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NATIONAL RESEARCH COUNCIL
DIVISION OF MECHANICAL ENGINEERING
OTTAWA, CANADA
LABORATORY MEMORANDUM

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SUBJECT A Preliminary Assessment of Automatic Starters
for Chain Saws

PREPARED BY W. Grabe

ISSUED TO

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1.0 Purpose

An investigation was undertaken to determine the feasibility of an automatic starter for chain saws. A number of diverse schemes was considered; the more promising ones were studied in some detail, see Fig. 1. The purpose of this memorandum is to sum up the results of this preliminary study, and to provide a basis for any decisions which have to be made with regard to further work in this field.

2.0 General Requirements

A chain saw is a wood cutting tool which has to be brought to the job by the operator. The job may be on the ground or in a tree. This requires the saw to be handy, well-balanced, and of light weight. The weight of a typical light-weight chain saw is of the order of 13 pounds. If an automatic starter were added to the saw, its weight would, obviously, represent ballast during the cutting operation, and it would have to be kept to an absolute minimum if the advantage derived from ease of starting were not to be cancelled by the additional burden.

The automatic starting device would have to store enough energy to assure starting of the gasoline engine under representative conditions. With most two-stroke engines this means at least 5 to 10 fast rotations of the crankshaft; under adverse climatic conditions it could well be more. An approximate energy requirement is 20 ft-lb/crankshaft revolution.

It might be said that chain saws are quite often handled roughly and are operated under severe working conditions. Therefore, it would be imperative for all automatic starter components to be rugged. Maintenance requirements should be of the simplest kind.

If the energy source for the starter were other than the fuel carried in the chain saw tank, it should be readily available if it were of the expending type, e.g. power cartridges.

Finally, the cost of the automatic starter and, if applicable, the energy source must be low enough to make this feature attractive for the buyer. While this consideration may not lie within the province of the research engineer, it may well be the decisive factor in the final analysis.

3.0 Types of Starters

3.1 Manual Starters

A manual starter is defined as one where the energy input required for starting the engine is by the operator. The most common forms used with small combustion engines are the recoil type, the rope type, and the power spring type. The latter kind stores the energy in a power spring from where it can be released rather quickly. The main advantage is that high power requirements (rate of energy release) can be met. The other two types, being more common, do not differ in principle. In the first case, the rope is contained in a casing into which it is wound by a spring after each starting attempt. In all three types, a mechanical clutch engages the starter pulley with the crankshaft for the duration of the starting cycle.

It is not suggested that the manual starting mechanism be discarded; it should be retained as a reliable standby for low temperature starts, energy failure (batteries), or absence of energy (cartridges).

3.2 Automatic Starters

3.2.1 Energy Contained in Engine Fuel

3.2.1.1 General

Upon first inspection, the utilization of energy contained in the engine fuel appears to promise an elegant solution. The energy is always available, and the cost in fuel per start would probably be overlooked by many purchasers. The study of some individual configurations, however, brings out a number of technical problems which will be discussed below.

3.2.1.2 Spring Energy Storage

A common energy storage is a mechanical spring. The spring would have to be loaded by the engine which would require a rather complicated arrangement. To transmit energy from the fast moving engine to a rather stiff spring (high energy storing and release within short distance) would in all probability involve some gearing. The loaded spring would then have to contain energy roughly equivalent to 3 to 4 quick rope pulls or about 300 to 400 ft-lb. From space availability considerations, a working distance (if one thinks in terms of a coil spring)

of 1/2 ft would probably constitute the limit. This results in a mean working force of 600 to 800 lb. It can easily be discerned that such a spring together with the necessary ancillary items, such as pinion, rack, gearing, clutches (overriding, flywheel), and linkage would be far too bulky and heavy for practical application.

If a "one-shot" capacity is considered, giving the impetus equivalent to one rope pull of manual starting, the weight could probably be significantly reduced. The probability of starting the engine with one burst, on the other hand, seems to be too low to regard this as a reliable starting means.

3.2.1.3 Compressed Gas

Energy can be stored in^{the} form of compressed gas, either air or combustion products. A small compressor driven off the engine could compress air into a chamber. Alternatively, high pressure combustion products could be bled into this chamber. For starting, these gases would be expanded through a piston and cylinder or a turbine. The execution of these schemes may take rather complex forms. One of the major problems will be leakage from the chamber. If starting capability after overnight storage were considered essential, highly effective and thus expensive sealing would be required. Bulkiness of any of the above configurations may be another serious problem.

If the design parameters permitted hand-starting after overnight storage, this proposal may merit some closer study.

3.2.1.4 Injected Fuel Combustion

A direct utilization of the energy contained in the fuel could be effected by injecting a measured amount of gasoline into a cylinder; igniting the gasoline/air mixture; and letting it expand against a piston which, through rack and pinion, transmitted the work to the engine crankshaft. This system would need a separate ignition circuit, including a set of batteries as an energy source for the spark. Scavenging of the burnt gases would represent some difficulties.

Matters would be simplified greatly, if the starting process took place directly in the engine cylinder. One reason against suggesting this configuration is that, for starting, the engine has to be turned rapidly through about 5 crankshaft

revolutions, in order to provide the proper ignition conditions. It is rather doubtful whether a single working stroke of the engine can store enough energy in a normal-sized flywheel to effect 4 further revolutions. On the other hand, one might succeed in matching one stroke of the auxiliary piston with the required number of crankshaft revolutions. Furthermore, it appears that positioning the engine piston automatically at T.D.C. before each starting attempt will be substantially more difficult than doing the same with the starter piston.

Other problems may arise from establishing a fixed amount of fuel which will form a suitable combustion mixture at different temperatures, humidities, and levels of air purity, if one allows that scavenging of burnt gases from previous starting attempt will not be complete. Therefore, the degree of reliability may not be too high.

If it is envisaged that the batteries used for providing ignition sparks be of the rechargeable type, and that charging should occur internally through a generator, then one is not too far away from an electric starter, as will be shown below.

3.2.2 Energy Provided Separately

3.2.2.1 General

In this part, automatic starter principles will be discussed in which the energy input is other than the engine's fuel. The two energy sources considered are power cartridges and electric storage batteries. It could be argued that storage batteries belong to the previous category if they are recharged periodically by a built-in generator, because the starting energy comes from the fuel, and the batteries only store it.

3.2.2.2 Power Cartridges

In the past, solid propellant cartridges have been used for starting larger engines, e.g. Diesel engines, reciprocating aircraft engines, and turbojet engines. These cartridges are of necessity quite large and powerful. In the small calibre range, power cartridges are used in stud drivers and cattle stunning guns.

Two starting configurations could incorporate power cartridges as an energy source. In one scheme, the powder would be burned in a chamber. The combustion products/air

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mixture would then be expanded through a nozzle and turbine, which would drive the crankshaft. The difficulties with this particular approach are that because of irreversible heat transfer to the air in the chamber, and because of substantial losses in nozzle and turbine, the overall efficiency would be very low. It can be shown that the larger the chamber, the lesser will be the available energy from the powder. On the positive side, the turbine would not require positioning of the engine piston at T.D.C. before each start.

The other, more attractive, configuration has the burnt charge expand against a piston in a cylinder. The work would be transmitted through rack and pinion to the engine crankshaft. A spring and an overriding clutch between pinion and crankshaft would permit the starter piston to return to firing position. Some way would have to be found to relieve the pressure in the starter cylinder when the piston is returned. Fouling of the starter piston arising from residue in the combustion products would have to be dealt with with a minimum of inconvenience to the operator.

It is envisaged that the firing mechanism be of the automatic type with an array of cartridges contained in a magazine. Thus each starting attempt would constitute nothing more than the pulling of a trigger or pushing of a button once for each cartridge.

Since this scheme is, perhaps, one of the more promising ones, a word may be said about the economic side. Presupposing the successful solution of all engineering problems, the availability and price of the power cartridges will be of great importance. The requirements for easy supply appear to eliminate special cartridges as contenders because they would be obtainable only through the somewhat limited chain saw dealer network. Thus, the starter may have to be designed around existing power cartridges which have some undesirable characteristics (high burning rate, high stress concentrations in rim-fired cartridges).

The retail price of a .22 calibre power cartridge is of the order of 5 ¢ per cartridge*. With an estimated 40 starts per day, the operating costs of this kind of starter appear to be prohibitively high, although discussions with an ammunition manufacturer suggest the price need not be this high.

* In Ottawa area.

3.2.2.3 Electric Starter

A chain saw equipped with an electric starter is at present being introduced to the market. The following discussion is based primarily on the information about this starter which was published in a trade magazine*. Ten nickel-cadmium batteries supply energy to a starter generator. The starter button simultaneously opens a "de-stroking" port to facilitate cranking of the engine when starting electrically. "De-stroking" means that through opening of a special port in the cylinder, the effective pressure ratio is reduced for automatic starting. When the saw is operated, the starter-generator recharges the batteries within a few minutes. The weight of the automatic starter components is estimated to lie between 3 and 4 pounds. The batteries are designed to last the life of the saw. Thus, the only operating expense for the starter occurring to the operator is the cost of the gasoline which is needed for charging the batteries.

The saw looks very compact. No information is available on the ruggedness or reliability of the electric starter. In case of failure, the manufacturer's repair service would very likely be required. Based on retail prices quoted by a local dealer, the starter produces an increase of 50% in the sales price of the saw.

3.2.2.4 Detached Electric Starter

As emphasized earlier, any weight added to the saw by an automatic starter is ballast which is very much felt while handling the saw. Conceivably, an electric starter could be developed as a separate unit which would be attached to the saw for starting only. The advantages would be that the weight of the starting unit would not be so critical, that the weight of the saw would not be penalized, and that the unit could be purchased as an optional item. The inconvenience of keeping track of the starter unit and of attaching and detaching it for each start could be partially alleviated by carrying the unit knapsack fashion. The advantage of having the batteries recharged by an engine driven generator, as is done with the described built-in starter, would be lost in this scheme.

* "Push-Button Chain Saw McCulloch First". Chain Saw Age, August 1966, p. 4.

The idea of separating the automatic starter from the saw could, of course, be applied to any configuration, not just an electric one.

4.0 Discussion

- (1) None of the configurations which utilize the energy contained in the engine fuel appear promising, mainly because of general bulkiness and complexity. The electric starter is not included in this group.
- (2) A power cartridge starter has the disadvantages that cartridges must be kept available and that the cost of these cartridges may prove to be prohibitively high. Technically, this scheme has some merits.
- (3) The electric starter combines the feature of utilizing the engine fuel with compactness and relative lightness and appears to be one of the best technical solutions of the problem. The necessity for de-stroking, however, is indicative of a marginal power level.
- (4) While an automatic starter constitutes a welcome feature, it is doubtful whether the convenience will outweigh the additional cost and weight of the saw.
- (5) It should be pointed out that starting schemes using energy contained in the fuel, including electric starting, may have a psychological advantage over schemes where the energy is provided separately, e.g. power cartridges. That is because the operating costs for the starter do not appear as a separate expenditure in the former category.

CHAIN SAW STARTING SCHEMES

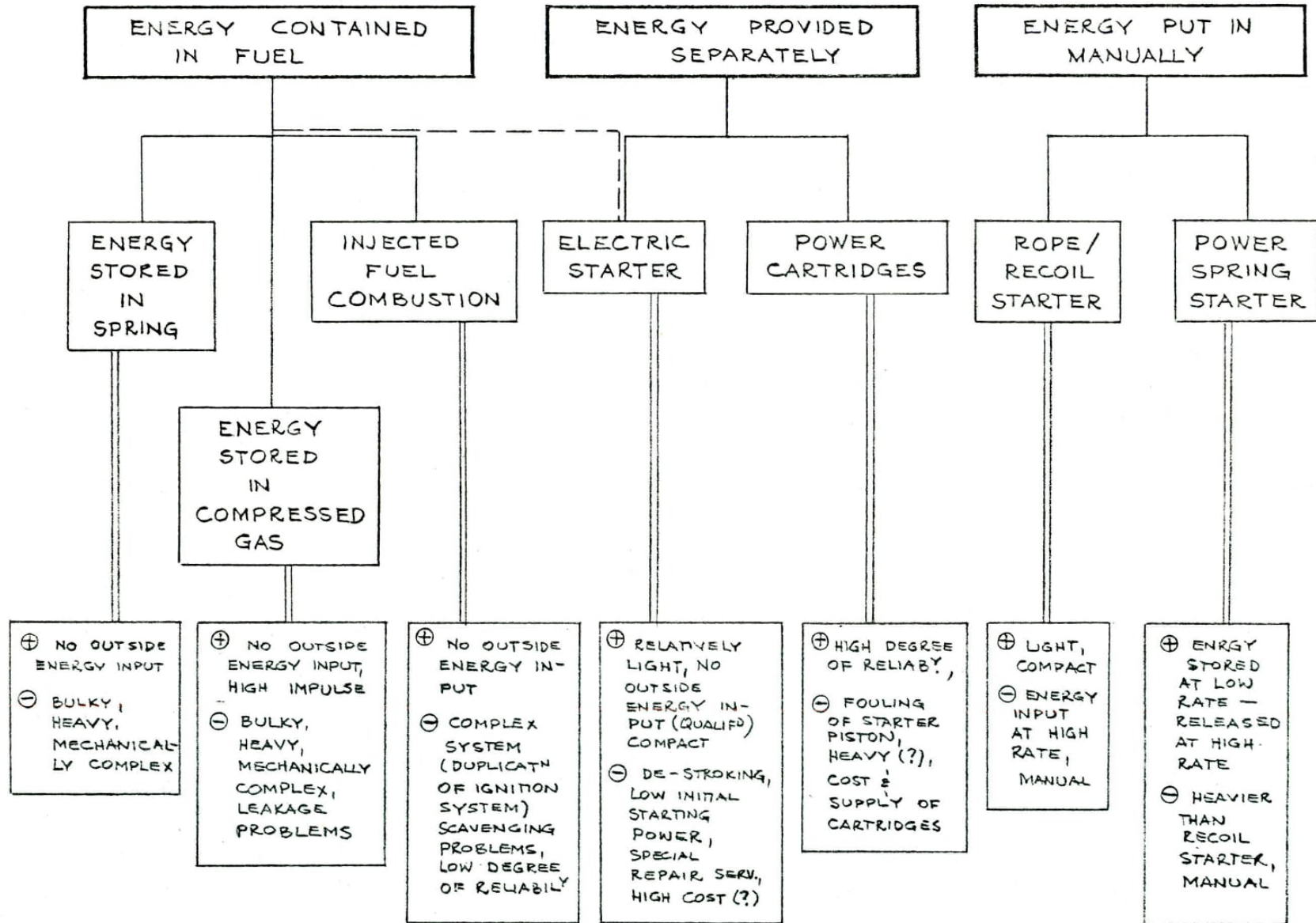


FIG. 1