closely as they can. This sort of procedure results in a transportation system that is as highly efficient as it is possible to make it. In the past some of the electric-truck companies have failed due to their not having analyzed the conditions under which the trucks had to operate. There were many complaints which gradually worked against the companies, until today very few of the original electric-truck firms are in existence. I have been connected with the application of motors in the electric-truck industry since it first started. I have seen companies grow up and drop away. Customers appreciate the advantage of being able to secure expert assistance from manufacturers in the solution of their transportation problems.

THE APPLICATION OF STEAM POWER TO AN AUTOMOTIVE TRUCK

By L L Scott[1]

The paper describes the steam-operated 2-ton truck developed by E. C. Newcomb and the author. It has a direct drive-shaft from the engine to a rear-axle worm, with a 5 to 1 gear-reduction at the axle, and is operated without any transmission or clutch. The engine has been simplified since the author's first report on it in 1919, the changes relating to valve-gear, crankshaft and cam design. After presenting illustrations and describing them, the author gives nine specific advantageous features in this steam powerplant and comments upon them, submitting charts of torque curves which are analyzed. The engine control, fuel, oil and water consumption are next described and discussed and the results of acceleration tests are then shown in tabular form, with comments thereon.

In connection with possible changes of detail in the design of automotive trucks, that have been brought to view by increased speed and the use of pneumatic tires, and because of the present status of the fuel situation, it occurred to me that a truck having an engine driving a rear-axle worm direct through a drive-shaft equipped with a 5 to 1 gear-reduction at the axle and that could be operated without any transmission or clutch, would be interesting to truck designers. A de-

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scription of the steam-operated 2-ton truck developed by E. C. Newcomb and me, which offers a solution to these problems, should consequently be of general interest.

In my previous paper, Steam Automotive System,[2] the details of design of the steam engine used on this 2-ton truck were described, but the engine has been simplified since that time. The changes in the construction of the engine relate to valve gear, crankshaft and cam design, and include many details that would not be of particular interest at present because of a lack of general knowledge of the problems involved. However, as very little is known concerning an engine that uses high pressures and temperatures for this kind of service, the details of its development can best be discussed thoroughly in a separate paper and I hope to do this later.

This truck was designed to carry a 2-ton load. The steam engine is located crosswise on the truck frame, as shown in Figs. 1 and 2, about where the transmission usually is on a truck driven by an internal-combustion engine. No transmission or clutch is used. In our latest design the engine is located just at the rear of the driver's seat and can be mounted either horizontally or vertically as desired. By so locating the engine the steam and the exhaust lines are shortened and so is the shaft that drives the radiator fan, but the axle drive-shaft is thus made longer. The engine shaft is directly connected to the worm-driven axle through a drive-shaft. The camshaft, which operates the valves, is adapted to be shifted axially for controlling the cut-off and reversing the engine when backing the truck. A pedal operated by the left foot, similar to the clutch pedal on a truck driven by an internal-combustion engine, is used to shift the cam.

A sectional drawing of the engine, showing the crankshaft, drive-shaft and dynamo drive, is reproduced in Fig. 3, and the relative positions of the various parts of the system are brought out in Fig. 4. It is surprising how free this engine is from vibration and how smoothly it operates, even without a flywheel. The engine has two double-acting cylinders of 4-in. bore and 5-in. stroke and gives the same number of impulses as does an eight-cylinder internal-combustion engine, with the added flexibility of steam. It will be noted that a one-piece crankshaft is used, with plain connecting-rod bearings and two ball bearings for the journals. The engine flywheel

[2] See TRANSACTIONS, vol. 15, part 1, p. 392.

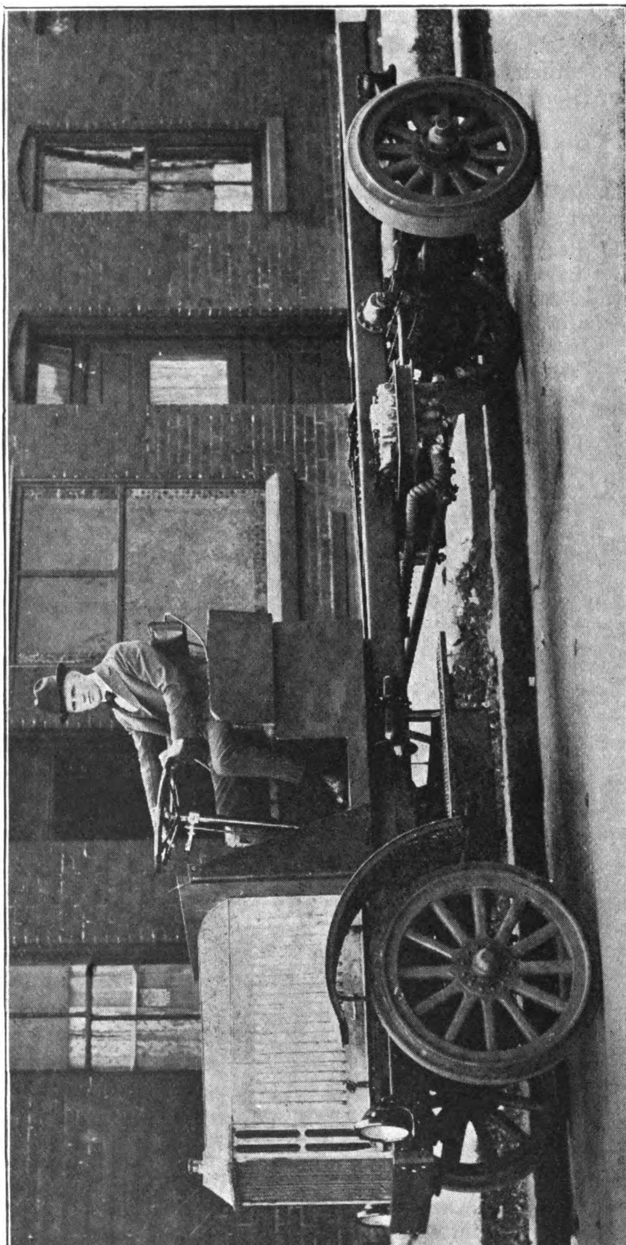

FIG. 1—VIEW OF THE COMPLETE TRUCK SHOWING CROSSWISE POSITION OF THE ENGINE ON THE TRUCK FRAME

serves as a pulley to drive the dynamo and affords an arm to which to attach the thermoid coupling. The front end of the dynamo shaft serves as a drive for the radiator fan.

Advantageous Features

The features of special interest in this steam power-plant are that

(1) Because the engine is directly connected to the drive-shaft, it cannot be run unless the rear wheels also turn. This prevents racing the engine or allowing it to run when loading or unloading the truck, which is a common practice with some drivers
(2) All kinds of road can be negotiated with the same gear-ratio between the engine and the rear axle
(3) The dump type of body can be used satisfactorily because a steam hoist can be installed if desired

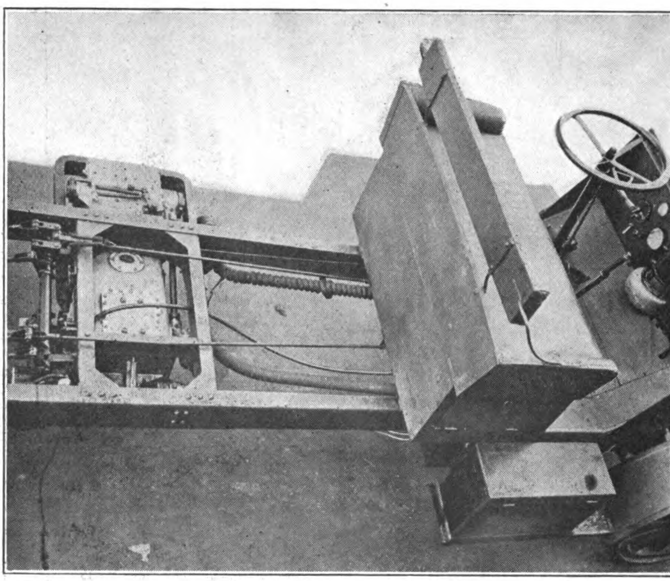

Fig. 2—View Looking Down on the Truck Showing Relation of Engine Location to the Driver's Seat

(4) Driving is more simple and the number of accidents should be reduced for this reason
(5) The rapid acceleration is conducive to safer operation at street corners and intersections
(6) No gear-shifting is necessary when starting
(7) Carbon does not collect in the engine

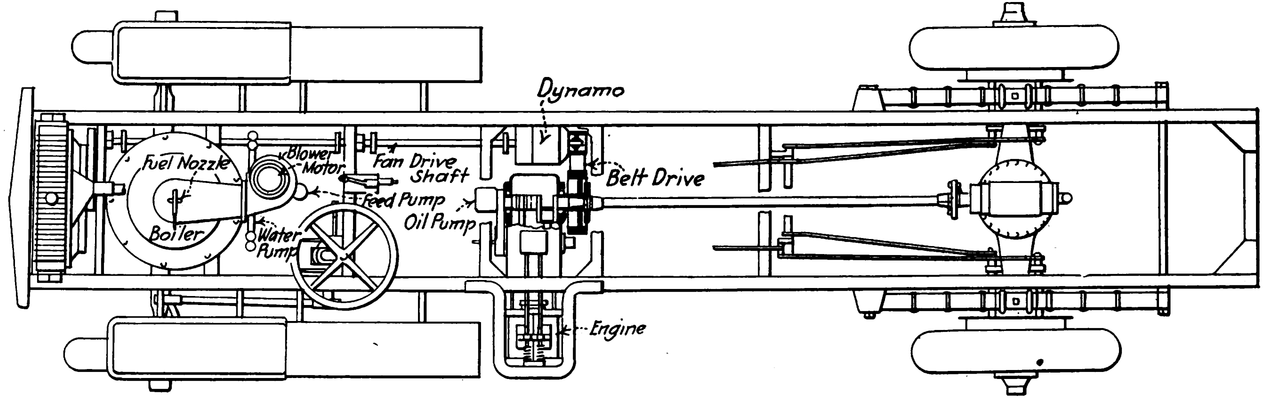

FIG. 3—PLAN VIEW OF THE COMPLETE TRUCK SHOWING THE LOCATION OF THE CRANKSHAFT, THE DRIVE-SHAFT AND THE DYNAMO

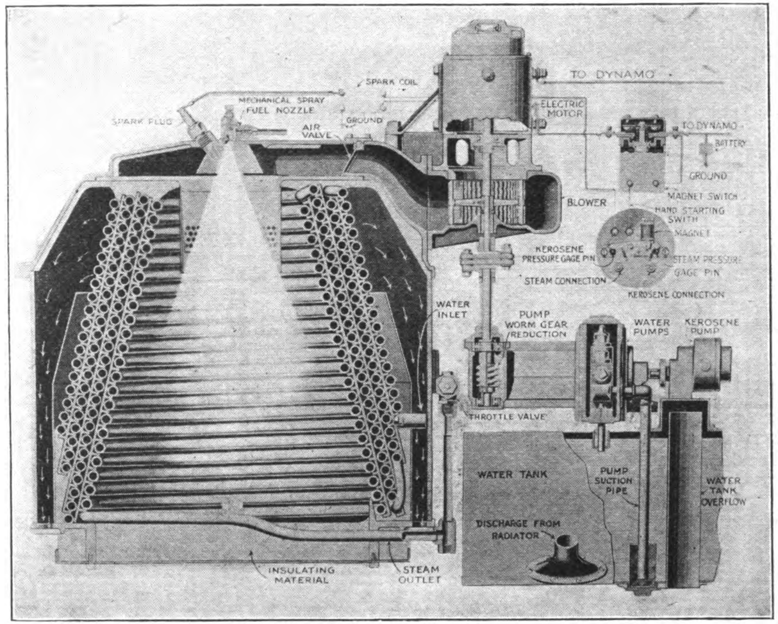

Fig. 4—The Relative Position of the Different Parts of the System

(8) The valves do not require regrinding
(9) Dust cannot be sucked into the engine and the truck should, on this account, remain operative for longer continuous periods than in the case of trucks driven by an internal-combustion engine

The boiler is located under the hood as shown in Fig. 5. Steam can be raised in less than 1 min. from a cold start. No effort is required in getting up steam other than turning a switch. No stuffing-boxes are used on the engine or pump. The water and fuel-pumps are operated by an electric motor, which is controlled by a switch on the steam gage.

Fuel oil, gas oil, kerosene, gasoline or any mixture of these fuels can be used. This makes possible the utilization of 80 per cent of the crude oil available. It is possible also to use powdered coal or coke as a fuel. The fuel is cleanly and completely burned, without experiencing any of the long list of troubles common to the explosive type of engine that are due to the present grade of gasoline.

The lubricating oil, which can be of the same grade as that used to lubricate internal-combustion engines, is carried in the crankcase of the engine. All parts in the

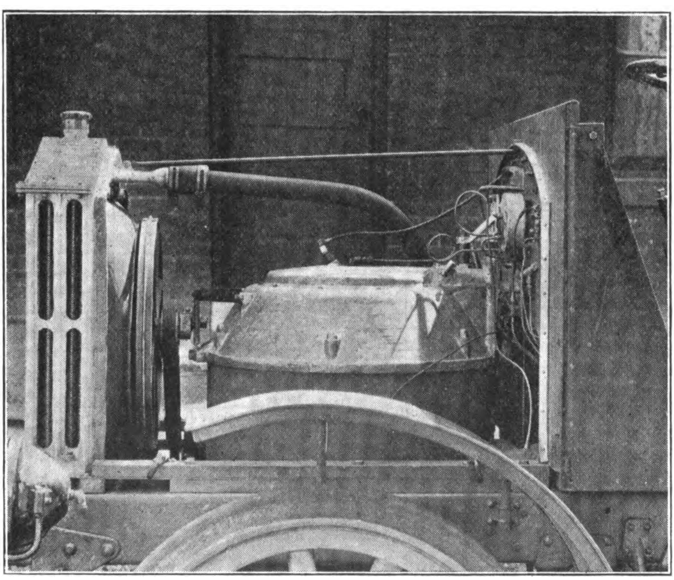

FIG. 5—THE BOILER IS LOCATED UNDER THE HOOD

crankcase are lubricated by splash. A small valveless oil-pump is used to pump oil from the crankcase to the steam line for lubricating the cylinders. The engine is of the poppet-valve type, and the valves require little or no oil.

The weight of this steam powerplant, including the engine, boiler and water, is practically the same as that of an internal-combustion engine powerplant of similar capacity, inclusive of the cooling system, clutch and transmission.

Torque Curves

Fig. 6 shows the characteristic torque curves of the internal-combustion engine and the steam engine powerplants, the two becoming identical at 1000 r.p.m. The

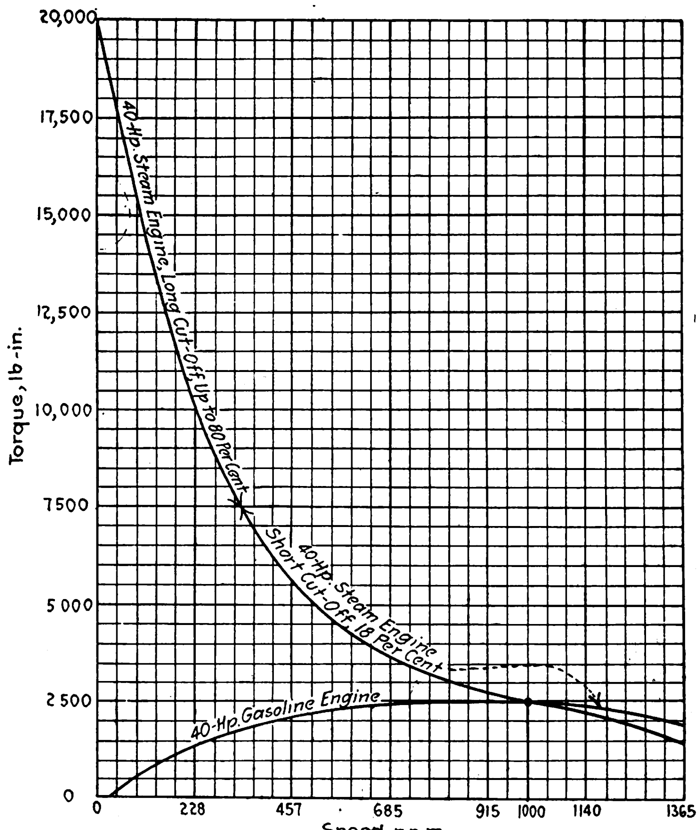

Fig. 6—Characteristic Torque Curves of a 40-Hp. Internal-Combustion Engine and a Steam Engine Developing the Same Power

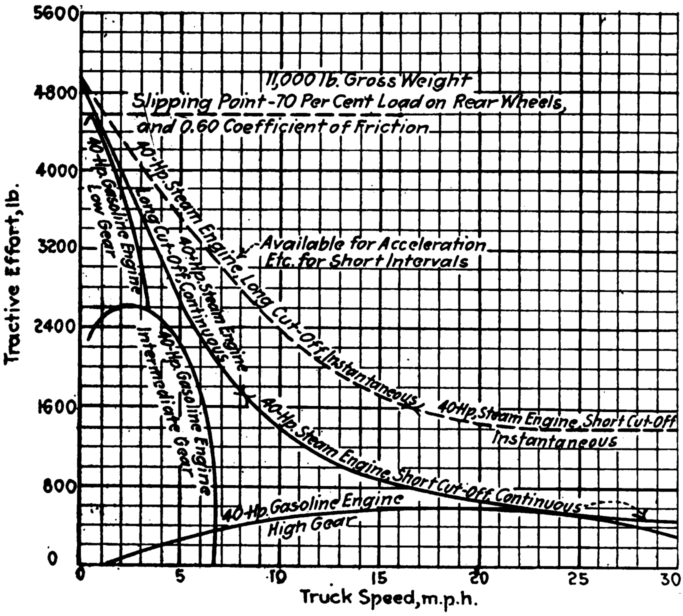

FIG. 7—THE RESPECTIVE PERFORMANCES OF THE STEAM AND INTERNAL-COMBUSTION ENGINES WHEN APPLIED TO A 2-TON TRUCK HAVING A GROSS WEIGHT OF 11,000 LB.

particularly noteworthy feature is the ability of the steam engine to maintain a constant horsepower over almost the entire range of speed on the short cut-off, thus insuring maximum economy of operation above 300 r.p.m.

Fig. 7 shows the respective performances of these powerplants when applied to a 2-ton truck having a gross weight, when loaded, of 11,000 lb. Each is a high-speed truck equipped with 8 x 40-in. pneumatic tires on the rear wheels and has a 5 3/7 to 1 gear-ratio in the axle. The low and the intermediate gear-ratios between the engine and the rear wheels are assumed to be 50 to 1 and 25 to 1 respectively. For purposes of illustration, only three speeds are assumed. This is not in accordance with usual practice for this particular case, but it introduces sufficient gear-changes to demonstrate the method of operation. The efficiency of the worm-gear axle is assumed to be 90 per cent in each case and the transmission also is assumed to be 90 per cent efficient.

It is noteworthy that the steam-engine curve in Fig. 7 meets the tractive effort of the truck equipped with the internal-combustion engine at 22 m.p.h. and that the steam-engine performance is above that of the internal-combustion engine at all other points. When grades become steep, gear-shifting must be resorted to in using an internal-combustion engine powerplant. With a truck so driven, when starting a load up a heavy grade it is very difficult to change to a higher gear without stalling the engine and many drivers will continue to use low gear, racing the engine to acquire speed. The truck driven by a steam engine does not encounter this difficulty. Fig. 8 shows the performance on grades of each of the powerplants shown in Fig. 7.

Engine Control

The truck is started forward simply by opening the throttle. For an extreme pull, the cam is shifted into the long cut-off position by pushing the left pedal forward until it comes to a stop. As no latch is provided in the long cut-off, the driver naturally will release the left pedal, which will shift the cam to the short cut-off. In the short cut-off position any kind of running can be accomplished, even the climbing of a 14-per cent grade at 8 m.p.h. When extreme grades are encountered, the cut-off can be lengthened by pressing the left pedal forward.

To reverse the engine for backing the truck, the left pedal is moved forward until it strikes the long cut-off stop; then, by tilting the pedals slightly, it will clear the long cut-off stop and can be pushed forward until it stops. This is the reverse position. It is possible to use the reverse as an emergency brake, thus eliminating the necessity of equipping the truck with airbrakes.

All parts of the powerplant are accessible. The boiler top can be removed and the coils exposed within a few minutes. The spark-plug and the fuel-spray nozzle are located at the top of the boiler and can be removed quickly. Access to the fuel and water-pumps is afforded by the ample space allowed under the foot-boards. The gages are mounted on the dash and when the hood is raised their connections are exposed. The two connecting-rod bearings are the only ones in the engine that are adjustable and they can be reached easily by removing the back cover of the engine case. The engine can be removed from the truck within 10 min. It should be borne in mind that this type of engine requires no valve-grinding or carbon-deposit removal, and that it has no carbureter, magneto, spark-plugs and the like.

In view of the fact that this truck has no transmission, in the accepted sense of this term, there is a material saving in power. This type of steam engine shows about the same efficiency at one-quarter load as at full load, which is much better performance than that of the internal-combustion engine. I understand that gearbox efficiency becomes as low as 70 per cent in some instances.

With a gear-reduction at the rear axle of from 5 to 5½ to 1, it is possible to slip the rear wheels on a dry pavement when the truck is fully loaded. When the truck is traveling 25 m.p.h., the engine speed is about 1200 r.p.m. The high torque at low engine-speeds makes the gearbox unnecessary and allows this plant to fit into the high-

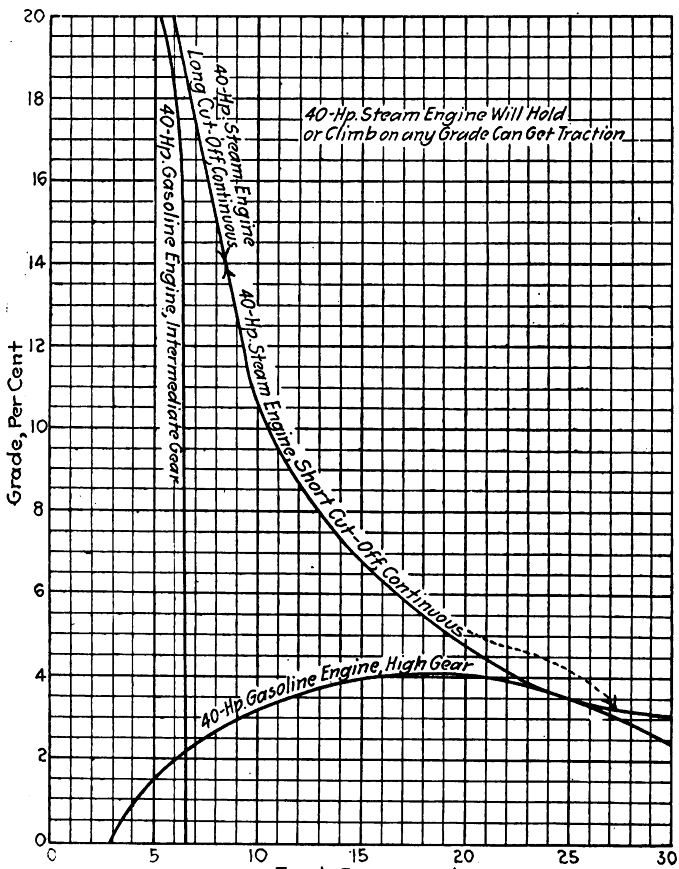

FIG. 8—COMPARATIVE PERFORMANCE OF THE TWO TYPES OF POWER-PLANT ON GRADES

speed pneumatic-tired truck without excessive engine speed and without transmission or clutch.

As an example of the advantage of eliminating the transmission and clutch on trucks used in bus service in some of the large cities as many as 1000 stops per day are made, requiring several thousand gear-changes. Frequent stops and starts with a heavy load are very destructive to a truck equipped with an internal-combustion engine, with which a transmission and a clutch are required. There has been considerable comment on the adaptability of the internal-combustion engine driven truck to bus service. The steam plant is ideal for this service, some of its advantages being smooth operation, rapid acceleration, flexibility, self-starting with no chance of "killing" the engine at some critical moment, that when the bus stops the engine also stops, and that exhaust steam heat for cold weather is available at no extra expense.

At atmospheric temperatures of 85 to 90 deg. fahr., we have driven a fully loaded truck 700 miles on the streets of St. Louis with only one tank of water. In cool weather, this water mileage is increased greatly. Long water-mileage is important because it reduces the foreign matter brought into the system and no trouble is caused by encrustation of the boiler tubes; also, it permits the use of alcohol to prevent freezing in cold weather.

Fuel, Oil and Water Consumption

With a load of 4400 lb. we get from 5½ to 6 miles per gal. of fuel, with either kerosene or fuel oil, and 300 miles per gal. of lubricating oil, with solid tires. A communication from one of the large oil companies dated Sept. 30, 1920, quoted water-white kerosene of 41-deg. specific gravity, in tank-car lots, at 11 cents per gal. f.o.b. Tulsa, Okla. Gasoline was quoted in similar quantities at 23 cents per gal. f.o.b. Tulsa, and 24-deg. specific gravity fuel oil in tank-car lots was priced at 8¼ cents per gal., f.o.b. Sand Springs, Okla. It should be remembered that the radiator is entirely empty when the truck is not running. When the truck is running the radiator is used to condense the steam into water, which then runs into the water-tank. The parts containing water are located around the boiler, which will retain heat for 12 hr.

In localities where the water contains large quantities of calcium and magnesium, it can be run through a small tank containing a mineral substance resembling clay or

TABLE 1—ACCELERATION TESTS—CHASSIS ONLY—NO LOAD[3]

From Zero Speed to M.P.H.	SOUTH Time, sec.					Average Time, sec.	Accel-eration, m.p.h. per sec.	NORTH Time, sec.					Average Time, sec.	Accel-eration, m.p.h. per sec.
	1	2	3	4	5			1	2	3	4	5		
10	3.6	..	3.0	2.7	3.0	3.08	3.25	3.0	3.0	3.0	2.6	2.7	2.87	3.49
15	5.4	..	4.0	4.7	4.4	4.62	3.25	4.0	4.8	4.4	4.4	4.4	4.40	3.41
20	7.2	7.2	6.8	6.2	6.7	6.82	2.93	5.8	7.8	6.9	7.4	6.4	6.86	2.92

[3]Using long cut-off for starting; then using short cut-off. Run was made on level ground.

shale that is mined in South Dakota and makes the water softer than rain water. A tank of the size used in residences for heating water will soften 1000 gal. per day. This material is highly charged with exchangeable sodium. It is placed in a filter container in this condition and the water to be softened is passed through it. Having a strong affinity for the calcium and the magnesium in the water, the substance combines with these elements and gives up its sodium to the water in proportionate amounts. When the substance has become charged with calcium or magnesium, by a simple process of admitting a solution of sodium chloride the mineral substance is restored to its original state.

The saving in fuel and oil costs in comparison with the internal-combustion engine driven truck is evident, to say nothing of the saving in upkeep and repair due to the freedom from valve-grinding and carbon removal and to the elimination of the transmission and clutch.

On a 2-ton truck operating 60 miles per day, I estimate that a saving in fuel cost of $1 per day can be effected with the steam powerplant, thus saving $300 per year. The saving on lubricating oil at 25 cents per day would amount to $75 per year. Adding the saving because of the elimination of valve-grinding and carbon removal, about $30 per year, and the saving on general overhauling, about $100 per year, brings the total estimated saving to $505 per year.

Acceleration Tests

It is well known and generally recognized that any properly made steam car can accelerate much more quickly than can one driven by an internal-combustion engine. Attention is called again to the long cut-off

Table 2—Acceleration Tests—Chassis Only—No Load[4]

From Zero Speed to M.P.H.	Time, sec.		Average Time, sec.	Acceleration, m.p.h. per sec.
	1	2		
10	....	3.0	3.0	3.33
15	....	4.5	4.5	3.33
20	7.0	7.2	7.1	2.82

[4]Using long cut-off throughout.

TABLE 3—ACCELERATION TESTS UNDER LOADED CONDITIONS—TOTAL WEIGHT, 11,065 LB.

From Zero Speed to M.P.H.	SOUTH Time, sec.					Average Time, sec.	Acceleration, m.p.h. per sec.	NORTH Time, sec.					Average Time, sec.	Acceleration, m.p.h. per sec.
	1	2	3	4	5			1	2	3	4	5		
10	5.0	4.0	4.2	..	3.2	4.10	2.44	3.4	4.2	3.2	3.8	3.2	3.51	2.85
15	9.0	6.4	7.2	7.0	6.0	7.12	2.11	6.0	6.5	5.8	5.9	6.0	6.04	2.30
20	12.0	11.0	11.7	10.3	11.1	11.22	1.78	10.0	10.0	9.5	8.9	8.8	9.44	1.95

curve in Fig. 7. Acceleration tests of this truck were made at St. Louis by representatives of the Fifth Avenue Coach Co., of New York City, in November, 1920. Table 1 gives the results obtained in runs made with the chassis only, with no load, on a level street. The nominal diameter of the rear tires was 40 in. and their actual diameter 43 in. The speedometer was checked by counting the number of wheel revolutions per mile, this number being 938. The weights are as follows: Chassis, 5960 lb.; allowed for three passengers, 505 lb.; total weight, 6465 lb. The weight on the front wheels was 3100 lb. and that on the rear wheels 2860 lb. Under the same conditions as stated for the tests in Table 1, but using the long cut-off throughout, the results given in Table 2 were obtained.

In runs made after the body and the load had been placed on the chassis, the weight complete was 10,560 lb.; allowed for three passengers, 505 lb.; total weight, 11,065 lb. The weight on the front wheels was 3795 lb. and that on the rear wheels 6765 lb., without passengers. The acceleration test results are given in Table 3.

Alternate readings were taken of the blower periods, on and off, in runs made with the chassis loaded. The first run covered a distance of 4.95 miles with no stops. The blower was on 33.8 per cent, and off 66.2 per cent of the time. Under similar conditions, except that sixteen 5-sec. stops were made and that the distance was 5 miles, within the elapsed time of 19 min. and 19 sec., the blower was on 30.5 per cent, and off 69.5 per cent of the time. Table 4 gives the results of braking tests made on level ground.

Acceleration tests were made also on the grade locally known as Dead Man's Hill, the loaded weight being 11,065 lb. The run to the bottom of the hill is 7.75 miles, which was made in 24.84 min. at an average speed of 19.2 m.p.h. The speed at the bottom of the hill was 28 m.p.h. and the lowest speed on the hill, which has a 10-per cent grade and is a winding road, was 15 m.p.h. The results of these tests are given in Table 5.

A test was made on the failure of the spark to light the fuel spray. The spark-plug wire was disconnected from the spark-plug and the fuel was then turned on, thereby filling the combustion-chamber with kerosene vapor. When the fire was lighted again in the normal way, there was no explosion nor any smoke.

Another test was made on the failure of the fuel sys-

TABLE 4—STEAM BRAKE TESTS

Run No.	Time. sec.	Distance, ft.	Speed, m.p.h.	Direction
Reverse, with no steam				
1	8.4	54	15	South
2	8.0	60	14	South
3	10.0	63	16	North
4	9.0	72	14	North
5	10.0	81	15	North
Reverse, with steam				
1	7.4	51	15	North

tem. The fuel was prevented from entering the combustion-chamber, thereby allowing the boiler to fill with water after the temperature was sufficiently low. After a short period the engine was cut off by the pressure gage. No damage whatever occurred.

A third test was made on the failure of the water system. The water was by-passed, thereby allowing the temperature to climb. The temperature reached 780 deg. fahr. and then the fuel was shut off by the solenoid valve.

Additional tests were made on Nov. 14, 15 and 16, 1920, the total loaded weight being 11,065 lb. in each case, with results as stated under Runs Nos. 1, 2, 3 and 4, on the following page.

Additional Run No. 3, made on fuel oil by Messrs. Wotton and Reese, was only for the purpose of testing the operation of the truck. It was limited to a 6-mile run, which was insufficient to warm up to efficient operation. No changes were made in the system in any way. We simply changed from kerosene to fuel oil and then

TABLE 5—ACCELERATION TESTS ON DEAD MAN'S HILL—TOTAL WEIGHT, 11,065 LB., GRADE 10 PER CENT.—WINDING ROAD

From Zero Speed to M.P.H.	Time, sec.			Average Time, sec.	Acceleration, m.p.h. per sec.
	1	2	3		
5	....	3.2	3.7	3.4	1.470
10	8.0	4.8	4.8	4.8	2.080
15	27.0	22.6	21.8	22.2	0.675

ADDITIONAL RUN NO. 1

Total Distance, miles	49.9
Elapsed Time, hr.	3¼
Starting Time from Cold Boiler, min.	1
Temperature at 0.2 Miles Distance, deg. fahr.	650
Miles Run on Stored Steam	0.4
Number of Stops Made	178
Average Speed, m.p.h.	15.3
Water Used, gal.	1
Fuel Used, gal.	9⅛
Miles per Gallon of Fuel	5.49

Note:—After 3 hr. 3 min. the brush on the dynamo became loose.

ADDITIONAL RUN NO. 2

Total Distance, miles	35.5
Elapsed Time, hr.	1¾
Average Speed, m.p.h.	20.3
Maximum Speed, m.p.h.	32.0
Minimum Speed, Solomon Hill, m.p.h.	13.0
Fire Cut-Off on 10-Per Cent Solomon Hill Grade	3 times
Miles per Gallon of Fuel	6.59
Water Used, gal.	Slightly less than 2

ADDITIONAL RUN NO. 3

Total Distance, miles	6.2
Fuel Used, gal.	1

Note:—Appeared to run the same as with kerosene, with no odor or smoke.

ADDITIONAL RUN NO. 4

Total Distance, miles	30.9
Elapsed Time, hr.	1.6
Atmospheric Temperature, deg. fahr.	40
Average Speed, m.p.h.	19.3
Fuel Used, gal.	4 2/3
Miles per Gallon of Fuel	7
Water Used, gal.	1

started immediately, showing that almost any kind of fuel can be used without very much alteration. Many times I have changed from kerosene to gasoline, then to fuel oil and after that to a mixture of the three fuels, without any noticeable change one way or the other in operating performance.

Fig. 9 shows the truck equipped with a body and loaded. It will be noted that pneumatic tires are used. This truck has been run at 35 m.p.h., which was by no means the limit of its speed.

Table 6 gives the mileage per gallon of fuel and per

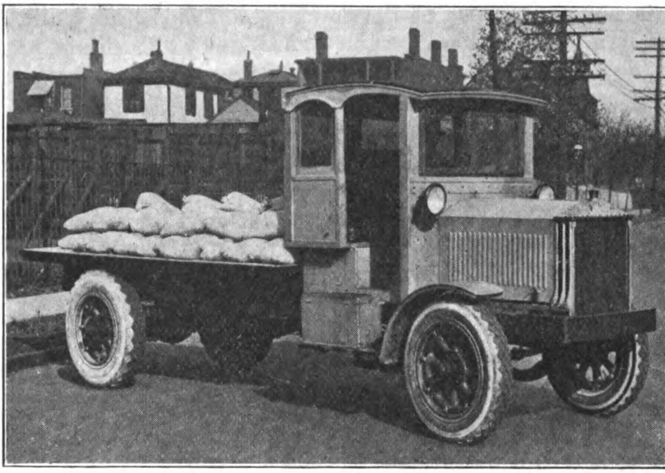

FIG. 9—THE LOADED TRUCK WHICH WAS USED IN THE TESTS

gallon of oil obtained with several different types of truck in tests conducted by a prominent oil-refining company.

FUTURE DEVELOPMENT

It is possible to equip this truck with some disengaging clutch for coasting. Such additional equipment will increase greatly the mileage that can be secured from unit quantities of fuel and feed-water.

We have a process for using steam to propel a truck or an automobile that will give a fuel mileage on our truck of from 18 to 20 miles per gal. of kerosene or fuel oil, if the details can be worked out in a way that is practical for use under ordinary operating conditions.

TABLE 6—MILEAGE PER GALLON OF FUEL AND OF OIL

Type of Truck	Capacity, tons	Mileage Obtained per Gallon	
		Gasoline	Oil
Bourne	2	4.72	91.3
White	2	5.21	45.3
Packard	3	4.30	128.5
White	5	3.14	20.1

It is now in process of development and has been built, but it is still in the experimental stage.

THE DISCUSSION

A. L. NELSON:—With reference to Mr. Scott's discussion of the steam engine there is one point in comparing it with the internal-combustion engine which I think we should not fail to consider. Apparently he assumes that the inefficiency of the gasoline engine at partial loads will continue to remain as great as it has been. We should not assume that the internal-combustion engine will not be developed further. I believe that there is a very good chance of increasing the efficiency of the internal-combustion engine, not at full loads particularly but at the loads under which the engine is used in a truck. I think it would be well worthwhile to make comparisons with this in view.

WILLARD J. GRAMM:—How does Mr. Scott take care of the problem of freezing in winter?

L. L. SCOTT:—It is taken care of in one way by putting alcohol in the water. The water mileage in cold weather is such that this can be done without excessive cost. If the truck is being operated every day, it is not necessary to do anything for the reason that all parts containing water are under the hood. Freezing will not take place because in our particular arrangement there is about 4 in. of refractory material at the bottom of the boiler that retains heat for from 14 to 16 hr. In the event of freezing, the boiler, for example, will not be damaged in any way. The tubes will withstand a pressure of about 30,000 lb. per sq. in. and ice at that pressure is impossible. We are using alcohol right along in our touring car and our truck in cold weather.

Mr. Nelson spoke about the future. There are possibilities of all sorts of things. We have been working with the internal-combustion engine for many years and are making comparisons with what we have today. I mentioned also the possibility of future development of a steam plant that can show much greater efficiency than has been shown with steam plants to date. Taking the two types of apparatus as they are today, we are able to show a higher fuel-mileage on a lower grade of fuel. Of course, there are many other things to take into consideration besides that one point, such as the ability to burn the fuel regardless of its cost, the cost of oil, repair bills and the like.

C. O. GUERNSEY:—I think that none of us should close our minds to any possible line of development that would permit us to use a greater percentage of the crude oil. I do not entirely agree with what Mr. Scott states. I have just made some rough calculations taken from figures given in Mr. Scott's tables. I may have made some assumptions that are not warranted but the figures I have are I think approximately correct. In one of the runs he reported 7 miles per gal. of oil with a total weight of, roughly, 5½ tons. I have assumed the road tractive effort required to be 60 lb. per ton, this being probably the requirement for an average country road, which I understand was the condition under which the truck was operated. Assuming 19,000 B.t.u. per lb. of oil burned, he is operating with an overall efficiency of somewhere around 11 per cent. That is neither particularly worse nor much better than we can get ordinarily from a gasoline engine.

Mr. Scott quotes some mileage figures for various trucks. I have no doubt that they are reasonably close to what is obtained in ordinary use in the hands of the average user, the trucks probably not being in the best of condition. However, Mr. Scott's figures are taken for experimental runs. I think for comparison we should give the gasoline engine the benefit of the same condition. It is easily possible with a conventional 2-ton truck without any special tuning up or anything of that sort to get from 7 to 9 miles per gal.

Undoubtedly, the steam engine does hold some possibilities. If Mr. Scott can develop a powerplant having an overall efficiency such as he mentions, we certainly should be very much interested. It seems to me that there is another line of development which possibly is being looked into under cover, but which has not been discussed to any great extent at the Society meetings; that is, the constant-pressure type of engine, possibly a combination of the steam and the internal-combustion engine systems. A theoretical diagram of such an engine shows a thermal efficiency of from 41 to 48 per cent, depending upon the compression used and other conditions. Such a system would have also the advantage of operating at a better efficiency under part than under full-load conditions. This is another avenue that we should not overlook.

R. B. HALL:—Has Mr. Scott used double or triple-expansion engines in his steam truck or experimented with them?

MR. SCOTT:—We have not. The only type of engine we have ever used is a simple uniflow or semi-uniflow double-acting engine. We have got steam rates below 12 lb. per hp-hr. This equals any test result that I know of with engines anywhere near the size of ours, including triple-expansion engines. We did not feel justified in using anything more complicated than the engine we have.

THE CARE AND MAINTENANCE OF MOTOR TRUCKS

BY N J SMITH[1]

The object of this paper is to point out some of the difficulties of motor-truck maintenance and to suggest lines of improvement. The buyer and user of a motor truck sometimes experiences disappointments due to the lack of coordination between the engineering and sales departments of a truck company. The term "service" is often misunderstood by the purchaser and misrepresented by the salesman, which results in dissatisfied customers. Salesmen should have accurate information on the service policy of their company and on all guarantees which they are authorized to make.

After rehearsing many of the difficulties encountered in truck maintenance, the author discusses in some detail the needed improvements in truck design, passing then to details of maintenance practice and methods of handling repairs. The results stated are those of actual experience, which prove that it is more economical to expend money for the prevention of trouble than to apply the same amount and more toward repairing defects.

The object of this paper is to point out some of the difficulties which present themselves in motor-truck maintenance, and to suggest, if possible, the lines along which improvement seems most needed, in order that these difficulties may be reduced to a practical minimum. Sometimes the buyer and user of a motor truck experiences disappointments due to a lack of coordination between the engineering department and sales department of the truck company. The term "service" is often misunderstood by the purchaser of the truck and mis-

[1] Consumers Co., Chicago.