136. Then the engine of the Panhard and Renault automobiles use a liquid hydro-carbon vapor mixed with air to constitute the charge.

A136. Yes, in all explosion engines where the mixture must be homogenous in order to simultaneously burn throughout in a very short period of time.

XQ137. Is not the charge for the Brayton engine also composed of a liquid hydro-carbon mixed with air?

A137. The particles of hydro-carbon entering into combustion with air cannot be burned unless first transformed into a gas. As for the Brayton motor, the combustion can only take place progressively upon the introduction of air and hydro-carbon, the latter may be separately introduced, its vapors may be burned by air entering the cylinder under compression in the same manner in which the petroleum in an ordinary lamp[249] is burned in a stream of air which produces the flame of the lamp. In the Brayton engine and in all engines in which the combustion takes place at constant pressure the fuel is burned progressively, either in proportion to its introduction with air, with which it may be previously mixed, or by air introduced which enters in close proximity to the hydro-carbon, separately introduced, carrying with it the heat generated by previous combustions.

XQ138. What do you rely on for your statement of the operation of the Brayton engine, as you give it in answer 137?

A138. On the very description in Brayton's patent of February 10, 1872, granted M. Brayton, numbered 94,180, and besides, upon the theory of operation of all constant pressure combustion engines.

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[248] See the note above regarding the Carnot's vision of heat.
[249] See the *Davy lamp*.

ADJOURNED UNTIL NOVEMBER 8, 1906, SAME PLACE, at 10:30 A. M.

MET PURSUANT TO ADJOURNMENT.

SAME PARTIES PRESENT. SAME PLACE.

XQ139. Is the Brayton patent of February 10, 1872, #94,180, you refer to in answer to question 138, the Brayton French patent of that day and number?

A139. Is the patent from which I am quoting a reproduction of the American patent taken by Brayton for his motor?

XQ140. Please answer whether the Brayton patent of February 10, 1872, No. 94,180, actually referred to in giving your answer to question 138, is not a printed copy of the French Brayton patent of that date and number?

A140. The very title of the pamphlet in which the Brayton patent[250] is inserted indicates that this document is really a reproduction of patents taken in France at that time. The document which I have placed on the table is an official publication of "Imprimerie Nationale[251]."

NOTE: The printed copy referred to by the witness in his questions and answers 138, 139, and 140, is marked for identification at the request of complainant's counsel, and a copy or translation will be agreed on if it is hereafter desired to offer one.

XQ141. Please look at the drawing of the United States Letters Patent to George B. Brayton, No. 125,166, dated April 2, 1872, and state whether they are not exactly the same as drawing appearing in connection with the printed copy of the French Brayton patent No. 94,180 of February 10, 1872, to which you have referred?

A141. Yes; these drawings are absolutely the same, and represent exactly the same arrangements.

XQ142. Do you know of any other French patent to George B. Brayton than No. 94,180, of February 10, 1872, to which you have referred in your testimony?

A142. I know of none.

XQ143. Is your knowledge of the Brayton engine and of its construction and operation based on this Brayton French patent No. 94,180 of February 10, 1872?

[250] The Brayton US patent: US125166A.
[251] Imprimerie Nationale.

A143. Yes; partly on that, and partly also on the work which has been done by other persons with a view to explain and describe the history of gas engines at large.

XQ144. Did you ever before see the United States Letters Patent to George B. Brayton, No. 151,460, dated June 2, 1874[252], a copy of which is now shown you?

A144. I have not seen the document which is shown me but I recognize the arrangement owing to the knowledge that I have acquired from other sources.

XQ145. In answering the last question, you looked at the printed copy of "La Nature" dated November 20, 1880[253] and published in Paris. Does this contain a description of the Brayton engine in conformity to what is shown of his United States patent No. 151,568, of 1874?

A145. The description given by the publication "La Nature" refers to a Brayton motor using petroleum oil as a fuel. The design appears to be similar to that shown in the drawing of the American patent, No. 151,468. I must, however, call attention to a mistake in the description given by "La Nature"[254] in error, which is not justified or reproduced in the drawing in the publication. As a matter of fact, a paragraph of that description says, that the cam shaft rotates at half the speed of the engine shaft, and that the engine operates according to the 4-cycle Otto type. The drawing shows, on the other hand, very clearly, that the cam shaft turns at the same speed as the motor shaft, and that this type of engine is most certainly an engine in which combustion takes place under constant pressure. Moreover, it is shown very clearly in the latter part of the description that the description and drawing referred to an engine of this type. It is said besides that, referring to a lecture delivered by Prof. H. Draper[255] before the American Philosophical Society, that this engine "is started by means of a match, and that in less than one minute it begins and continues to operate normally." This last statement constitutes, therefore, irrefutable proof that the operation of this motor, supplied by petroleum as fuel, is based on the same principle as the one described by Brayton in his first patent of 1872. On that there can be no

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253 **1880** - La Nature: “Moteur à pétrole de M. Brayton”.

254 Arthur C. Krebs in that time is also a reviser of "La Nature" periodical.

255 Prof. Henry Draper.

question that we have to deal in this case with a combustion engine which is of the "constant pressure" type notwithstanding the fact the fuel is delivered to it in liquid form. Moreover, Brayton claims in a very precise manner that this method of combustion does not exert a spasmodic or explosive force on the piston, but rather a pressure caused by the expansion behind the piston of expansable[256] gas when it begins to act upon it and during the whole period of admission of the gaseous mixture. This manner of utilizing the motive power, developed by the combustion of the gaseous compounds, differs radically from the method which characterized all the engines previously built to utilize the same motive power.

XQ146. Did you ever hear or know of a Brayton engine described or illustrated as of the 4-cycle type?

A146. No, I have never heard of it or known of it. At this time the Brayton engine was referred to as the most perfect type of internal combustion engine operating at "constant pressure". Engines operating exactly on the same principle but using coke as fuel have even been built, and I have seen several of them in operation at this time or shortly after, that is to say, after 1880.[257]

XQ147. How closely did the Brayton vertical engine, which you saw at a garage in New York on October 29th or 30th, 1906, conform in construction to what is shown and described in "La Nature" of November 20, 1880, to which you have referred?

A147. I have not verified all the details in the construction of this engine, but it appears that it very closely resembles the engine shown in the cut in the publication […]

NOTE: The printed copy of "La Nature", dated November 20, 1880, referred to in the testimony, is now marked for identification at the request of complainant's counsel, and a copy of translation will be agreed upon if it is afterwards desired to offer one.

MET PURSUANT TO ADJOURNMENT, SAME DATE.

SAME PARTIES PRESENT, SAME PLACE, 2:40 P. M.

[256] Sic.

[257] A. C. Krebs seems here referring to engines operated with coke powder. See above notes on powder engine.
Revue industrielle : revue mensuelle technique et économique | **1935**-01-01 | Gallica (bnf.fr)

XQ148. What are the differences in construction between the Selden 3-cylinder and the Selden single-cylinder engine, on the one side, which you saw at the garage on October 29th, or 30th, and the Brayton vertical engine you saw there?

A148. The 3-cylinder and the 1-cylinder Selden engine which I saw at the garage appeared to me as having been studied and constructed according to the principle set down by Brayton in his several patents, of which the vertical engine that I saw at the same place is an embodiment. The differences existing between those two engines are of two kinds: First, differences which relate to the design of mechanical parts and their arrangement and assemblage, which can be almost infinitely varied without modifying the actual principle of operation of the engine;[258] second, in the Selden 3-cylinder engine, as it is built and in the description given in the patent relating to it, I must note an obscure point relating to the formation of the combustible mixture;[259] in this description, beginning with line 105, it is stated that the air compressed by the pump is led into the working cylinder through a valve operated by a cam, together with a given amount of liquid hydro-carbon injected by a pump into the combustion chamber. This point appears to me to be very vaguely described in the patent specification; and on the other hand, no special arrangement seems to have been provided in the engine to insure the formation or production of a gaseous combustible mixture, capable of causing a proper operation of the engine. The drawing which forms part of the Selden patent is still more silent on this point, and one cannot help but wonder whether or not Selden did clearly realize the great importance of this special point when he filed his patent and later on constructed his engines. This disclosure appears the more striking when one considers that in all his several patents Brayton took especial care to give the most precise and complete details as to how he conceived the production of combustible mixture, preceding its introduction

[258] **1911**, **Judge Noyes**:" *Now, gas engines were old at the time of the application for this patent and had been used for various purposes*."
[259] **1911**, **Judge Noyes**:" *The Selden engine has no distinctive external vaporizing device, while, as we have seen, the defendants' engine is equipped with a carburetter which determines the proportions of the mixture to be admitted to the cylinder and also increases its homogeneity. But by the construction shown in the patent the air vaporizes the hydrocarbon in the passage leading to the cylinder, and we think the carburetter, while undoubtedly an adjunct of great importance and advantage, should be held not beyond the range of equivalents.* […] *We are satisfied that the slow combustion method necessarily involves slow operation; not only because of the time required for combustion between strokes, but on account of the comparatively nonhomogeneous character of the mixture. We are also satisfied that it gives less power in proportion to the size of the engine than the explosion method*."

into the cylinder. Third, in the Brayton patent,[260] also in the engine built by him, there can be found located on the admission valve, a small orifice arranged so as to allow the continuous passage, either of carburetted air, if the combustible gaseous mixture has been formed before reaching this valve, or of compressed air, which becomes carburetted in its passage close to the porous surfaces, soaked with hydro-carbon, which is placed beyond the valve. The purpose of this being to maintain a small flame above the wire netting in the cylinder, which flame will serve for the purpose of causing the inflammation of the gaseous mixture when the inlet cam allows it to enter the working cylinder for driving the piston. This small hole only exists in the valve of one cylinder in the 3-cylinder Selden engine. Fourth, In the Brayton engine described in his second patent, 151,468, the space existing between the top of the cylinder and the top of the piston is reduced as much as possible. This arrangement is excellent, and Brayton did certainly adopt it for the purpose of increasing the efficiency of his engine. In the Selden engine which I saw at the garage, this excellent arrangement did not exist.

XQ149. Have you ever made actual tests with the Brayton engine by taking diagrams with indicator or with the monograph to determine what takes place in the working cylinder, and if so, what was the result?

A149. Nos. I have made no such tests?

XQ150. Have you ever made actual tests with either the Selden 3-cylinder engine or the Selden 1-cylinder engine you saw at the garage, by taking diagrams with indicator or with the monograph to determine what takes place within the working cylinder, and if so, what was the result?

A150. No, I made no such tests.

XQ151. You have spoken of "constant pressure" and "constant volume" type of gas engine. How are these types distinguishable in diagrams obtained, showing what takes place within the cylinders?

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[260] **1911**, **Judge Noyes**: "*With respect to the second type, the constant pressure compression engine, Mr. Clerk says (page 31): "In it the engine is provided with two cylinders of unequal capacity. The smaller serves as a pump for receiving the charge and compressing it; the larger is the motor cylinder, in which the charge is expended during ignition and subsequent to it. The pump piston, in moving forward, takes in the charge at atmospheric pressure; in returning compresses it into an intermediate receiver, from which it passes into the motor cylinder in a compressed state. A contrivance similar to the wire gauze in a Davy lamp commands the passage between the receiver and the cylinder, and permits the mixture to be ignited on the cylinder side as it flows in without the flame passing back into the receiver. The motor cylinder thus receives its working fluid in the state of flame, at a pressure equal to, but never greater than the pressure of compression. At the proper time, the valve between the motor and the receiver is shut, and the piston expands the ignited gases till it reaches the end of its stroke, when the exhaust valve is opened, and the return expels the burned gases*"."

A151. The mere inspection of diagrams does not permit to determine in any absolute manner the mode of operation of an engine. The shape of the curves shown by the diagrams is completely modified by advancing or retarding ignition, and may lead to a false interpretation. Diagrams must merely be considered as complementary information and cannot be relied upon as always showing what is going on inside of the cylinder and what is the result of the mechanical arrangement used.

XQ152. What is your understanding of the words "constant pressure," and what do you mean by them in your testimony?

A152. I have already stated in my answer to question 47 that internal combustion engines are divided into two classes, one of which includes the engines in which combustion takes place under constant pressure. This type of engine is clearly characterized by the Brayton engine, the method of operation of which is described in all its detail in the patents mentioned heretofore. I need not describe again the theory of the operation which has been so well set forth by Brayton, but from a mechanical view-point this engine may be distinguished from those of other classes (engines in which combustion takes place under constant volume) in that, in the former type of engine the admission valve always opens from the interior of the cylinder to the exterior, to allow the gaseous mixture to pass; while in the other class of engines this same valve opens from the exterior to the interior of the working cylinder.[261] The engines belonging to the class in which combustion occurs under constant pressure present also this peculiarity, which differs from the engines belonging to the second class, in that they can be operated by supplying them either with compressed air from a tank, or by supplying them with steam generated by a boiler under pressure. The Brayton and Selden engines, which I have seen, precisely comply with the latter condition.

XQ153. From whom did these expressions, "constant pressure" and "constant volume" come into the internal combustion engine art?

A153. These expressions are currently used in lectures which have been delivered for a long period, by eminent professors.[262] They result, moreover, from the studies and the works of Brayton, who very clearly established this

[261] A. C. Krebs introduces here a new distinctive property between constant pressure and constant volume types of engines.
[262] After “authorities”, and “genius”, we see A. C. Krebs referring now to “eminent professors”, without naming them.

distinction in two paragraphs of his patent specification of 1872, which I have cited in answer to question 145.

XQ154. Are you unable to state who first classified internal combustion engines as "constant pressure" and "constant volume"?

A154. No; this classification has been known for more than 30 years, and it is so logical that it must have naturally originated in the minds of the people who have been occupied with these questions.[263] It is currently used […].

XQ155. Then this classification of the engine, as constant pressure and constant volume, in your belief, was one which grew up practically from observation of the engines themselves?

A155. These applications have not resulted from the construction of the engines themselves, but from the very theories that led to their construction. Practical results showed, after the trials of Lenoir, that it would be simpler to burn the fuel as it is done in a lamp or in a fire place that is to say, in a more regular and more progressive process than to burn the whole mixture suddenly, as had been attempted by Lenoir. The efforts of the mechanical parts are thus rendered more regular, and it was Brayton who seems to have been the first who had the conception of the combustion under constant pressure, and who well disclosed its whole action.

XQ156. What is the first printed publication which, to your knowledge disclosed or used both the terms "constant pressure" and "constant volume", as classifying internal combustion engines?

A156. I am not able to say. These expressions were used for a very long time by all persons occupied with these questions, and although at the present time the Brayton and similar engines have been abandoned, for at least 25 years the classes of engines have been represented, on the one hand, as "combustion under constant volume", by all the 4-cycle engines using either city gas or water [gas] ranging from 1/4 horse-power to 3,000 horse-power, and in speeds from 1800 to 100 revolutions per minute; and on the other hand in the class of "combustion under constant pressure" we only find the Diesel engine, which is nothing more than the Brayton improved, in which heavy oils can be burned.

[263] See above notes referring to Carnot's principles.

ADJOURNED UNTIL 9:30 A. M. NOVEMBER 9, 1906.

XQ157. Referring to the Diesel engine which you mention, have they been practically and successfully built and operated?

A157. Diesel engines have been continuously made for less than six years, but their very delicate construction, necessary in view of the extreme accuracy required, does not at the present time permit their being made except as relatively heavy engines per unit of power, and does not permit them to exceed 100 to 120 revolutions per minute. In practice, it has not been possible to go below 25 horse-power for a single cylinder, and at no time has it been thought possible to use this type of engine in the construction of automobile vehicles.[264]

XQ158. But it is not a fact that the Diesel engines, as known to you, are very efficient?

A158. Yes, the Diesel engine which is a development of the Brayton engine is an improvement over the latter and gives an efficiency much better than was possible with the Brayton engine.

XQ159. In fact have not the Diesel engines shown a higher efficiency than any other internal combustion engines?

A159. No, at the present time the consumption per horse-power of Diesel engines is the same for like power developed, as engines with combustion under constant volume[265], but the Diesel engine is the only one that can practically use liquid fuel of high specific gravity, that is to say, what one calls heavy oils. This latter advantage is inherent in the mode of operation of the engine, that is to say, the way that the fuel is introduced into the cylinder and burned. As a matter of fact, the fuel in the Diesel engine, as in the Brayton engine, is admitted during a certain period of and from the beginning of the piston stroke, and burns all the time it is being introduced. The combustion is therefore progressive, by successive quantities, which facilitates the combustion of heavy oils.

XQ160. Did you personally use, or can you cite any use of the term "constant pressure" as denoting a cycle of internal combustion engine prior to 1879?

[264] See above the other A. C. Krebs mentions to Diesel engine.
[265] A. C. Krebs said in **1934** that one of the purposes of his carburetor was to ovoid waste of gasoline.

A160. I cannot recall at so early a date the name of any work positively containing these terms, which, after all, are only expressions summarizing the analytical study of thermodynamic phenomena made use of in the construction of engines.[266]

XQ161. But did you personally use the term "constant pressure" prior to 1879?

A161. I cannot recall that I made use of that expression, but I am certain that at that period internal combustion engines were grouped in those two classes which are perfectly defined by these expressions. After all, the expression itself cannot change the order of things. In 1882, when I was working on an engine for balloons, I thought that the method of causing the fuel to burn pro[gressively] enable me to produce more easily and more surely a light engine. I had made a mistake and I did not persist in it. Mr. Selden, as early as 1879, had the same idea as I. He thought that employing the method used by Brayton, for the construction of his engines, would enable him to realize an engine capable of propelling a vehicle. He was mistaken as I also was, but he did not recognize his mistake.[267] The engine which he constructed is a reproduction more or less well built (rather less), of the Brayton engine. His engine, such as could have been constructed at that time, that is, conforming to the specification and drawings of his patent, is an engine incapable of running. Later on, by the use of a recent method of ignition he endeavored to obtain better results, but as it exists, and as I have seen it in the automobile garage Oct. 29th and 30th last, this engine is incapable of running under load for more than a few minutes.[268] The reasons therefore, upon which I base my opinion can be readily appreciated by all persons familiar with thermodynamic questions and in particular the question of construction of internal combustion engines.

XQ162. Was there any effort made to run the Selden 3-cylinder and 1-cylinder engines at the garage in New York in your presence on October 29th and 30th?

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[266] See the above notes referring to the Carnot's principles.

[267] A. C. Krebs admitting a mistake is a rare event. We can see here he tries to take advantage of this weakness.

[268] **1961**, **Greenleaf**, p.161: "Motor World, *the pro-A.L.A.M. organ, was compelled to admit that the engine could not operate successfully according to the terms of the patent, even with the initial aid of electric ignition. It was a fearful performance. The engine belched flame and thick clouds of smoke, and the exhaust pipe turned red hot*."

A162. A trial was to have been made with them in the presence of experts. The latter desired to first examine these engines in all theirs details. That [inspection] had permitted the ascertaining of certain differences in arrangement from such as are indicated in the patent, and of such a nature as to modify the operation of the engines from the operation that may be construed from the patent. The engines were then reassembled in conformity with the specification of the patent and the experts then requested that they might see the engine run. The party's plaintiff declined, - I do not know for what reason, and the engines were not put in operation.

XQ163. As you never saw an attempt made to run these Selden 3-cylinder and 1-cylinder engines, how can you say how they will run?

A163. I have said that the Selden engines were a bad copy of the Brayton engine, and here are the reasons: (1) The Ratio of the volume of the pump and the volume of the gas introduced into the working cylinder is too small to give a sufficient compression to obtain passable efficiency. (2) The volume of clearance behind the working piston at the beginning of the admission of gas is too large, as well, in order to obtain good efficiency. (3) The admission valve stem passes through an opening which permits loss of air at the time the valve is opened in a manner which very appreciably diminishes the compression. (4) No suitable arrangement to insure a homogeneous and combustible mixture is found in this engine where the liquid hydro-carbon enters to mix with the air. This point, however, is very important and Brayton took care to describe very minutely in his patent the particular arrangement that he intended to insure what is called carburetion. (5) The liquid hydro-carbon cannot fail to incompletely mix with the air introduced, in view of which it must undergo decomposition, owing to the action of the heat generated during the operation of the engine and produce carbon deposits, which in time will clog either the gauzes or the exhaust valve or even the walls of the cylinder and the piston. (6) Finally the patent and annexed drawing do not mention or indicate any cooling system for the head or the cylinder. Without doubt, Mr. Selden, for the purpose of making his engine lighter, omitted that important part of the engine which had not been neglected by Brayton. To summarize, in the engine which is described in the patent the ignition of gas is badly provided for, because the combustible mixture may vary at any moment, owing to the fact that

there is no special arrangement to produce a suitable and homogeneous mixture. There is no cooling means for the walls, and as the expansion of gas in this engine is very little, the drop of temperature of the gases is almost solely due to the transmission of heat through the walls. The cylinder walls not being properly cooled, the lubricating oils would be rapidly brought to a temperature of decomposition and volatilization causing carbonaceous deposits, which, at the end of a short time will stop the operation of the engine. The carbonaceous residue from the liquid hydro-carbon introduced and […] with the action of the valves and very soon vary the condition of operation of the engine. I understand by good operation of an engine, operation at full power for several hours. Engines which are not capable of running steadily and regular for at least ten hours cannot be considered practical engines. The Brayton engine is certainly capable of fulfilling these conditions.

XQ164. Does your last answer 163, apply to the actual Selden engines you saw at the garage?

A164. I am sure there is here no desire on any one's part to deceive anybody. As a matter of fact, the Selden patent defines the question here at issue, (1) by a specification, (2) by drawings. The Selden engines which I saw at the garage are made in accordance with the general provisions and details shown and described in the patent. Still, apparently, some details have been modified afterwards. I do not insist upon the question of dimensions, particularly of the air inlet and its distribution. I admit that the patent drawings are rather diagrammatic of the construction and relative dimensions have not been observed, but I believe, and especially as concerns ignition, that the principle set forth in the patent and well defined as a matter of fact in the arrangement used by Brayton and reproduced, so to say, by Selden in his patent, must be considered in full in the matter at issue. I need not, therefore, for the present, take into account an arrangement […] parts used in effecting it, and which has been employed to materially alter the original ignition system.

XQ165. Do you consider it reasonable to impose on the engine of the Selden patent tests and conditions as to power and perfect operation only now being met by the perfected internal combustion automobile engine of the present day?

A165. My answer to question 163 does not require of the Selden engine that it shall produce the power which is actually given by engines employed in automobiles. It simply states the conditions which it was fair to impose at that time on any engine worthy of the name. When I speak of maximum power, I mean the power of which an engine is capable, not power of another engine. As far as it concerns the duration of operation, that is a factor independent of the type of engine or its power; what was true in 1879 is true today, that is, so long as an engine is built to produce work it cannot be looked upon as good unless it is capable to continue in operation for ten hours. Such a clause is always included in the specifications between customers and manufacturers in which it is agreed to furnish engines. However, in this particular case, I figure that after two hours of regular operation equilibrium of temperature between the different parts of the engine is established. As a matter of fact, admitting that the Selden engine would really run regularly at starting, it would, long before that time, reach a temperature which would cause it to stop.

XQ166. Does the admission valve open outwardly in the […]

A166. The Diesel engine, as I have explained, is a Brayton engine improved in the following manner: in the Brayton engine air compressed by pump is introduced into the cylinder to burn the fuel progressively as it enters. In the Diesel engine the improvement consists in completely separating the air and fuel and introducing the former first into the cylinder at a very high pressure, then in further raising the pressure by the piston of the cylinder acting as a pump, up to 35 atmospheres, the fuel mixed with air is then introduced by a valve opening from the interior to the exterior.

ADJOURNED UNTIL MONDAY, NOVEMBER 12TH, 1906 AT 10:15 SAME PLACE.

MONDAY, NOV. 12, 1906, 10:45 A.M.[269]

XQ167. Was not the water jacketing of internal combustion engines known practically prior to 1879?

Objected to[270] as irrelevant and immaterial for the reason that Selden's patent expressly claims water cooling by enclosing water in the crank case as an improved form of engine.[271]

A167. Yes, it was known ever since work was begun on the construction of internal combustion engines.

XQ168. For example, was not the Otto engine you had in 1878 provided with a water jacket for cooling purpose?

Same objection.

A168. Yes, evidently, and no one has ever doubted it.[272] Feeling that this whole discussion is spreading over matters of secondary interest, I would like, before defining the meaning attached to these two definitions, "combustion under constant pressure" and "combustion under constant volume," to submit a few technical explanations with a view to clearly establishing the reason for these definitions. At first let me say that the term "compression"[273] employed in connection with thermic engines is but of secondary importance as it cannot be used to define the two classes of engine in question. All internal combustion engines operate with compression. It is merely a question of the relative degree of compression.[274]

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[269] **A. C. Krebs letters to his wife**: "*New-York, le 11 novembre **1906**:* [...] *Hier nous avions eu journée superbe pour notre excursion à West Point. Le pays est réellement très beau*. [...]"

[270] Note that defendant's objections are rare, by comparison with complainant's ones.

[271] **1909**, **Judge Hough**: "*Water jackets were old in **1879**, and had been used in many forms*." **1911**, **Judge Noyes**: "*The drawings show that the Selden engine has an inclosed crank chamber; it being a continuation of the working chamber. It is true that the only function of the inclosed crank case mentioned in the written specification is that of a cooling chamber. But it is referred to and it is clearly shown in the drawings, so that we think the patentee entitled to claim as a feature of his patent any benefits necessarily accruing from its use*."

[272] From that moment A. C. Krebs starts showing he is losing patience regarding complainant's questions.

[273] **1911**, **Judge Noyes**: "*The engine is described in the claim as "a liquid hydrocarbon gas engine of the compression type." Being an engine of this kind, it must, in the first place, be an internal combustion engine, which (using the definitions in the complainants' brief) is an engine in which "the fuel is burned in the engine cylinder and the heat energy thereof utilized by the expanding gases acting on the piston." In the second place, it must be a gas engine, which is "an internal combustion engine wherein the fuel is burned in a gaseous or vaporous condition." In the third place, it must be a liquid hydrocarbon gas engine, which is a gas engine "wherein the gaseous form of fuel is derived from a hydrocarbon liquid, such as petroleum, alcohol, etc." In the fourth place, it must be a gas engine of the compression type, which is "a gas engine using a compressed charge of gaseous fuel," and in which, consequently, the charge-containing space back of the piston will, at the time of ignition, "receive a larger amount of fuel in relation to its size than if the fuel was admitted thereto under mere atmospheric pressure."* "

[274] **1911**, **Judge Noyes**: "*These two engines — the Brayton* [**1872** - US125166A, **1874** - US151468A] *and the Otto* [**1876** - [US178023A] *— play important parts in this case. We shall later have occasion to examine them at length and to compare them as belonging to two well-defined types of compression gas engines — the "constant pressure" type and the "constant volume" type*."

In order to well represent the phenomena taking place inside a cylinder of an internal combustion engine, I am […] I will first take up the case of the Lenoir engine as an example. Let AB be a line representing the piston stroke. Let us represent by ordinates above these lines the pressures beginning from vacuum, which is represented by AB. The atmospheric pressure line would be represented by the line ab. At the moment when the piston is at the end of its stroke in B moving towards A, the pressures will be less than atmospheric pressure, being represented by the line bm and representing that point of the stroke at which the admission ceases and ignition is effected. At this point m the piston possesses a comparatively high speed and the piston speed is in fact represented at any part of the stroke by the projection on AB of an object starting from B and describing at a constant speed the half circumference BOA. If now, for instance, the period of time during which combustion occurs is represented by the arc of circumference m'n', the piston will have progessed from mn measured on BA during the same period of time. It can be now readily understood that the volume of the combustible gases Bm at the time of ignition has become greatly increased during the time occupied by the combustion, since it has become Bn.

The Lenoir engine cannot therefore be said to be an engine in which combustion occurs under constant volume. Neither is it possible to consider it as an engine in which combustion occurs under constant pressure, since the curve[275] representing the pressure during the period of time occupied by the ignition follows the line mb and from that point it nearly follows a hyperbolic curve which represents the law of expansion of gases, until the piston has reached point Q, at which point exhaust takes place.

It is the study of this diagram which had led investigators to occupy themselves with the realization of means permitting a better utilization of the heat developed by the combustion, by obtaining greater expansion.

Two methods presented themselves: first, trying to obtain the condition of expansion taking place in a steam engine[276] by doing work from the very beginning of the piston stroke, after which the gases would expand while continuing to do work.

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[275] Here A. C. Krebs prefers his diagrammatic curves to the experimental diagrams seen above.

[276] **1911**, **Judge Noyes**: "*The* [Brayton] *engine worked well and smoothly; the action of the flame in the cylinder could not be distinguished from that of steam; it was as much within control and produced diagrams quite similar to steam*."

It is this type of engine which has been designated under the terms of "constant pressure motor." This expression correctly represents the phenomena which it is intended to produce in the cylinder and which as a matter of fact takes place nearly as intended.

The phenomena are reproduced in Figure[277] 2 in which the same notations are employed. B, that is to say at the time when the piston is at the verge of beginning its power stroke, the mixture is admitted at a pressure which is above atmospheric pressure, ignition beginning simultaneously. The admission continues until n at a very nearly constant pressure, which pressure is the one given by the tank or the pump feeding the motor. In this case the period of time occupied by the combustion is much greater and can be measured from the half-circumference by the arc Bn'. One will notice the complete analogy existing between this diagram and the diagram obtained in a steam engine. This diagram represents the mode of operation of the Brayton engine.

The second means of causing combustion to do work on the piston from the very beginning of its stroke consists, according to the principle laid down by Beau de Rochas, in locating the explosive mixture in a closed chamber of well defined volume located behind the piston and igniting the mixture before the motion of the piston begins: i.e., when its speed is zero. The combustible gases stored behind the piston (after having been previously compressed to a pressure represented by Bm) burn at a speed which increases greatly the higher the pressure produced. As the piston moves at a very slow speed, if the period of time required for the combustion is represented by the length Bm, combustion will have been completed while the volume will not have, so to speak, very much changed. The pressure reached will be considerable at the start and the work of expansion will immediately begin, lasting almost during the whole stroke of the piston; that is until the exhaust begins at q. But experience has shown that there was still a further advantage in causing combustion to take place under a volume as constant as possible. To accomplish this result experimenters have been led to cause the ignition of the mixture to take place even before the piston has reached the dead center, in such a manner that the

[277] Unfortunately, the A. C. Krebs figures are not yet identified within the huge amount of the trial archives. Maybe the Krebs demonstration would be precise enough to allow their reconstitution by today engineers.

ignition will have been completed before the piston has materially progressed in its power stoke.

Figure 4 indicates how these phenomena take place.

In Figure 3 the period of time occupied for the ignition is measured by the angle BOn'; this same angle on Figure 4 is located so as to include between the points m' n' the point B. Combustion is therefore completed before the piston has materially progressed in its power stroke. The quantity Bn' is what is termed early ignition. This early ignition, as it has just been defined, and which is not necessary to effect in internal combustion engines in which combustion takes place under constant volume, is another point which characterizes the two classes of engines in question.

It is indeed not possible to compare the operation of the Lenoir engine to the mode of operation which we have just analyzed (Figures 3 and 4). One may object that the Lenoir engine, operating without previous compression of the combustible mixture, should differ from a Brayton engine for instance, in which the ignition of the charge (said to be under pressure) is accomplished after its introduction. We may then represent what takes place by Figure 5. This figure, judging from its appearance, is not anything else but the reproduction of Figure 1, in which the atmospheric line passes below the point m. Combustion takes place during the period of time m'n', during which the volume of the cylinder has increased to almost double its original volume. It cannot therefore be stated that combustion takes place under constant volume. It does not take place either under constant pressure. Yet this mode of operation which brings us back to the so imperfect arrangement of Lenoir, is precisely the one which takes place in the case of the Selden engine when timed ignition is effected by means of the spark plug which has recently been employed to operate this engine.

We may also represent, in a most striking manner, the major differences which distinguish the engine in which combustion takes place under constant pressure, from those in which combustion takes place under constant volume, and for this it is only necessary to take in account the work absorbed by the compression of the combustible mixture before its combustion. Figure 6 brings up these differences. In the engine in which combustion takes place under constant pressure, the actual work produced is represented by the surface A d

c, which is the difference between the work performed by the working piston A d C D, and the work of the pump A c C D. In the engines in which the combustion takes place under constant volume, the work produced is the difference between the work done on the working piston A d f E, and the work required by the previous compression of the mixture A c B. The two principles which govern these operations are very different. It is not therefore surprising that the results produced are also different. This difference is shown quite well by Figure 6, which shows that with combustion taking place under constant volumes it has become possible to obtain today an amount of work almost double that obtained in the case where combustion takes place under constant pressure. And indeed, it is only since the work of Diesel, and in fact quite recently, from a practical point of view, that it has become possible to burn under a great pressure comparable to that obtained in engines in which combustion takes place under constant volume; that it has become possible, as I have already said, to burn the combustible in a progressive manner as it is introduced into the cylinder, and during a very short fraction of its stroke, so as to make possible expansions comparable with the expansions which are secured in engines in which combustion takes place under constant volume. In summing up the differences existing between the Selden engine and the engines which are at the present time used on automobiles, they can be characterized by the following points:

Storing of the charge behind the working piston and ignition of this charge by early ignition in such manner that combustion is completely effected before the piston, which is crossing at this time its dead center, has had time to materially vary the volume of the cylinder in which combustion takes place. This mode of operation in 4-cycle is the only one, as I have explained, in question number [278], by means of which a maximum pressure can be attained at the time of combustion with a minimum of mechanical complication. All other types of engines using pumps to compress the mixture previous to its combustion cannot enter into this class. The point of maximum pressure is not reached at a dead center, and as this condition is absolutely indispensable and necessary to obtain a good efficiency of engines in which combustion takes place under constant volume, the engine using pumps cannot enter into the same class.

[278] Question number is not given in the original text.

Returning now to the question of water circulation, I will say that the circulation of water, the object of which is to prevent the temperature of the walls from reaching too high a degree under the action of the heat resulting from the combustion of the mixture, must be the most effective the less the expansion of the gases after burning. Thus, it can be conceived, and as a matter of fact practical results have shown, that in the case of combustion engines operating under constant volume, where all the work produced is caused by the expansion of gases, the cooling of the walls need to be as great as in the engine in which the work produced is only partly due to expansion. This point can be more grasped if in a combustion engine at constant volume, ignition is caused to take place late, instead of causing it to take place at the necessary time. The operation of an engine effected in this defective manner resembles very closely that of the Lenoir engine, where the pressure, during the combustion, varies at the same time as the volume. It also resembles closely that of a combustion engine operating under constant pressure, since combustion takes place during a fraction of the piston's stroke.

The water circulation, which was thought necessary from the very beginning in the construction of gas engines is therefore much more necessary in the case of engines of the Brayton and Selden type, as I have just explained. One cannot therefore understand why the Selden engine is not provided with some kind of water circulation.

MET AT 4:35 P. M. SAME PLACE.
SAME PARTIES PRESENT.

I have thought it necessary to volunteer the above explanation because I was of the impression, judging from the question which had been addressed to me by the honorable attorney for the complainant, that I had not made myself sufficiently clear upon the question of classifying motors into:

Motors in which combustion takes place under constant pressure,

Motors in which combustion takes place under constant volume.

I trust that I may be excused on the ground that previous to my arrival in New York I had no idea whatever of the sort of question that would be addressed to me.

Besides, during the two and a half hours that have just elapsed between the time set for the hearing and the actual time of its beginning, I have had the pleasure to notice, while glancing through a treatise of Dugald Clerk on gas engines, which happened to lay on the table, that I was in accord with his ideas on the subject, (Page 29), with the exception, however, of a slight difference of opinion concerning the early gas engine, and about which I have given reasons that I believe justify their exclusion from this very logical classification.[279]

[279] Note that A. C. Krebs gives the ending word of his argumentation to the “logical principle”.

NOVEMBER 13, 1906.

MET AT 10:40 SAME PLACE;

SAME PARTIES PRESENT;

First question asked the witness at 11 o'clock.

XQ169. I have asked you a very simple question 168, which is as follows: "For example, was not the Otto engine you had in 1878 provided with a water jacket for cooling purpose?" Is not the first part of your answer to this question 168, as follows: "Yes, evidently, and no one has ever doubted it." Is not this answer a direct answer to a well defined question?

A[280]. Yes, it is the answer to the question, but I wanted to mention the other matter which I afterward referred to.

XQ170. Have you not been told that you were to answer my questions directly and not to volunteer theories which are not direct answers to my questions?

A. That statement was necessary at the end of my answer to 168, to enable me to properly answer questions which would be put to me later.

XQ171. Have you ever been a witness in a suit and cross examined by an attorney?

A. I have been called as an expert in France, which corresponds somewhat to the present examination.[281]

XQ172. Do you understand that while testifying in this case your duty is to answer my questions, and to give direct answers to the questions I ask you?

A. I fully understand my duty, but I discharge it in such a manner as to most clearly set forth the facts relating to this case.

Complainants counsel now request defendant's counsel to instruct the witness, as the witness does not appear to be familiar with the practice on cross-examination in this country, that the answers of the witness should be responsive to the cross questions asked and not introduce new matter, which is irresponsive.

Counsel for defendants states that the witness is under oath that he understands that he is under oath and that he is making such answers as he

[280] From that point answers are no more numbered in the original text.
[281] Note the connection of this sentence with the above discussion about “authorities”.

deems proper. The explanation which he made in answer 168 was given because counsel for complainants had been examining him about the two types of engines therein referred to and because the witness deemed it his duty to clearly set forth what he meant by his classification of internal combustion motors into such classes.

Counsel for defendants further states that counsel for complainants has not been cross examining the witness on matters brought out on the direct examination and that he has warned and that he now warns said counsel that he will insist that the witness has been made a witness for the complainants.

Counsel further protests against the unwarranted delay and length of time consumed so far on cross-examination and calls attention to the fact that since the cross-examination commenced counsel for complainants has never commenced at the time to which the meeting was adjourned but has without exception been from fifteen minutes to two hours and a half late, and this in spite of the fact that he is aware that the witness desired to sail for Europe last Thursday, November 8th, and now wishes to sail.

Complainants' counsel calls attention to the fact that this witness is being examined and cross-examined in the French language involving the translating of all questions and answers from English into French and back into English in order to make a record, this being done because it was stated to complainants' counsel at the beginning of the witness' testimony that he could not speak or understand or read the English language, at least in such a way as to be able to testify. This method adopted wholly by reason of the witness' inability in this respect has inevitably caused delays and effort having been made to proceed during the entire working day, involving translation into English of each day's testimony, a work of four hours usually to be done between the hours of five P. M. on one day and 10 A. M. the next. That complainants' counsel and Experts are greatly handicapped in this whole matter by the necessity of making the record in French, and that it is physically impossible to proceed with the expedition had in this matter, and that the statement as to a delay of two hours and a half caused by complainants'

counsel is absolutely misleading, as by consent necessary time was taken to translate the irresponsive answer of witness, Number 168, Complainants' counsel being unable to proceed until the technical answer has been actually translated.

Counsel for defendants states that the examination and cross-examination are being conducted in French at the request of Mr. B. R. Betts, counsel for the complainants, that before the examination commenced, counsel for defendants suggested that the regular practice of employing an interpreter be adopted.

Counsel for defendants now requests that the Commissioner designate an official interpreter.

With regard to the delay, Counsel for defendants wishes to state and charges that there is an unwarranted delay in the part of the complainants. That yesterday, about 11:45, counsel for complainants refused to proceed further until he had a translation made of the answer to question 168, that an adjournment was then taken until 2 o'clock. That about 2 o'clock counsel for complainant said that he could not have the translation completed until about 3, at which time he agreed to appear, that as a matter of fact he did not appear until 4:30, and then stated that he did not intend to cross examine any further, and that as the record will show did not cross examine him.

Complainants' counsel states that the translation of the very technical answer referred to occupied by LePontois, who has been acting as the official translator of this testimony from the time the adjournment was taken, working at Mr. Betts' office with stenographers, and without lunch, until after 4 P. M., and that complainants' counsel and expert immediately on receiving the translation and hastily glancing over it, came back to Coudert Brothers' office, where they found that the witness, Mr. Krebs, desired to add something to his answer, which he then did, consisting of the last paragraph thereof, and it then being 4:45 adjournment was taken.

Examiner being present says that the Examination of this witness shall commence at ten o'clock each day until one o'clock, recess taken until two o'clock to continue to 4:45 each day until the testimony of the witness is completed, exclusive of Sunday, and on Saturdays from ten to half past one.

The Examiner states that with the consent of counsel for the respective parties, he appoints Leon LePontois as interpreter.

(Complainants' counsel, in view of the situation presented, and the refusal of defendants' counsel to inform the witness that the answers must be responsive to the question, now requests the Commissioner, John A. Shields, Esq., to personally instruct the witness as to his duties in answering cross-questions, and in particular that his answers must be responsive to the question, and must not contain volunteered and irresponsive matter.)

The examiner instructs the witness that he must answer the questions directly and in response to the question put and in accordance with his view of the matter.

XQ171[282]. Who called your attention to the book of Dugald Clerk on "the gas and oil engine" (published by John Wiley & Sons New York 1904)[283] and which you referred to in answer to XQ168?

A. I found it lying on the table[284] and merely looked over it as I stated in my answer to XQ168.

XQ172. Had you ever seen this technical work of Dugald Clerk or any edition of it before you found it lying on the table yesterday as you say?

A. No, never.

XQ173. Did you discuss this work of Dugald Clerk with any one before you gave your answer to XQ168?

A. No.

[282] This question number is used twice in the original text.

[283] The book of Dugald Clerk on "the gas and oil engine" (published by John Wiley & Sons New York **1904**).

[284] **1961**, **Greenleaf**, p.224: *"Several weeks before the* [**1911**] *hearing, Coudert visited the law office of Samuel R. Betts to discuss routine arrangements for the appeal. Betts was occupied with other matters and kept Coudert waiting for about thirty minutes. Coudert passed the time examining a collection of books and magazines spread on a table in the reception room. Among the publications was a set of proofs from the latest British edition of Clerk's book on internal combustion engines, an enlarged and revised edition of which had been brought out in 1909. Consulting the index, Coudert found no reference to Selden; nor was the name mentioned in the historical summary of the gasoline engine and the automobile. Moreover, Clerk admitted that the modern motor car could not be traced to any single patent! Coudert immediately secured a copy of the book and incorporated pertinent passages in his oral argument and brief*." **Clerk**, **Dugald**, **THE GAS, PETROL, AND OIL ENGINE, vol. II**, ("new and revised edition", John Wiley & Sons Ed., New York, **1913**), p.479: "*The change from the larger slow-running internal combustion engine to the small high-speed light fuel motor, though in theory simple, proved to be practically a lengthy and difficult task. To the skill and perseverance of Gottlieb Daimler (1834-1900) is largely due the credit of this successful adaptation of the Otto cycle gas engine, whereby modern automobilism has become a practical achievement*." Selden is not mentioned in any Clerk's book. See the above note referring to the **1896** Clerk's book edition.

XQ174. Do you understand or can read technical English sufficiently to understand accurately that book of Dugald Clerk in English?

A. Yes, I can follow an English technical description in a general way and more especially when this description is supplemented by drawings.[285]

XQ175. How did you happen to turn to the particular page no. 29 of the Clerk book which you have referred to in answer 168?

A. By merely looking over the book and I made a note of it.

XQ176. There are no drawings for page 29 of Clerk's […]

A. The terms are almost French.

1 P. M. Adjourned to meet again at 2 P. M.

Met at 2 P. M. pursuant to adjournment.

XQ177. Referring to your answer 168 did you discuss the subject matter of that answer with any one before giving it on the record?

A. I did not speak to any one about it. I had studied the matter forming the base of that answer on Sunday.

XQ178. Did you discuss the subject matter of that answer 168 on either Saturday November 10th or Sunday, November 11th, with any one?

A. I have not discussed the matter with any one.

XQ179. Have you ever published in print any discussion relating to the subject matter of that answer No. 168?

A. I have not written or published any article on this matter but I know this question as I studied it practically and also because of the work that has been done on internal combustion engines. I have been compelled to more thoroughly yet study it after the first questions that have been asked me on this subject, so as to sum up my ideas on the matter in a precise manner and I possess this subject very clearly at the present time.[286]

XQ180. What printed work do you recognize as an authority upon the subject matter covered by your answer No. 168?

[285] Saying that he can read technical matters in the English language, A. C. Krebs contradicts somewhat himself with his above statements.
[286] Hearing A. C. Krebs the "practical man", it seems the only counsel's questions excited his mind and decided him to formalize his thought about his experiments. This movement can be seen as a rest of the military "instruction process". See the note below where he expresses to his wife his satisfaction about this work.

A. Quite a number of books have been published on the subject of internal combustion motors. Every author of course has his own interpretation of phenomena, but all the different opinions are of course subject for discussion. I have summed up in my answer the actual state of the question and such as it has been established since a very long time.

XQ181. You have not answered my XQ180 which asked you to state what printed work you recognized, if any, as an authority upon the subject matter covered by your answer No. 168?

A. I do not recognize any one as an authority on the question as the various opinions are subject to discussion.

XQ182. Then in your opinion the classification of internal combustion engines is not yet definitely determined?

A. Yes; this is a part of the theory of internal combustion engines on which every one agrees, with the exception of slight difference of opinion on secondary matters as I have stated in my answer to question 168.

XQ183. Is there any expert authority who has printed and published his views in French on the subject of classification of internal combustion engines and whom you recognize as an authority?

A. No; I can not say that I can cite the name of any one having written a book on the subject, for I do not remember the names of the authors of the numerous books that I have read on the subject, in a general way all experts agree on this subject, and Clerk himself, as I have been able to ascertain in reading part of his book, yesterday, is of the same opinion.

XQ184. Dugald Clerk in his book you have referred to, throughout distinguishes between engines igniting the charge without previous compression and engines igniting the charge with previous compression, the compression referred to being always that above atmosphere. Do you not recognize that there is such a distinction?

A. Such a difference does not possess the importance which seems to be attached to it. It is merely a question of where you place the starting point. This whole discussion can be better generalized if the absolute vacuum is considered as the starting point? This same reasoning applies to the question

of temperature. The theories regarding these questions are always based on the absolute zero as being the starting point.[287]

XQ185. But supposing the starting point is at atmospheric pressure as the question supposes and answer XQ184?

A. I can answer this question in stating that Clerk commits a slight mistake in his distinction and to demonstrate it I merely propose to bring a motor (with previous compression) at a height superior to five thousands meters, for instance the pressure at which the mixture will be introduced in the cylinder will then be lower than the atmospheric pressure, considered at the sea level.

XQ186. The absolute zero you referred to in answer 184 as being the starting point on which the theories are based is merely a theoretical starting point, is it not?

A. The study of natural philosophy[288] teaches us that in order to establish a better term of comparison between phenomena, we endeavor to free them as much as possible of the secondary questions which might render their general inspection more complicated or more obscure. In analytic algebra, the functions representing the progressive development of the phenomena are all brought back to what is called their primary ordinates. The absolute zero is no more an abstracted word that the vacuum is. The absolute zero can be absolutely determined.

XQ187. Can any practical internal combustion engine be started at what you call the absolute zero in the last answer?

A. I will answer this question by asking you whether ~~you look at it from~~[289] one can place himself in the infinite, ~~point of view~~ and ~~still~~ nevertheless the infinite does exist.

XQ188. Referring to the Lenoir engines as you have known them, do they ignite the charge at a pressure which is never above atmospheric pressure, and without previous compression of the charge?

[287] A. C. Krebs introduces in the discussion the notion of "starting point" about engines classification.
[288] A. C. Krebs introduces the old notion of "natural philosophy", reminiscence of the eighteenth-century sciences. Doing that the "practical man" is pointing the mathematics as the absolute abstraction in the field of his research.
[289] Crossed out in the original text.

A. Ignition takes place at a pressure which is inferior to the pressure at which the charge is introduced in the cylinder. In the case of the Lenoir engine, the pressure of admission is that of atmospheric pressure.

XQ189. Referring to the Brayton engines, do they ignite the charge at a pressure which is above atmospheric pressure and with compression previous to ignition?

A. In the Brayton motor the mixture is introduced in the cylinder at a pressure which is above atmospheric pressure. This pressure is obtained by means of a pump which has previously compressed the air of this mixture in a tank at a suitable pressure. Ignition is effected at the pressure possessed by the gases after their introduction in the working cylinder (See drawing No. 2 and corresponding explanations in my answer 168).

XQ190. Referring to the Otto four-cycle engines used in the Panhard automobiles, do they ignite the charge at a pressure which is above atmospheric pressure, and with compression previous to ignition?

A. In the case of Otto four-cycle engines, igniting is effected under various conditions of pressure, these pressures depending on the amount of work which is required from the engine. These pressures are even and very often below atmospheric pressure, but in all cases the mixture has been previously compressed behind the piston. This follows from the very principle upon which this class of motor is based. (See explanation and drawings 3 and 4 shown in answer to question 168).

XQ191. In the Otto four-cycle engines of the Panhard Company as actually operated, is not the charge at the moment of ignition at a pressure above atmospheric pressure?

A. I have just answered that the pressure at the time of ignition is extremely variable. In the case of powerful engines running with very small load and running very slowly I have often noticed by diagrams taken, that this pressure at the time of ignition was below the atmospheric pressure. This can be readily understood since the quantity of gas introduced at the period of admission has been so small that during the compression stroke it cannot be compressed to atmospheric pressure.[290]

[290] This A. C. Krebs statement asserting the possibility of ignition at a pressure below the atmospheric pressure seemed not known by experts on the trial. It will be further discussed until the very end of the testimony. See above notes.

Adjourned to Monday, November 14, 1906, at 10 A. M.[291]

[291] **A. C. Krebs letters to his wife**: "*New-York, le 13 novembre **1906**:* [...] *Je suis resté au bureau de 9h à 1h et de 2h à 6h. Louis se porte comme un charme. Il s'est promené hier dans l'après-midi avec Melle Dorigny et une amie américaine. C'est tout-à-fait les mœurs d'ici. La maman Dorigny laisse sortir ainsi sa fille. Ils sont allés tous les trois à la statue de la Liberté et sont revenus à 5h. Pour moi je ne sais encore quand mon affaire finira. Hier j'ai bien posé la question et l'ai développée de manière à ne laisser subsister aucune ambigüité. Mes adversaires sont paraît-il très ennuyés. Je les ai mis maintenant dans une position où ils n'ont rien à gagner pour eux à prolonger l'interrogation à moins de poser des questions oiseuses qui n'avanceront à rien et feront perdre du temps. Il faut m'armer de patience dans cette circonstance. [...] Notre hôtel est le type de l'hôtel américain confortable où des familles demeurent. Ce matin j'avais envoyé Louis à la découverte de la famille "Valentine" pour laquelle j'ai des lettres de recommandations de Mr Lemoine* [administrateur Panhard]. *Louis a vu le père qui lui a donné l'adresse de sa femme et de sa fille. Elles demeurent à l'hôtel St Georges. Très bel hôtel dans le genre du nôtre à la 28° rue. Ils n'ont pas d'autre chez soi ! Ils nous ont engagés à dîner un de ces jours (quand ma voix sera revenue) à l'hôtel Waldorf. Ces mœurs sont renversantes. Le fils qui a 22 ans est venu voir Louis ce soir avant dîner et l'a emmené à son cercle. Nous n'avons pas idée en Europe d'installations comme celle-là. Demain il ira encore avec lui à l'usine* [Panhard] *qui est du côté de Brooklyn.*" (Underlined by us).

Met at ten o'clock, pursuant to adjustment, same place, same parties present.

XQ192. Do you mean to testify that the automobile engines of the Panhard Company as actually used in operating the automobile vehicles in general use ignite the combustible charge when it is at a pressure less than that of the surrounding atmosphere?

A. The statement that I have made is the result of observations that I have made in my laboratory.[292] Referring now to the question just addressed to me, I can say that on an automobile the motor delivers the power which is required of it. This power is limited on one hand by the maximum which can be delivered by the motor, on the other hand the power required by its mere operation without carrying a load. The pressure at which ignition takes place is, therefore, a direct function of the power which is to be delivered by the motor. I have not ascertained whether or not the motor being placed on a vehicle the pressure at which ignition takes place falls sometimes below that of the atmosphere. I will add now that I do not consider this "point" as presenting any interest whatever.

Counsel for Complainants objects to answer as not being responsive.

XQ193. XQ192 repeated.

A. ~~The statement that I have made is the result of observations that I have made in my laboratory. Referring~~

A. I have never intended to state that in the case of the Panhard-Levassor automobile the ignition of the mixture is accomplished in practice under a pressure below that of the atmospheric pressure.

XQ194. What has been your practical experience with two-cycle internal combustion engines on vehicles?

A. I have never experienced with two-cycle motors on vehicles, but I have experienced with them in my laboratory as I also have done with four-cycle motors.

[292] See above the A. C. Krebs mention of the Daimler laboratory in Cannstadt. As well as workshops, the A. C. Krebs interest for laboratories is constant all along his career. He organized laboratories in the Chalais-Meudon aerostatic park, in the Paris fire department, and finally in the Panhard & Levassor factory.

XQ195. Do you know that two-cycle internal combustion engines have been used and are being used on automobiles?

A. I know of it. I also know that steam motors are used for propulsion of automobile vehicles. This does not prove, however, that there is any point of similarity between these motors.

XQ196. Do you know of a vehicle which was called the Roger vehicle, and driven by a two-cycle internal combustion engine, and was that vehicle used in France?

A. I have heard of the existence of the Roger vehicle. It has been used in France. This type of automobile has not been in use as far as I know for the last ten years. I cannot tell whether the motor mounted on this vehicle was a two-cycle motor or a four-cycle motor.

XQ197. Was the engine known as the "Benz" engine used on the Roger vehicle in France?

A. I believe that the Roger vehicles that I have seen were equipped with a Benz engine.

XQ198. Were the Benz engines which you knew of as used on the Roger vehicles two-cycle engines?

A. No; the motor which I saw mounted on a Roger vehicle in about 1894 or 1895 appeared to me to be a four-cycle motor.

XQ199. Do you not know that Benz two-cycle engines were used in France?

A. I know that Benz two-cycle engines have not only been employed in France but even constructed there.

XQ200. Do you not know that Benz two-cycle engines (which you have just testified were made and used in France) were used to propel automobiles?

A. This may be quite possible but I have never paid any attention to it.

XQ201. Did you ever hear or know of automobiles made and run in the United States under the names of "Elmore" and "Duryea" and which have been driven by two-cycle internal engines?

A. In my answer to question 195 I have stated that I knew of the existence of automobile vehicles propelled by means of two-cycle motors. The names of Elmore and Duryea are not unknown to me.

XQ202. Do you know the names of Elmore and Duryea in connection with automobiles driven by two-cycle internal combustion engines?

A. Yes, I have examined this question at the proper time. The engine used at a time by these constructors have not excited my interest for a long time; unless I am mistaken this type of motor has not been manufactured for a long time.

XQ203. Do you not know that the Elmore Companies of the United States have during the last few years made and sold hundreds of automobiles driven by two-cycle internal combustion engines and are still making and selling them?[293]

A. I am very glad to know of it, but I knew nothing about it.

XQ204. On a two-cycle engine is it not possible to have ignition in advance of dead center, substantially as in the four-cycle engines?

A. I have not studied the process of realizing this advance. But as a matter of fact it is not possible to obtain such advance to ignition in the case of the two-cycle motors, such as they are defined, by the Brayton and Selden patents, which engines belong to the class of internal combustion engines in which combustion takes place at constant pressure.

There exist indeed two-cycle engines which really, however, belong to the four-cycle type. In these engines the two parts of the cycle, expulsion of burned gases, and introduction of the fresh combustible mixture are suppressed by a very clever form of mechanical construction. In the construction of these motors the cycle of operation takes place under such conditions that at the time of ignition, the explosive mixture finds itself in the conditions which are absolutely necessary and even indispensable to enable the combustion to take place under constant volume. It may be, therefore, said that although these motors belong to the two-cycle type of engine, they really belong to class of internal combustion engine in which combustion is effected under constant volume.[294]

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[293] That American fidelity to the two-cycle engine points the automobile history in this country.

[294] A. C. Krebs adds here a new "limit case" in order to demonstrate anew the validity of the distinction between constant pressure and constant volume engines. **1909**, **Judge Hough**: "*These are the very things which are at the foundation of success. To be sure (as will be considered more fully later) no very great degree of success can be reached without improvement over **1879** in carburetors, and electric ignition, and increase of knowledge concerning the respective mechanical possibilities of two, four and six cycle engines. The faster, also, the reciprocating parts of an engine move, the greater the necessity of constant and abundant lubrication, and Selden's lubrication is confessedly primitive; and, finally, the great difference between any results Selden's most optimistic supporter can claim for him in **1879**, and the successes of 1909, arises from increased compression, so that engine weight per brake horse power has now been reduced to about 10 pounds*." **1911**, **Judge Noyes**: "[The Brayton and the Otto engines] *also differed in another important particular. The Brayton was a two-cycle engine. The Otto was a four-cycle engine. Turning to the complainants definitions, we ascertain that "a cycle is a series of movements composing one complete operation," and that the following is a definition of the term "two-cycle engine": "An engine whose operation is completed by two strokes, viz., a power stroke and a scavenging or exhaust stroke. If of the compression type the power stroke*

Answer objected to as irresponsive and volunteered.

XQ205. But you have not directly answered my question No. 204, which was whether on a two-cycle engine it is not possible to have ignition in advance of dead center?

A. The appellation (two-cycle engine or four-cycle engine) is not sufficiently clear, as I have shown you in my last answer, to enable me to answer your question in a precise manner. This appellation needs to be completed by some information which would enable me to know whether you are speaking of an internal combustion engine in which combustion takes place under constant volume or under constant pressure. I could also answer your question, if you stipulated the name under which the motor, you refer to, is known. This question as formulated by you is not precise; it is much too vague to permit me to answer it in a way which would not lead to a misinterpretation of my answer.

XQ206. Are there not two-cycle internal combustion engines in which it is possible to have ignition in advance of dead center?

A. Yes; provided that the mode of operation of these motors is such that combustion does really take place under constant volume.

1 P. M. Adjourned for lunch, to meet at 2 P. M., same place.

Met at 2:10, P. M.

XQ207. Can you refer me to any published work where two-cycle engines are distinguished as "constant pressure" and "constant volume" two-cycle engines?

A. I could not for the reason that two-cycle engine may belong in some cases to either one of the classes (constant volume, constant pressure).

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simultaneously compresses the charge for the next power stroke, the charge thus compressed being admitted to the cylinder at the end of or during the scavenging or exhaust stroke." The term "four-cycle engine" is thus defined: "An engine whose operation is completed in four strokes. Always of the compression type. First stroke sucks in the gaseous charge at atmospheric pressure; second stroke compresses the charge; third stroke is the power stroke; fourth is the scavenging or exhaust stroke." The compression stroke in the two-cycle engine of the earlier art usually compressed the charge into an intermediate receiver from which it was admitted in a compressed state to the cylinder. This was the construction of the Brayton engines which were provided with outside mechanism in which compression took place before the charge was let into the cylinder. The four-cycle engine, on the other hand, as represented by the Otto engine, had no such intermediate receiver. The single cylinder served alternately the purposes of motor and pump, and the charge was also compressed in it."

XQ208. How do you determine in a specific engine which way it is run under particular conditions? This question is asked in view of your answer 207.

A. In order to determine the way in which it runs I will be obliged to examine the motor or to look at a drawing of it supplemented by a description of some kind.

XQ209. What would be your actual examination of any engine by which you would determine which way it was running under existing conditions?

A. The process of examination varies according to the case. There can not be a special means fitting all cases. The result is deducted from the chain of conclusions which result from the progressive examinations of the means adopted for the realization of the motor.

XQ210. In the case of your Panhard four-cycle engines what is the actual method you adopt to determine actual conditions and operations within the engine cylinders while the engine is running?

A. The type of motor being perfectly well determined since in this case it is a Panhard-Levassor motor, I know that I have to deal with an engine in which combustion is effected at constant volume. The process used to make certain that every organ operates normally and as intended that it should, consist in running the motor under a load by means of a brake[295] and to set the point of ignition as to obtain the maximum power corresponding to the dimensions of the engine. In the case where we have to deal with an engine having new dimensions, the brake test is sometimes completed by the examination of the diagrams which confirm the first test and give curves similar to the one I have shown in figure 4 in my answer to question 168.

XQ211. Does the brake test you refer to in answer 210 determine whether the engine is running at constant pressure or at constant volume?

A. The brake is merely an apparatus having for function to measure the power developed by any motor[296]. It does not make any difference whether this motor is a steam or a gas, or an electric motor. The brake can give in each

[295] The **1905**-11-13 A. C. Krebs made a communication to **the French Académie des sciences** entitled : "On a dynamometric brake intended for the measurement of the power of motors, which allows the use, in electrical form, of the major part of the work developed".
[296] The A. C. Krebs dynamometric brake is presented in Paris at the **1903** A.C.F. show to demonstrate the operation of the krebs carburettor. **1905**-12-09 – La Revue industrielle.

case but one information, that is the power which it absorbs, which is equal itself to the power delivered by the motor to which it is attached.

XQ212. What do you mean by "examination of the diagrams" as you say in answer 210. How are these diagrams made and for what purpose?

A. The examination of the diagram furnishes information about the ~~manner in which the~~ variations in pressures ~~are formed and vary~~ inside the cylinder. These informations[297] are of a great help in determining whether the pressures takes place and succeed each other as intended.

XQ213. How are these diagrams secured from the cylinders of the Panhard engine?

A. Exactly in the manner required by the apparatus used to take the diagram.

Answer objected to as not responsive.

XQ214. Well, what apparatus is used to take diagrams from the cylinders of the Panhard engines at their works under your direction?

A. I have employed Richard indicators, Carpentier indicators[298] and several types of registering manographs.

XQ215. Does the card diagram when taken confirm the fact that the engine is running on the constant volume cycle as has been assumed by you as predetermined in the case of Panhard engines?

A. In the case where the engine operates badly or when its normal mode of operation is modified, such diagrams are obtained that it does not become possible to determine by their mere examination whether or not one deals with a motor operating in such a manner that combustion takes place under constant volume.

Objected to as irresponsive.

XQ216. Referring to XQ and answer 215, state what is the fact when the engine operates well?

A. Yes; in the case of the Panhard motor I will say that when the motor operates satisfactorily, the diagram is always similar in shape to the model diagram that I have given, figure 4.

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[297] Sic.

[298] The Carpentier manopraph. **1907 - Traité général des automobiles à pétrole**, Lucien Périssé : Diagramme d'un moteur de 1 ¼ cheval à grande vitesse (1.640 tours) obtenu avec un indicateur optique. This document shows multiple engine diagrams. A photo of a diagram produced by this optical instrument exists in the Panhard archives.

XQ217. If an internal combustion engine runs at constant pressure, would not the taking of diagrams in the way you have described show that fact?

A. Yes, since the diagram will be a picture expressing the variations in the pressure which it has been intended to realize.

XQ218. Do not the diagrams obtained from the cylinders of Panhard engines show differing pictures of what is occurring within the cylinders corresponding to varying conditions under which the engines are run?

A. Diagrams do not always indicate what is going on inside the cylinder. As I have said in my answer 215, the internal combustion motors operating under constant volume are liable to be placed in conditions of operation very similar to the conditions in which the motors operating under constant pressure are placed. I will even apply this remark to the Lenoir motor. This is one of their peculiarities, but it does not follow from this remark that they must be classified in the class of the constant pressure motor. A motor which has been constructed and set in view of operating normally with combustion under constant volume may be made to imitate the behavior of a motor operating under constant pressure and even that of a Lenoir motor, but such motor will never be able to operate as well. I will take the liberty in order to show that […] no confusion can be on the subject to propose the following comparison: will it ever come to any one's mind to comprise in the same class, man and a monkey, and yet man can do all what is accomplished by the monkey, but the latter cannot accomplish what is done by man. The conclusion seems to me very easy to deduct from the above.[299]

Adjourned to Thursday, November 15, 1906, at ten o'clock at the same place.

[299] A. C. Krebs refers anew to the traditional notion of “natural philosophy” (see above).

NOVEMBER 15, 1906.

Met pursuant to adjournment, parties present as before.

CROSS-EXAMINATION OF THE WITNESS ARTHUR CONSTANTIN KREBS, CONTINUED BY MR. BETTS.

XQ219. You say in answer 218 that "the internal combustion motors operating under constant volume are liable to be placed in conditions of operation very similar to the conditions in which the motors operating under constant pressure are placed." Specify the conditions of operation to which you referred in that statement.

A. I have not made the statement that engines which have been constructed in view of causing the combustion to take place under constant volume, could operate as engines constructed to burn the gases under constant pressure.

I have said that diagrams given by engines in which combustion takes place under constant volume can in some cases resemble very much to the diagrams given by engines in which combustion takes place at constant pressure, when they operate normally according to the cycle selected. It is for that reason that in my answer No. 151 I stated diagrams cannot be trusted to determine (a priori) to which category of engines, the engine under observation belongs. These appearances are produced when the combustion is retarded by a suitable course, (voluntary or involuntary).[300]

XQ220. Do you classify internal combustion engines by their construction, as distinguished from classifying them by their thermic cycle of operation when you refer to constant pressure and constant volume?

A. It seems to me that there can be no doubt about this question. Engines are classified according to the thermic cycle on which they operate.

XQ221. Do not the card diagrams obtained from internal combustion engines represent the thermic cycles on which the engines are operating at the time the diagrams are taken?

A. No; they cannot represent exactly what is taking place in the cylinder on account of their construction.

[300] **1907 - Traité général des automobiles à pétrole**, Lucien Périssé: "Étude des diagrammes."

The moving parts of indicators possess a certain amount of inertia which often introduce errors in the curve traced by them. These errors have to be rectified afterwards as well as possible. I have already said in my answer 151 that the diagrams cannot be solely depended upon to approximately determine what is going on inside a cylinder, unless the type of motor which has given the diagram is previously known.

XQ222. Can you state any better or more accurate way of determining what is actually taking place as to pressure within the engine cylinders in actual operation, and the actual thermic cycle on which they are operating, than by obtaining card diagrams?

A. The best method as I have already stated is the brake method. Theory indicates that the maximum amount of work obtained for a given amount of combustible fuel burned, corresponds with the greatest expansion. As a matter of fact, the expansion is much greater if the pressure existing behind the piston at the moment where it begins its stroke is as large as possible. It is in order to obtain this ideal condition that Beau de Rochas has described the best method which can be employed, that is to say, to cause the combustion to take place under constant volume. Actual experience has confirmed his theories, and from it the special category of motors operating under constant volume is born.

Answer objected to as entirely irresponsive to the actual question which is now repeated.

XQ223. I now repeat XQ222 which you have entirely failed to answer:

"XQ222. Can you state any better or more accurate way of determining what is actually taking place as to pressure within the engine cylinders in actual operation, and the actual thermic cycle on which they are operating, than by obtaining card diagrams?"

A. Diagrams cannot be said to constitute a method for the determination of the true thermic cycle on which the operation of an engine from steam engines is based. It is in fact possible to obtain from steam engines or from air pumps diagrams which are very similar to those given by thermic engines. The examination of a diagram does not even permit to determine whether or not one has to deal with a thermic cycle.

Answer objected to as not responsive to the question, and as not answering it.

XQ224. XQ222 and XQ223 is[301] now repeated to the witness.

A. I wish to know whether by the word "actual" you mean the ensemble of the diagram or a point of this diagram at a determined point of the piston stroke.

Adjourned to meet at 2 P. PM.

Met pursuant to adjournment.

XQ225. I mean the ensemble of the diagram?[302]

A. I will answer question 224 by dividing it in two parts, as these two parts, in my opinion, cannot be linked together.

First part. I do not know of more accurate means to obtain diagrams than the apparatus of which I mention the names in my answer 214.

Second part. No.[303] It is not possible to determine by the reading of a diagram the type of motor that one has to deal with, "steam, compressed air, internal combustion, etc." It is still more possible to determine by its appearance the kind of thermic cycle which has been employed to trace a diagram.

Answer objected to as irresponsive, and the witness is requested to give a direct answer to the question.

XQ226. I now repeated XQ222 and XQ223 and XQ224, which you have entirely failed to answer; and which embody the same question.

"XQ222. Can you state any better or more accurate way of determining what is actually taking place as to pressure within the engine cylinders in actual operation, and the actual thermic cycle on which they are operating, than by obtaining card diagrams?"

A. I desire to bring to the attention of the honorable attorney for the complainant that question 222 comprises two sentences. Each one of them

[301] Sic.
[302] Sic.
[303] Sic.

constitute one question and that both questions cannot be linked together. The relation between the two questions will be better explained by this comparison.

Can you indicate to me better means for painting the surface other than the use of a brush and color and tell me who is the manufacturer of the color. This comparison will perhaps be sufficient to explain why I am compelled to separate my answer in two parts in order to give two precise answers.

Answer objected to as entirely irresponsive and volunteered.

XQ227. As you insist that there are two separate questions involved in my XQs 222, 223 and 224, in your opinion, although you have not answered either one of them I will now ask you first,

"Can you state any better or more accurate way of determining what is actually taking place as to pressure within the engine cylinders in actual operation than by obtaining card diagrams?"

I call your attention to the fact that we are considering internal combustion engines and also to the fact that I am not asking what is the most accurate apparatus to obtain diagrams but I am asking just what the question states?

A. The question has not been modified and I believe that I have given to questions 222, 223 and 224 the answer that they require. I will sum up now all my answers as follows: It is not possible to require a diagram to indicate more than it can actually indicate. By asking any more from a diagram, one runs the risk to give to its appearance a misconstrued interpretation, and I will add that I do not know of any apparatus which can give better results than the indicators which are actually in existence.

Above answer except the last sentence objected to as irresponsive.

XQ228. In your last answer do you mean better results in ascertaining what is actually taking place as to pressure within the engine cylinders in actual operation?

A. Yes; the expression "better results" can only be applied to that since I have stated that the examination of a diagram and I will add no matter how well it is taken cannot permit to determine the type of motor from which the diagram has been obtained.

XQ229. What do you mean by the expression "type of motor" in the above answer, do you mean cycle of operation within the cylinder?

A. No; I mean to define by this expression a motor operated by steam or compressed air or by internal combustion, etc.

XQ230. Confining your answer to internal combustion engines, will not an ensemble card diagram well taken by the apparatus you have mentioned in your testimony, indicate to you as a picture whether the cycle of operation within the cylinder at the time such diagram is taken is more nearly of a constant volume character, or more nearly of a constant pressure character?

A. I answer no, basing my answer on the various reasons that I have previously given in my answer to the preceding questions.

XQ231. Do card diagrams taken as set forth in the last question indicate nothing to you as to whether the cycle of operation within the cylinder at the time such diagrams are taken is more nearly of a constant volume character, or more nearly of a constant pressure character?

A. A diagram is not a ~~person~~ puzzle. I never examine a diagram unless I can see written on the diagram the following indications which are necessary and indispensable for its reading: 1st. Type of motor under examination. 2nd. Number of revolutions. 3rd. Particularity of the ignition. 4th. What result was it proposed to obtain. An examination such as is proposed by the honorable attorney will never come to the mind to any one wishing to speak seriously.

Adjourned to Friday, November 16th, 1906, at 10 A. M., same time and place.

Met pursuant to adjournment, same place, same parties present.

CROSS-EXAMINATION OF ARTHUR CONSTANTIN KREBS CONTINUED BY MR. BETTS.

XQ232. Do not card diagrams taken as set forth in the previous questions show you variations of pressure within the engine cylinders, and supposing you are given the four points of information stated in your answer 231?

A. Before answering this question I must be permitted to state that in the insistence shown in trying to oblige me to state that the examination of a diagram permits the determination of the type of motor from which the diagram has been taken, seems to bring confusion in a question which can be so easily settled since we possess all necessary elements to form our opinion.

I will now answer directly to this question by simply repeating what I have stated in my answer to question 221. No, the curve shown on the diagram does not exactly reproduce what is going on inside the cylinder where the pressures varies[304].

> Answer objected as not responsive to the question. The witness is politely requested to pay close attention to the questions and to give direct answers thereto. For example, there was […] reproduce" which the witness has dragged into his answer expressly for the purpose of evading the question. Complainant's counsel now repeats the question and insists on a direct and fair answer.

XQ233. XQ232 repeated.

A. I will then modify my answer which the statement I have made previously about this question rendered very clear, I thought.

The diagrams give information about the variations of pressure in a cylinder, but this information is inexact.

XQ234. To what is the inexactness due?

A. In my answer 221 I gave the reason.

XQ235. Did you ever see or obtain card diagrams from Panhard automobile engines which diagrams approximated more closely to constant pressure diagrams than any other kind of diagram in appearance or character?

A. I do not remember ever having made such comparison.

[304] Sic.

XQ236. When Panhard automobile engines are running well-throttled and with ignition only partially advanced, or you may consider any other under-load actual running conditions as in City streets, do not the card diagrams under such conditions show a closer approximation to constant pressure diagrams than to constant volume diagrams in appearance and character?

A. The answer to this question has already been made in answer to question 218. I have not taken diagrams under the conditions which have just mentioned. The diagrams that I have examined and taken under the conditions stated in my answer 218 permit any interpretation that one may choose.

The same answer could apply to the case of diagrams taken according to the conditions stipulated in question 236.

XQ237. Then you do not know really what variations of pressure occur in the Panhard automobile engine cylinders when the engine is running under the conditions prevailing in actual traffic in city streets, do you?

A. No, I do not know, and I will add that under such conditions of operation no two successive piston strokes are alike.

XQ238. How do you know that fact you state in the last answer?

A. By trials made under similar conditions by means of a brake in a laboratory.

XQ239. Referring to your direct testimony (answers 2 and 13) you mention your work on dirigible balloons and on internal combustion engines in connection therewith? Is it not a fact that the result of your work in the endeavor to […] was a failure and that practically you abandoned then this effort to utilize the internal combustion motor for balloons?[305] and did in fact adopt an electric motor operated by a very light battery which electric motor was used to equip the dirigible balloon "La France" which you mention?

Defendants counsel objects to the question on the ground that it is irrelevant and immaterial and on the further ground that answer to the question has already been fully stated in the witness' direct examination.

A. There was in this matter a question of opportunity which led me to select the electric motor in preference to the petrol engine.

[305] Sic.

XQ240. But in fact did you succeed during this period from 1877 to 1885 in producing an internal combustion engine which was operative and of sufficient lightness in proportion to power to enable you to actually apply it to the work you then had in hand?

A. By reason "of the question of opportunity" which I have mentioned in my preceding answer, I did not follow the study of a motor which I did not need to use any longer.

XQ241. Well, then you in fact did not during this period produce an internal combustion engine which was operative and sufficiently light in proportion to power to be actually applied to the work you then had in hand, is that not so?

Same objection.

A. The only answer to this question is the one I have made in the preceding answer. I have stopped the studies on the internal combustion motor which I had begun in view of applying to the balloon for reasons which were independent of my own will. Had it been necessary for me to continue these studies for the same purpose I would have not hesitated to follow the path indicated by Otto and followed by Daimler. It is what I have done as soon as I have had to deal with automobile vehicles[306].

But since the honorable attorney is so very anxious to know my thoughts about this matter, I will repeat, if this may please him, what I have already said before, when I began to study a combustion motor for balloons, I had made a mistake.

Complainants' counsel objects to the answer as entirely irresponsive and volunteered. The question is absolutely direct, plain and simple, does not require into the witness' thoughts, merely asks a response to an absolute question of fact, readily answered.

Complainants' counsel on the record now calls the attention of the witness to the statement and instruction put on this record on November 13, 1906, after answer to XQ172 by Examiner, Mr. John A. Shields, before whom this testimony is being taken, and at the request of complainants' counsel, and in the following words:

[306] Since **1894** for the Paris Fire department.

"The examiner instructs the witness that he must answer the questions directly and in response to the question put, and in accordance with his view of the matter."

Complainants' counsel earnestly requests defendants' counsel to explain this matter to the witness so that responsive answers may be made, no matter what the views of the witness may be and that some progress may be made towards terminating this deposition, which under the methods of answering adopted by the witness very possibly in ignorance of the methods prevailing in answering questions under our practice in this country, is being unduly and unnecessarily prolonged.

Adjourned to meet at two P. M. at the same place.

Met pursuant to adjournment.

Counsel for defendant states that if the cross-examination has been unduly prolonged, the fault rest with complainants' counsel and not with the witness.

Counsel for complainants' as a matter of fact has not devoted one day of cross examination to the subject matter of the direct examination. What is more counsel for complainants' has wasted a lot of time in a fruitless endeavor to have the witness give an answer from which an inference could be drawn that the type of motor can be determined by a diagram, when as he and every one who has any knowledge on the subject knows that diagrams differing greatly in appearance can be obtained from the same engine, and also that engines of different types can be manipulated so as to produce diagrams closely resembling each other.

Counsel for defendants again takes this occasion to warn the counsel for complainant that he will insist that as to all matters not relating to the direct examination, Commandant Krebs is a Witness for the complainants.

Complainants counsel does not accept the statements of fact above made by defendants counsel as correct.

Complainants' counsel regrets to note on the record that defendants' counsel has just had translated to the witness by the interpreter the statement made on the record by defendants' counsel after the previous question, because that statement read to the witness can only result in encouraging him in his conduct in not answering questions, and is also on its face leading and suggestive to the witness as to the character and kind of testimony he should give on the subject which has been inquired about, and is an absolutely incorrect statements as to the subject matter of the cross examination, and what complainants' counsel has endeavored to show thereby.

XQ242. I now repeat XQ241 which is an absolutely plain, simple question of fact, and capable of being answered "yes" or "no" and request you to give a direct answer to the question as to what the fact was:

"Well, then you in fact did not during this period produce an internal combustion engine which was operative and sufficiently light in proportion to power to be actually applied to the work you then had in hand, is that not so?"

Same objection.

A. I have had no occasion of constructing this motor which had merely been studied because I received orders on the subject. I cannot answer either yes or no to the question asked if I want to give an answer […]

Answer objected to as not responsive.

XQ243. Well, then you did not in fact in the period from 1877 to 1885 construct the motor referred to in the last question Nos. 241 and 242, did you?

A. The answer follows from what I have said before. No, I have not constructed such motor because I did not have to construct it.

XQ244. What was the weight per horse power actually developed, of the electric outfit embodied by you in the balloon "La France", considering the weight of the entire electric plant carried by the balloon?

A. I cannot remember it.

XQ245. Give the weight per horse power actually developed approximately, as near as you can recollect it?

A. I cannot give you any information whatever on this subject.

XQ246. What horse power, as near as you can state, was developed by this electrical outfit put by you in "La France" balloon?

A. About ten horse power.

XQ247. Can you give me the weight per horse power actually developed of the electrical outfit which was put into the sub-marine boat “Gymnote” in the period from 1886 to 1889?

A. I cannot even approximately remember it.

The question of weight has no importance in this case.

XQ248. When you say the question of weight has no importance "in this case", do you refer to the engine for the boat “Gymnote”, and if so, why has it no importance?

A. This results from the very conditions of operation of a sub-marine boat. It becomes sometimes necessary to put ballast in the boat and the weight of the latter may be replaced by the weight of the engine.

XQ249. Is not the same true in regard to other boats, not sub-marines?

A. I do not know. There may be different cases.

XQ250. During the period from 1877 to 1885, at whose expense were conducted your investigations in your endeavors to obtain or produce a motor light enough in weight in proportion to power to be utilized upon balloons?

A. The shops of Chalais-Meudon where these experiments were conducted is[307] a military arsenal, placed under the control of the War Ministry. All the expenses were paid out of its budget.

XQ251. Referring to answer second of your testimony, you have stated that "in 1889 the first application of this Daimler engine was made to a vehicle by the firm Panhard-Levassor".[308]

Please state as nearly as you can what was the weight of this entire vehicle including its motor thereon?

[307] Sic.

[308] **1889** - First Panhard & Levassor experimental car: “Première voiture de course”.

A. I absolutely know nothing about it.

XQ252. What was the horse power of this Daimler motor you refer to as applied to a vehicle by the firm Panhard-Levassor in 1889?

A. About 2 H. P., I believe.

XQ253. What was the weight of this Daimler motor of 1889 referred to, complete with its motor equipment?

A. I absolutely do not know what the weight was.

XQ254. Is there any way you can suggest for me to learn the weight of this Daimler motor of 1889 referred to. For example, is it matter of record anywhere, or published anywhere, to your knowledge?

A. You might find information in the catalogues of the firm Panhard-Levassor. Several of these catalogues having been offered as exhibits in this case.

XQ255. Do you know where such information exists in the Panhard-Levassor catalogues?

A. I do not know anything about it.

XQ256. When did you personally first see a Daimler engine in operation?

A. in 1889.

XQ257. Was this the Daimler motor which was first applied to a vehicle by the firm Panhard-Levassor in 1889?

A. No.

XQ258. When was it that you first did see a Daimler […]

A. About 1894, I believe.

XQ259. From 1889 when you say you first saw a Daimler motor until 1894 when you say you first saw a Daimler motor mounted on a vehicle, what work did you yourself do toward developing or adapting the Daimler motor so as to be used on a vehicle?

A. I did not do any special work on the subject. I was merely a spectator.

XQ260. In view of your last answer I call your attention to a statement you made in answer No. 13, as follows:

> "About 1890 I was instructed to study for the fire Brigade of Paris vehicles for salvage apparatus, and at that time I attempted to follow up the work that was being done to adopt the small petrol engine of Daimler to automobile vehicles."

How do you reconcile this statement with that of your last answer No. 259 that you were "merely a spectator"? from 1889 to 1894?

A. Both my answers agree perfectly. The period elapsing between 1890 up to 1894, about, was one of expectation, that is to say a period of incubation or study and it is said at the end of the sentence referred to by you, that I began to materialize my studies. As a matter of fact I wish to state those dates are rather distant from the present time and that I have cited them in an approximative manner.

XQ261. In your answer No. 2 you state:

> "In 1889, the first application of this Daimler engine was made to a vehicle by the firm Panhard-Levassor".

But in answer No. 14 you state

> "In 1891 the firm Panhard-Levassor made the first vehicle equipped with its Daimler engine".

How do you reconcile these two statements.

A. I have stated in answer 2 that in 1889 the Daimler motor was for the first time mounted on a vehicle. This is an experiment which begins, which is followed up and it is only in 1891 (answer 14) that the arrangement studied and tried since 1889 permit the construction of the first vehicle which was offered for sale.

XQ262. Is it not the fact that the use of electric motors for dirigible balloons which you attempted in the period between 1877 and 1885, was abandoned and that the motors now in use for dirigible balloons are petrol motors of the same general construction as your Panhard automobile motors?

A. I have not occupied myself with the question of dirigible balloons since 1885. I cannot, therefore, answer the question.

Adjourned until Saturday, November 17, 1906 at the same time and place.

NOVEMBER 17, 1906.

Met pursuant to adjournment. Parties present as before.

CROSS-EXAMINATION OF ARTHUR CONSTANTIN KREBS, CONTINUED BY MR. BETTS;

XQ263. In your answer No. 13 you state that:

> "At present I am still constructing petrol engines of the same power for dirigible balloons for the war Department, which are still lighter than those for the sub-marines."

How do you reconcile this statement with your answer to XQ262 where you say you have not occupied yourself with the question of dirigible balloons since 1885?

A. My answer is absolutely exact. I have received orders for engines of a certain power and certain weight which I admit are to be mounted on dirigible balloons, but the only part that I have taken in this question has merely been to deliver motors which would be built in accordance to the specification mentioned in the contract. I have nothing whatever to do as far as the balloons themselves are concerned.

XQ264. What is the power and weight of the engines to be mounted on dirigible balloons which you refer to in the last answer and are they of the same character as to construction and operation as your Panhard automobile engines?

A. I regret to be unable to answer this question. The order that I […] strictly of a confidential nature. I find myself, therefor, compelled to invoke professional secrecy.

I will add that I cannot understand very well how this question can be of any interest in the case in which I am a witness.

Answer objected to as irresponsive.

XQ265. Leaving out of the question the details of these engines for dirigible balloons which you say are a professional secret, please answer the general question as to whether the engines are of the same general character as to construction and operation as your Panhard automobile engines?

A. The motors are analogous to the latter and belong consequently to the class of engines operating under constant volume.

XQ266. During the period from 1877 to 1885 when you were working on dirigible balloons in the way you have stated in your testimony, would not motors or engines of the kind you are now constructing for dirigible balloons have been a very desirable thing if then attainable?

A. But, certainly, since they are good now.

XQ267. What was the horse power and weight of the Daimler engine which you referred to in answer to 258 as the first one you saw mounted upon a vehicle about 1894, as you believed?

A. I do not know. Catalogues shown as exhibits might […]

XQ268. State the horse power and weight of the earliest Daimler engine of which you can state those details and identify that engine as to time when you first saw it and first knew its weight and horse power?

A. As my memory about this motor is not very distinct, I take the catalogues shown in the case and I find that they contain the following information as I have stated before.

I take the catalogue of 1892 and I find that the first motor that I have handled is a motor indicated on the catalogue as being a two-cylinder engine having a "nominal power" of two horse, its indicated weight being given as 150 kilograms (330 pounds approximatively).

XQ269. State what is the horse power and weight of the first Daimler motor you saw applied to a vehicle and of which you knew or can state the horse power and weight and please identify that motor and vehicle by time and catalogue?

A. It is the one of which I have spoken in the preceding answer.

XQ270. Does not this same catalogue to which you are referring and which is marked defendants exhibit 183, Nov. 3, 1906, show or give descriptions of single cylinder motors of one-half horse power, weighing 132 pounds, also of single cylinder motors of one horse power […] horse power, weighing 485 pounds?

A. This catalogue shows drawings of single cylinder engines and a brief description of these engines. The table gives for a given power information relating to the weight, the space occupied and the type.

Answer objected to as not responsive to the question.

XQ271. Do you find on the catalogue defendants exhibit No. 183, of Nov. 3, 1906, and on page two thereof, a tabular statement in which is mentioned

single cylinder engines of one-half horse power weighing 132 pounds, also single cylinder engines of one horse power weighing 242 pounds, also of single cylinder engines of two horse power, weighing 485 pounds, offered for sale by Panhard & Levassor, the weights given being without including the base?

A. Yes. The weight of the base varies according to the application which is made of the motor and becomes zero in the case of an automobile.

XQ272. Do the weights of the engines given in the tabular statement of defendants' exhibit No. 183, referred to in the last answer exclude any parts which are necessary for the operation of the engines on the vehicles, and if so, name such parts excluded?

A. I know nothing about it, but it is very unlikely that the weight given does not comprise the weight of all the organs necessary for its operation.

XQ273. Please specify what you understand is included under the column in which is given the weight of the engines excepting their base on this catalogue, defendants' exhibit No. 183, as included in the engine when weighed?

A. Exactly what is shown in the pictures in the catalogue. I cannot give you more information on the subject because as I have stated before I do not wish to commit any error.

XQ274. What was the weight of the vehicle including the engine, which you say in answer to XQ268 and XQ269 was the vehicle on which was put the first Daimler motor of which you could state the horse power and weight, the engine being a two cylinder engine having a nominal power as you say of two horse and as mentioned in the table in catalogue exhibit No. 183?

A. I cannot tell.

XQ275. Did you actually see operate the vehicle referred to in the last question and in answers 268 and 269?

A. I have seen automobiles operated by motors having the power mentioned.

The first automobile that I saw was equipped with the first motor that I ever saw mounted on a carriage.

XQ276. Did this first automobile vehicle you saw equipped with the first Daimler motor that you saw mounted on a carriage, and which I understand to be the vehicle you have referred to in your answers 268 and 269, run or operate in a satisfactory manner?

A. A distinction must be established between the vehicle equipped with a motor which vehicle I saw operating for the first time and the first automobile motor that I have had in hand (reponse[309] 168).

All the vehicles which I have seen in operation equipped with Daimler motors did run perfectly well.

XQ277. Was that true of the first vehicle equipped with a Daimler motor of two horse power which you have saw in operation? Did it run perfectly well?

A. Yes.

XQ278. Please state whether any of these Panhard & Levassor vehicles with the engines originally in them and referred to in this catalogue, defendants' exhibit No. 183 are still in existence in the same form or condition, or substantially the same, as they were about 1892, and if so, where are they or any of them?

A. I know nothing about it, if such a vehicle exists, which is possible, parts worn out by use may have been replaced.

XQ279. What is the existing vehicle of the Panhard & Levassor […]ing in substantially the same construction and condition of vehicle and engine, subject, of course, to necessary repairs having been made, and which dates furthest back as to time of its manufacture and first operation or sale? Where is that vehicle and in whose possession or under whose control at present?

A. I know of the existence of such vehicle dating from 1892, but I do not know where it is.

Adjourned until Monday, November 19th, 1906, at 10 A. M.

[309] Sic.

NOVEMBER 19TH, 1906.

Met pursuant to adjournment,

Same parties present.

CROSS-EXAMINATION OF MR. ARTHUR CONSTANTIN KREBS CONTINUED BY MR. BETTS.

XQ280. Looking at the picture of automobile on the 3rd page of the catalogue, defendants exhibit No. 183, does that correctly represent the appearance of the Panhard & Levassor vehicles they manufactured and you saw operating at the time?

A. Yes.

XQ281. How long did the Panhard-Levassor vehicles continue to be made in appearance practically like that picture on exhibit No. 183?

A. To about 1895 for the two-seated vehicles.

XQ282. Did the Panhard and Levassor Co. to your knowledge ever make an automobile driven by internal combustion engines in which the engine came directly under any portion of the vehicle in which the passengers were actually seated?

A. Yes.

XQ283. When was that?

A. Since about ten years?

XQ284. When did the Panhard & Levassor Co. first import any automobiles of their manufacture into the United States as near as you can give the time?

A. The Panhard-Levassor Co. has begun to import automobiles […]

XQ285. Did not Panhard-Levassor automobiles, which were imported into the United States, more than three years ago carry the name-plate &c. of that Company, showing that they were manufactured by that company?

A. The Company's name-plate is placed on every automobile shipped by the factory.

XQ286. Through whom did the Panhard-Levassor Co. import automobiles into the United States more than three years ago and before it began the importation under its own name as you say in answer 284?

A. The Panhard & Levassor Co. did not have any authorized intermediary.

XQ287. When in fact was the first importation of Panhard & Levassor automobiles into the United States, in any way?

A. I cannot say.

XQ288. How many Panhard & Levassor automobiles have been imported into the United States down to the present time that you know of?

A. I cannot give a definite answer stating how many Panhard automobiles have been imported from the very beginning.

XQ289. Well give the statement of your knowledge in the matter, whatever it is?

A. About two hundred and fifty, by the Panhard & Levassor Co. itself.

XQ290. As general manager of the Panhard & Levassor Co., are you a member of the Board of Directors who determine the policy and conduct of that Company?

A. I am not a member of the Board of Directors but I am generally present at the meetings, and give an account of what is going on, asking the Board of Directors' authorization in my conduct of the most important business matters.

XQ291. Are you a stockholder in the Panhard & Levassor Co.?

A. Yes[310].

XQ292. Do you receive compensation from the Panhard & Levassor Co. for your services as general manager?

A. Yes.

XQ293. Do your duties as general manager of Panhard & Levassor Co. include your advising them or consulting with them with reference to this suit and the other suits brought in the United States on the Selden patent against purchasers and users of Panhard & Levassor automobiles?

A. As far as this actual suit is concerned, yes, but in the case of suits brought against third parties, no.

XQ294. Do you know that instructions have been given by the Directors of the Panhard & Levassor Co. to the firm of Coudert Brothers in New York to appear and defend any suits brought on the Selden patent against customers[311] of the Panhard & Levassors Co. who have bought or are using in the United States […]?

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[310] A. C. Krebs owns 2 shares of the Panhard & Levassor Company.

[311] **1961**, **Greenleaf**, p.177: "*Beginning in October, **1903**, the Ford Motor Company included in its advertisements a guarantee of protection to agents and individual purchasers. […] "WHEN YOU BUY A FORD MOTOR CAR FROM JOHN WANAMAKER, YOU ARE GUARANTEED AGAINST ANY TROUBLE WITH THE TRUST. That's all the insurance any man will want*." "

A. I did not know. The handling of suits of this nature is wholly placed in the hands of a party who has full charge of our litigation.

XQ295. Who is the party you refer to in the last answer?

A. Mr Prevots, residing at 4 Place St. Michel, Paris.

XQ296. Do you not know that the Panhard & Levassor Co. give a guarantee to persons buying their automobiles to defend them against suits brought against them on the Selden patent?[312]

A. Yes, and it is the Company's duty to do so.

XQ297. Various letters and catalogues have been put in evidence in connection with your testimony given. From what source did you obtain these?

A. These documents have been sent to the firm of Coudert Brothers by Mr. Prevots.

XQ298. These letters and catalogues are all of dates prior to 1897 when you became actively connected with the Panhard & Levassor Co. Do you rely on the statements made in these documents for your testimony as to what the Panhard & Levassor Co. did prior to the time you actively joined them, and in so far as those documents contain statements?

A. No. They merely corroborate what I knew myself about the matter.

XQ299. Did you yourself make any examination of the files of the Panhard & Levassor Co. before you came over here on this occasion in order to ascertain facts and find documents?

A. Personally I have not made any such searches but I have given orders to deliver to Mr. Prevost[313], all the documents for which he asked. Previous to my departure he furnished me with a list of all the documents sent by him to the firm of Coudert Brothers.

XQ300. Please let me inspect the list of documents you refer to in your last answer so that I may ascertain which of the documents found in the files of Panhard & Levassor Co. and sent by Mr. Prevost to Coudert Brothers they have thought it best to offer in evidence and which of those documents they have thought it best not to offer in evidence?

A. I have not the document with me and moreover I did not read it.

[312] This information is not given elsewhere.
[313] Sic.

Counsel for defendants states that at the close of the examination to-day he will allow counsel for complainants to inspect at this office the documents produced from the files of the Panhard Co.

The only objection to producing them now is that the witness is very anxious to sail for Europe on Thursday.

XQ301. […] make an additional charge to customers when you give them the guarantee to defend them against suits brought on the Selden patent and beyond what you charged when you did not give them the guarantee?

A. I do not know what is done in this matter by parties who having bought vehicles from the Panhard & Levassor Co. to sell them afterwards, representing themselves as agents. I can say though that as far as the vehicles sold by the Panhard & Levassor Co. are concerned, we never ask from any one any additional charge whatever to insure them guarantee against any such a suit.

XQ302. In view of your attendance at meetings of the directors of the Panhard & Levassor Co. and in your capacity as general manager, do you not know that the defense of this suit against the Panhard & Levassor Co. and of the suit against H. & A. C. Neubauer on the Renault machines (in both of which suits you are now testifying by a single deposition), is being paid for not merely by Panhard & Levassor Co. alone, but also in part by Renault Frères[314], and also by contributions from other Companies and firms established in Europe?[315]

Counsel for defendants instructs the witness not to answer the questions as it is not proper cross-examination.

~~Witness decline to answer.~~

A. I do not know, Mr. Prevost having full charge of all Panhard-Levassor interests.

XQ303. Do you know there is a combination of European manufacturers in which the Panhard & Levassor Co. is included and which combination through its members is contributing to a fund for the defense of the so-called test suits

[314] Sic.
[315] Panhard & Levassor is the leader of the interests of French manufacturers in the Selden case.

on the Selden patent against Panhard & Levassor Co. on their machines and against H. & A. C. Neubauer on the Renault machines?[316]

A. I do not know what has been done about this matter.

XQ304. Who would know the facts about this?

A. I do not know who could give you an answer on such a hypothetical question.

XQ305. Please give a list of the present directors of the Panhard & Levassor Co.?

A. This list may be found anywhere. Here it is however: President, Menard Dorian[317], Vice President, Garnier[318], R. Panhard[319], H. Panhard[320], Holtzer[321], deKnyff[322], Pierron[323], Lavertujon[324] and Prevost[325].

Recess until 2 P. M.

[316] **1961**, **Greenleaf**, p.180: "[…] *Early in **1906** Trevor nevertheless imported a **Panhard** car. The A.L.A.M. detectives reported the violation and Trevor was summoned to court. Judge Emile Lacombe held him in contempt of court and imposed a fine on the hapless student. Trevor paid the fine and was left with three machines he could neither use nor sell!*"
[317] Paul Menard Dorian.
[318] Garnier.
[319] René Panhard.
[320] Hippolyte Panhard.
[321] Holtzer.
[322] René de Knyff.
[323] Georges Pierron.
[324] Lavertujon.
[325] Georges Prevost.

XQ306. From the time you went actively with the Panhard & Levassor Co. in 1897, has not your personal work in connection with internal combustion engines and your practical experience thereon been exclusively in connection with the automobiles produced by that Company and efforts to improve them?

A. All of my efforts and personal work have been entirely directed towards the general managing of all the technical and commercial business of the Company Panhard & Levassor.[326]

XQ307. Has not your actual practical experience with automobile construction and automobile engines been during that period from 1897 to the present day when you have been with the Panhard & Levassor Co.?

A. No.

XQ308. Has the Panhard-Levassor Co. ever made a three-cylinder internal combustion automobile engine? And if so, when?

A. yes, about 1902 or 1903, I believe.

XQ309. Did those three-cylinder engines work in a satisfactory way?

A. Yes.

XQ310. When did you first see a three cylinder internal combustion engine?

A. I don't remember; the number of cylinders bears no […] latter may be and are actually constructed according to the needs with one, two, three, four or six cylinders.

XQ311. I notice that the Panhard & Levassor Co. are manufacturing engines of six cylinders for 1907 models[327] or some of them. What is the advantage of six cylinders over one or two cylinders?

A. They have been built according to orders placed in our Company for some use of which I am ignorant. Personally I prefer a four cylinder engine[328].

XQ312. I asked you what were the advantages of a six cylinder engine beyond a one cylinder or two cylinder engine?

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[326] As Managing Director A. C. Krebs is responsible for both technical and commercial aspects of the firm's business.

[327] **1961**, **Greenleaf**, p.185: "*The Pope Manufacturing Company, a member of the A.L.A.M., produced three makes of gasoline cars at plants in Connecticut, Ohio, and Maryland, and an electric model at its Indianapolis factory. Grossly overcapitalized and managed on an unsound financial basis, it was one of the first motor car companies to collapse in the panic of **1907**, going into bankruptcy after failing to meet obligations of more than $400,000. The loss of one of its most prominent members belied the touted role of the A.L.A.M. as a stabilizer of the motor vehicle industry. More serious was the failure of the Electric Vehicle Company later that year. The company's property had been mortgaged since **1902**. Its financial position weakened rapidly after the panic struck in **1907**. Unable to borrow money to meet $2,500,000 in mortgage bonds held by Morton Trust Company, a banking adjunct of the Whitney-Ryan traction syndicate, the Electric Vehicle Company went into receivership on December 10, **1907**.*" A **1906** Panhard car in New York.

[328] The Panhard & Levassor **1907** four-cylinder engine.

A. They are better balanced.[329]

XQ313. Is this also true of a three cylinder engine as compared with a one cylinder engine?

A. No, it is not possible to absolutely balance a three cylinder engine[330], no more than it is possible to absolutely balance a one or two cylinder engine.

XQ314. How many three-cylinder automobile engines have the Panhard & Levassor Co. made?

A. About four or five hundred. These three-cylinder engines were built especially for England.

XQ315. What was the lowest horse power of any of these three-cylinder engines?

A. All were of the same power, ~~ten~~ nine […] horse power about.

XQ316. Have you not considered these three-cylinder […]

A. No. The three cylinder engine has been built by utilizing cylinders of the twelve horse power four-cylinder type. This was possible since the cylinders of our motors are independently built.

XQ317. But do you not consider the use of three cylinders in your engines as an improvement on the use of one or two cylinders?

A. No; it is above all a question of room taken by the engine and chiefly in our case is simplification in the manufacturing process, since by using one type of cylinder five different powers can be obtained.[331]

XQ318. What was the weight of the Panhard Levassor three-cylinder engines of about nine horse power of which you have spoken?

A. About one hundred eighty kilograms (396 pounds) although I cannot recollect exactly.

XQ319. What is the weight of a Panhard engine of 24 H. P. of the present time?

A. I could not tell exactly; the weight of these motors varies according to the use. For instance, we have built motors which only weigh three kilograms (6.4 lbs.) per horse power, the water jackets containing no water.

XQ320. Were these last for use on automobiles?

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[329] A. C. Krebs patented a balanced engine: FR306968A, GB190114881A, US778542A.

[330] The Panhard & Levassor three-cylinder engine.

[331] “By using one type of cylinder five different powers can be obtained” : this was made possible thanks to the system of engines with separate cylinders.

A. Yes.

XQ321. How lately were these last engines built?

A. These results (three kilograms per H. P.) has been obtained as early as 1901.[332]

XQ321.[333] Referring to the Panhard & Levassor catalogues which you produced on your direct testimony, do you know as matter of fact that the weights given in those catalogues for engines stated to give two horse power, were the actual weights of engines in fact made by that company and that such engines did in fact give practically in operation the two horse power attributed to them in the catalogue?

A. Their mechanical output was superior to the figure given by the catalogue.

All motors manufactured by the Panhard & Levassor Co. deliver as a matter of fact and effectively a power superior to the power indicated on the catalogues. As far as the weight is concerned I may say that it is always given as closely as possible, giving round figures however.

XQ322. Please note that I am asking you about the catalogues produced on your testimony and which are of a date before you entered the employment of the Panhard & Levassor Company. These catalogues give two horse power for certain engines as a catalogue statement, but the question is do you personally know, outside the catalogue, whether these engines of that time did give more or less than two horse power actually?

A. Yes, I know that these motors delivered a power superior to two horse power as I tried them on the brake […]

As a matter of fact the motor mentioned in the catalogue as delivering two horse power gave actually on the brake 2 and 3/4 horse power.[334]

XQ323. Well, what was the weight of that engine to which you refer in your last answer?

A. I refer you to the catalogue.

XQ324. How is it you remember a different horse power from the catalogue, but only remember the weight from the catalogue?

[332] See the above note related to Santos Dumont and the A. C. Krebs research for light engines.
[333] The XQ321 question number is given twice in the original document.
[334] A. C. Krebs has continued this policy of certainty of the power developed by the engines sold by the brand with its dynamo-dynamometer.

A. For the reason that I occupied myself above all with the power developed by the engine, and moreover, these engines which have been constructed until 1895, in large numbers, were known as giving two and three-quarter horse power.

XQ325. What date can you give as the first year in which you tested an engine manufactured by Panhard & Levassor and which developed more than 2 horse power?

A. In the year 1894.

XQ326. Is it not true the internal combustion automobile engines of the present day with the large horse power obtained, which you have stated on your direct testimony, is substantially the same in mechanical construction and operation as the Daimler engines made by the Panhard & Levassor Co. in 1895?

A. Yes; these large motors solely differ from the latter by dimensions, details of construction and the arrangement of parts.

XQ327. When and where did you first see a printed statement of the Beau de Rochas theory of the operation of four-cycle internal combustion engines?

A. Over thirty years ago, but I cannot state where and when I saw that statement printed for the first time. I have read in its entirety the Beau de Rochas patent.[335]

XQ328. Do you not know that the printed statement of the theory of Beau de Rochas was first called to the attention of Otto when it was put in as a defense to Otto's suit upon his English patent brought in the English Courts? and as a defense against Otto's patent in the suit brought thereon in the German Courts?

A. No.

XQ329. As you remember did you know of the description of the Beau de Rochas theory during the period between 1877 and 1885 and particularly while you had and were working with your Otto four-cycle engine of 1878?

A. I have not occupied myself with these theories on account of this Otto motor. I have already said all I can say on this matter.

XQ330. You have already said that you had an Otto four-cycle motor in 1878, and you have said that you knew of the theory of Beau de Rochas about thirty years ago. Did you know of the Beau de Rochas theory while you had the Otto four-cycle motor you got in 1878?

[335] The Beau de Rochas patent: FR52593.

A. I cannot recollect.

XQ331. From where did you first obtain the idea or knowledge that the Beau de Rochas theory was applicable to the Otto four-cycle internal combustion engine?

A. I know nothing about it. This patent was public property at that time.

XQ332. You certainly must at some time have learned or appreciated that the theory set forth by Beau de Rochas, was in practical application embodied in Otto four-cycle internal combustion engines? When did you first reach that appreciation or knowledge?

A. At this time this fact was public knowledge.

XQ333. State what you mean by this time, what period?

A. That same period referred to by the attorney.

XQ334. Well, what do you understand that period to be, give the years?

A. I refer you to the period cited in questions 328 and 329. I cannot give you any more precise information about it.

XQ335. Well, do you mean the period between 1877 and 1885 as mentioned in XQ329?

A. As you please.

Answer objected to as irresponsive.

XQ336. XQ335 repeated.

A. I cannot give you a more precise answer.

XQ337. Do you not know that in Otto's patent which he took for his internal combustion engine, he set forth a […] in the terms of his patent as an object the securing of gradual combustion within the engine cylinder?

A. Yes, but it has been recognized that this theory was not correct. I refer you to my answer to Q100.

XQ338. In 1878 when you bought the Otto engine you have referred to, was it appreciated by you that this engine ran upon the Beau de Rochas theory or cycle?

A. There couldn't be the least doubt in my mind.

XQ339. When you bought this Otto engine of 1878 was any representation made to you by the builders or sellers as to whether it was an explosion engine or not?

A. I do not know. I did not need to ask them about it. It was generally known to be an explosion engine.

XQ340. Was not your Otto engine of 1878 supplied with gas from the ordinary streets mains or a gas tank?

A. Yes, it was City gas.

XQ341. When did you first operate or see operated an Otto four cycle engine which was supplied with gas by means of a carburetor, deriving its liquid from a supply of liquid hydrocarbon and as distinguished from being supplied with City gas?

A. In 1889.[336]

Adjourned until Tuesday, November 20, same time and place.

[336] It is clear here that the ordinary operation of a gas engine around **1880** was planned with city gas.

NOVEMBER 20, 1906.

Met pursuant to adjournment.

Parties present as before.

Counsel for Defendants states that the witness has arranged to sail for France on Thursday of this week, and that the interpreter cannot act after to-day, owing to his business engagements.

Counsel for defendants, therefore, requests that the cross-examination be closed to-day and that if necessary a session be held tonight in accordance with the suggestion of the Examiner, made some time ago.

Complainant's counsel states that he is making and will make every effort to finish the cross-examination at the sessions of to-day and to-morrow and is willing to work extra time for that purpose if necessary.

(342)Q.[337] Whose make or invention of carburettor[338] was that which you saw operated on an Otto four cycle engine'89, as you say in answer 341?

A. I do not know.

Q. 343.[339] Whose make and invention was the first carburettor you ever saw operated in connection with a four cycle Otto engine?

A. I could not tell really as I have seen many of them.

344 Q. Whose make and invention was the first carburettor you ever saw operated at all in connection with an internal combustion engine?

A. I cannot give you any precise information on this subject. This was too long ago.

Q. 345. Whose invention and manufacture of carburettors were put upon the Daimler engines which were first manufactured by the P. & L. Co., and put upon vehicles?

A. I cannot tell as every part of the motor, carburettor included was built by the Panhard, Levassor Company.

Q. 346. Whose invention of carburettors were those which were put upon the Panhard Levassor vehicles like those sold in catalogues, Deft. Ex. 183?

A. I am absolutely unable to tell the name of the inventor.

[337] Sic.
[338] Sic.
[339] Sic.

XQ347. Are you ignorant of the name of any inventor of carburetors for internal combustion engines, either those used by Panhard & Levassor, or any others, before you, yourself, invented your carburetor?

A. No. Among the many carburetors that I have seen none was considered as patentable.

Answer objected to as irresponsive.

XQ348. Tell me what carburetors were in use by the Panhard & Levassor Co. on their internal combustion engines […] their construction? Were they attributed to any individual by name. Did they permit of the operation of the engine?

A. Several types of carburetors have been successively used. The surface carburetor, the atomizing carburetor. The mode of operation of these carburetors is so well-known that it is hardly necessary to describe them. They did operate perfectly well when they were set to give their best efficiency for a determined speed of the motor. These carburetors came to the Panhard & Levassor works with the patterns furnished by Daimler. I know nothing more on this subject.

XQ349. Did not these carburetors which were manufactured and used by Panhard & Levassor prior to their adoption of your carburetor operate so as to enable the automobile engines to run and to propel the vehicles?

A. Yes, very well.

XQ350. Have you not understood that the carburetors which came to the Panhard-Levassor works with the patterns furnished by Daimler were of Daimler's invention?

A. I know nothing about it.

XQ351. Did the Panhard & Levassor Co. to your knowledge ever employ a carburetting device in which the entire supply of gasolene[340] or liquid hydrocarbon was boiled by or subjected to the heat of a furnace?

A. I know nothing about it.

XQ352. Have the Panhard & Levassor Co. to your knowledge ever operated their automobile engines deriving the supply from a tank of compressed gas carried on the vehicle as distinguished from a supply of liquid hydrocarbon carried on a vehicle and utilized in connection with a carburetor?

[340] Sic.

A. I have never heard about such idea.

XQ353. Have not the Panhard & Levassor Co. so far as you know always carried the supply of liquid fuel for their automobile engines in a suitable tank on the vehicle and withdrawn the liquid fuel therefrom and vaporized it at a rate to accord with the working of the engine?

A. The hydrocarbon liquid contained in a tank carried by the vehicle has always been brought to the motor by the intermediary of the carburetor having for function to regulate its supply to the motor.

XQ354. Referring to the carburetor you have mentioned on your direct examination as your invention, when and where and by whom was the first Krebs' carburetor, as referred to, constructed?

A. I cannot answer this question as I consider it as being wholly exterior to the case.

Answer objected to as irresponsive.

XQ355. Have you taken out patents in the United States for your carburetor, and if so, give me the numbers and dates of them?

A. I do not recollect and I consider that it has nothing to do whatever in the case.

Answer objected to as irresponsive.

XQ356. You are not the judge of whether questions have something to do with the case or not. You must certainly know whether you have received any patent in the United States for your carburetor. I ask you whether you have or not taken out or been granted any patents in the United States for your carburetor.

A. I know nothing about it.

Counsel for defendants admits that Mr. Krebs has obtained Letters Patent of the United States, No. 734,421, dated July 21, 1903. These letters patent are in evidence, Defendants' exhibit No. 161.

XQ357. Has any patent for your carburetor been granted to you in France, and if so, give date and number if you can.

A. Yes, a patent has been applied for in France but I cannot recollect the date or number.

XQ358. Did you yourself build the first carburetor of the kind you have described on your direct examination? as your design, and if not, who did do it?

A. It was built at the Panhard-Levassor works.

XQ359. To your knowledge have any suits been brought either in Europe or the United States under any patents granted you or on your application for […] parties alleged to copy or infringe such carburetor patents?

A. As far as I know, no such a suit has ever been brought about these patents.[341]

XQ360. When was the earliest use of the carburetor which you refer to on your direct examination and which is generally known as the "Krebs carburetor", and where was that use?

A. At the Panhard & Levassor works. I cannot at the present time recollect the exact date of its first application. I will state, however, that this happened about five years ago.

XQ361. Did you ever hear of carburetors known by the name of "Bultler" carburetors[342] or "Maybach" carburetors[343], and did not carburetors so named exist prior to your own invention of the "Krebs" carburetor?

A. In a vague manner I heard of those names.

XQ362. Are you aware or did you ever learn that the English patent to Daimler for "Float Feed Aspirating Carburetor" was declared invalid in England because of the prior patent for carburetor to Butler of England?

A. Yes, in a vague manner.

XQ363. Are not "Float Feed Aspirating" features of construction embodied in the so-called “Krebs” carburetors, you have testified about on your direct?

A. I do not claim to have invented a carburetor. I merely brought important improvements to float feed carburetors […]

XQ364. Are you not aware that many other forms of carburetors are in practical and successful use on automobiles in connection with internal combustion engines, than the specific form of carburetor you have referred to as of your design and which is known as the "Krebs" carburetor?

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[341] Panhard & Levassor will have the Mercedes carburettors illegally using its automatic carburettor patent seized in Nice. An agreement will be reached between the parties thus avoiding bad publicity for the two brands.

[342] "Bultler" carburetors”.

[343] “Maybach carburetors”.

A. I am aware of it.

XQ365. Do you know Mr. Aimé Witz of France[344] as an authority or expert on the subject of internal combustion engines and has he published a book or books on the subject, and if so, have you ever read them?

A. My answer to the three above questions asked is : I know of Witz and his books, but I do not recognize anyone as an authority on these questions. See my answers to questions 95, 96, 97, 98, 99, 100 and 101.

XQ366. Before you came over to this country on this occasion, did you receive any letter or letters from counsel or experts in the United States or from any one explain to you in regard to giving testimony here in this case, and did you write any letter or letters on the subject, and if so, please produce all of such correspondence?

A. As I have already stated in a previous answer, I came here without having had previously any communication whatever, either verbal or written with any one relating to the manner in which I was to give testimony, I only […]

XQ367. Do you not know that Benz successfully ran in Germany a vehicle equipped with an internal combustion engine and before Daimler ran a vehicle equipped with his internal combustion engine?[345]

A. Yes, I heard of this in a vague manner.

XQ368. Do you know or have you heard of an engine in accordance with the invention of François Million[346]?

A. I do not remember of having heard such name.

XQ369. Have you ever heard of any French patent or patents to an inventor named Henri Menn[347], or of any internal combustion engines built or used under any such patents?

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[344] Aimé Witz: obituary.

[345] **1961**, **Greenleaf**, p.33: "*It is bootless to claim priority for either Daimler or Benz as father of the gasoline automobile. More important is the fact that the Daimler high-speed four-stroke engine led directly to the rise of the motor vehicle industry. In **1891** the Parisian firm of **Panhard & Levassor**, which in **1886** had begun producing Daimler engines under license, brought out a horseless carriage designed by Emile Levassor that used the improved Daimler V-engine of **1889**. The Panhard automobile, as developed by **1895**, had the essential features and mechanical arrangement of **the modern motor car**. It had a separate body and chassis, with intervening elliptical springs; a vertical motor in front, with clutch and gearset behind the engine; and rear-wheel drive and hub brakes.*"

[346] Jean François Marie "Francisque" MILLION.

[347] **1909**, **Judge Hough**: "*Menn (French 118.109, in **1877**) is at best an impossible gas engine, in a structure irrelevant to this case.*" **1961**, **Greenleaf**: *"For example, in **1877** a French civil engineer, Henri Menn, patented a huge road locomotive driven on petroleum. Menn boasted that the vehicle could "traverse the deserts which border Algeria or the Steppes of Russia", but his specifications belied this trumpeted hope. Powered by a fifty-horsepower engine, the Menn locomotive weighed about eighteen tons. It was never built.*" Mr. Menn actually will continue with locomotives: FR129372, FR129381.

A. I do not remember.

XQ370. Did you ever hear or know of any patents granted to or engines made under the inventions of persons named Carre[348] or Brothier[349]?

A. I don't remember.

XQ371. Did you ever hear or know of the practical use or an automobile of what I term an external combustion engine, that is an engine in which the charge is burned in a chamber outside of the working cylinder and the expansible gases resulting from the combustion, conducted from the said chamber to the working cylinder by means of pipes?[350]

A. No.

Recess until 2 P. M.

XQ372. Do you know or have ever heard of an automobile which was propelled by a hot air engine such as the Ericcson engine[351] or by a compressed air engine employing a tank containing a supply of compressed air under heavy pressure or by an ammonia engine?

A. I do not remember of it.

XQ373. In fact did you ever hear or know prior to 1895 of an automobile constructed in accordance with what is shown in the Rosenwald patent No. 116.871 of 1877[352], defendants' exhibit No. 108, being actually constructed and operated?

A. No.

XQ374. Did you ever know or hear of the free piston type or construction of engine like that of Otto & Langen[353] or Hallowell[354], or Barsanti[355] & Matteucci[356], being actually used on an automobile to propel it prior to the year 1895?

A. No.

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[348] **1869** - Carre FR84782: "Moteur à air dilaté par la combustion des hydrocarbures liquides."
[349] **1865** - Brothier FR67881: "Machine à gaz à force variable."
[350] The external combustion engine is the principle of the steam engine.
[351] John Ericsson: The hot air Ericson engine. The Ericson cycle.
[352] See note above.
[353] **1876** - Otto engine: US178023A.
[354] Hallowell: unidentified.
[355] Barsanti.
[356] Matteucci.

XQ375. Did the Panhard-Levassor Co. ever use for automobiles a slow speed internal combustion engine which required to be geared up instead of being geared down, so as to give a higher instead of a slower speed to the axle?

A. I do not know, as far as I am concerned.

XQ376. Do you know of the Panhard & Levassor Co. ever constructing an automobile which was actually and successfully operated by a gas engine of the free-piston type?

A. Not to my knowledge.

XQ377. Referring to the Lotz vehicle of 1867 and the Bollee vehicle[357] of 1878 which you have mentioned in your direct evidence, were not both of these driven by steam engines?

A. Yes.

XQ378. Did not the manufacture of these vehicles stop at that time so far as you know?

A. I know nothing about it.

XQ379. Have you ever heard of them since the times you mention in your testimony?

A. I don’t remember.

XQ380. Has the Panhard & Levassor Co. ever manufactured automobiles driven by steam engines?

A. No.

XQ381. Why have not the Panhard Co. made steam automobiles?

A. I do not know the reason of it.

XQ382. As an engineer and expert in the art of automobile construction is your preference for internal combustion engines as the motive power of automobiles as compared with steam engines for the same purpose.

A. I do not know whether one type is preferable to the other. It is chiefly a question of opportunity.

XQ383. But as a matter of fact you prefer yourself the internal combustion engine for automobiles because you consider it better and more perfected and more applicable to such vehicles, is that not so?

A. No, judging from what I see every day.

[357] See note above.

XQ384. What percentage of automobiles manufactured in France are driven by internal combustion engines as compared with automobiles which are driven by steam engines?

A. No, I could not say what the proportion is.

XQ385. Is not very much the larger proportion, now manufactured and which has been manufactured in France to your knowledge, of automobiles driven by internal combustion engines, than those driven by steam engines?

A. I do not know. That may be.

XQ386. Have the Panhard & Levassor Co. ever made experiments with steam engines for propelling automobiles?

A. I do not know whether it did or not.

XQ387. You never heard of their making such experiments, did you?

A. No, I never heard of it.

XQ388. Have you any knowledge of steam traction engines having been used in France?

A. I believe that they have.

XQ389. Were not these very heavy and slow speed vehicles?

A. I have no exact figure present in my mind at the present time, but of course the weight of these tractors and their speed were depending upon the use for which […]

XQ390. What were the uses for which these steam traction engines were designed and to which they were actually applied in your knowledge?

A. I could not tell you.

XQ391. In the efforts made by yourself and others to adapt the internal combustion engine for the propulsion of road vehicles or automobiles, were you aided, or was any one aided to your knowledge by what had been done in connection with steam traction engines and steam driven vehicles?

A. I do not know. I cannot remember of anything.

XQ392. Can you now set forth any way in which your knowledge of steam traction engines has helped you in what you have done in the development of the internal combustion motor and its application as a driving engine for Panhard & Levassor automobiles?

A. I cannot answer. I know nothing about this.

XQ393. Then, you cannot point out any way in which steam traction engines or steam driven automobiles have helped you in developing internal combustion engines and adapting them for the automobiles of the Panhard & Levassor Co., is that the fact?

A. No.

XQ394. Can you state when gasoline was first used in France as fuel for internal combustion engines on automobiles?

A. No. I cannot.

XQ395. Did the pneumatic tire for automobiles originate with the Panhard & Levassor Co., and if not, with whom did it originate?

A. The firm of Panhard never occupied itself with this question. The first pneumatic tires actually mounted on the wheels of its automobiles, were mounted at the expense of the customers who bought the vehicles.

XQ396. Then it was from the customers who bought the vehicles that the first suggestion of pneumatic tires on Panhard automobiles came, and they were only put on the Panhard machines at the special request and expense of the customer?

A. I understand that this question requires two answers. To the first, I would answer yes. Answering the second, I must say that I do not know whether the pneumatic tires were placed on the wheels at their expense or not.

XQ397. Have the original Daimler engines constructed by the Panhard & Levassor Co. with cylinders at a V angle with each other or the double track side groove cams of those engines, remained in use or has that construction been abandoned?

A. No. That construction has been abandoned since 1894.

XQ398. Do you know that a number of Panhard-Levassor automobiles were sold having iron tires, and before pneumatic tires came into general use for automobiles?

A. I am aware of it.

XQ399. In your answer to direct question 46 you say in giving the changes made year by year, in Panhard & Levassor automobile construction, that in 1904 you changed from cone to multiple disc clutch, was not the multiple disc clutch used by other automobile manufacturers before the Panhard & Levassor Co. and taken by your designers from previous users in Italy or England?

A. No, it is precisely the contrary which happened.[358]

XQ400. Do you mean to testify that the use of multiple disc clutch by Panhard & Levassor Co. in 1904 was the first use of that form of clutch in connection with automobile construction?

A. Yes, to the best of my knowledge. I will add that I attach but a very small importance to this fact. This type of clutches having become at that time, public property.

XQ401. Referring again to your answer No. 46, had not the "direct drive" on high speed been used in connection with automobiles by other constructors, and more particularly by Monsieur Renault previous to the adoption of that mechanism by Panhard & Levassor Co.?

A. Yes, but the Renault Co. employs a special type of direct drive which differs from the type employed on the Panhard automobile. This "direct drive" has long been public property.[359]

XQ402. Referring again to answer 46, had not the [reversing gear device the Panhard & Levassor] Co. changed in 1901 been used practically prior to that date by other automobile manufacturers and adopted by your Company after it had been proved satisfactory?

A. No. As in the case of friction clutch, the contrary took place; at any rate this device has become public property.

XQ403. When did that reversing gear device become public property, if you know?

A. No, I could not tell when this device became public property, but I am certain that it is public property.

XQ404. Was not this reversing gear public property when it was first put by the Panhard Co. into the construction of its automobiles?

A. It is quite possible.

XQ405. Did not the Panhard & Levassor Co. have to make many trials and do a large amount of work, covering several years, to reach the result of adapting the Daimler engine to actually, successfully drive a road vehicle or automobile?

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[358] The A. C. Krebs multi-plate clutch patent: FR340185A.

[359] Panhard & Levassor will be dependent on the **1902** Renault patent for direct drive but also on the patent for attacking the differential by a universal joint.

A. Not that I know of. As the motor was working very well the success was certain inasmuch as automobile vehicles were already in existence.

XQ406. How many years was it after the Panhard & Levassor Co. secured the license or rights under the Daimler patent or engine before that Company sold an automobile equipped with that engine?

A. I do not know.

XQ407. In your answer No. 46 you have said that in 1901, the Panhard & Levassor Co. cast engine cylinder and head in one piece. Had not this been done by other manufacturers, including some other French firms, before the Panhard Company, did it?

A. It is quite possible.

XQ408. In your answer to question 46, you say that in 1901 the Panhard & Levassor Co. changed its engine control on Panhard automobiles from "hit and miss" to throttle control of mixture. Had not throttle control of mixture[360] been employed on automobile engines before Panhard & Levassor Co. made this change in 1901?

A. Not that I know of.

XQ409. Do you remember a time when Monsieur Clement[361] was President of the Panhard & Levassor Co. and whether there was not received at that period and after you actively went with the Company, various drawings of automobile vehicles and parts made by the Pope manufacturing Co[362]., motor carriage department, of the United States, which drawings were open to examination by yourself and certain others of the designers of the Panhard Company, and were in fact examined or seen?

A. I remember perfectly well that I saw at the date mentioned at the factory of M. Clement at Levallois Perret, Pope vehicles, but I never saw or had drawings of these vehicles […]

XQ410. Do you not remember that a vehicle made by the Pope Mfg. Co., which you saw at M. Clement's factory at the date mentioned, had its engine control by throttle control of mixture?

[360] The automatic throttle control of mixture with the **1900** A. C. Krebs "**Centaure carburetor**" patent: GB190016467A.
[361] Adolphe Clément-Bayard.
[362] The Pope Manufacturing Company.

A. The only Pope vehicles which I saw at M. Clement's factory, towards the end of the year 1898, were only electric vehicles[363].

XQ411. In your answer 46, you have said that in 1898 the steering mechanism[364] in the Panhard & Levassor was changed. You have also stated that Mr. Levassor died in 1897 in an automobile accident. Is it not a fact that this latter circumstance influenced a change of steering mechanism on the Panhard & Levassor automobiles and the adoption of a system of steering which at that time was known under the name of "Pope-Columbia direction" and had been illustrated in trade papers as the "Pope-Columbia direction"?[365]

A. I answer no the question asked, and I do add this: The question of steering is one that I have taken up towards the end of 1897, as soon as I had acquired a sufficient knowledge of the operation and of the organization of the Panhard & Levassor business. This steering device was not anything else but an adaptation of means already known and used since a very long time for the same object.

Adjourned until Wednesday, November 21, 1906, same time and place.

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[363] **1961**, **Greenleaf**, p.58: "*After searching for a suitable plant, the* [Whitney] *syndicate decided to use the facilities of the Pope Manufacturing Company of Hartford. In the opening days of April, **1899**, shortly after acquiring the Electric Vehicle Company, Whitney conferred with Colonel Albert A. Pope in New York City. Their meeting was the first step toward an alliance which raised the Selden patent from obscurity and made it a weapon of monopoly*." P.63: "*Together with the few other engineers who shared his minority view [on May 13, **1897**, to celebrate the formal opening of the Pope electric auto plant], Maxim repeatedly proposed the commercial production of gasoline cars, but years passed before the Pope executives accepted the idea," and then only due to the invasion of the United States by French cars with the motor in front," as Henry Souther pointed out*." P.64: "*The bicycle era produced a large and complex body of patent litigation, and no producer was more vigilant than Pope in protecting his controlling rights. His company held the basic Lallemont patent, under which it collected ten dollars on every bicycle made by other firms*." P.66: "*A further consolidation occurred on May 3, **1899**, when a new concern, known as the Columbia & Electric Vehicle Company, was incorporated by the Pope-Whitney group*."

[364] The Krebs 1898 irreversible steering mechanism.

[365] **The Automotor Journal**, January 30, **1904**, p.121: "*BLUFF AND THE SELDEN PATENT. The fight in the United States in connection with the Selden patent and other minor patents controlled by the Association of Licensed Automobile Manufacturers is proceeding apace, and there appears to be a prospect of some definite legal decision being come to as a result of the present tactics. For the sake of the general automobile industry it is to be hoped that the attempt to corner manufacturers, both in the United States and abroad, will signally fail, particularly in view of the outrageously flimsy patent on which the main claims are based.* […] *By way of having a second barrel to their gun, the Association* [A.L.A.M.] *are beginning to move in connection with some of their minor patents, and under this policy they are suing the American house of **Panhard and Levassor** in connection with the Columbia Steering Mechanism, known as the Back Lock Steering Device. The actual patent in this case alleged to have been infringed is one filed in June, **1896**, and granted May 6th, **1902**, to Hiram Percy Maxim (No. 699543), and another filed in **1897** and issued in June, **1902**, to Pope and Maxim (No. 702448). Altogether a pretty kettle of fish appears to be coming to the boil*." **1961**, **Greenleaf**, p.178: "*Although the A.L.A.M. used the Selden patent as its main instrument of aggression, it gave warning in **1903** that it would also wield the more than four hundred patents individually owned by its licenses.* […] *The first of the infringement suits involving these minor patents was lodged on January 5, **1904**, when the Electric Vehicle Company brought proceedings against the American branch of **Panhard & Levassor** for infringement of the back lock steering mechanism patented by Hiram P. Maxim in **1902***."

NOVEMBER 21, 1906.

Met pursuant to adjournment.
Parties present as before.

CROSS-EXAMINATION OF ARTHUR CONSTANTIN KREBS RESUMED BY MR. BETTS.

XQ412. State when M. Clement was President of the Panhard & Levassor Co.?

A. As far as I can remember M. Clement was President of the Panhard Co. from 1899 to 1901.

XQ413. Did you during that period hear or know of a system of steering mechanism under the name of "Columbia direction"?

A. I do not recollect.

XQ414. Did you examine the steering mechanism on the Pope vehicles you say you saw at M. Clement's factory towards the end of the year 1898?

A. I have looked at the automobile all over it is quite possible that I saw the steering mechanism.

XQ415. Was not the death of Mr. Levassor in an automobile accident due to some failure or accident connected with the steering gear of a Panhard & Levassor automobile which he was driving?

A. No. I cannot say that positively.

XQ416. But did you not hear and understand at the time that such was the fact?

A. It is quite possible, but personally I do not know […]

XQ417. Did not the Panhard & Levassor Co. have at their factory, to your knowledge, at some time the Pope electric vehicle or vehicles which you say in answer 410 you saw at Mr. Clement's factory?

A. The Panhard Co. never had such vehicle at its factory for any length of time. It is quite possible, however, that the electric vehicle referred to were brought to the Panhard factory as many other vehicles were brought there.

XQ418. Did not you at about that time say, yourself or was it not said to you by some one connected with the Panhard Co. that the steering mechanism of that Pope electric automobile was a good feature and worth introducing while other features of the machine were too expensive?

A. I do not remember.

XQ419. Is it not that the change in the steering mechanism on the Panhard & Levassor automobiles which you have described in your testimony was made at or about the time that this Pope electric automobile was in the possession of M. Clement and was seen by you?

A. No, I have said in my answer 411 that a study of such modification in the steering mechanism had begun at the end of the year 1897. Mr. Clement introduced in his factory at Levallois Perret the Pope vehicles at the end of 1898. The Panhard-Levassor racing car of May 1898, Paris-Amsterdam race[366], were already equipped with the new steering mechanism. As a matter of fact and as I have stated in my […] which had been employed for a long time for similar purposes.

XQ420. Do you know of any internal combustion engines which were described or which existed prior to the Brayton engine as that is described in the Brayton U. S. patents of 1872 or 1874 and which you would classify as constant pressure engines?

A. I do not know anything about it.

XQ421. Do you mean that you do not know of any?

A. I do not know of any.

XQ423. Is it not a fact that prior to the year 1900 almost all automobiles propelled by internal combustion engines had motors of not more than 8 H. P. so far as you know?

A. No.

XQ423. How was it prior to 1899 whether a large proportion of automobiles driven by internal combustion engines were not of 8 H. P. or less?

A. No.

XQ424. Please look at the two original letters now shown you and which I have received from defendants' counsel, Mr. Murray, and which are dated February 15, 1890 and August 7, 1890, respectively and state if you recognize the signature thereto as that of Armand Peugeot[367]?

A. No, I cannot certify the signature, not knowing Armand Peugeot's signature.

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[366] The **1898** Paris-Amsterdam-Paris race. See the Panhard & Levassor racing car from the Paris-Amsterdam-Paris race bought by C. S. Rolls in **1898**, and which he named in his photo album: "The first car in Britain fitted with wheel steering."

[367] Armand Peugeot.

XQ425. Are not these letters referred to and shown you from the files of the Panhard & Levassor Co.?

A. I consider them as belonging to the files of the Panhard & Levassor Co.

Complainants' counsel asks that the two original letters produced and referred to above be marked for identification by the Examiner, and they are so marked.

XQ426. You never have seen the Selden engines, either the three cylinders engine or the one cylinder engine which you inspected at the garage in New York on October 29th and 30th, actually running or operating have you?

A. I have already answered no.

XQ427. Have you not been informed by any of the counsel in this case or by any of the defendants' experts, such as Mr. Jesse Smith[368] or Prof. Carpenter[369], or by any one, that these Selden engines of three cylinders and one cylinder had been actually run and seen running by defendants' counsel and experts?

A. No.

XQ428. Can you tell me the word "automobile"[370] was first used in connection with vehicles driven by internal combustion motors, or about when. When did it come into nomenclature of the art in France?

A. No, I could not tell you.

XQ429. Please look at the printed French publication shown you, and state whether you do not find in the upper figure of the drawing on page 389 of the Brayton engine[371], that there is shown a restricted opening into the cylinder owing to a baffle-plate and which opening is relatively small compared with the size of the chamber for combustion marked D on the drawing?

A. This drawing is too crude to permit me of giving my opinion on the relation between volumes.

It is not, however, in this moment that I have noticed the arrangement mentioned in the question, but in the United States patent 151,468[372], which

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[368] Mr. Jesse Smith : see notes above.
[369] Professor Rolla C. Carpenter.
[370] **1971**, **Bishop**, p.7: " The *word "automobile" is a French word*."
[371] The Brayton: **1872** - US125166A, **1874** - US151468A.
[372] See above the Brayton motor mentions.

was shown to me to enable me to say whether the drawing in La Nature represented fairly well an arrangement similar to one described in the patent.

XQ430. Does not the drawing of Brayton United States patent 151,468 referring specially to figure 3, show in fact a carburetor for the Brayton engine?

A. It is certainly what Brayton intended to build for a carburetor.

XQ431. Referring to your answers to questions 55 and 56 and also to the printed copy of the Selden patent No. 549,160 now shown you, is that the printed copy you examined in giving answer No. 56?

A. Yes.

Counsel stipulate that the copy referred to is an ordinary printed copy of which the size of which copy is one of the regular printed copies of patents issued by the United States Patent office.

XQ432. Please state at the printed or lithographed sheet of drawings now shown you and of which the field within the rectangular border lines measures about 8 in. x 13 in., and which on its face has the printed statement G. B. Selden road engine, No. 549,160, Patented Nov. 5, 1895, 2 Sheets--Sheets 2, &c. Please look at fig. 3 of this drawing[373] and particularly at the portion thereof marked P' and the small chamber to the left thereof, and the lines which appear on said drawing between the chamber T' and this smaller chamber to the left, and state in the first place what you understand to be indicated by the vertical dotted lines there shown? and you are requested to use a magnifying glass which I now hand you.

A. These dotted lines mentioned cannot in my mind represent anything except if the drawing is supplemented by description.

XQ433. Do you say that these dotted lines on this drawing referred to do not represent to you as accustomed to read and understand drawings wire gauze fabric or sheets between the large chamber T' and the smaller chamber to the left?

A. No. These lines do not represent anything to me.

XQ434. Looking now at the curved black line on Fig. 3 of this Selden drawing, immediately to the left of the dotted lines just referred to and to the short black lines immediately to the left of this curved black line, near

[373] Selden road engine patent: US549160.

the top and the bottom thereof, do those lines on that drawing represent or indicate anything at all to you as to construction shown?

A. These lines do not represent anything to me.

XQ435. But now that you have seen the Selden engines as actually constructed as you saw them at the garage, do these lines referred to on the Selden drawing indicate anything to you as to what they represent in the construction actually put into the Selden engine?

A. Now that I have seen a motor constructed, I understand that these lines are meant to represent the springs of the valve shown which is also badly represented by the black lines which separate chamber T' from the small chamber at the left. But, while I am aware of this, I do not see a point of rest for these springs since the dotted lines which are supposed to represent the wire gauze do not indicate anything to me in the drawing.

Complainants' counsel offers in evidence the full size lithographed copy of sheet 2 of the drawing of Selden patent No. 549,160 which has just been examined and referred to by the witness and the same is marked […]

XQ436. I now show you a copy of Fig. 1, Fig. 2 and Fig. 3 from the English patent to Maybach, No. 16,072, dated August 25, 1893[374], and contained on page 33 of a printed pamphlet entitled "Bulletin No. 8 of Association of Licensed Automobile Manufacturers"? and ask you what you call the part marked g in each of those figures 1, 2 and 3?

A. A valve with its stem and the spring shown in dotted lines. The spring rests on one end on the frame, on the other end on a nut screwed at the end of the valve stem.

XQ437. Is there not shown in these drawings, Fig. 1, 2 and 3 a chamber just outside of the valve g into which a liquid fuel pipe leads close to the cylinder?

A. Yes, very clearly.

XQ438. Do not these drawings shown you represent the first form of that float feed aspirating carburetor[375], and which is very generally used in automobile engines to-day?

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[374] The Maybach carburetor patent: GB189316072 – "*Improvements in the Method of Producing the Explosive Mixture in Hydrocarbon Engines*".
[375] Carburetor: the float chamber.

A. These drawings are very clear drawings intended to represent float aspirating carburetors, but I have not seen carburetors built exactly as shown. Carburetors could be constructed with these drawings.

XQ439. Do you not know that the Lenoir engine was constructed, double acting, with electric ignition from a single source?

A. Yes, vaguely.

XQ440. Was there not used on such a Lenoir engine a distributor in connection with a source of electricity[376] […]

A. Yes, I believe that was the case.

XQ441. Did not the French electrician, M. Dumoncel[377], describe electric batteries of the dry or semi-dry type prior to 1879?

A. I have no recollection about it.

XQ442. Is it not a fact that the Panhard & Levassor Co. continued until the year 1900 to use hot-tube ignition?

A. Yes, it is a fact, but not an absolute fact.

XQ443. Did not the Panhard & Levassor Co. ever sell machines for use in the United States which were fitted with both hot-tube and electric ignition[378]?

A. I cannot say.

XQ444. Did not the Panhard & Levassor Co. ever manufacture automobile engines which were fitted with both hot-tube and electric ignition, and if so, down to what time?

A. Yes; this double ignition was provided upon request from purchasers and the double system may yet be asked by customers.

XQ445. In fact was not the Panhard & Levassor Co. obliged to change from hot-tube ignition to electric ignition for their engines by the demands of customers for electric ignition?

A. No. This change has been made when electric ignition became practical, reliable positive and at least equal to hot-tube ignition by the reliability of its operation.

XQ446. Do you know that electric ignition was used prior to its adoption practically by the Panhard & Levassor Co. for its engines?

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[376] The Lenoir engine: "*a distributor in connection with a source of electricity*"
[377] **1872** - Comte Théodose du Moncel: "*Exposé des applications de l'électricité*: Pile portative et à effet constant de MM. Breton, frères".
[378] **1907** - Both hot-tube and electric ignition.

A. I was aware of it, but electric ignition did not give satisfactory results except in the case of single cylinder engines.

XQ447. Is not the chamber marked with the letter T' in Fig. 3 of the drawing of the Selden patent now shown you, entirely unobstructed from the black lines shown on that drawing to the left of the dotted line and which indicate the clap-valve of the Selden engine you saw, unobstructed, I mean, to the cylinder pump, and in a similar way to the clear chamber shown in Fig. 3 of the Maybach patent drawing[379] referred to in XQ436?

A. I cannot say anything about it. This drawing is too incomplete to permit me to look upon it as being comparable to the construction shown by the drawing illustrative of the Maybach patent.

XQ448. In the Selden drawing Fig. 3 do you see or can you point out any constriction or contraction of the space running from the black line to left of the dotted line and towards and into the combustion chamber marked T^1?

A. I again state that this part in the drawing of the Selden motor is so confused that the lines do not represent anything very precisely. The drawing of an engine must be so made that its reading cannot give rise to doubtful interpretations. I see lines which […]

XQ449. Do you understand or have you been informed that under the law applicable in the United States, the Letters Patent to Selden on which this suit is brought, No. 549,160, dated Nov. 5, 1895, and for which his application was actually filed in the U. S. Patent office on May 8, 1879 carry back the date of Selden's invention as to everything which was described and shown in his application as filed to at least the date of May 8, 1879? and that it is only matters which existed prior to that date and indeed prior to the date on which you actually invented what he set forth in his filed application that can act to anticipate or limit his patent as finally granted, Nov. 5, 1895?

A. Yes, of course, but our vehicles operate by means of quite different methods and the results are also different.

Cross-examination closed, at 2:30 P. M.

Adjournment taken to 3:30, P. M.

[379] The "Maybach carburetor".

Re-direct examination by Mr. Murray.

RDQ450. Have you arranged to sail for France tomorrow morning?

A. Yes.

RDQ451. Is the date of your departure later than you expected and if so, why?

A. I engage passage to sail on November 8th, and again on November 15th. These two postponements were due to this deposition.

RDQ452. Have you made any study of the patents and publications in this case?

A. No.

RDQ453. Do you know where the Lenoir shop was in Paris[380]?

A. Not exactly.

RDQ454. State if you know the distance between Paris and Joinville-le-Pont?

A. About 12 kilometers, that is about 7 2/10 miles.

RDQ455. In answer to XQ191 you referred to a charge in an Otto 4-cycle engine where after the compression stroke the pressure is less than the atmospheric. Briefly explain if you can why the pressure is less than atmospheric?

A. In such conditions of operation, the cylinder walls are cold, because the power developed is nearly zero and because there is a circulation of water sufficient to prevent the cylinder walls from reaching the temperature of vaporization of water. It follows, therefore, that the residual burned gases left in the clearance space and containing themselves a large amount of steam, becomes largely condensed; moreover the admission of gas takes place under a comparatively large degree of vacuum. Besides the very active vaporization of the light hydrocarbon liquid taken in the charge produces a further considerable lowering of temperature. It can be, therefore, conceived that the temperature of the gases (both residual and newly introduced) being very low, the volume of these gases becomes considerably [reduced] […]

RX by Mr. Betts.

[380] Lenoir lived in Paris.

RXQ456. Referring to your answer to RDQ455, why would the cylinder walls be cold if the engine had been running?

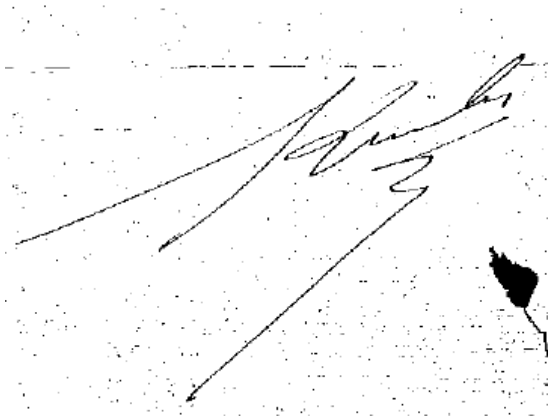
A. In the case referred to I have assumed that the motor had not been running, was cold and the circulation of the water also cold, and in making this statement I merely meant to allude to conditions which may happen in a laboratory[381].

RXQ457. Then the conditions you have supposed in giving answer 455 are not conditions of actual practical operation delivering large power for unit of weight, are they?

A. No.

Re-Cross closed.

It is stipulated that the witness may read over and sign his deposition before the stenographer and that questions and answers 1 to 172 inclusive are subject to corrections as to translation, corrections, if any, to be agreed upon between counsel and all points as to which they do not agree to be decided by a translator to be appointed by the Commissioner.



[381] The Panhard & Levassor laboratory used for helicopter trials in **1913**.

THE HORSELESS AGE

September 22, 1909
p. 327

LEGISLATIVE and Legal

The Selden Decision.

One of the most celebrated cases in the annals of patent ligation was decided in the lowest court last week, when Judge Hough[382] at New York sustained the Selden patent. The case against the Ford Company had been pending for six years, and the long delay before a decision was rendered caused interest in the case to wane, to a considerable extent, in recent years. It probably also lulled many of those interested in the outcome into a false feeling of security. The importance of the decision makes it worth the while to briefly review the litigation. The entire automobile world is interested in the matter, because not only the manufacturer of an infringing article but also the seller and user thereof are liable to the inventor or the owners of the patent[383].

The Selden patent, of which infringement was alleged, is No. 549,160, which was issued to George B. Selden, of Rochester, N. Y., November 5, 1895. Application for the patent was made as far back as 1879 (on May 8), the issuing of the patent being delayed by the applicant by making changes in the claims or taking such other steps as are allowed by the present law. The broad claims of the patent were first drawn attention to by the Commissioner of Patents in his annual reports for 1895, and the claims were printed in a special article in THE HORSELESS AGE of December, 1896. Although the existence of the patent was thus early brought to the attention of the motor vehicle industry, no heed was given it by experimenters during the next few years, and no decisive steps appear to have been taken to compel its recognition by the industry until the patent was sold to the Electric Vehicle Company, of Hartford, Conn., which was in 1900.

Suit for infringement was then brought against the Winton Motor Carriage Company, of Cleveland, Ohio, at that time the principal American makers of gasoline automobiles in the United States, and their New York agents. Defendants entered a writ of demurrer, claiming that the patent was void for lack of patentability, but this was overruled on November 9, 1900. The Winton Motor Carriage Company some time later acquired a license under the Selden patent. The claims under the patents were then strongly urged, and about 90 per cen. of all American manufacturers of gasoline automobiles were induced to take license under the patent, and formed the Association of Licensed Automobile Manufacturers in New York in May, 1903. Under the terms of the license agreement each member of the association has to pay a license fee on the selling price of his product, of which nearly equal parts go to the Electric Vehicle Company[384] and the association, respectively. The first action under the patent taken by the association was against Smith & Mabley, agents for French Charron cars. This suit was brought in April, 1903[385], but was settled out of court[386].

Among the few important manufacturers at the time the Licensed Association[387] was formed, who did not join, was the Ford Motor Company[388], of Detroit. A suit was brought against the company and against its New York agents in October, 1903. It is this suit which has now been decided by Judge Hough. The complete opinion, with the exception of foot notes[389], follows:

The application for the patent on which these actions are based, was filed in 1879, or more than 16 years before the grant was made.

The principal claim in suit (No 1) reads thus:

"The combination with a road locomotive, provided with suitable running gear, including a propelling wheel and steering mechanism, of a liquid hydrocarbon gas engine of the compression type, comprising one or more power cylinders, a suitable liquid fuel receptacle, a power shaft connected with and arranged to run faster than the propelling wheel, an intermediate clutch or disconnecting device and a suitable carriage body adapted to the conveyance of persons or goods, substantially as described."

The second claim varies from the first only in requiring the "suitable carriage body" to be "located above the engine", while the fifth claim sets forth substantially the same combination, but specifically describes the engine as comprising a plurality of cylinders with "pistons arranged to act in succession during the rotation of the power shaft." [390]

These three claims are alleged to be infringed by all the defendants.

This statement of complainants' position seems sufficient to show that the subject-matter of these suits is the modern gasoline automobile.[391] The defendants are severally[392] the manufacturer, seller and user of the Ford machine, a well-known American make, and the maker and importer of the Panhard, a celebrated and typical French Product. If these defendants infringe, it is because complainants own a patent so fundamental and far-reaching as to cover every modern car driven

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[382] **1961**, **Greenleaf**, p.197: "[Parker wrote to Henry Ford:]*"Now Hough is said to be cranky & I know is not a patent judge.*"" P.198: "*The hearing occupied six days and terminated on June 4*, [**1909**], *the five cases being argued as one*." P.201: "*In his closing argument for the defendants on June 4, Frederic R. Coudert said that a victory for the Selden interests would be "hopelessly unjust." His clients, Panhard & Levassor, had built salable automobiles well before the disclosure of the Selden patent. It would be immoral, and contrary to the public interest, if Selden were permitted to monopolize an art and an industry to which his patent had contributed nothing. Selden had no right to exact tribute from pioneers who had dedicated "all their time not to the practice of law and the preparation of patent claims, but to the development and perfection of the automobile.*""

[383] **1961**, **Greenleaf**, p.86: "*Yet the history of the American patent system demonstrates that the constitutional provision for promoting "the progress of science and useful arts" has tended to become a bastion for entrenching privilege to the detriment of effective competition*."

[384] **1961**, **Greenleaf**, p.71: "*In **1899** the grand resources of the Electric Vehicle Company stood at more than $100,000,000, virtually all of it on paper. We have seen that the electric automobile could not find a market justifying this nominal capitalization unless the guaranteed outlets projected by Withney-Ryan syndicate developed rapidly*." P.74: "*The Electric Vehicle Company could enforce its legal monopoly only by filing infringement suits*."

[385] **1961**, **Greenleaf**, p.125: "*The timing of the suit was calculated to extract the maximum benefit in publicity and advertising fot the Selden forces. The action was brought at the beginning of the 1903-1904 season, when new models were being readied for the market. This had been a common tactic in other major patent litigations*."

[386] **1961**, **Greenleaf**, p.99: "*On April 15, **1903**, the importing firm of Smith & Mabley submitted to a pro confesso decree*."

[387] **1961**, **Greenleaf**, p.100: "*The licensed association brought to the Selden patent a prestige it had never possessed, but few of the licensees, despite the public pronouncements of the A.L.A.M., privately believed in the validity of the patent. Their position was summed up in the observation that it was "cheaper to join than to fight.*""

[388] **1961**, **Greenleaf**, P.63: "*Where many Midwestern makers* [in **1899**] *strove after volume production for a middle-income market, auguring the day of the popular-priced [gasoline] car, the New England builder aimed at the limited production of costly [electric] automobiles.*" P.103: "*With few exceptions, the manufacturers who had joined the A.L.A.M. were committed to the policy of building cars for a luxury market. Other auto producers, most of them outside the licensed association, believed that the future of the industry lay in the lower-priced machine.*" P.110: "*That Henry Ford's application for a Selden license was rejected by the A.L.A.M. because he was a lowly "assembler" must be accounted one of the exquisite ironies of American industrial history*." P.113: ""*Selden Pat. Not Workable," Ford scrawled in one of the vest-pocket notebooks he kept for jotting down his thoughts.*" P.169: "*As the medium through which the Selden patent case was dramatized for a national audience, Ford gained a wider reputation, and it was during these years that the legend of his unorthodox individualism shone with its first luster*."

[389] Thanks to the site http://www.kcstudio.com/selden09.html we restituted the original notes in their original form from the periodical: **The Power Wagon** - A Journal for Those Employing Commercial Motor Vehicles, October **1909**, No. 59, Selden Patent Upheld.

[390] **1911**, **Judge Noyes**: "*Reading his statement of the difficulties encountered, his manner of meeting them, and the advantages of his discovery, we think it evident that he understood that an engine suitable for a light vehicle could not be taken bodily from the prior art and used without change, but that modification and adaptation were required*."

[391] **1911**, **Judge Noyes:** "*The subject is most important; the interests involved, of great magnitude; the record, phenomenally long; and the questions presented, complex*."

[392] **1961**, **Greenleaf**, p.128: "*All of these suits, in which the fundamental issues were essentially the same, were later consolidated in one hearing for purposes of adjudication. The Electric Vehicle Company, the nominal complainant, refused to enter duplicated testimony from the Panhard suits into the Ford record and instead insisted that depositions be taken again. As a result, the Selden case record attained formidable proportions*."

by any form of petroleum vapor[393] and as yet commercially successful.

Such a claim lends interest even to such a record as is here submitted, and requires careful examination, to the end that the parade of forces in this court may at least serve to shorten and simplify the certain conflict in the appellate tribunals. (Note.)

[NOTE.—It is a duty not to let pass this opportunity of protesting against the methods of taking and printing testimony in equity, current in this circuit (and probably others), excused, if not justified, by the rules of the Supreme Court[394], especially to be found in patent causes, and flagrantly exemplified in this litigation. As long as the bar prefers to adduce evidence by written deposition, rather than *viva voce* before an authoritative judicial officer, I fear that the antiquated rules will remain unchanged, and expensive prolixity remain the best-known characteristic of Equity.

But reforms some times begin with the contemplation of horrible examples, and it is therefore noted, that the records in these cases, as printed, bound, and submitted, comprise 36 large octavo volumes, of which more than one-half contain only repeated matter: i. e., identical depositions with changed captions, and exhibits offered in more than one case. In reading the testimony of one side in one set of cases, there were counted over a 100 printed pages recording squabbles (not unaccompanied with apparent personal rancor) concerning adjournments, and after arriving at this number it seemed unnecessary to count further. In many parts of the record, there are not 5 consecutive pages of testimony to be found without encountering objections stated at outrageous length, which may serve to annoy and disconcert the witness, but are not of enough vitality to merit discussion in 2,000 pages of briefs. Naturally tempers give way under such ill-arranged procedure, and this record contains language, uncalled for and unjustifiable, from the retort discourteous to the lie direct (E. G. Ford C. R. pp. 2873, 2967, 2968, 2987, 2988). And all this lumbers up the court record room[395], while clients pay for it!

Even when evidence in equity was taken by written answers to carefully drawn interrogatories, the practice was not marked by economy or celerity; but stenography and typewriting, the phonograph and linotype, have become common since our rules were framed, have made compression and brevity old-fashioned, increased expense, and often swamped bench and bar alike by the quantity, rather than the quality, of the material offered for consideration.

Motions to expunge and limit cross-examination should have been made in these cases, though they are feeble remedies exposing counsel to personal reproach, and rendering judges afraid of keeping out of evidence what they cannot (on motion, at all events) understand. But the radical difficulty, of which this case is a striking (though not singular) example, will remain as long as testimony is taken without any authoritative judicial officer present, and responsible for the maintenance of discipline, and the reception or exclusion of testimony.]

Upon one question of law all counsel are agreed. The patent claims under consideration are all for combinations. There is, of course, no agreement that the combinations set forth are patentable, and none as to the interpretation of their language, if valid at all; but there is no denial that in form nothing but combinations are claimed.

This is emphasized, because it seems to open and simplify the discussion. Selden does not pretend to have invented any new machine or combination of matter, in the same sense that Whitney invented the cotton gin[396] or Howe the sewing machine. He does not in application or claim specify any one mechanical device for which in some branch of art a prototype cannot be found. There had been and were in 1879 running gears, propelling wheels, steering mechanisms, gas engines, etc., of many forms, and his patent covers no one form of any of these parts of his "road locomotive." He does assert that he selected, adapted, modified, co-ordinated, and organized the enumerated parts (including the usual mechanical adjuncts of each part) into an harmonious whole, capable of results never before achieved, and of an importance best measured by the asserted fact that after 30 years no gasoline motor car has been produced that does not depend for success on a selection and organization of parts identical with or equivalent to that made by him in 1879[397].

If this be true, it may be held at once that in such a mental operation and such an important result therefrom, invention, and that of a high order, undoubtedly does reside. Where Bradley, J., declined definition, he would be a bold man who tried it; but I am sure that invention is easily discernible as that which vitalizes Selden's selection, if that selection and its results have been truly described.

Broadly speaking, the defense in these cases rests on a denial of the truth of the foregoing summary of Selden's performance, which denial has two parts: (1) Selden did not do what he now asserts; and (2) defendants' combinations differ from Selden's, being neither identical nor equivalent[398].

In considering what Selden did, and the meaning of the words in which he described and claimed his achievement it is to be remembered that whether his combination constitutes invention and whether it possesses novelty and utility are primarily questions of fact[399], as to which the very grant of the patent raises a presumption[400] in favor of complainants, while the demurrer decision (in Electric Vehicle Co. v. Winton Motor Co., [C. C.] 104 Fed. 814) is here controlling authority to the effect that on its face, plus all matters of which the court can take judicial cognizance, the patent is valid.

To ascertain, therefore, how far defendants have succeeded in meeting the burden of proof, which in all matters of fact lies on them, it seems fair to begin by discovering from all the evidence what was the state of the art when Selden filed his application in 1879.[401] (Note.)

[NOTE. —From uncontradicted testimony, 1877 might well be fixed as the date of the invention alleged in this patent application. No anticipation or prior use, however, has been urged during 1877-79[402]. The experts, however, have throughout spoken of the art of 1879 as controlling, and that time is therefore taken as a convenient starting point.]

But what is the art as to which this enquiry is to be made? On this preliminary point it seems to me that defendants' testimony and argument have taken too wide a range, or at least laid undue emphasis on matters of little moment.[403] This invention does not belong to the steam engine art,[404] nor that of any engine, regarded alone; nor is it fruitful to examine carefully the development of traction engines, whether primarily designed to haul "trailers," or transport persons and goods over their own wheels. Boats, also, and tram cars, propelled by engines of any kind furnish but a limited field for useful investigation[405]. The enquiry is: How stood art (and science too) in 1879, in respect of a self-propelled vehicle with a considerable radius of action over ordinary highways, and capable of management by a single driver, and he not necessarily a skilled engineer?

Or, to use a phrase frequently occurring, in the testimony and exhibits, what was known of the "horseless carriage" industry in 1879, either at home or abroad?

The answer given by the evidence is entirely plain: There was no such industry, the art existed only in talk and hope, no vehicle even faintly fulfilling the requirements above outlined had ever been built, and there is no competent and persuasive evidence that any experiment had ever moved 100 feet, or revealed an organization warranting the expectation that it ever would do so.

Some examination of the kindred arts, above alluded to, serves to explain this situation. For more than 100 years, steam as a prime motor, had dominated the world of mechanic art. Steam as the power for a self-propelled road vehicle had been exhaustively

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[393] **1911**, **Judge Noyes**: "*In the light of events we can see that had he appreciated the superiority of the Otto engine and adapted that type for his combination his patent would cover the modern automobile. He did not do so. He made the wrong choice, and we cannot, by placing any forced construction upon the patent or by straining the doctrine of equivalents, make another choice for him at the expense of these defendants who neither legally nor morally owe him anything*."

[394] This underlined text, coming from the final decision, was not present in this article.

[395] **1961**, **Greenleaf**, p.141: "*The testimony in the Panhard cases added to the record. The exhibits, which included several engines and automobiles, taxed the space of a large room where they were held in the custody of the court. It was reported, with only mild exaggeration, that "the accumulated evidence and exhibits in the case would fill standard freight-cars*.""

[396] **1961**, **Greenleaf**, p.88: "*Beginning with the frustrated attempt by Eli Withney to enforce his cotton gin patent, virtually all of the basic inventions which have transformed our national economy have been involved in patent controversies.* […] *By **1890**, when the Sherman Antitrust Act was passed, patents had become familiar weapons of business warfare*. […] *Between **1890** and **1912** monopolistic practices were fortified with legal immunity as the patent pool and similar forms of combination were used for restricting output and competition in many sectors of the economy*."

[397] **1911**, **Judge Noyes**: "*Consequently, when we see that 30 years ago an application for a patent was filed which even pointed the way to the modern automobile, we can hardly fail to receive the impression that an idea of great importance must have been embodied in it. But, as we shall later see, the development of the automobile was not so sudden as we have thought. It developed step by step at the beginning; the startling activity has come at the end. Moreover, a great idea maybe embodied in a patent, and yet the patentee take nothing of value by it. That which he takes is that which he describes and claims. His discovery may be of importance, but he may limit it by his claim, and his claim may proceed in the wrong direction*."

[398] **1911**, **Judge Noyes**: "*The defenses are: (1) That if the patent be broadly construed it is invalid. (2) That if it be construed less broadly, but according to legitimate rules of construction, the defendants do not infringe*."

[399] **1911**, **Judge Noyes**: "*In considering the validity of the patent, we are met, at the outset, with contentions of some of the defendants that prior uses anticipate, and that that which it discloses is an aggregation rather than a combination. But the questions of novelty and invention often run together, and the inquiry whether a given association of elements is more than an aggregation is only a phase of the question of invention*."

[400] **1961**, **Greenleaf**, p.78: "*On November 9, **1900**, Judge Alfred C. Coxe handed down an opinion overruling the demurrer. The decision was a blow to the anti-Selden forces*."

[401] **1911**, **Judge Noyes**: "*This requires an examination of the state of the art in **1879**—the date of the application and, consequently, of the alleged invention*."

[402] The **1909** final decision does not mention this underlined text.

[403] This underlined text, coming from the final decision, was not present in this article.

[404] **1911**, **Judge Noyes**: "*For some years subsequent to **1830** steam carriages for common roads were used to a considerable extent in England for transporting goods and passengers*."

[405] **1911**, **Judge Noyes**: "*The testimony shows clearly that prior to **1878** Brayton had successfully applied his engine for propulsion purposes in boats.* [...] *The evidence, including sketches, shows geared down transmission, the use of disconnecting clutches, and the presence of liquid fuel receptacles. Indeed, if the claim be given the broad construction of covering the use of all compression gas engines, it might be read on the Brayton boat construction — If the words "motor boat" and "boat" were substituted for "road locomotive" and "carriage." Still we appreciate the substantial difference between the problem of propelling a boat and the motor vehicle problem and are not inclined to hold that this use constituted an anticipation, although it may properly be considered in determining the question of invention.* [...] *The contention that such a use did not anticipate this application because that experiment was on water and this invention is designed for use on land seems untenable*."

worked over[406], and patents obtained, from Trevithick[407] (British 2,599, of 1802) to Monnot[408] (U. S. 197,485, in 1877); and the result was the traction engine. It made no difference whether it carried passengers or hauled freight. The actual type and only type was a boiler on wheels, of enormous weight, slow speed, and small radius of action.

But the numerous experiments with steam road wagons had (however meager the success attending them) served to make known to that wholly ideal and fictitious person, "the man skilled in the art," something of the organization of any road vehicle capable of operation by a small crew[409]. Steering mechanism, operated by wheel before the driver, independent turning of the fore wheels, the chain drive, as well as beveled gear connection between power and driving shafts, devices for disconnecting power from running gear and letting engine run free, plans for brake control of quite a modern sort, and stowage of motive power in parts of the vehicle remote from passengers—all had been practiced or suggested. From patents and publications scattered over two continents and more than two generations there can be reconstructed (and defendants have done it on paper) something that is very far from even a good theoretical road wagon, but which does contain most of the elements of Selden's combination; and this represents the art, known to the man skilled in both theory and practice, a good mechanic, with a scientific education and widely read in the technical literature of all civilized nations, by whose incredible knowledge the achievements of patentees are so often measured.

Obviously if a fairly good road wagon cannot be reconstructed in 1909 out of materials so industriously collected from the scattered knowledge of 1879, it is desirable to ascertain whether there then existed some one lack, whether the art then required some one thing which was wholly missing, in order to produce a practical self-propelled road vehicle.

It seems to me plain that there was such lack, and it may be stated in the language of one of the numerous inventors who procured long and elaborate patents relating to road locomotion, and never (so far as this record shows) did anything more.

Savalle[410] (French 77,644, in 1867) says in a certificate of addition dated March 16, 1869:

"I have tried to apply to road locomotives, several motors operating by air expanded by the heat produced, *either by the explosion of gas*[411], or by air forced over a metallic surface, heated by coal or other combustible, or also *by petroleum*.

These *divers forms of motors* apply perfectly when it concerns the *traction of omnibuses* or other large vehicles of this kind; but when it is necessary to apply this kind of locomotion to *light carriages*, only carrying one to six persons or to drive a velocipede, these means become impracticable by the large space which they require."

The lack, the something that had to be supplied before it was worth while to organize the vehicle, was the engine. Steam had thus far failed, and this record seems to show that at about the time Savalle[412] wrote, the gas engine as a road wagon motive power began to be mentioned in serious publications, and patent specifications. (Note.)

[NOTE. —In making this statement Le Monde Illustré and Pinkus (British 8,207, of 1839) have not been overlooked. The former proves nothing that relates to the form of engine to be considered in this litigation, while the absence of all later mention proves the car a sporadic failure. Pinkus was speaking of tram cars, and the use of such a publication against Selden by the Patent Office, was to say the least, not very intelligent.]

Savalle was much mistaken in asserting that any of the assorted motors mentioned by him had successfully driven an omnibus or any similar conveyance; but he early hinted at the truth that in some form of motor actuated by a product of petroleum would be found, if not the immediate solution of the problem, at least the missing element that would make the solution sure.

This missing element Selden avers he discovered, and it follows that over his engine the conflict in these cases has raged through several volumes.[413] In trying to ascertain, however, the status in 1877-79 of engines in any way resembling Selden's, the court is fortunate in having in evidence a book entitled "The Gas Engine" published in 1885 by Mr. Dugald Clerk[414], who has also testified with admirable clearness as an expert for complainants.

It appears that the materials for this book were gathered during the very period of Selden's experiments, while so completely has Clerk furnished a classic on the history of the gas engine art that even counsel who sharply criticize his evidence, support their arguments from his book to such an extent that it is not too much to say that many chapters thereof could be reconstructed from their briefs.

In 1879 "internal combustion" engines were well known, and had reached a considerable degree of commercial success, despite the fact that the reasons for their success or more frequent failure were very ill understood.

The fact that fuel might be burned in the engine cylinder itself, that such burning (if of gases) produced an expansion thereof, and that such expansion might be utilized by allowing it to push the piston, was and is the basic proposition.

This knowledge had produced the Lenoir engine in 1860 and the Hugon in 1865, constructed in close adherence to the steam engine of the day, and giving less than one horse power per ton of weight. Both normally used illuminating gas at atmospheric pressure.

The Otto free piston engine of 1867 marked an advance in effectiveness, but no form of gas engine had yet appeared which (so far as shown) was more than suggested as the propulsive power of a road wagon.

In 1861 Million, and a year later Beau de Rochas, Siemens, and others, pointed out the advantage of compressing the gaseous fuel before ignition, in order that the expansion should be both greater and quicker, with the greatest possible pressure at the beginning of the expansive movement; and in 1872 Brayton in America, and in 1876 Otto in Europe, introduced compression engines, the latter with great commercial success.

The change from a gaseous fuel burning at atmospheric pressure to the same fuel burned under compression was a change of *kind*; for, though formed of the same chemical elements, the compressed fuel possessed a power, when used by men who live by breathing atmospheric air, that uncompressed and commercially possible gases did not and could not exert in any non-compression engine even as yet imagined. It therefore seems clear that the phrase "compression type,"[415] as applied to internal combustion engines, is reasonably indicative of a class, and appropriately describes an unmistakable and invariable species of the genus gas engine. (Note.)

[NOTE. —Compression is a relative word. Men can for short periods live and work in a caisson where the air is compressed; but a Lenoir engine, if it could operate in the caisson, would be a noncompression engine still, though using the air of its immediate environment. It is density of fuel, as compared with the air into which the engine exhausts, that determines and defines compression. This seems overlooked in some of defendants' cross-examination (Clerk, X-Q, 156-163), and neglected in some portions of their argument.]

The evidence is persuasive that the increasing success of the gas engine, produced in the middle '70's of the last century, repeated dreams (they are no more) of applying a gas engine to a road wagon.

In 1877 Rosenwald[416] (French 116,871) made a picture of a brougham having an Otto free piston engine perched in an apparently insecure position between passenger and driver. His is a paper patent only, and is in my opinion clearly shown to be inoperative for reasons of which one only may be mentioned: The most improved type of Otto engine then known weighed over half a ton per horse power. He did not use the most improved type, and did not propose any improvement or modification which would have prevented his brougham from going to pieces at the first jar of his motor. (Note.)

[NOTE.—Hilton & Johnson (British 10, of 1878)[417] and Roberts (British 711, of 1877) are provisional only. If these patentees were not able to complete their own inventions, this court cannot be expected to perceive them.

Menn (French 118,109, in 1877) is at best an impossible gas engine, in a structure irrelevant to this case.]

This patent is the suggestion nearest to Selden, and is mentioned for comparison hereafter.

Although by 1879 internal combustion engines had separated into the compression and non-compression classes, they were (and still are) all known as gas engines, irrespective of the condition of their fuel immediately before the work of preparing it for combustion begins. The term originated, doubtless, when coal gas was the only gaseous fuel known; but the vapor of petroleum or of any product thereof (gasoline or petrol) is just as much a gas as another, and 30 years ago there was, and there is now, no

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[406] The **1769** "First self-propelled vehicle" of Nicolas-Joseph Cugnot.

[407] Trevithick - The World's First Locomotive : Trevithick steam carriage.

[408] Monnot : Road Engine patent.

[409] **1961**, **Greenleaf**: "*The French patent secured by Onésiphore Pecqueur in **1827** for a steam vehicle disclosed many of the basic features of the automobile. It described an engine mounted above springs in the front of the body, differential gearing, chain drive to the rear axle, a clutch, change gears for varying the speed, and a fixed front axle with steering arms. Theses constructions were incorporated in most of the motor vehicles built before the middle of the nineteenth century.*"

[410] **1867** Savalle patent : "improvements to locomotives for ordinary roads, and application of dilated air engines to omnibuses and other vehicles".

[411] We restitute here the *italic* writings from The HORSELESS AGE. These italics are not present in the final decree.

[412] **1911**, **Judge Noyes**: "*The Savalle French patent of **1867** described how the Lenoir engine could be applied to road vehicles. This patent referred to the difficulty of applying such engines to light carriages.*"

[413] **1911**, **Judge Noyes**: "*In examining these questions we have been greatly aided by the work of the judge of the Circuit Court in blazing the way through the mass of testimony and defining the issues to be decided. While we may be unable to adopt the conclusions stated in his very able opinion, we must at the outset acknowledge our indebtedness to it.*"

[414] Dugald Clerk: see the note under the Krebs' testimony.

[415] **1911**, **Judge Noyes**: "[…] *it is clear that, if there were nothing more in the case, invention would not be shown in the mere combination of (1) a carriage, (2) a drive, and (3) a gas engine, or even a hydrocarbon gas engine. The elements were old and the combination neither novel—as producing any new result nor as showing any new co-operative action. It follows, then, that, if we are to find invention and novelty in the broad combination of the patent, they must be in the use of a hydrocarbon gas engine of the compression type.*"

[416] **1911**, **Judge Noyes**: "*The Rosenwald French patent of **1877** was for a carriage propelled by a noncompression gas engine. This vehicle had reducing gears and a clutch or "disengager". The engine described was of the free piston type and was poorly adapted for use in a road locomotive.*"

[417] **1961**, **Greenleaf**, p.204: "[…] *the Hilton & Johnson patent of **1878**, provided for the use of all "petroleum or other like motors" in a combination much like Selden's.*"

distinction, generally obtaining, between engines whose fuel as ordinarily purchased is coal gas, and those using gasoline or crude petroleum, provided that what ultimately burns in the cylinder is that vaporous substance, "capable of expanding indefinitely" — which *is* gas. (Note.)

[NOTE.—Encyc. Brit. (9th Ed., 1878-1889) Vol. 6, p. 310. It is curious and instructive that this publication contains no reference at all to road locomotion by gas engines. Under "Steam Engines" (Vol. 22, p. 522), see Lenoir, Brayton, Otto, and Clerk treated under the subhead "Gas Engines." This article was evidently written in 1886-87, immediately after the publication of Clerk's book, which is referred to.]

But if the substantial difference between compression and non compression engines was known and recognized, certain other terms of art which have been far too much used in this litigation were non-existent in 1879. A great superstructure of argument has been built upon the difference between "constant pressure" and "constant volume" engines.[418] These terms appear to have been devised by Mr. Clerk[419], and first used in his book before alluded to, as convenient phrases useful in studying the operation of engines, and classifying their phenomena. The terms are instructive, as is the separation of nouns into declensions and verbs into conjugations; but much of the argument about the words attaches an undeserved importance to them. In all internal combustion motors, the result of expanding the burning gaseous fuel is to drive the piston; that is, the cylinder chamber in which the expanding gas is confined gives way on the piston side (so to speak). If the piston head offers no more resistance than will permit it to move under the expansive force produced by the initial compression alone, evidently since the piston moved under that pressure, it will be maintained to the end of the stroke, the expansion produced by ignition serving to keep up that "constant pressure."[420]

If, however, the compressed charge must be ignited before the piston moves, then whatever volume thereof is introduced into the cylinder increases (by combustion) its pressure on the piston head, before the engine operates, and the machine is described as "constant volume."[421]

In both phrases "constant" refers to condition, at the instant piston movement begins, compared with that at the moment the fuel charge is inserted. If between the two moments pressure increases, then the volume is constant; while, if volume increases, pressure is constant.

These conditions are theoretic. If in a constant pressure engine the load or piston resistance is suddenly increased, the expansive power produced by compression alone may not start movement before ignition or explosion; and accordingly (if too much importance be attached to phrases) the type of engine has changed. Of course, nothing of the kind has occurred. The relation of piston head to cylinder walls relative to time of explosion has changed, and it may nowadays (in many engines) be changed at will to suit load and speed by throttling and by timed ignition. These variations have been observed in all the engines testified about in this case. They occur, or may occur, in all compression engines, and are no more significant of specific or generic differences than are variations in rapidity of breath in different men, or in the same man at different times[422].

From this attempted outline of the knowledge and achievements of 1879, it seems to me that the way was singularly clear for any one who would really produce the thing described in Selden's first claim.

Success is never anticipated by any number of failures, and when it is clearly kept in mind that what Selden claims is a combination, and not any one of its elements[423], the defendant's references to prior patents and publications may be thus finally disposed of so far as this court is concerned.

Much has been said concerning this inventor's personality[424], and there is some importance therein, as showing the likelihood of his comprehending his own experiments, and telling the truth about them. The record shows him always interested in mechanical pursuits, receiving an appropriate education for the theoretical side thereof [425], but not himself a skilled practical mechanician.

His application for a patent on a rubber tire wheel, made in 1869, is significant and interesting, and, in view of quite recent litigation in this circuit, instructive. Taking his evidence in connection with his letters and notes, he is shown especially attentive to traction problems from his early manhood. I am persuaded that he carefully studied Brayton's engine and understood it practically; but his knowledge of the theory of thermodynamics seems fairly illustrated by a remark to his workman, Gomm, when his original engine turned over: "We have struck a new *power*." There is no satisfactory evidence that before application filed he knew thoroughly anything of Otto's compression engine[426]. All this was not a very complete equipment; but he had the true inventor's enthusiasm, and for more than five years (as the Chief Justice said of Morse, in 15 How, 108, 14 L. Ed. 601) "He pursued these investigations with unremitting ardor and industry, interrupted occasionally by pecuniary embarrassments."

When he was ready to file his application, he had completed and experimentally operated one cylinder of a three-cylinder engine of the general type Brayton had patented in 1872 and 1874. He intentionally built a plurality of cylinders, to obviate or minimize the necessity for a fly wheel. He produced an inclosed crank case (which immediately reduced weight to an enormous extent), and used a small piston with a short stroke (which made possible the speed that would compensate for the loss of piston head area).

This engine, with allowance for adjuncts Selden did not use, but (as experience has shown) should have used, weighed less than 200 pounds per brake horse power, as compared with over 800 pounds in the lightest form of Brayton's, and is capable of over 500 revolutions per minute, as against less than 250 by any type of gas engine known, built or suggested in 1879.[427]

These I find to be facts regarding the engine built by Selden before application filed. He then caused to be made a model and mechanical drawing of his suggested vehicle and actual engine, and submitted the same, with specification and claims, to the Commissioner of Patents.

Avoiding for the present the language of his original application, and the effect of the numerous changes therein during its many years in the Patent Office, was the thing fairly revealed by the model and drawings, and conceived under the circumstances above set forth, the embodiment of a combination patentable in 1879? [428]

I think the answer is emphatically, "yes"; that which is not obvious to skillful men is usually (as remarked by Mr. Clerk in his evidence[429]) invention, and certainly what Selden shows in his model, and by the drawings, which have remained unchanged for 30 years, was anything but obvious. The inventive act is shown by comparing Selden and Rosenwald. If the latter's brougham had actually carried its engine, and traveled even a little, he might nevertheless (on defendant's own argument) have found his patent invalid by American law, because each part of his vehicle was doing just what it had always done, without any new "co-operative law," while his engine in particular was the same motor which, before it was applied to the brougham, had perchance driven a lathe and might to-morrow do something else. Rosenwald might have been held a mere aggregator (however successful); but Selden's combination cannot be taken apart, and each element recognized as something that had done the same thing or sort of thing before. [430]

The adaptation of the engine alone was something never before attempted (so far as shown). Such adaptation might have involved an infringement on

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[418] **1911**, **Judge Noyes**: "*The two types are called respectively the "constant pressure type" and the "constant volume type." Although these terms may have originated since the date of the invention, they correctly describe the types or classes of compression engines then in existence. No better explanation of them can be found than in Mr. Clerk's work entitled "The Gas Engine," which was published in **1887** and which has been offered in evidence. In this book he also shows the construction and working processes of the two types of engines and the differences between them, as stated in the footnote his book (page 29) Mr. Clerk divides gas engines according to their work processes into three well-defined types: "1. Engines igniting at constant volume, but without previous compression. 2. Engines igniting at constant pressure with previous compression. 3. Engines igniting at constant volume, with previous compression*."

[419] **1911**, **Judge Noyes**: "*Mr. Clerk said in his testimony that the reference in the patent to existing well-known engines was "to the Brayton constant pressure engines"*."

[420] **1911**, **Judge Noyes**: "*The Brayton engine, to which we have referred, was a constant pressure compression engine. Mr. Clerk said in his book (page 32) that it was one of the most successful of that kind, and also said (page 154): "The engine worked well and smoothly; the action of the flame in the cylinder could not be distinguished from that of steam; it was as much within control and produced diagrams quite similar to steam*." **1961**, **Greenleaf**, p.207: "[…] *on this point* [Hough] *accepted Clerk's testimony in its entirety*."

[421] **1911**, **Judge Noyes**: "*Otto seems to have first successfully applied it, and his engine came into general use. This engine was operated by a series of timed explosions and, as we shall later see, was the prototype of the modern automobile engine. It is clear from this examination that the statement heretofore made that the Brayton and Otto engines differed in being respectively constant pressure and constant volume engines is sustained by the record. They also differed in another important particular. The Brayton was a two-cycle engine. The Otto was a four-cycle engine*."

[422] **1911**, **Judge Noyes**: "*Still, classification might be based upon matters of form and not of substance. The elements of the combination are things and not names.* […] *We must then consider the materiality of the differences between the engines in question*."

[423] **1911**, **Judge Noyes**: "*To recapitulate, we have examined the prior art and have found the different elements of the combination, other than the engine, admittedly old. We have also found the engine element old and represented by two types*."

[424] **1961**, **Greenleaf**, p.148: "*As a patent attorney of long standing, Selden gratuitously displayed his knowledge of his branch of the law, interlarding his replies to Parker's queries with arch comments, and sometimes scarcely concealing his hostility. His self-confidence was formidable, even to the point of arrogance*."

[425] **1961**, **Greenleaf**, p.8: "*In **1867** George abandoned his classical course at Yale and entered the Sheffield Scientific School. His two years there as a special student were probably the happiest of his youth*."

[426] **Kennedy**, E. D., THE AUTOMOBILE INDUSTRY - The Coming of Age of Capitalism's Favorite Child, ED. Reynal & Hitchcock, New York, **1941**, P.47: "*But Selden did not think that Otto engine was any good. In his diary (which was introduced in evidence in the trial) he referred to the Otto engine as "another of those damned Dutch engines"*. **1961**, **Greenleaf**, p.44: "[…] *with the comment that the "Dutch way of Otto was impracticable*"."

[427] **1961**, **Greenleaf**, p.23: "*Despite the structural changes made by Selden, the operating principles of the Brayton and Selden motors were identical. Both were two-cycle, constant pressure engines using external compression*."

[428] **1961**, **Greenleaf**, p.38: "*While other inventors infused their machines with life, Selden spun a paper web to ensnare the gasoline automobile as his original creation and legal monopoly*." P.43: "*The life of his application shows approximately one hundred separate changes made by Selden*."

[429] **1911**, **Judge Noyes**: "*Indeed, Mr. Clerk, himself, says: "I have already stated that if the Lenoir, Brayton, Otto and Langen, and Otto Silent motors were all supposed to be in active existence and running, doing stationary work, that the mere selection of one of these motors without alteration and the application of any one of them without alteration of any kind would not involve an act of invention"*."

[430] **1911**, **Judge Noyes**: "*Selden did not, however, obtain a patent for his improvement upon the Brayton engine, but made the improved engine an element in his road locomotive combination. But no new co-ordinate action of the members of the combination is shown*."

Brayton; but that did not prevent Selden's combination from being strikingly new, useful if it would work, and eminently patentable. [431]

To sum up what is shown to have been the mental concept embodied in 1879 by Selden's model and drawings: With Brayton's engine in mind, he organized a new road vehicle. To be sure, he did substitute one old and well known prime mover (gas) for another (steam); but in so doing he devised and used an arrangement of Brayton's engine never before attempted, one that Brayton himself never suggested, made, or patented, and without which the road vehicle was an impossibility.

This mental concept constituted invention, if capable of reduction to operation, and if *any operative* example (not *all* operative examples) thereof was shown by the patentee.

If this doctrine be admitted or found, defendants before attacking the operativeness of Selden's vehicle, seek to limit the scope of the patent by asserting that the combination is not infringed by any vehicle whose engine is not substantially identical with that described in drawings and specifications, notwithstanding the language of the claim "liquid hydrocarbon gas engine of the compression type."

Thus it is asserted, that since Selden and Brayton show a spray of petroleum mixed with and carried by compressed air into the combustion chamber, they do not show a true gas engine; that the use of a carbureter separate from the engine proper[432], and producing gaseous mixture which it feeds to the engine, is something outside the patent and avoiding infringement; that a water jacket being shown by Selden in a peculiar and unusual equivalent or attempted equivalent, is something outside the combination, and when used by defendants differentiates defendant's engine and combination from anything that infringes; and that, since Selden evidently shows in his drawings ignition by a constant flame, he is confined thereto, and cannot use electric ignition, while defendants, by using the same, do vary the combination.

I have already tried to show that Brayton's petroleum engine, Lenoir's illuminating gas engine, and an Otto machine driven by gasoline, are now, and were in 1879, not only "gas engines" in the sense that they all operate on the same scientific principles, but they were known as and called "gas engines," by those best qualified to speak.

To make gas in one place rather than another must be an immaterial variation, where a primary patent (such as this by complainants' contention) is under consideration. Water jackets were old in 1879, and had been used in many forms, and both flame and electric ignition had been used and were well known to gas engineers of the day, although in 1879 it seems to me that the flame method was by far more successful than the electric as applied to compression machines.

The force of these objections, based on the face of the drawings and specifications, as compared with the claims, depends on whether the patent is viewed as a primary or pioneer one[433], or the contrary; and this in turn depends on the state of the art at the time of invention. The art I have attempted to describe at perhaps too great length, because upon its condition this whole litigation seems to hinge.

If I have correctly apprehended it, there was clearly room for a pioneer patent; and it must now be held that on its face and in view of the art, Selden's is such a patent. This means that Selden is entitled to a broad range of equivalents, and this rule as applied here results in this crucial inquiry: Was Selden (or any one else) entitled in 1879 to appropriate as one of the elements of any patentable combination a "liquid hydrocarbon gas engine of the compression type"?

I think he was, and so was any other inventor; but he was the first so to do[434]. If this be true, then the use or disuse of any then well-known mechanical appliance, which will increase the efficiency, usefulness, or commercial success of such combination, without changing what defendants call its co-operative law, (Note.) is on the one hand open to Selden, and on the other will not free defendants from infringement.

[NOTE.—This phrase which runs through all defendants' argument, seems to be defined (Main Brief p. 157) as "a new mode of operation," referring to Rapp v. Central, etc., Co. (C.C.) 158 Fed. 440. It is insisted that Selden's combination introduced no new "co-operative law", and must therefore fail. The trouble with this argument is that there never was such a combination as Selden's before 1879, and there is nothing to compare it with but paper projects and admitted failures.

The same phrase is repeatedly used, when quoting Ex. parte Faure, 52 O. G. 752. If Selden had merely utilized Brayton's existing engine to drive a wagon, the doctrine of the case cited[435] might have applied. Perhaps it would have been good American law against Rosenwald; but if Selden selected, adapted, and united old elements to produce a new result, the phrase is inapplicable.]

Although there were in 1879 many liquid hydrocarbon gas engines of the compression type, there was not one which in its then form could be made an element (and the most important element) in a road wagon combination[436], and the radical difficulty was the same that Savalle had confessed to 10 years before.

Selden on paper certainly—whether actually will be considered later—solved that difficulty, and such solution gave him the right to claim broadly the *thing* which was the leading element in his invention, when used in his combination. Thirty years have passed, and counsel admit that no successful gasoline motor car fails to use a liquid hydrocarbon gas engine, of the compression type, with a short rapid stroke, and inclosed crank case, and a plurality of cylinders.

These are the very *things* which are at the foundation of success. To be sure (as will be considered more fully later) no very great degree of success can be reached without improvement over 1879 in carburetors, and electric ignition, and increase of knowledge[437] concerning the respective mechanical possibilities of two, four and six cycle engines. The faster, also, the reciprocating parts of an engine move, the greater the necessity of constant and abundant lubrication, and Selden's lubrication is confessedly primitive; and, finally, the great difference between any results Selden's most optimistic supporter can claim for him in 1879, and the successes of 1909, arises from increased compression, so that engine weight per brake horse power has now been reduced to about 10 pounds.

But these are nonessential, if in 1879, Selden could lawfully use as an element in his patentable combination, the "compression type," or species of a whole genus of engines. As already stated, I think he could, and did, and further showed and made an exemplar of said "type."[438] (Note.)

[NOTE.—As quite possibly my foregoing efforts to follow defendants' argument on the interpretation of the specification and claims in the combined light of prior and present art have failed of complete success, the following statement may be excused: Defendants seem continually to assume (without saying so) that Selden invented nothing more than a modified Brayton engine, and then assert that they do not infringe because they do not use that particular motor, and do use a modified Otto. They admit that the claim is for a combination, but continually seek refuge in defenses that would be good against any patent on Selden's engine, but are worthless against the combination if it be patentable at all. Mr. Selden is a member of the bar, especially devoted to patent causes. He seems to have been his own solicitor during most of his contests with examiners over this application, and the clearly and simply worded claims in suit are good professional work. He has avoided the trap into which Morse fell (O'Reilly v. Morse, 15 How., 62, 14 L. Ed. 601), and thereby lost most of the fruits of his efforts. This case seems to me suggestive, in that the Chief Justice several times speaks of "process" as legally synonymous with "combination." And see Morse's claim restated so as to avoid the criticism that destroyed it in 19 Harv, Law Review, p. 37. I think Selden might have patented his engine as an improvement on Brayton; but he would have had to pay Brayton a royalty, and these suits would certainly never have been possible.]

Thus far the claims and specifications have been treated as though they were presented to the Commissioner in 1879, in the shape they left his office in 1895. This was not the case. Nothing remained in 1895[439] of the language of 1879 but the description of

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[431] **1911**, **Judge Noyes**: "*The claim is held to be valid as covering a combination in a road locomotive of the different elements with a liquid hydrocarbon compression engine of the Brayton type*."

[432] **1911**, **Judge Noyes**: "*We think the carburetter, while undoubtedly an adjunct of great importance and advantage, should be held not beyond the range of equivalents.*"

[433] **1911**, **Judge Noyes**: "*But any contention that a motor vehicle constructed by the patentee according to the teachings of the patent operated so successfully as to demonstrate that Selden had solved a great problem and is entitled to the status of a pioneer inventor is, we think, without foundation*."

[434] **1911**, **Judge Noyes**: "*But the prior art did not permit such a patent. Every element in the claim was old, and the combination itself was not new. Combinations of non compression gas engines with the other elements had been in use, and Brayton had employed a "liquid hydrocarbon engine of the compression type" in a vehicle*."

[435] **1911**, **Judge Noyes**: "*And, even if the Brayton engine had been used only for stationary purposes, it is by no means certain that its mere selection for incorporation in a motor vehicle without adaptation would have involved invention. In re Faure's Appeal, 52 OH. Gaz. 754 (Supreme Court, District of Columbia), is in point. In that case Faure claimed a patent for the combination of an electric motor with a vehicle. It appeared in that case, as in this, that boats had been propelled by the same kind of motor. The court said (page 756): "It is evident that the mechanical arrangements for applying the power are not new, being familiar to all experts; and that the result is not new, viz., the movement of vehicles by electrical storage batteries. It is admitted that Trouvé had propelled boats in this way. The contention that such a use did not anticipate this application because that experiment was on water and this invention is designed for use on land seems untenable. The propulsion of vessels through water by such batteries is within the same principle as locomotion on land*."

[436] **1911**, **Judge Noyes**: "*The pioneer inventors appear to have been Daimler and Benz abroad and Duryea, Olds and Ford (and perhaps one or two others) in this country*."

[437] **1911**, **Judge Noyes**: "*Electric ignition was considered impracticable. But when the electric art had developed it was seen that the electric ignition could be made superior to flame ignition and it would permit much higher speed. But the change was not indicated by the Selden patent, which refers only to flame ignition. The inventors added a carburetter to the Otto engine in which the charge of gasoline and air was mixed in exact proportions before it was conducted to the cylinder for compression.* […] *The patent in no way pointed in the direction of the carburetter.* […] *Other changes in the direction of decreasing weight and bulk and increasing speed were made. But these inventors were actually taught nothing in these matters by the Selden patent, and if it had been before them they would, as we have seen, have learned nothing definite from it.*"

[438] **1911**, **Judge Noyes**: "*So, lastly, we reach the question: Is the constant volume engine the equivalent of the constant pressure engine, under a patent entitled to a fair and reasonable, but not broad, range of equivalents? This is not a question of differences in terminologies or theories. It is a question of differences in principles and things*."

[439] **1961**, **Greenleaf**, p.45: "*In July, **1895**, only three months before his patent was issued, Selden requested cancellation of the term "compression mechanism" from his claims*. […] *His petition was granted, but Selden could not change his drawing and specification, which clearly showed the external compression mechanism of the Brayton engine*."

the vehicle and engine (and not all of that). The claims were reworded and the specification amplified many times, and usually, after a rejection made or criticism offered by the examiner, Selden did nothing by way of amendment or reply for about two years—the extreme limit of inactivity permitted him by the then rules of Patent Office practice.

By these means he received in 1895 a patent for an invention of 1879, and in the meantime had never built a motor car, and never succeeded in getting any one sufficiently interested in his theories to experimentally try them out with larger means and better mechanical ideas than Selden himself had.[440]

During the later years of this period, and while Selden was in very leisurely fashion combating examiners who evidently had small conception of what was meant by light self-propelling vehicles usable on the common roads, Duryea, Olds, Ford, and others in America, and the Panhard and Peugeot Companies (and many others) in France were experimenting with actual cars, and in 1894 a public race meet was held in France, whereat cars now as archaic in appearance as Selden's, demonstrated that they actually could propel themselves from Paris to Rouen at about 12 miles an hour. The engines of some of them were modified Ottos, and "liquid hydrocarbon gas engines of the compression type," and it must be found that when Selden's patent issued there had been developed engines answering to his phrase, which, as a matter of history are note derived from his engine—that others reached his type without knowledge of him or his labors. Indeed (while certainty is impossible), it is my belief from this evidence that Selden had contributed little to motor car advancement in the United States, and nothing at all abroad. As a matter of fact, I believe that nearly all the cars made in the United States when these actions began were modeled on French ideas, and used engines descended from Otto through Daimler, and not from Brayton through Selden or any other American. In short, this American patent represents to me a great idea, conceived in 1879, which lay absolutely fallow until 1895, was until then concealed in a file wrapper, and is now demanding tribute from later independent inventors (for the most part foreign) who more promptly and far more successfully reduced their ideas to practice.

But the patent speaks from the date of its issue, and unless Selden did something unlawful during his 16 years' wrangle with examiners, or unless intervening American rights, available to defendants, sprang up while Selden was rewording claims, he is within the law[441], and his rights are the same as those of the promptest applicant.

Without prolonging discussion, it may be held briefly that Selden did not overstep the law. He did delay[442]. He was not in a hurry. He could not get any one to back him, and doubtless appreciated that, if he was ahead of the times[443], it was wise not to let his patent get ahead too. If he had gotten his grant in 1880, without a moneyed backer, the patent might and probably would have expired, or nearly so, before any one saw its possibilities; and, if the business world had seen them within 17 years, that term would then so nearly have expired that Selden would never have been able to get to final hearing before it ran out. At best, an accounting and not an injunction would have been his lot. The difference he may well have considered as a lawyer, and personally I believe he did think of it. If he did not delay unlawfully, what intervening rights did he permit to spring up?

Remembering that Selden clearly showed a "liquid hydrocarbon gas engine of the compression type" in 1879, and actually manufactured one, I think it clear that his original claim was wider than any of those in suit. The third claim as originally filed read thus:

"The combination in a road locomotive provided with suitable running gear and steering mechanism, of a *gas engine*, traction wheels, and an intermediate clutch or disengaging device, substantially as set forth."

It is true that throughout the original papers he speaks continually of "Gas engine L," that being the alphabetical designation given his motor in the drawing submitted; but the claim quoted shows how wide was his original demand, and without further elaboration I hold, with complainants, that all subsequent changes of claim are in diminution or contraction of this first statement of invention.

The file wrapper, cross-examination thereon, and argument concerning it form a bulky volume; but it seems to me sufficient to quote from the amendment of June 6, 1889, when Selden amplified his specification by inserting the following:

"I have succeeded in overcoming these difficulties by the construction of a road locomotive propelled by a liquid hydrocarbon engine of the compression type, of a design which permits it to be operated in connection with the running gear, so that the full carrying capacity of the body of the vehicle can be utilized for the transport of persons or goods, and which, by dispensing with skilled attendance and with steam boilers, water, water tanks, coal and coal bunkers, very largely reduce the weight of the machine in proportion to the power produced, and enables me, while employing the most condensed form of fuel, to produce a power road wagon which differs but little in appearance from, and is not materially heavier than, the carriage in common use, is capable of being managed by persons of ordinary skill at a minimum of trouble and expense, and which possesses sufficient power to overcome any usual inclination." [444]

And at the same time he put what is now claim 1 into substantially its present shape. The language last quoted is in the final specification, it describes the *thing* which Selden conceived and pictured in 1879[445], and in 1889 the man skilled in the art, though he knew more than he did in 1879, did not know as much as Selden sets forth in the quoted words. It was still possible for the gasoline compression engine to be made part of a patentable road wagon combination. No one in the United States has passed, or even caught up with, Selden, while foreign efforts have been fairly and attractively told by Mr. Krebs, of the Panhard Company. He quite fully depicts the history of meritorious and successful efforts in road locomotion, apparently as ingenious as Selden's and more vigorously pursued; but they did not begin until after 1879, and in 1889 were still clearly behind Selden's concept.[446] (Note).

[NOTE.—It is not intended to admit or assert by this that, even if some one had between 1879 and 1889 devised an engine or a combination, which if devised in 1869 would have been a clear anticipation of Selden, such person's device would be a defense to these suits. The fact that no such device exists renders discussion of this point unnecessary. Benz has not been overlooked, but is not thought to require further mention.]

Defendants have advanced many other arguments based on the contents of the file wrapper. Thus the original third claim, above set forth, declares a combination *in* a road locomotive, while the first claim in suit covers a combination *with* a road locomotive. The change is declared to be an abandonment of the original combination. It is further shown that some patent examiner rejected certain claims, referring to the Pinkus patent, *supra*, and thereupon Selden amended the claims and disavowed and disclaimed Pinkus. The argument based on this is that since Pinkus' "co-operative law" is the same as Selden's, the disclaimer of Pinkus was in effect an abandonment of the very combination now relied on.

I have already indicated my view of the major premise of the last proposition; but these arguments, and many others of the same ilk, cannot prevail if it be true that Selden clearly showed in 1879 the *thing* he had invented. If so, he could rewrite the description of that *thing* as many times as the rules of practice permitted down to 1895. That such rewriting is all Selden did I believe to be true.

Defendants now urge that Selden's invention is inoperative. The one-cylinder engine built by Selden on the three-cylinder casting in 1877-78 was put in evidence as Exhibit 47. Thereafter the cylinders of Exhibit 47 were all bored out or rebored, new working parts fitted to them, and the engine put into a vehicle, the whole called Exhibit 89, completed in the winter of 1905-06, and constituting the first physical embodiment of Selden's patent[447]. The complainant licensee, Electric Vehicle Company, also constructed a new engine from the patent drawings (Exhibit 132) and a complete vehicle (Exhibit 157).

Defendants aver that neither of these vehicles is a Chinese reproduction of Selden's drawings, and have devoted volumes of print to recording and arguing about the performances of Exhibit 89.

In my opinion Exhibit 89 as constructed was such Chinese reproduction. Exhibit 157 was not[448]; complainants having changed the water cooling device, used only electric ignition and made some other departures from the mechanical details shown in the drawings. But these variations were (as previously indicated) within the range of equivalents permitted to a primary patent. (Note.)

[NOTE.—Great complaint is made of the "destruction" of Exhibit 47, and after defendants learned of the construction of Exhibit 89, they frequently demanded that Exhibit 47 be produced, knowing that it could not be done. I can see no force in the complaint; the function of an exhibit is to furnish evidential information, and it is too obvious for argument that whatever value (it is not much) Exhibit 47 has, it was enhanced by building even the rebored cylinders into Exhibit 89. It may also be noted here

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[440] **1961**, **Greenleaf**, p.52: "*Finally, Selden might assign his rights to organized interests capable of implementing the legal monopoly*."

[441] **1961**, **Greenleaf**, p.49: "*But, as the creation of a patent lawyer, the Selden car was an almost impeccable legal invention.*"

[442] **1961**, **Greenleaf**, p.39: "*The privilege of amendment was lawful, but intentional delay for the purpose of dominating an industry or an art which had meantime come into being was illegal. However, it was extremely difficult to prove deliberate delay with intent to embrace similar devices later invented by others.*" P.40: "*Other inventors of that day also tried to profit by this flaw in procedure. Few matched the tactics of Selden.*"

[443] **1911**, **Judge Noyes**: "*We are of the opinion that the patentee had ideas "ahead of the times" and appreciated many aspects of the problem to be solved in creating a practical motor vehicle*. […] *In our opinion the statement in the patent that any form of compression engine may be employed is inconsistent with the intention disclosed by the patentee in the patent as a whole and should not have too much stress laid upon it.*"

[444] **1911**, **Judge Noyes**: "*A patent is granted for solving a problem, not for stating one. Its description must explain the invention itself, the manner of making it, and the mode of putting it in practice. In the absence of knowledge upon these points, the invention is not available to the public without further experiments and further exercise of inventive skill*."

[445] **1911**, **Judge Noyes**: "*He undoubtedly appreciated the possibilities of the motor vehicle at a time when his ideas were regarded as chimerical. Had he been able to see far enough, he might have taken out a patent as far reaching as the explosive action was the very thing which Brayton, who invented the engine which Selden modified desired to avoid.*"

[446] **1961**, **Greenleaf**, p.45: "This assertion […], while manifestly true in **1879**, did not accurately describe Selden's knowledge of the art ten years later."

[447] **1961**, **Greenleaf**, p.150: "*Actually, Exhibit 89 was new in every respect with the exception of the cylinder casting and the crankshaft."*

[448] **1961**, **Greenleaf**, p.152: "*Exhibit 157, which resembled a truck, diverged in important particulars from the patent specifications*."

that in my opinion Selden's original drawings indicate the existence of a check—or wicket-valve in the appropriate place. It was a well known and perfectly simple mechanical adjunct, it should have been there, it was by no means the key of the invention, and Rebasz's testimony is probable and uncontradicted.

The so-called Ford-Lenoir machine[449] has received attention. To me it is interesting but irrelevant. Mr Clerk did intimate that he doubted whether any vehicle with a non-compression engine could move at all. Mr. Ford has shown that he was mistaken. By making the engine four times the size of Ford's compression type, there is obtained about one-seventh of the power. It hardly seems that the pleasure of contradicting Clerk was worth so much trouble.]

The evidence on the subject of operativeness is the most flagrant example of unsupervised testifying I have ever seen or heard of.

Whether in 1905 Exhibit 47 was any better than scrap, whether Exhibit 89 would start on flame ignition, whether Exhibit 132 showed diagrams revealing volume or pressure constant, were perhaps interesting, but unimportant questions. They raised a false issue, over which months of time and volumes of print have been expended.

The serious, and I think only, question was, and is, whether a machine made in substantial conformity to drawings and specifications, without going beyond the range of equivalents permitted, was operative, even though rudimentary. Exhibit 157 answers to this description, and its performances[450] may, I think, be thus summarized: It is a wretchedly poor car for 1905; there were probably as good, if not better, cars in 1895[451]; but it is a marvel of invention for 1879. And that is more than enough for the purposes of these cases.

One instance of alleged prior use remains. Before 1879 Brayton undertook to furnish an engine which would drive an omnibus to certain men in Pittsburg[452]. It is shown that he endeavored to adapt his then well-known engine to traction purposes. That he failed utterly is clearly proved. The reasons for his failure are not so clear; but the failure is enough to invalidate the defense[453].

No litigation closely resembling these cases has been shown to the court, and no instance is known to me of an idea being buried in the Patent Office until the world caught up to and passed it, and then embodied in a patent only useful for tribute[454].

But patents are granted for inventions. The inventor may use his discovery, or he may not[455], but no one else can use it for 17 years. That 17 years begins whenever the United States so decrees by its patent grant. That the applicant for patent rights acquiesces in delay, or even desires delay, is immaterial to the courts, so long as the statute law is not violated. On these principles complainants are entitled to a decree. (Note.)

[NOTE.—The legal principles relied on are so simple, (the difficulty being only with the opinion evidence) that it has not seemed necessary to quote from decisions. The leading cases considered are (as to nature and act of invention) Smith v. Dental Vulcanite Co., 93 U. S. 486, 23 L. Ed. 952; Loom Co. v. Higgins, 105 U. S., 580, 26 L. Ed. 1177; Potts v. Creager, 155 U. S. 597, 15 Sup. Ct. 194, 39 L. Ed. 275; (as to probative value of references) Seymour v. Osborn, 11 Wall, 516, 20 L. Ed. 33; (as to meaning of "pioneer" patent, and effect of file-wrapper) Hobbs v. Beach, 180 U. S., 383, 21 Sup. Ct. 409, 45 L. 586; (effect of delay in patent office) U. S. v. Bell Telephone Co., 167 U. S., 224, 17 Sup. Ct. 809, 42 L. Ed. 144; (right to deny use to others while patentee not using) Continental Paper Bag Company v. Eastern Paper Bag Company, 210 U. S. 424, 28 Sup. Ct. 748, 52 L. Ed. 1122.]

The Panhard machine does not, in my judgment, infringe the second claim. Construed as they have been in this opinion, infringement of claims 1, 2 and 5 by the Ford machine, and of 1 and 5 by the Panhard[456] can hardly be said to be denied.

It is so found, and decrees will pass accordingly.

C. M. HOUGH, U. S. D. J.

September 8th, 1909.

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[449] **1911**, **Judge Noyes**: "*But no reason is advanced why the Lenoir engine was not capable of propelling a vehicle.*" **1961**, **Greenleaf**, p.164: "*This* [1904 Ford-Lenoir] *motor exemplified the art of the gasoline engine as it existed not later than **1867**, twelve years before Selden applied for his patent.*" P.165: "*Impartial observers of this demonstration gave equally laudatory accounts of the car's operating capacities.*" P.205: "*This was directly linked to Clerk's admission that the Selden claim might be laid open to re-examination if it could be demonstrated that a non-compression engine could successfully power a road carriage.*"

[450] **1961**, **Greenleaf**, p.150: "*In two days [June 14 & 15, **1907**], and with many mechanical breakdowns, this advanced version [Exhibit 157] of the Selden vehicle succeeded in covering a distance of two and one-quarter miles.* […] *Exhibit 89 traveled a total distance of 1,309 feet at an average speed of 4.94 miles an hour.*" P.161: "*Motor World, the pro-A.L.A.M. organ, was compelled to admit that the engine could not operate successfully according to the terms of the patent, even with the initial aid of electric ignition. It was a fearful performance. The engine belched flame and thick clouds of smoke, and the exhaust pipe turned red hot.*"

[451] **1961**, **Greenleaf**, p.49: "*There is no doubt that in **1895** the Selden automobile was obsolete.*" P.53: "*In **1895**,* [US] *financiers had been stonily indifferent to motor vehicle development; in **1898**, seventeen makers produced 239 cars with a combined value of $219,600. Even on such a modest showing, Eastern capital scented an opportunity for reaping profits.* […] *In **1900**, thirty-four companies with an aggregate capitalization of $173,000,000 were incorporated. Most of these also sank from sight.*" P.54: "*"To aim at the control of as many patents as possible has become the fad among prospective manufacturing companies," commented a trade obsrerver.*"

[452] **1961**, **Greenleaf**, p.20: "*A Brayton engine was also employed in a partially successful attempt to drive a Pittsburg omnibus in **1878**, but the experiment was cut short by a disapproving city council.*"

[453] **1911**, **Judge Noyes**: "*The Brayton engine was also used upon an omnibus in **1878**. The weight of the testimony is that the omnibus was run by the engine a very short distance, but the experiment cannot be regarded as having been either mechanically or commercially successful.*"

[454] **1911**, **Judge Noyes**: "*The public gained absolutely nothing from his invention, whatever it was. From the point of view of public interest it were even better that the patent had never been granted. Judge Hough was quite within bounds in saying: "No litigation closely resembling these cases* […]*".*" **1961**, **Greenleaf**, p.206: "*To make this beginning, Hough adopted an erroneous perspective that did violence to historical reality. He ignored the evolutionary character of the mechanized road vehicle and treated the Selden claims as a cataclysmic development in the history of this branch of invention.*"

[455] **1961**, **Greenleaf**, p.174: "*In **1906**, after Selden secured the financial support of a group of Buffalo and Rochester businessmen for manufacturing passenger automobiles, he made the painful discovery that he could not enter the industry unless he secured a license under his own patent. Having assigned his rights, Selden solved his dilemma by acquiring the license of the Buffalo Gasolene Company, which on November 13, **1906**, became the Selden Motor Vehicle Company. As one historian of the industry observes, "the situation probably ranks unique in the annals of patent law, where the patentee himself is debarred from manufacture, although willing to pay royalties to himself.""*

[456] **1961**, **Greenleaf**, p.214: "*To the mass exodus of the independents there might have been added a more serious defection had it not been for the timely action of Frederic R. Coudert. In the fall of **1909**, as the unlicensed manufacturers began their march into the Selden ranks, Coudert learned that his clients, **Panhard & Levassor**, were again planning to call a retreat. The case, they told Coudert, had been protracted and costly. Furthermore, they did not believe that the relatively small American trade in foreign cars justified their continued opposition. Coudert cabled his French clients: "Wait until I come over". Reaching Paris, he conferred with Panhard and Neubauer officials. The decision, said Coudert, could be reserved. Final judgement would enhance the prestige of the French independents and save them from the exaction of tribute. Still the Frenchmen were skeptical. Coudert then made an astonishing offer. "I have confidence that we can win, gentlemen, and I will show you that I have it", he declared. "If you will make the appeal, and pay the routine costs of printing—I cannot legally do that myself—I will charge you nothing for my services in case I lose". The offer was accepted. Had Coudert failed to bring about this dramatic reversal, the position of the Ford Motor Company before the courts would have been gravely weakened.*"

THE FEDERAL REPORTER, vol. 184, THE CIRCUIT COURTS OF APPEALS AND CIRCUIT AND DISTRICT COURTS OF THE UNITED STATES, St Paul West Publishing ed. March-April, **1911**, 991 p., p. 893-916.

The Columbia Motor Car Company and George B. Selden, Complainants-appellees Vs. C.A. Duerr & Co. and Ford Motor Company, Defendants-appellants: The Same Vs. The O.J. Gude Company, Defendant-appellant. The Same Vs. John Wanamaker Et Al, Defendants-appellants. Appeal from the Circuit Court of the United States for the Southern District of New York. Transcript of Record.

COLUMBIA MOTOR CAR CO. et al. v; C. A. DUERR[457] & CO. et al.

(Circuit Court of Appeals, Second Circuit. **January 9, 1911**. On Taxation of Costs, February 8, 1911.) Nos. 168-170, 173, 174.

1. PATENTS (§ 117*)—CONSTRUCTION AND OPERATION—EFFECT OF DELAY IN PATENT OFFICE. Where an applicant for a patent followed strictly the statutes and rules of procedure of the Patent Office, the courts cannot exact a greater measure of diligence from him, and the fact that he took advantage of the delays which the law permitted him cannot affect the consideration to which his patent is entitled when granted. [Ed. Note.—For other cases, see Patents, Dec. Dig. § 117.*]

2. PATENTS (§ 101*)—VALIDITY—COMBINATION CONTAINING UNDESCRIBED ELEMENT. A patent is granted for solving a problem, not for stating one, and a claim for a combination which embraces an element only in case it is made capable of being employed in the combination and without disclosing means of adapting it is invalid as disclosing nothing definite. [Ed. Note.—For other cases, see Patents, Dec. Dig. § 101.*]

3. PATENTS (§ 245*)—INFRINGEMENT—EQUIVALENTS. A constant volume gas engine is not the equivalent of a constant pressure engine under a patent entitled to a fair and reasonable, but not a broad, range of equivalents. [Ed. Note.—For other cases, see Patents, Dec. Dig. § 245.*]

4. PATENTS (§ 328*}-VALIDITY AND INFRINGEMENT—GASOLINE AUTOMOBILE. The Selden patent, No. 549,160, for an improved road engine, granted in 1895 on an application filed in 1879, claim 1, covers, broadly speaking, a combination of three elements—the carriage, the drive mechanism, and the engine. The first two elements were concededly old, and no novelty is disclosed in them. The engine, described as a "liquid hydrocarbon gas engine of the compression type," was also old; there being at the time of the application two forms of such engine in extensive use—the Brayton, or constant pressure, engine with slow combustion and constant flame ignition, operating without explosion, and the Otto, or constant volume, explosion engine. The combination itself was not new in an inventive sense, as the Brayton engine had been applied to motor boats and to some extent to vehicles. As thus broadly stated in the language of the claim, it is void for lack of invention in view of the prior art, but as limited by the specification and drawings, which show an engine of the Brayton type, with certain improvements and adaptations resulting in a decrease in weight and bulk in proportion to the power produced and in increase in speed, the claim discloses invention and is valid as covering a combination embracing as a novel element an improved liquid hydrocarbon engine of the Brayton type. As so limited, the claim is not infringed by the modern gasoline automobile in which the engine is of the Otto constant volume or explosion type with electric ignition.

5. WORDS AND PHRASES—"CONSTANT PRESSURE ENGINE"—"SLOW COMBUSTION",—"NONEXPLOSION." A "constant pressure engine" is one in which the cylinder pressure remains the same during the outward travel of the piston while the volume of flame increases. The pressure is applied continuously. This mode of operation is also called "slow combustion" and "nonexplosion."

6. WORDS AND PHRASES—"CONSTANT VOLUME ENGINE." A "constant volume engine" operates in a different manner from a constant pressure engine. The volume during ignition theoretically remains constant; the pressure increases. The action is spasmodic and is kept in motion by a series of explosions.

Appeals[458] from the Circuit Court of the United States for the Southern District of New York. Suits

[457] **1961**, **Greenleaf**, P.125: "*Duerr was the Ford agent in New York City*."

[458] **1961**, **Greenleaf**, p.222: "*The hearing on appeal opened on November 22, **1910**, in the old Post Office Building in Manhattan before a full bench of the United States Court Circuit Court of Appeals for the Second Circuit*."

in equity by the Columbia Motor Car Company and George B. Selden against C. A. Duerr & C0. and the Ford Motor Company, against the O. j. Gude[459] Company, against john Wanamaker[460] and others, against Société Anonyme Des Anciens Établissements, Panhard & Levassor[461], and Andre Massenat, and against Henry & A. C. Neubauer[462]. Decrees for complainants, and defendants appeal. Reversed.

The decrees of the Circuit Court sustained the validity, and found infringement of letters patent No. 549,160 granted November 5, 1895, to the complainant George B. Selden for an improved road engine. The corporation complainant is the exclusive licensee under the patent. The opinion of the Circuit Court is reported in 172 Fed. 923. Livingston Gifford, Frederic R. Coudert[463], and Edmund Wetmore (W. Benton Crisp, R. A. Parker[464], john P. Murray, and Charles K. Offield, on the briefs), for appellants. Samuel R. Betts, William A. Redding, and Frederick P. Fish (Edward Rector and john W. Peters, on the briefs), for appellees. Before LACOMBE[465], WARD, and NOYES, Circuit judges[466].

NOYES, Circuit judge[467]. Although the title of the alleged invention as stated in the preamble of the patent is an "improved road engine," it is claimed to embrace the essential elements of the modern automobile and has been sustained as being "so fundamental and far reaching as to cover every modern car driven in any way by petroleum vapor and as yet commercially successful."

The subject is most important; the interests involved, of great magnitude; the record, phenomenally long; and the questions presented, complex. In examining these questions we have been greatly aided by the work of the judge of the Circuit Court in blazing the way through the mass of testimony and defining the issues to be decided. While we may be unable to adopt the conclusions stated in his very able opinion, we must at the outset acknowledge our indebtedness to it.

Ordinarily the first thing to be looked at in a patent suit is the patent. That is the source and measure of the patentee's rights. But in this case it seems desirable before we examine the patent to take up some preliminary considerations, the disposition of which may serve to indicate the standpoints from which the patent should be regarded in the examination to follow.

This patent was applied for in 1879 and granted in 1895. For over 16 years the application lay in the Patent Office and the applicant took full advantage of the periods of inactivity permitted by the rules and statutes. It is apparent that he delayed just as long as possible the issue of the patent to him. During this long time the automobile art made marked advances along different lines, and when, in 1895, the patent was granted, it disclosed nothing new. Others had then made the patentee's discovery and had reduced it to practice in ignorance of what he had done. While he withheld his patent, the public learned from independent inventors all that it could teach. For the monopoly granted by his patent he had nothing to offer in return. The public gained absolutely nothing from his invention, whatever it was. From the point of view of public interest it were even better that the patent had never been granted. Judge Hough was quite within bounds in saying:
"No litigation closely resembling these cases has been shown to the court and no instance is known to

[459] **1961**, **Greenleaf**, p.127: "*Among the first purchasers of Ford motor cars in New York was the O. J. Gude Company, an advertising concern which pioneered in the use of illuminated displays on Broadway*."
[460] **1961**, **Greenleaf**, p.127: "[…] *John Wanamaker and his associates, who had succeeded Duerr as the Ford agent in New York*."
[461] **1961**, **Greenleaf**, p.127: "*A third action, which did not involve Ford, was filed on December 28, **1903**, against the French firm **Panhard & Levassor** and the manager of its New York branch, André Massénat. This suit against the Panhard interests, makers of one of the most prominent imported lines marketed in the United States, covered a foreign manufacturer*."
[462] **1961**, **Greenleaf**, p.127: "[…] *Henry and Albert C. Neubauer, a firm of Dutch importers whose main offices were in Paris. The suit against the Neubauer agency, which had sold **Panhard** and Renault motor cars in the United States, covered an importer of automobiles*."
[463] **1961**, **Greenleaf**, p.223: "*The most effective appearance for the defense was made by Coudert. His oral argument, reinforced by a superb brief, challenged the basic assumption of the trial court that the Selden patent, as viewed against the state of the art in **1879**, marked the borderline between success and failure. Coudert combined moving eloquence with penetrating and often mordant analysis*."
[464] **1961**, **Greenleaf**, p.128: "*Parker contented that the invention claimed by Selden was neither patentable, useful, nor operable.* […] *In the height years of litigation that lay ahead, Parker was to return to this theme again and again as Goliath of monopoly came under attack in and out of the courts*."
[465] **1961**, **Greenleaf**, p.144: "*On January 20, **1906**, John P. Murray of the Coudert law firm requested the permission of the court to take testimony abroad on the performance of the Marcus vehicle and named witnesses in Vienna he wished to examine. Murray furnished a detailed mechanical description of the car operated in **1875**, noting that it was in the possession of the Automobile Club of Vienna. The Selden lawyers opposed the motion, but observed that the defendants were free to make another application to interrogate witnesses abroad. The defendants, however, never made further attempts to obtain testimony on this foreign contribution. Their failure to explore this achievement remains a puzzling aspect of the Selden case. They thereby lost a major opportunity to challenge Selden's claim that he alone had given the gasoline automobile to the world*."
[466] **1961**, **Greenleaf**, p.226: "*About six weeks later, on January 9, **1911**, Judge Noyes read the unanimous opinion of the court*."
[467] **1961**, **Greenleaf**, p.227: "*The court recognized the basic technology of the modern gasoline automobile as the product of social invention, made that technology available to common use, and threw open the doors of the motor vehicle industry to all who chose to enter. The opinion ranks as one of the most meticulous analyses of a patent ever handed down in an American court*."

me of an idea being buried in the Patent Office while the world caught up to and passed it, and then embodied in a patent only useful for tribute."

It is urged that we should regard unfavorably the patent on account of this delay in the Patent Office, should seek to avoid giving it a broad construction, and should permit the alleged abuse of the law to weigh against the standing of the complainants in a court of equity. But the patentee acted wholly within his rights. He merely took advantage of the delays which the law permitted him. He followed strictly the statutes and rules of procedure, and the courts cannot exact a greater measure of diligence from him. When the patent was granted under the authority of the law, it became entitled to the consideration accorded to any other patent. If the statutes and rules permit unnecessary delays, they should be changed; but we reject the view that this court owes any duty to relieve against their operation. This patent, even if it be useful only for tribute, must be viewed without prejudice and with absolute judicial impartiality.

But, while we should be careful to avoid viewing the patent with disfavor, we should be equally careful to avoid considering it with too much favor on account of its subject-matter. Fifteen years ago hardly any one had seen an automobile. Ten years ago they were rare. To-day they are in use by tens of thousands, and tens of millions of dollars are invested in them and in their manufacture. The development of the automobile has been nothing short of phenomenal, and every one is inevitably impressed with its importance. Consequently, when we see that 30 years ago an application for a patent was filed which even pointed the way to the modern automobile, we can hardly fail to receive the impression that an idea of great importance must have been embodied in it. But, as we shall later see, the development of the automobile was not so sudden as we have thought. It developed step by step at the beginning; the startling activity has come at the end. Moreover, a great idea may be embodied in a patent, and yet the patentee take nothing of value by it. That which he takes is that which he describes and claims. His discovery may be of importance, but he may limit it by his claim, and his claim may proceed in the wrong direction.

So, from any standpoint, we come in this as in other patent causes to the patent in suit in which at its commencement the patentee thus states the object of his invention:

"The object of my invention is the production of a safe, simple and cheap road locomotive, light in weight, easy to control, and possessed of sufficient power to overcome any ordinary inclination."

The patentee then states the difficulties encountered, his manner of overcoming them, and the advantages arising therefrom:

"The difficulties heretofore encountered in the application of steam to common roads are the great weight of the boiler, engine, water and water tanks, the complicated apparatus necessary to adapt the machine to the roughness of the roads which it must traverse, the necessity of the attendance of a skilled engineer to prevent accidents, and the unsightly appearance of the locomotives built on this plan. I have succeeded in overcoming these difficulties by the construction of a road-locomotive propelled by a liquid-hydrocarbon engine of the compression type, of a design which permits it to be operated in connection with the running-gear, so that the full carrying capacity of the body of the vehicle can be utilized for the transport of persons or goods, and which, by dispensing with skilled attendance and with steam-boilers, water, water tanks, coal, and coal bunkers, very largely reduces the weight of the machine in proportion to the power produced and enables me, while employing the most condensed form of fuel, to produce a power road-wagon which differs but little in appearance from and is not materially heavier than the carriages in common use, is capable of being managed by persons of ordinary skill at a minimum of trouble and expense, and which possesses sufficient power to overcome any usual inclination."

The patent then describes—as we shall later see with more particularity—the body, wheels, and connections of the vehicle and the engine furnishing the motive power.

The first claim of the patent is the broadest, and the questions of validity and infringement have been presented wholly with respect to it. It is the vital claim in the case and is as follows:

"The combination with a road-locomotive, provided with suitable running gear including a propelling wheel and steering mechanism, of a liquid hydrocarbon gas-engine of the compression type, comprising one or more power cylinders, a suitable liquid-fuel receptacle, a power shaft connected with and arranged to run faster than the propelling wheel, an intermediate clutch or disconnecting device, and a suitable carriage body adapted to the conveyance of persons or goods, substantially as described."

The defenses are:

(1) That if the patent be broadly construed it is invalid.

(2) That if it be construed less broadly, but according to legitimate rules of construction, the defendants do not infringe.

In considering the validity of the patent, we are met, at the outset, with contentions of some of the defendants that prior uses anticipate, and that that which it discloses is an aggregation rather than a combination. But the questions of novelty and invention often run together, and the inquiry whether a given association of elements is more than an

aggregation is only a phase of the question of invention. We shall primarily test the question of the validity of the patent by the answer to the inquiry, whether it discloses the exercise of the inventive faculties in view of the prior art.

This requires an examination of the state of the art in 1879—the date of the application and, consequently, of the alleged invention. (NOTE.)

[NOTE. The date of the filing of the application—May 8, 1879—is prima facie the date of the alleged invention. The complainants, however, seek to overcome the presumption that that is the date and to carry it back to December, 1877. But, while we have no doubt that the patentee conceived the general idea of the subject of the patent some time before he applied for it, there was no such reduction to practice or description of the whole structure as would serve to antedate the date of the application. It is true that the patentee made one of the elements of the combination (the engine) some months before he applied for the patent, but he did not make the combination itself (the road locomotive) until many years afterwards, and that is what he claims a patent for. Moreover, we fail to find that any adequate description of the combination claimed was made any substantial time before the application. But, while it is well to fix a starting point, the question between the dates is of little practical importance, as we find no prior use materially affecting the patent between 1877 and 1879.]

In tracing its development we shall find that the combination described in the claim developed, to some extent, along with its elements. But this was by no means entirely so, and we think that a correct appreciation of the subject can best be obtained by considering:

(a) The development of the elements of the combination;

(b) The development of the combination itself—the motor vehicle.

The claim is for a combination possessing six elements:

(1) "A road locomotive provided with suitable running gear, including a propelling wheel and steering mechanism."

(2) "A liquid hydrocarbon gas engine of the compression type, comprising one or more power cylinders."

(3) "A suitable liquid fluid receptacle."

(4) "A power shaft connected with and arranged to run faster than the propelling wheel."

(5) "An intermediate clutch or disconnecting device."

(6) "A suitable carrying body adapted to the conveyance of persons or goods."

Or, departing from the language of the claim, these are the elements:

(1) The carriage (including the running gear, the body, the propelling wheel and the steering mechanism).

(2) The drive (including the power shaft and connections and the intermediate clutch or disconnecting device).

(3) The engine (including the liquid fluid receptacle).

The claim contains no limitations with respect to the carriage element, and the specification states that the body of the road locomotive "may be of any ordinary or desired form with any number of seats and with or without a top."

Reading the claim by itself, any wheel vehicle for the conveyance of persons or goods would come within its language, and the only limitation the specification could possibly impose upon it would be that the carriage should be of such a type that the engine could be located upon it without obstructing the body or platform.

So, there are no limitations in the claim with respect to the running gear, propelling wheel, or steering mechanism. While the specification and drawings show particular structures, there is no suggestion that the claim is confined to any particular form. Manifestly there was nothing novel in the carriage element.

With respect to the drive element: The claim describes no particular form of power shaft except that it shall be so connected and arranged as to run faster than the propelling wheel. Thus any speed reducing gear between the driving and the driven shaft would come within the language used. Gearing down to gain leverage under similar conditions was, however, old in the art. Mr. Dugald Clerk[468]—the distinguished and very competent witness for the complainants—says:

"It was old in the art for a motive power engine to run at a greater speed than the propelling axle."

The claim likewise imposes no limitation upon the intermediate clutch or disconnecting device, and such devices were old in the art in 1879. They were commonly interposed between stationary engines and the load and had been employed in steam engines; the purpose being the same as here—to

[468] **1961**, **Greenleaf**, p.224: "*Several weeks before the* [**1911**] *hearing, Coudert visited the law office of Samuel R. Betts to discuss routine arrangements for the appeal. Betts was occupied with other matters and kept Coudert waiting for about thirty minutes. Coudert passed the time examining a collection of books and magazines spread on a table in the reception room. Among the publications was a set of proofs from the latest British edition of Clerk's book on internal combustion engines, an enlarged and revised edition of which had been brought out in* ***1909****. Consulting the index, Coudert found no reference to Selden; nor was the name mentioned in the historical summary of the gasoline engine and the automobile. Moreover, Clerk admitted that the modern motor car could not be traced to any single patent! Coudert immediately secured a copy of the book and incorporated pertinent passages in his oral argument and brief.*" P.225: "*"Will this court prefer the theories of Clerk, the retained witness, to those of Clerk, the disinterested scientist, composing the 'classic' on gas engines?" asked Coudert*."

permit the engine to run without driving the vehicle. The drive element of the claim was old.

The engine element in the claim is the one which requires the most extended consideration. It is the feature of the patent.

The engine is described in the claim as "a liquid hydrocarbon gas engine of the compression type." Being an engine of this kind, it must, in the first place, be an internal combustion engine, which (using the definitions in the complainants' brief) is an engine in which "the fuel is burned in the engine cylinder and the heat energy thereof utilized by the expanding gases acting on the piston." In the second place, it must be a gas engine, which is "an internal combustion engine wherein the fuel is burned in a gaseous or vaporous condition." In the third place, it must be a liquid hydrocarbon gas engine, which is a gas engine "wherein the gaseous form of fuel is derived from a hydrocarbon liquid, such as petroleum, alcohol, etc." In the fourth place, it must be a gas engine of the compression type, which is "a gas engine using a compressed charge of gaseous fuel," and in which, consequently, the charge-containing space back of the piston will, at the time of ignition, "receive a larger amount of fuel in relation to its size than if the fuel was admitted thereto under mere atmospheric pressure."

Now, gas engines were old at the time of the application for this patent and had been used for various purposes. We shall have occasion to examine their use for propelling vehicles when we come to trace the development of the motor carriage itself. So liquid hydrocarbon engines were in use, both of the compression and non compression types. The phrase in the claim, "a liquid hydrocarbon engine of the compression type," is descriptive of the Brayton engine, which came into use about 1873, and of the Otto compression engine, which came into use a little later but still was in the antecedent art. The Brayton was undoubtedly the leading compression engine at the time of this application, but it was later superseded by the Otto.

These two engines—the Brayton and the Otto—play important parts in this case. We shall later have occasion to examine them at length and to compare them as belonging to two well-defined types of compression gas engines—the "constant pressure" type and the "constant volume" type. But it is unnecessary to describe them at this time nor to define the terms which we have just employed. It is sufficient now to state the fact that the engine element of the claim—considered as an engine and not necessarily as a part of a combination—was in existence at the date of the alleged invention.

To recapitulate, we have examined the prior art and have found the different elements of the combination, other than the engine, admittedly old. We have also found the engine element old and represented by two types. We must now examine the art with reference to the combination itself and ascertain what, prior to 1879, had been the development of motor vehicles, particularly those for the carrying of passengers and goods.

For some years subsequent to 1830 steam carriages for common roads were used to a considerable extent in England for transporting goods and passengers. But the rapid development of the railroad locomotive as well as the opposition to the use of steam vehicles upon highways soon drove them out of use, so that for many years before the application for this patent steam engines had been used upon highways in this country and in England only for traction purposes.

Gas motor vehicles came later. As we have seen, gas engines were old in the art. The first suggestion of their use to propel road carriages was in 1860 in connection with the Lenoir engine. The Lenoir patent embraced the use of liquid hydrocarbon in the form of vapor, and the engine was successful for stationary purposes. It was a non compression engine. An illustration published in Paris in 1860 showed a vehicle propelled by this engine, and it was described in various publications. If such a motor vehicle were operated, it undoubtedly ran slowly, and the engine had great weight in proportion to power. But no reason is advanced why the Lenoir engine was not capable of propelling a vehicle.[469]

The Mackenzie English patent of 1865, which the patent itself states was in the prior art, was for the use of steam or "compressed air or other motive power instead of steam" for driving an omnibus or carriage. The structure of this patent included the use of a geared down chain and clutch.

The Savalle French patent of 1867 described how the Lenoir engine could be applied to road vehicles. This patent referred to the difficulty of applying such engines to light carriages.

The Kirkwood English patent of 1874 was for an engine "worked by the explosive force of a mixture of gas and atmospheric air," and which, among other uses, might "be incorporated in the structure of an ordinary tramway car or other vehicle."

The Rosenwald French patent of 1877 was for a carriage propelled by a noncompression gas engine. This vehicle had reducing gears and a clutch or "disentangler." The engine described was of the free piston type and was poorly adapted for use in a road locomotive.

Other patents are shown in the prior art—to Menn, Wilson, and others. But, without examining them or further considering those which we have outlined, it is clear that, if there were nothing more in the case, invention would not be shown in the mere combination of (1) a carriage, (2) a drive, and (3) a gas engine, or even a hydrocarbon gas engine. The

[469] See the **1909**, Judge Hough note regarding the **1904** Ford-Lenoir machine.

elements were old and the combination neither novel as producing any new result nor as showing any new co-operative action.
It follows, then, that, if we are to find invention and novelty in the broad combination of the patent, they must be in the use of a hydrocarbon gas engine of the compression type.

We have seen that hydrocarbon gas engines of the compression type were old in the art and were represented by the Brayton constant pressure engine and the Otto constant volume engine. The inquiry then is whether either of those engines was ever combined with the other elements for propulsion purposes before the application for this patent.
The testimony shows clearly that prior to 1878 Brayton had successfully applied his engine for propulsion purposes in boats. Several launches from 25 to 35 feet in length had been equipped with and operated by them. The evidence, including sketches, shows geared down transmission, the use of disconnecting clutches, and the presence of liquid fuel receptacles. Indeed, if the claim be given the broad construction of covering the use of all compression gas engines, it might be read on the Brayton boat construction—if the words "motor boat" and "boat" were substituted for "road locomotive" and "carriage." Still we appreciate the substantial difference between the problem of propelling a boat and the motor vehicle problem and are not inclined to hold that this use constituted an anticipation, although it may properly be considered in determining the question of invention.
It also appears that about 1874 Brayton used one of his engines to propel a street car upon a trial track near the city of Providence. The car was propelled back and forth over the half-mile track, and it also ran up a slight grade. Some passengers were carried. There were reversing and disconnecting devices. The engine was large and heavy in proportion to the power which it furnished and—an accident taking place—it was not long used. More power in proportion to weight was necessary for commercial street railway purposes, and the plan of installing these engines was given up; financial considerations entering into this determination. But, although the experiments did not develop a commercial success, they were successful from a mechanical standpoint. The engine ran the car considerable distances and carried passengers. This use was not an abandoned experiment but an abandoned attempt to induce the railway company to equip the cars with the Brayton engine. The perfected structure was capable of practical use, although there was much room for improvement. It was not embryotic or inchoate. The combination of the engine, the drive, and the carriage was used in public, and thereafter it required the use of the imitative, and not of the inventive, faculties to claim, without modification, the same combination. The use of the engine in one vehicle pointed directly to its use in another vehicle.
The Brayton engine was also used upon an omnibus in 1878. The weight of the testimony is that the omnibus was run by the engine a very short distance, but the experiment cannot be regarded as having been either mechanically or commercially successful. This use will not be considered as in the antecedent art.
In the state of the art thus disclosed the patentee filed his application for a patent. As we have seen, he claimed broadly the combination of a "liquid hydrocarbon gas engine of the compression type" with the other elements. It is true that in the specification and drawings he described and showed a particular type of engine, but he also said:
"Any form of liquid hydrocarbon engine of the compression type may be employed in my improved locomotive."
Taking the patent according to its terms, the case apparently presented is the ordinary one in which a patentee claims a broad invention and describes what he considers to be the best mode of applying it, but is not confined to that method. And if the prior art permitted such a patent in this case it might well be that it would be valid. But the prior art did not permit such a patent. Every element in the claim was old, and the combination itself was not new. Combinations of non compression gas engines with the other elements had been in use, and Brayton had employed a "liquid hydrocarbon engine of the compression type" in a vehicle.
Even if the Brayton uses were not precisely anticipatory, we can reach no other conclusion than that with them in the prior art the claim in question must be held invalid for want of invention if it be given the broad construction the language apparently calls for. Moreover, if we give it a slightly narrower construction and treat it as covering the selection of the Brayton type of compression engine, the same conclusion must be reached. Invention would not be involved in the mere choice of that type of engine, for Brayton had previously made the same selection for his street car and boats. And, even if the Brayton engine had been used only for stationary purposes, it is by no means certain that its mere selection for incorporation in a motor vehicle without adaptation would have involved invention.
In re Faure's Appeal, 52 Off. Gaz. 754 (Supreme Court, District of Columbia), is in point. In that case Faure claimed a patent for the combination of an electric motor with a vehicle. It appeared in that case, as in this, that boats had been propelled by the same kind of motor. The court said (page 756):
"It is made evident that the mechanical arrangements for applying the power are not new, being familiar to all experts; and that the result is not new, viz., the movement of vehicles by electrical storage batteries. It is admitted that Trouvé had propelled boats in this way. The contention that such a use did not

anticipate this application because that experiment was on water and this invention is designed for use on land seems untenable. The propulsion of vessels through water by such batteries is within the same principle as locomotion on land."

In Shaw Electric Co. v. Worthington (C. C.) 77 Fed. 992, 993, the patent was for an improvement in traveling cranes through the substitution of independent electric motors for the power previously furnished by steam power. Judge Acheson said:

"The facts, then, being as above stated, what element of invention is to be found in the patent here in suit? In view of the previous employment of electric motors in propelling street cars, driving machinery in mills, working elevators, etc., the mere application of electric motors to traveling cranes certainly did not involve invention, even had Shaw been the first to operate cranes electrically. The inventive faculty was no more exercised here than in a multitude of other instances in every branch of industry where the electric motor has been substituted for the steam engine or other source of power."

Indeed, Mr. Clerk, himself, says:

"I have already stated that if the Lenoir, Brayton, Otto, and Langen, and Otto Silent motors were all supposed to be in active existence and running, doing stationary work, that the mere selection of one of these motors without alteration and the application of any one of them without alteration of any kind would not involve an act of invention."

It must be distinctly borne in mind that we are not now considering the alteration of any engine for the purposes stated in the patent; the question of the superiority of a combination embracing a modified or reorganized engine, or the invention involved in making it. We are, for the time being, taking the claim as it reads in connection with the broad statement in the specification, and we conclude that, taken in that way, invention is not disclosed. It should also be observed that this conclusion is not inconsistent with a holding that the patent is valid upon its face. The antecedent art as shown by the testimony goes far beyond that disclosed by the patent or that of which the court could take judicial notice.

But we are reluctant to so construe the claim that it must be held invalid for want of invention. We are of the opinion that the patentee had ideas ahead of the times and appreciated many aspects of the problem to be solved in creating a practical motor vehicle. Reading his statement of the difficulties encountered, his manner of meeting them, and the advantages of his discovery, we think it evident that he understood that an engine suitable for a light vehicle could not be taken bodily from the prior art and used without change, but that modification and adaptation were required. In our opinion the statement in the patent that any form of compression engine may be employed is inconsistent with the intention disclosed by the patentee in the patent as a whole and should not have too much stress laid upon it. We also think that we should examine the specification, including the drawings and the model, to determine whether the patentee in addition to expressing the need of adapting an engine to the purposes of a motor vehicle shows that he actually adapted one. It may well be that the claim as limited by the specification should be held to be valid.

As already shown, the patentee states at the commencement of his patent that the object of his "invention is the production of (1) a safe, (2) simple and (3) cheap road locomotive, (4) light in weight. (5) easy to control, and (6) possessed of sufficient power to overcome any ordinary inclination."

He then, as shown in the extract from the patent quoted at the beginning of this opinion, points out the difficulties involved in the use of steam engines upon common roads, and states that he has overcome them by his road locomotive propelled by his liquid hydrocarbon engine of the compression type.

He next states that the advantages of his invention are:

> (1) Dispensing with steam boilers, coal, and water, and the structures necessary to their use, and employing a condensed form of fuel, thereby reducing the weight of the machine in proportion to the power produced;
>
> (2) Producing a power road wagon light in weight, capable of being managed by persons of ordinary skill, and having sufficient power for ordinary purposes.

The patentee also describes with reference to the drawings the body of the road locomotive, the driving wheels, the clutches, the gearing, the springs, the fifth wheel, the steering device, the brake, and other parts of the structure and also indicates the preferable location of various devices and preferable methods of connection.

The patentee describes with reference to the drawings the engine element, pointing out (1) the air reservoir, (2) the air pump, (3) the working cylinder, (4) the inlet valve, (5) the cam shaft, (6) the combustion chamber, and other details. He also briefly describes the operation of some of the different parts. The description, however, both of the construction and operation of the engine, is quite incomplete. This was appreciated by the patentee, for he concluded his description by saying:

"As the general construction and mode of operation of liquid-hydrocarbon engines of this class are well known, it is considered unnecessary to further describe them here."

As the patentee thus refers to the existing art for a more complete description of his compression engine, and as we have ascertained that there were two different types of compression engines in the art represented respectively by the Brayton and Otto

engines, we must now find what those types were in order to determine which the patentee selected.

The two types are called respectively the "constant pressure type" and the "constant volume type." Although these terms may have originated since the date of the invention, they correctly describe the types or classes of compression engines then in existence. No better explanation of them can be found than in Mr. Clerk's work entitled "The Gas Engine," which was published in 1887 and which has been offered in evidence. In this book he also shows the construction and working processes of the two types of engines and the differences between them, as stated in the footnote. (Note.)

[NOTE. In his book (page 29) Mr. Clerk divides gas engines according to their work processes into three well-defined types:

"1. Engines igniting at constant volume, but without previous compression.

2. Engines igniting at constant pressure with previous compression.

3. Engines igniting at constant volume, with previous compression."

It is not necessary for the purposes of this case to examine the operation of the first type—the non compression engine. With respect to the second type, the constant pressure compression engine, Mr. Clerk says (page 31):

"In it the engine is provided with two cylinders of unequal capacity. The smaller serves as a pump for receiving the charge and compressing it; the larger is the motor cylinder, in which the charge is expended during ignition and subsequent to it.

"The pump piston, in moving forward, takes in the charge at atmospheric pressure; in returning compresses it into an intermediate receiver, from which it passes into the motor cylinder in a compressed state. A contrivance similar to the wire gauze in a *Davy lamp* commands the passage between the receiver and the cylinder, and permits the mixture to be ignited on the cylinder side as it flows in without the flame passing back into the receiver.

The motor cylinder thus receives its working fluid in the state of flame, at a pressure equal to, but never greater than the pressure of compression. At the proper time, the valve between the motor and the receiver is shut, and the piston expands the ignited gases till it reaches the end of its stroke, when the exhaust valve is opened, and the return expels the burned gases.

"The ignition here does not increase the pressure, but increases the volume. The pump, say, puts one volume or cubic foot into the receiver; the flame causes it to expand while entering the cylinder to two cubic feet. It does the work of two cubic feet in the motor cylinder, so that, though there is no increase of pressure, there is nevertheless an excess of power over that spent in compressing.

With respect to the constant volume compression engine, Mr. Clerk (page 33):

"The compression cylinder may be supposed to take in the charge of gas and air at atmospheric temperature and pressure; compress it into a receiver from which the motor cylinder is supplied; the motor piston to take in its charge from the reservoir in a compressed state; and then communication to be cut off and the compressed charge ignited.

"Here ignition is supposed to occur at constant volume, that is, the whole volume of mixture is first introduced and then fired; the pressure therefore increases. The power is obtained by igniting while the volume remains stationary and the pressure increases.

"Under the pressure so produced, the piston completes its stroke, and upon the return stroke the products of the combustion are expelled."]

It is apparent from the descriptions in this work that a "constant pressure engine" is one in which the cylinder pressure remains the same during the outward travel of the piston while the volume of flame increases. The pressure is applied continuously and not spasmodically. This mode of operation is also called "slow combustion", and "nonexplosion."

A constant volume engine operates in a different manner from a constant pressure engine. The volume during ignition theoretically remains constant; the pressure increases. The action is spasmodic. The piston moves by explosive action and is kept in motion by a series of explosions.

The Brayton engine, to which we have referred, was a constant pressure compression engine. Mr. Clerk said in his book (page 32) that it was one of the most successful of that kind, and also said (page 154):

"The engine worked well and smoothly; the action of the flame in the cylinder could not be distinguished from that of steam; it was as much within control and produced diagrams quite similar to steam."

And in Prof. Thurston's contemporaneous report (1873) concerning the Brayton engine, quoted in Mr. Clerk's book (page 157), it is said:

"The operation of the engine is precisely similar in the action of the engine proper and in the distribution of pressure in its cylinder to that of the steam engine. The action of the impelling fluid is not explosive, as it is in every other form of gas engine of which I have knowledge."

The Otto engine, on the other hand, was a constant volume compression engine. Although the leading idea of compression and ignition at constant volume had been suggested before the time of this engine, Otto seems to have first successfully applied it, and his engine came into general use. This engine was operated by a series of timed explosions and, as we shall later see, was the prototype of the modern automobile engine.

It is clear from this examination that the statement heretofore made that the Brayton and Otto engines differed in being respectively constant pressure and constant volume engines is sustained by the record. (Note.)

[NOTE. We shall continue the examination of the differences between these engines when we consider the question of infringement.]

They also differed in another important particular. The Brayton was a two-cycle engine. The Otto was a four-cycle engine. Turning to the complainants definitions, we ascertain that "a cycle is a series of movements composing one complete operation," and that the following is a definition of the term "two-cycle engine":

"An engine whose operation is completed by two strokes, viz., a power stroke and a scavenging or exhaust stroke. If of the compression type the power stroke simultaneously compresses the charge for the next power stroke, the charge thus compressed being admitted to the cylinder at the end of or during the scavenging or exhaust stroke."

The term "four-cycle engine" is thus defined:

"An engine whose operation is completed in four strokes. Always of the compression type. First stroke sucks in the gaseous charge at atmospheric pressure; second stroke compresses the charge; third stroke is the power stroke; fourth is the scavenging or exhaust stroke."

The compression stroke in the two-cycle engine of the earlier art usually compressed the charge into an intermediate receiver from which it was admitted in a compressed state to the cylinder. This was the construction of the Brayton engines which were provided with outside mechanism in which compression took place before the charge was let into the cylinder. The four-cycle engine, on the other hand, as represented by the Otto engine, had no such intermediate receiver. The single cylinder served alternately the purposes of motor and pump, and the charge was also compressed in it.

Now, as the patentee in effect referred to an existing compression engine to supply the deficiencies in his description, and as the two existing types are represented by the Brayton and Otto engines respectively, the question is: which one did he refer to?

Comparing the engine drawings of the patent in suit with the Brayton patent drawings, we think it evident that the patentee adopted, and perhaps, adapted, the Brayton apparatus. Looking at the written specification, it will be seen that an external air reservoir and pump are provided, showing that the engine was of the Brayton two-cycle type. Reading further we observe that the patentee says:

"As it would be decidedly inconvenient to be under the necessity of extinguishing the flame in my improved traction engine whenever it was required to make a short stop, the clutch, Y (or the clutches, j j') is interposed between the engine and the driving wheels, so as to admit of the running of the engine while the carriage remains stationary."

This constantly burning flame (or other continuous ignition) was necessary to the operation of the Brayton constant pressure engine. It was the "living torch at the entrance of the cylinder" referred to in the Brayton patent. Its existence was not essential to the timed explosion operation of the Otto engine.

So without any expert opinion we should have no difficulty in determining that the engine of the patent is of the Brayton two-cylinder constant pressure type. And the testimony even of the complainants' expert is to the same effect. Mr. Clerk said in his testimony that the reference in the patent to existing well-known engines was to the Brayton constant pressure engines.

He also said in his report to complainants' counsel, after referring to the description in the patent:

"Stopping at this point it is necessary to recognize what type of engine is indicated. About this I have no difficulty whatever. I at once recognize it as an engine of the Brayton type operating on the constant pressure cycle. Although no description is given in the specifications, any one familiar with Brayton engines can see the air pump of smaller capacity than the motor cylinder; the air reservoir containing air compressed by the pump, and the inlet valve admitting air to the cylinder. *** Altogether I have no difficulty in seeing that the intention of the inventor is to operate by the constant pressure method, although he does not say so specifically."

It cannot therefore be questioned that the engine which the patentee referred to in the patent for the completion of his description was the Brayton engine. The Brayton mode of operation was adopted by reference as the Selden mode of operation, and this method, as we have already seen, was the constant pressure, two-cycle method.

The next question is: what modification does the patent show that Selden made in the Brayton engine? The Brayton patents and the testimony concerning the actual Brayton engines show that they were heavy and cumbersome in proportion to the power furnished. While such an engine did run a street car, it occupied considerable space, and a still larger and heavier engine would have been necessary to furnish sufficient power for the practical needs of the railway. The engines were poorly adapted for use in a vehicle upon common roads. When capable of furnishing sufficient power they were too heavy, and the reciprocating parts occupied too much space.

The written description of the patent, read in connection with the drawings, shows fairly that Selden made material improvements upon the Brayton structure in order to adapt it to the purposes of a road vehicle.

1. The drawings show that the Selden engine has an inclosed crank chamber; it being a continuation of the working chamber. It is true that the only function

of the inclosed crank case mentioned in the written specification is that of a cooling chamber. But it is referred to and it is clearly shown in the drawings, so that we think the patentee entitled to claim as a feature of his patent any benefits necessarily accruing from its use. We are also satisfied that the use of the inclosed crank case rendered unnecessary the heavy bed plates of the former Brayton construction and enabled the patentee to dispense with other heavy and cumbersome parts outside the casing of the cylinder.

2. We also think it is the better view that Selden by his alterations increased the speed capabilities of the Brayton engine. Higher speed was obviously necessary for the purposes of a light road vehicle, and it was such a vehicle that it was the object of the patent to produce. The elimination of cumbersome working parts by the use of an inclosed crank case necessarily increased, to some extent, the capacity for speed. The plurality of cylinders referred to, but not required by, the specification and shown in the drawings, produced, in the arrangement shown, continuous turning power and increased the speed possibilities over the old Brayton construction. The gearing ratio—the proportion of stroke to volume of cylinder—shown in the drawings, but not mentioned in the written specification, also gave increased speed. (Note.)

[NOTE. The rule is, of course, appreciated that while the drawings of a patent serve to make plain doubtful or ambiguous statements in the written description, they cannot go further and supply the entire absence of the written description required by the statute. A strict application of this rule would probably prevent us from considering what the drawings show concerning the gearing ratio or the working of the cylinders—these subjects not being mentioned in the description. But in view of the stated objects of the patent and in view of the fact that changes in the Brayton structure referred to in the description tend to increase speed capabilities, we have, thought that the rule should not be strictly applied in this case and that some weight should be given to what the drawings disclose in that direction, as supplementing the written description and not altogether as supplying its absence.]

The improvements, then, which Selden made in the Brayton engine, had these results:

(a) Decrease in weight in proportion to power produced.

(b) Decrease in bulk in proportion to power produced.

(c) Increase in speed.

To make these improvements we think that something more than mere mechanical skill was required, and, in view of the superior efficiency of the engine for the purpose for which it was designed, we hold that invention was involved. The complainants are probably right in saying in their brief:

"He (Selden) was compelled to materially reorganize the Brayton engines of the prior art even to such an extent that a separate engine patent would have been fully justified by the degree of invention involved."

Selden did not, however, obtain a patent for his improvement upon the Brayton engine, but made the improved engine an element in his road locomotive combination. But no new co-ordinate action of the members of the combination is shown. The improved engine furnished the power, and the other elements co-operated with it in the same way that similar elements had co-operated with the older engines. The superior results would seem to have arisen from the superiority of the engine element alone. But it is not necessary to determine whether the associated action, as such, produced a new and useful result. It is sufficient to sustain the claim to hold that the combination embraced a novel element. The claim is held to be valid as covering a combination in a road locomotive of the different elements with a liquid hydrocarbon compression engine of the Brayton type; the limitation to this type being read into the claim by the specification to save it from invalidity.

It must be understood, however, that we do not sustain the claim upon the theory that Selden invented a light engine, an engine of small bulk, or an engine of high speed, using those terms absolutely. We have made comparisons with, and have considered improvements upon the Brayton engines only. Compared with them, we think the Selden engine lighter, less bulky, and of higher speed. But we are not at all convinced that the Selden engine operating according to the Brayton or constant pressure method would be a high speed engine as compared with one operating according to the explosive method. Constant pressure involving slow combustion seems consequently to involve slow operation.

The complainants urge that it places too narrow a construction upon the claim to limit it to a combination of which the engine is an improved Brayton engine. They say that the improvements upon the Brayton engine which Selden shows in his patent merely illustrate the alterations and changes required by compression engines generally to fit them for the purposes of a light road vehicle. They say, in effect, that the engine element of the claim is any compression engine which has been adapted to vehicular purposes by changes similar to those made in the Brayton engine.

But we have been able to find that Selden reorganized the Brayton engine only by making close comparisons with that particular construction. We have nearly broken established rules by looking at the drawings by themselves to ascertain the changes made in that engine. There is little enough to be found about the improvements to it and nothing

at all about the alterations of other engines. The patent does not pretend or attempt to lay down any rule for reorganizing compression engines to fit them for vehicular purposes. It does not say that other kinds of engines than the Brayton type require changes. It does not say that the changes made in the Brayton engine could be made in other engines, or that, if made, they would fit them for use in motor vehicles. No one could learn from the patent whether the Otto engine could be constructed with an inclosed crank chamber, or whether the substitution of the gearing ratio shown in the drawing would increase or diminish its speed. With the patent before a person skilled in the art, experiments, certainly, and invention, not improbably, would have been necessary to determine the steps required to reorganize the Otto engine.

A patent is granted for solving a problem, not for stating one. Its description must explain the invention itself, the manner of making it, and the mode of putting it in practice. In the absence of knowledge upon these points, the invention is not available to the public without further experiments and further exercise of inventive skill. A claim for a combination which embraces an element only in case it is made capable of being employed in the combination and without disclosing means of adapting it discloses nothing definite. The questions remain: What engine is capable of being combined in a road vehicle? What changes are necessary to adapt it to the purpose? How are these changes to be made? If we were to construe the claim, as the complainants urge, we should be obliged to go further and hold it uncertain, indefinite, and consequently invalid. (Note.)

[NOTE. Any force whatever in the complainants' contention must grow out of the presence in the patent of the statement to which attention has already been directed that "any form" of compression engine may be employed. But, just as we found that by giving those words their natural meaning, the patent would be made so broad and sweeping as to be invalid in view of the antecedent art, so, if we construe them as meaning "any adaptable engine" or "any engine which has been adapted," we make the patent indefinite and invalid. If the patent is to be sustained, the language in question must be given a limited application. Under all the conditions we think that it should be construed as meaning merely that the patentee does not confine himself to any particular form or detail of the Brayton type of engine.]

For these reasons, we must hold that the claim of the patent, limited by the specification in the manner shown, is valid unless, indeed, we are satisfied that the patented structure was inoperative and without utility. But, without discussion, it is sufficient to say that we have no doubt that an engine constructed according to the teachings of the patent with its references to the Brayton engine would, in combination with the other elements, run a road vehicle. We think that the patent discloses an operative structure, and that is sufficient. The defense of want of utility is not sustained. But any contention that a motor vehicle constructed by the patentee according to the teachings of the patent operated so successfully as to demonstrate that Selden had solved a great problem and is entitled to the status of a pioneer inventor is, we think, without foundation. (Note.)

[NOTE. While the testimony with respect to the Selden vehicles constructed to illustrate the patent is sufficient to negative inoperativeness, it fails to show such practical success as to broaden the scope of the invention, and certainly does not disclose invention in and of itself. We should be unable to sustain the patent upon any such theory as that advanced by the complainants experts that Selden's invention consisted in producing "a successfully operative vehicle" or "as a new result," "a practically unobstructed vehicle capable of great range of action." Of course, the vehicle had to be successfully operative in the sense of showing utility to make the patent valid, but that result did not show invention and novelty. Those essentials we were able to find only elsewhere. Moreover, the result of obtaining a practically unobstructed vehicle arose from the location of the engine upon the axle which the defendants have not adopted, and that feature is not put forward in the complainants' briefs as being essential to the invention. And, furthermore, we are not at all convinced by the testimony concerning the vehicles in question—even assuming that their construction followed the teachings of the patent and nothing besides—that they showed capability for commercial use or possessed great range of action.]

We now come to the question of infringement, and as it is conceded that the defendants use a combination embracing all the elements of the claim other than the engine element, and as it is also conceded that they use an engine of some kind in connection with such other elements, the question of infringement resolves itself into the inquiry whether their engine is a modified Brayton engine or its equivalent. (Note.)

[NOTE. A distinction is made by the Judge of the Circuit Court in considering the question of infringement which, we think, is not well founded. He says in his opinion:

"Defendants seem continually to assume (without saying so) that Selden invented nothing more than a modified Brayton engine, and then assert that they do not infringe because they do not use that particular motor, and do use a modified Otto. They admit that the claim is for a combination, but continually seek refuge in defenses that would be good against any patent on Selden's engine, but are

worthless against the combination if it be patentable at all."

Undoubtedly a patent upon a combination may be broader than a patent upon any or all of its elements. The members may co-operate to produce a new and beneficial result or operate according to a novel method. But it is not clear that any novel co-operative action is shown in the present case and whatever new and beneficial result was produced by the combination seems clearly to have arisen from the superiority of the engine element alone. It has seemed well settled in the case that that which the patentee invented and used in his combination, was a modified Brayton engine. There would have been no invention in combining an unmodified Brayton engine with the other elements.

But all this is beside the question of infringement. Even if it be conceded that the combination patent has a different scope than a patent for an improved Brayton engine would have had, it is none the less true that, if the defendants do not use the modified Brayton engine and do use the modified Otto engine, they escape infringement unless the latter is an equivalent of the former. It is well settled that, to establish the infringement of a combination, the use of every element of the combination must be shown.]

But before we enter directly upon this inquiry we should briefly examine the development of the modern automobile and ascertain from what source the engines of the defendants' type were obtained, and, especially, whether they were borrowed from Brayton and Selden.

We have already noticed the motor vehicles of the art prior to 1879. Much had been attempted and little accomplished. Indeed it was not until about 10 years later, at the time of the Paris Exposition of 1889, that the real automobile art may be said to have begun. At that exposition a Benz automobile was exhibited, and later the public interest was stirred by the Paris-Rouen race. In this country public attention was first called to the automobile by the Daimler exhibit at the Columbian Exhibition in Chicago in 1893, and in 1895 the Times-Herald automobile race took place in Chicago. The pioneer inventors appear to have been Daimler and Benz abroad and Duryea, Olds and Ford (and perhaps one or two others) in this country. These inventors selected for their automobiles the Otto compression engine. They did not select the Brayton engine and, indeed, as Mr. Clerk says, the Brayton engine had practically disappeared from the market in 1889. Thus in their original type of engine they borrowed nothing from Brayton, and, of course, they could have actually borrowed nothing from Selden because his patent was not issued until 1895. In some of the first automobiles the engine was located on the axle as shown in the Selden patent. But this location below the springs caused too much jar to the machinery and was soon abandoned.

The Otto compression engine selected by these inventors has been modified and changed in its development into the modern automobile engine and adjuncts of importance have been added. But none of these changes was in fact taught by the patent in suit, nor could many of them have been taught by it had it been issued. And the possible changes which it did indicate were suggestive merely.

The Otto compression engine did not at first employ electric ignition. A flame with a moving slide produced the timed explosions. Electric ignition was considered impracticable. But when the electric art had developed it was seen that the electric ignition could be made superior to flame ignition and it would permit much higher speed. But the change was not indicated by the Selden patent, which refers only to flame ignition.

The inventors added a carburetter to the Otto engine in which the charge of gasoline and air was mixed in exact proportions before it was conducted to the cylinder for compression. In the engine of the patent the air vaporizes the gasoline in the passage leading to the cylinder, and the proportions necessarily vary. The patent in no way pointed in the direction of the carburetter.

When the inventors began to adapt the Otto engine to the purposes of a road engine, the desirability of lightness was apparent, and changes were made in the bed and castings so that the engine could be supported upon a steel frame instead of upon the heavy foundations used in stationary work. Other changes in the direction of decreasing weight and bulk and increasing speed were made. But these inventors were actually taught nothing in these matters by the Selden patent, and if it had been before them they would, as we have seen, have learned nothing definite from it.

We thus find that the defendants use an improved Otto engine which retains the principle of that type and is, in its essentials, a four-cycle constant volume (or explosion) compression gas engine. Obviously it is not identical with Selden's improved Brayton engine, which is a two-cycle constant pressure (or slow combustion) compression gas engine; and so the final question is whether they are, under the patent, equivalents.

It is, of course, clear that an inventor is not limited to the particular structure illustrated in his patent as the best form known to him provided his claim is broad enough to cover other or equivalent forms. If the claim in the present case could have been sustained as covering a combination of any hydrocarbon gas engine of the compression type with the other elements, the description in the specification of the modified Brayton engine would have been considered as a statement of the inventor's idea of the best form; but he would not have been confined to it, and the Otto improved engine would unquestionably have infringed. But we were unable

to sustain the claim as so construed and could only hold it valid as being limited to a combination in which a Brayton modified or reorganized engine should be a member. The patent as so construed necessarily permits only a very limited range of equivalent forms. Being confined to an engine element of a particular class or type, an engine of another class seems almost barred by the interpretation itself. Still, classification might be based upon matters of form and not of substance. The elements of the combination are things and not names. In this as in other patents for combinations we think that the unity of the combination will not be affected by the substitution of elements which, however they may be classified or designated, perform the same function in substantially the same way, while it will be destroyed by the substitution of elements which do not perform the same office in substantially the same manner.

We must then consider the materiality of the differences between the engines in question. We have already seen that broad differences exist and must now determine their nature and extent. In giving weight to dissimilarities—in saying what are substantial and what relate merely to form—we must consider the degree of invention shown in the patent, although we will be unable to disregard differences as in the case of a patent of a primary character. And we think this means in the present case that the patent is entitled to a fair and reasonable, but not broad, range of equivalents. What is a fair and reasonable range can better be determined in the concrete comparison rather than in the abstract definition.

A close comparison of the engines shows many differences. Some are obviously mere differences in shapes and designs and may be at once disregarded. The following are those which appear to be the most material:

(1) The Selden engine has external compression mechanism with a compressed air reservoir, while the defendants' engine has no such external mechanism but compacts the charge in the working cylinder. Were the compression of the charge the only object to be accomplished, undoubtedly the gas and air could as well be compressed to the requisite degree before entering the cylinder as by compression in the cylinder itself. And even if internal compression gave superior results it is probable that the one method would be the equivalent of the other. But if and in so far as outside compression is essential to a constant pressure engine, inside compression cannot be regarded as its equivalent unless we determine that the distinction between constant pressure and constant volume engines should be disregarded.

(2) The Selden is a two-cycle engine. The defendants' engines are four-cycle. The Selden engine compresses into an outside chamber simultaneously with its power stroke and with the next stroke drives out the burnt gases. Every second stroke is a power stroke. The defendants' engine draws in the charge with the first stroke and compresses with the second. The third stroke is the power stroke, and the fourth sweeps out the burnt gases. Every fourth stroke is a power stroke. But the first two strokes of the defendants' engine are merely pumping and compressing strokes, and, were the question here between a two-cycle explosion engine and a four-cycle explosion engine, we should have little difficulty in finding the one the equivalent of the other.

(3) The Selden engine burns the charge as mixed at the entrance to the cylinder, while the defendants' engine compresses and mixes the charge inside the cylinder. The result in the latter case is that by the compaction in the cylinder after admission the mixture is brought into a homogeneous state, while in the former case the gas and the air burn at the inlet to the cylinder in a more or less nonhomogeneous state with the pressure behind them. The materiality of this difference in operation, however, lies in the fact that the one form is that of the constant volume engine; the other, of the constant pressure engine.

(4) The Selden engine has no distinctive external vaporizing device, while, as we have seen, the defendants' engine is equipped with a carburetter which determines the proportions of the mixture to be admitted to the cylinder and also increases its homogeneity. But by the construction shown in the patent the air vaporizes the hydrocarbon in the passage leading to the cylinder, and we think the carburetter, while undoubtedly an adjunct of great importance and advantage, should be held not beyond the range of equivalents.

(5) The Selden engine has constant flame ignition, while the defendants' engine has timed electric ignition. Probably continuous electric ignition would be the equivalent of constant flame ignition; but whether intermittent or timed ignition, which is an essential feature of the constant volume engine, is the equivalent of continuous ignition, depends altogether upon whether the constant volume engine is the equivalent of the constant pressure engine.

So, lastly, we reach the question: Is the constant volume engine the equivalent of the constant pressure engine, under a patent entitled to a fair and reasonable, but not broad, range of equivalents?

This is not a question of differences in terminologies or theories. It is a question of differences in principles and things. It is wholly immaterial whether the terms "constant pressure" and "constant volume" were in use when the patent was first applied for, or when or by whom they were first employed. It is equally immaterial whether we use those terms at all. We might just as well use the terms "explosion" and "combustion" to designate the two types, and, indeed, have repeatedly used them in this opinion. But the terms "constant pressure" and "constant volume" are convenient phrases which in themselves indicate methods of operation and they

are used in Mr. Clerk's book to which we have referred and shall refer. So, although laying no stress whatever upon the mere names, we shall continue to use them.

It is also immaterial that by omitting the bye-pass which furnishes a constant supply of gas, by changing the timing of valves, and by using timed ignition, a constant pressure engine might be converted into a constant volume engine. The required alterations are by no means trivial, and the actuality of differences in principles and methods is not changed by the readiness by which they may be eliminated.

There is another matter which is also without importance. It is immaterial that a constant volume engine, under extraordinary conditions and with unusual adjustments, may be made to approximate the action of a constant pressure engine, or that a constant pressure engine under like conditions and adjustments may be made to approximate the action of a constant volume engine. The question is whether in their regular methods of operation the two types of engine are so similar as to be substantial equivalents.

Turning again—with the risk of repetition—to Mr. Clerk's book, we find that, in addition to his classification of compression engines as shown in the extract already quoted, he says, in speaking of the constant pressure type (page 152):

"In engines of this kind compression is used previous to ignition, but the ignition is so arranged that the pressure in the motor cylinder does not become greater than that in the compressing pump. The power is generated by increasing volume at a constant pressure. Engines of type 2 (constant: pressure engines) are therefore:

"Engines using a mixture of inflammable gas and air compressed before ignition and ignited in such a manner that the pressure does not increase; the power being generated by increasing volume.

"These engines are truly slow combustion engines; in them there is no explosion.

" The most successful engines of the kind is an American invention; although proposed in 1860 by the late Sir William Siemens, it was never put into practicable workable shape till 1873, when the American, Brayton, of Philadelphia, produced his well-known machine."

And of his type 3, or constant volume type, Mr. Clerk further says (page 165):

"Engines of this kind resemble those just discussed in the use of compression previous to ignition, but differ from them in igniting at constant volume instead of constant pressure; that is, the whole volume of mixture used for one stroke is ignited in a mass instead of in successive portions.

" The whole body of mixture to be used is introduced before any portion of it is ignited; in the previous type (constant pressure type) the mixture is ignited as it enters the cylinder, no mixture being allowed to enter except as flame. In type 3 the ignition occurs while the volume is constant; the pressure therefore rises; it is an explosion engine, in fact, like the first type (non compression) but with a more intense explosion due to the use of mixture at a pressure exceeding atmosphere. ***

"In the third type are included all engines having the following characteristics, however widely the mechanical cycle may vary:

"Engines using a gaseous explosive mixture, compressed before ignition and ignited in a body, so that the pressure increases while the volume remains constant. The power is obtained by expansion after the increase of pressure."

Mr. Clerk considered these differences between, constant pressure and constant volume so important that he made them the basis of classification in his book, and, notwithstanding his present testimony, we must regard them as substantial. (Note.)

[NOTE. Mr. Clerk uses the word "type" in his book in the sense of "kind" or "class. Thus he points out several different varieties of the different classes of engines. As we have quoted freely from the book, we have, to avoid confusion, used the same word in the same sense.]

It is true, as stated in the opinion of the judge at circuit, that in all internal combustion engines the result of expanding in any way the gaseous fuel is the driving of the piston; but the method of operation is not the same when it is driven by explosive action as when it is driven by slow expansion. So in all compression gas engines the charge is compressed before ignition; but the compression of the whole charge and its instantaneous firing at the moment of greatest compaction is a very different thing from the ignition of successive compressed portions—particle after particle—as they enter the cylinder. In the latter case the force upon the piston is progressive— "the action of the flame in the cylinder could not be distinguished from that of steam" (Mr. Clerk's book, page 154)—while in the former the force is spasmodic and explosive. These are differences in principles methods of operation. And these differences in principles and methods are substantial. We are satisfied that the slow combustion method necessarily involves slow operation; not only because of the time required for combustion between strokes, but on account of the comparatively nonhomogeneous character of the mixture. We are also satisfied that it gives less power in proportion to the size of the engine than the explosion method. (Note.)

[NOTE. Explosive action was the very thing which Brayton, who invented the engine which Selden modified desired to avoid. In his foundation patent of 1872, in speaking of the long show-burning operation of the combustible, he says:

"While in the state of expansion consequent upon ignition it (the flame) exerts, not a spasmodic or explosive force upon the piston at the very commencement of its stroke when the expanding gas begins to act upon it, and the quantity of gaseous mixture during its period of admission is in proportion to the extent of the movement of the piston and is put into the state of expansion upon passing the interceptors.
The statement concerning Brayton in "Engineering" for February, 1877, seems well founded:
"He turned his attention to the design of an engine in which an explosive mixture could be gradually consumed without the ordinary explosive action."

It is our opinion, for these reasons, that in this road locomotive combination embracing as its engine element an engine of the constant pressure type, the substitution in place of such engine of an engine of the constant volume type destroys the unity of the combination, because the two engines do not perform the same functions in substantially the same way. Granting the patent as broad in range of equivalents as its interpretation will permit, and giving due consideration to the degree of invention involved, still we are not able to hold that the Otto improved engine is the equivalent of the Selden engine or that the defendants infringe by employing it as an element of their motor vehicle combination.

Let us briefly notice the consequences of an opposite conclusion. The Otto engine was in the prior art. Assuming that it was not adapted for propulsion purposes in a light vehicle, it would seem clear that the first person who showed invention in reorganizing and adapting it would have been entitled to in patent for the improvement and, with Otto's permission, could have used the improved engine in a vehicle. Similarly it would seem, that he might have obtained a patent for a combination embracing the improved Otto engine as an element. But those things could not have been done if infringement is shown in this case. Selden, although selecting the Brayton engine which was designed to avoid the explosive type, yet pre-empted the field and prevented all improvements for propulsion purposes in that type.
While the conclusion of non infringement which we have reached leaves the patentee empty handed with respect to his patent for the short time it has to run, it cannot be regarded as depriving him through any technicality of the just reward for his labors. He undoubtedly appreciated the possibilities of the motor vehicle at a time when his ideas were regarded as chimerical. Had he been able to see far enough, he might have taken out a patent as far reaching as the Circuit Court held this one was. But, like many another inventor, while he had a conception of the object to be accomplished, he went in the wrong direction. The Brayton engine was the leading engine at the time, and his attention was naturally drawn to its supposed advantages. He chose that type. In the light of events we can see that had he appreciated the superiority of the Otto engine and adapted that type for his combination his patent would cover the modern automobile. He did not do so. He made the wrong choice, and we cannot, by placing any forced construction upon the patent or by straining the doctrine of equivalents, make another choice for him at the expense of these defendants who neither legally nor morally owe him anything[470].
The decrees of the Circuit Court are reversed[471], with costs, and the causes remanded, with instructions to dismiss the bills, with costs.

On Taxation of Costs[472].

PER CURIAM. We think that the cost of the supersedeas bond was a necessary part of the expenses of appeal, caused by the erroneous decision of the court below. Although the bond was allowed as a favor and was not a matter of right, it was necessary to protect the appellant's interests pending the appeal. As it has not been customary to tax the premiums on supersedeas or appeal bonds in the Circuit Court of Appeals, the action of the clerk is affirmed, but the appellant should be allowed to tax these premiums in the Circuit Court.
The decision of the clerk on the other items is correct, and his taxation is affirmed.

Judge Walter Chadwick Noyes

[470] **1961**, **Greenleaf**, p.236: "*For a short time Selden persisted in styling himself the "father" of the automobile, but even this public claim was abandoned after the summer of **1911**.* […] *In automotive history, Selden is remembered as the holder of a freak paper patent that precipitated the strangest controversy in the motor car industry*."
[471] **1961**, **Greenleaf**, p.234: "*The decision had an electric effect on the licensed manufacturers, who had converged upon Madison Square Garden for their* [**1911**] *annual automobile show. The gathering was thrown into an uproar. Yes virtually all of the licensees were satisfied with the outcome; it meant they would no longer pay tribute*."
[472] **1961**, **Greenleaf**, p.239: "*The expense of the suit was extremely heavy by the standards of the day. The court costs, which were borne by the A.L.A.M., came to about $23,700 in the Ford case alone. But these constituted only a small part of the total expense, which also included lawyers' fees, the retainers of expert witnesses (who, with the exception of Clerk, received between $40 and $50 a day), the salaries of engineers and mechanics, and the cost of patent searches here and abroad. Parker thought that $500,000 had been spent on the cases, yet this figure seems to be short of the mark.* […] *An estimate of one million dollars is probably not excessive*."