PROPOSAL
FOR
DESIGN AND FABRICATION

1/4 TON MECHANICALLY PROPELLED LOAD CARRYING DEVICE

RFP - 63 - RE - 514

Studebaker
CORPORATION

14 March 1963

STUDEBAKER CORPORATION

SUMMARY

This proposal presents a description of a design concept that preliminary engineering analysis indicates will produce a vehicle that will fulfill the requirements of RFP-63-RE-514. The concept presented is that of a tracked vehicle which is deemed necessary to give a low ground pressure of approximately 1 psi.

The vehicle is powered by a gasoline engine driving through hydrostatic transmission. This vehicle will float, traverse swamps and rice paddies and climb steep grades. Major problem areas will be in meeting the weight requirement and developing a light weight rugged track. It is expected, however, based on Studebaker's experience with building light weight vehicles of this general size that this vehicle can be built successfully within the scheduled time.

Preliminary cost estimates based on the prices obtained for the proposed components indicate that the price of such a vehicle in production quantities would be in the range of $850.00 to $990.00. This figure may change somewhat depending upon the final decisions regarding features to be included or deleted as a result of the development program.

TABLE OF CONTENTS

I. INTRODUCTION

This proposal is presented in response to RFP 63-RE-514 which requests design and fabrication of a 1/4 ton mechanical load carrying device for evaluation as a means of increasing the Army's mobility. Mobility of ground forces and particularly the individual foot-soldier must be increased to meet present and future battle-field conditions, whether in the jungles of Southeast Asia, the mountains of Korea or the tundra and snow of Arctic wastelands. Mobility of the individual front-line soldier has always been a problem, since he can only be as mobile as his equipment and his resupply capability permit. The foot-soldier in combat beyond those points accessible by "jeep" or "mule" must rely on resupply by man-packing by military or indigenous personnel. His movement is impeded and limited by heavy or bulky loads, such as crew-served weapons, ammunition, rations, or communications equipment.

The limited or "brushfire" conflicts, possible in the present political climate, pose especially difficult problems to individual combat operations in view of the particularly adverse environmental and terrain conditions usually encountered. The countries of Southeast Asia present particularly cogent examples of these adverse operational conditions. Information and data concerning the Vietnam and Laotian areas indicates that our allies are operating in areas where, at best, foot trails are the only access routes and, at times, troops must make their own trails directly through the dense and matted under-growth of the jungle. Under these conditions, the individual soldier must presently rely on resupply by man-packing. Also, the evacuation of wounded creates special problems, and it is not unusual for six to eight combat personnel to be out of action in simply transporting each wounded to the rear.

The problem then may be summarized as follows:

Provide the individual soldier with a vehicle to transport his supplies and equipment to any place he may be required to go on foot. Provide him with a lightweight, general-purpose vehicle to support his dismounted operations, particularly those operations in extremely adverse terrain where roads are non-existent and travel by foot is a necessity: jungles, swamps, rice paddies, and mountains. Provide him with a small, extremely maneuverable vehicle as narrow as possible for foot-trail operations, as quiet as possible to prevent detection of his location and as light as possible for ease of handling.

Studebaker has worked on this problem for the last year and a half - building and testing several prototype vehicles. These vehicles included various combinations of 3 and 4-wheel configurations, 2 and 4-wheel drive, mechanical and hydro-static transmissions, 2 and 4-cycle engines, terra tires, and various sizes of industrial tires. Pictures of the various vehicles and the results of the tests are contained in a later section of this proposal.

On several occasions the vehicles have been demonstrated to various elements of the Army. Valuable suggestions for improvements have resulted from these deomonstrations and these improvements have been incorporated in subsequent designs.

The tracked vehicle recommended in this proposal is based on the experience gained from building and testing these vehicles, plus the requirement for reduced ground pressure.

II. TECHNICAL APPROACH

A. Vehicle Requirements

RFP 63-RE-514 contains the general specification of the load carrying device desired by the Army. The requirement of being able to carry 500 lbs. of cargo on a light weight device (250 lbs.), to be propelled by an engine drive mechanism and having the capability of crossing swamps, rice paddies, and rough off-the-road terrain dictates a vehicle with 1 to 2 psi ground pressure. In order to fulfill this low ground pressure requirement, it has been determined that the vehicle must be equipped with tracks.

The vehicle must be designed for positioning the cargo weight as well as the engine drive mechanism to give a good center of gravity. The design proposed provides these characteristics plus the proper balance for flotation while in the water, going over rough terrain and up and down grades.

Using these general requirements, together with our experience on small load carrying powered vehicles, Studebaker has made a preliminary analysis which shows that such a vehicle could be built of commercial components (except for track grousers) within the weight requirement. The proposed vehicle would have the following characteristics.

(a) Size - Length 72"; Width 36" and Height 30" ground clearance of 12" weight 300 lbs. (which could be reduced 250 lbs. by use of two cycle engine).

(b) Materials used will be light weight aluminum and plastic where ever possible. None of the materials will be adversely effected by temperature in the range of -15° F to 125° F. Seals and surface treatment will be provided as necessary to withstand environmental effects.

(c) The use of track and the hydrostatic drive will give the required tractive force to allow traversing of mud and clay as well as sand and secondary roads, as required.

(d) A simple clean design will be maintained to minimize vulnerability to damage from sticks, stones, trees, grass and the like.

(e) No difficulty from noise is expected with this design as the engine has been muffled to come within the noise level requirement.

(f) No pneumatic or inflated suspension components are used and, therefore, operation over obstacles such as nails, spikes, glass, sharp pointed sticks, etc. will not adversely affect the operation.

(g) The inherent simplicity of this device requires no special training either in operation or in maintenance.

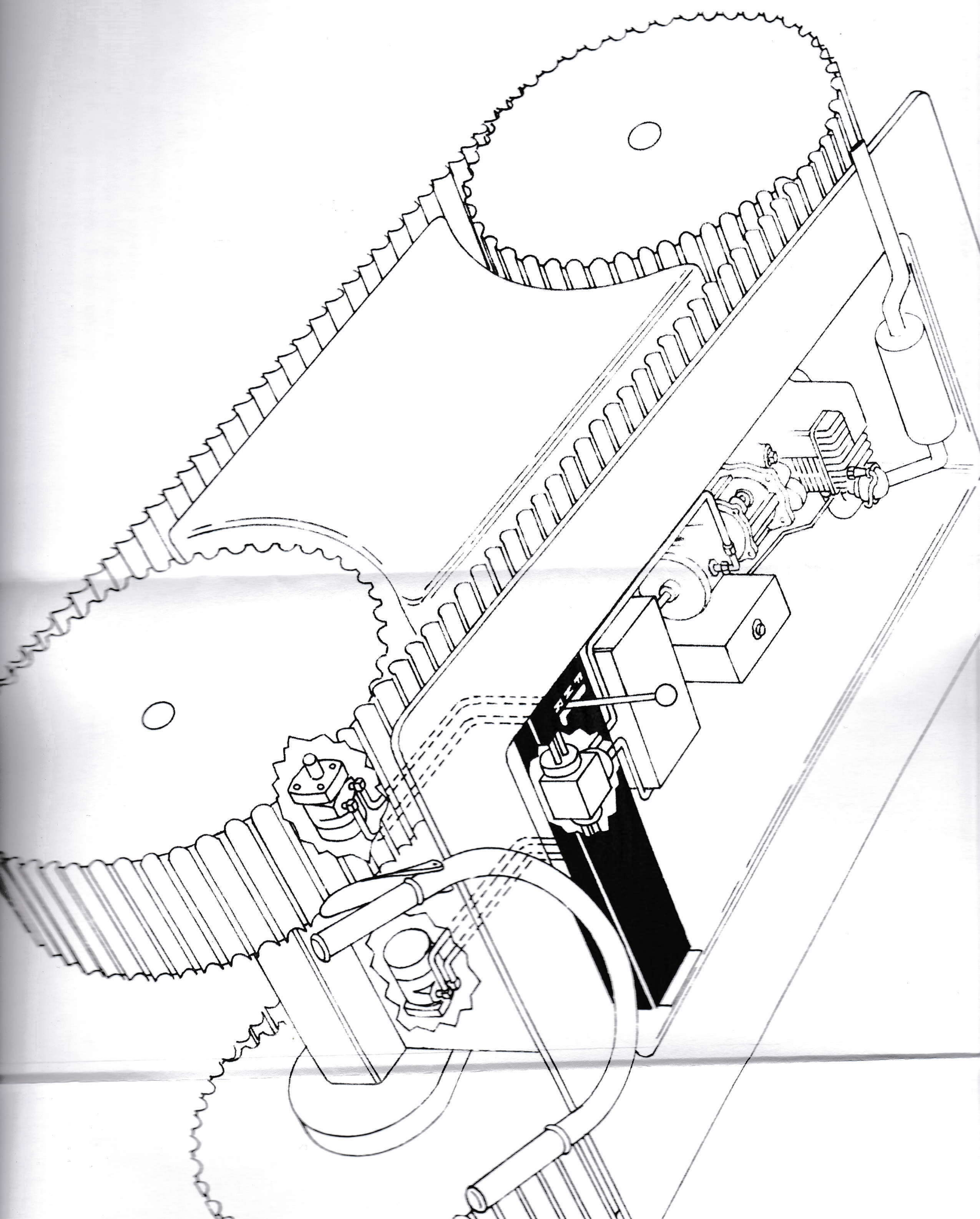
(h) This design will provide for the fully loaded device to be transported by Army personnel carriers such as the M 113, H21 and H34 Army Helicopters using exterior slings, and by Army fixed wing aircraft such as the caribou and the otter. It is capable of being parachuted from these aircraft. Tie down points for securing the cargo to the vehicle will be included. These can also be used to secure the vehicle for rail, marine, ground vehicle and air transport.

B. Description of Design

The vehicle requirements discussed in the previous section are proposed to be met by the vehicle shown by the artists concept of Figure 1. The construction of this concept has been the subject of a preliminary investigation to establish its feasibility. The results of this investigation have shown that a vehicle meeting the requirements of the RFP can be constructed. The present indications are that the vehicle should be constructed as described below, however, after a complete preliminary design is completed deviation of some of the detail could be expected. The main features of this concept are:

1. Track and Wheels

Because of the requirement of high ratio of load to vehicle weight, the track-laying concept must feature extreme lightness with ruggedness. No known design of tracks presently fulfills this requirement. Therefore, a new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light weight track concept is proposed. The proposed concept will use two belts per track with grousers rivieted to the belts. The proposed grousers are of an inverted "U" shaped section which provide two biting edges for increasing traction, as well as providing sufficient contact area for low ground pressure. Material is of a polyester laminate plastic which is strong, abrasion resistant and waterproof. It is impervious to fungus, mildew, corrosion etc. and resists adhesion of foreign matter, mud, etc. because of its slick surface.

The drive belts are of dacron cord laminate and coated for resistance to the elements.

The wheels for supporting and driving the tracks are for the preliminary approach commercially available bicycle hub-wheel-rim combination.

The tire portion, however, instead of being inflatable, is of a bonded urethane material, having integral molded cogs used to directly drive the track grousers. The diameter of the tire is such that it keeps the grousers from the road on hard surfaces but sinks in soft terrain which allows the track to provide flotation and traction. The bicycle hubs are of the speed-changing coaster brake type.

The wheel structure is stabilized and strengthened by filling the wheel with urethane foam making a drum the width of the track and of sufficient diameter to support the grousers at the outer ends of the track. This construction should give the necessary support to prevent throwing tracks on side slopes, it will prevent foreign material from fouling the wheels and provide flotation as well as strengthening the wheels. The general appearance of this construction is shown on Figure 1.

The space between upper and lower tracks and the wheels is shown to be filled with a piece of urethane foam. The purpose of this is to provide additional flotation, to keep foreign material out of the wheels and if needed to support the central area of the track to provide more uniform ground pressure. Test of the vehicle will be needed to determine if this feature will work satisfactorily and if it is needed.

2. Frame

The track driving wheels are supported by spindles attached directly to a light weight metal frame which supports the body. The body can be removed from the frame quickly by removing several clamps. The frame can be split and separated into two pieces for providing quick disassembly for easy transport in a knocked down condition. This then gives five pieces: (a) 2-half frames with wheel and track assemblies attached, (b) body, (c) engine and pump assembly in sub-frame, and (d) rear inside sub-frame with remaining hydraulic components.

Further breakdown is deemed to be unwarranted.

3. Propulsion Mechanism

The propulsion system proposed for this vehicle has been developed by Studebaker over the past one and one-half years working with the "Turtle" vehicle. Figures 2 through 7.

This propulsion mechanism will be built-up using an engine which will drive a hydrostatic transmission. The transmission utilized a variable displacement pump, three open center valves, one of which controls forward and reverse, the other two the hydraulic wheel motors.

A wheel motor drives each rear wheel, which is the power source for each track section on either side of the vehicle. This means of propulsion is sufficient for allowing the vehicle to climb a 60% grade at 1 - 1/2 MPH and to swim at 2 MPH.

The above described propulsion system causes the overall vehicle weight to be 50 pound over the specified requirement, because of the use of a 68 pound 4 cycle engine. This weight can be reduced sufficiently to make the vehicle fall within the required weight by going to a 2 cycle engine.

4. Body

The body would be a reinforced plastic type, water-proof and buoyant and of sufficient strength and rigidity to support the drive mechanism and the cargo loaded on its supporting pallet attached to the body upper edges. The design will include, if required, additional support members directly to the frame. These steps make an impact and puncture resistant hull of light weight design feasible and provides flotation for the vehicle.

5. Controls and Operation

The controls should be simple, to insure ease of operation, and a natural motion. Motor cycle type steering handle bars are provided to give operator control of speed through the variable displacement hydraulic pump. Steering the tracks would be accomplished by reducing flow to either wheel motor. Stopping can be accomplished by a quick "lock and unlock" device which will, when pulled back, shut off the flow of fluid immediately. For less quick stops the release of the throttle mechanism on the handle bar will allow the vehicle to stop normally.

6. Weight Estimate

The weight estimated for the design described shows 307.9 lbs. which is 57.9 lbs. over the specified requirement. This over weight condition is due to the use of a 4 cycle engine which Studebaker feels will give the performance specified in this RFQ. This weight can be reduced to fall in the required weight range by the use of a 2 cycle engine. The weights listed in the estimate breakdown are based on actual components used in building up the "Turtle" prototype vehicle (Figure 7) and calculated data supplied to Studebaker by component manufacturers.

WEIGHT ANALYSIS

Body	18.0
Engine	68.0
Pump	14.0
Valve Block (3)	7.5
Wheel Motors (2)	15.0
Plywood Board	9.0
Handle Bar Assembly	10.0
Hubs (4)	20.0
Axles (2)	7.0
Wheels (4)	10.2
Rims (4)	4.8
Foam (5.0 cu. ft.)	18.1
Oil Reservoir	4.0
Frame	11.0
Coupling	1.5
Grousers	21.5
Track	8.0
Misc. brackets & inside frame	18.0
Exhaust & muffler	8.0
Gas tank	2.0
Hose (14 ft.) 3/8"	9.8
Fittings (18)	9.5
Misc. fittings & linkage	3.0
	307.9

C. Program of Accomplishment

The development program for the proposed vehicle discussed in the previous section can best be described by dividing the work into phases. The work to be done in each phase is discussed in the following paragraphs:

(a) As soon as the contract is signed, work work will commence on the preliminary design of the vehicle following the concept shown in Figure 1. This work will entail the making of a full scale layout to determine space requirements for the commercial components and designing the various new components needed. Studies will be made of various methods of fabrication of the special components to determine the most economical method. The special components for this vehicle are the body, frame, track grousers and wheel assemblies. The first layout and study, will be made in accordance with the concept explained in the preceding section on the description of design. Several alternate methods will be studied where need for lighter weight or more economical construction is indicated.

The results of the preliminary design will be consolidated into a report containing a recommended design which will be discussed with the contracting agency. After agreement concerning the preliminary design has been reached, the final design phase will begin.

(b) Phase II - Final Design

The approved preliminary design will be detailed incorporating changes and improvements as agreed to with the contracting agency. The layout will be brought up to a date as required and details and top assembly drawings made according to Studebaker standard practice. The drawings will be identified in accordance with instructions of the contracting agency. A report will be prepared on this phase. This will define the final design as proposed to be built and will contain all of the calculations and details of the proposed construction. The approval of the contracting agency will be required prior to building the prototype.

Phase III - Fabrication of Prototype

After approval of the final design report, fabrication of the prototype vehicle will begin. Most parts are "off-the-shelf" components and so a short lead time is expected. The longest lead time is expected to be the track grousers. Present knowledge indicates that these will necessarily have to be specially designed and constructed for the vehicle because of the light weight requirements. It would be planned to design the grousers early in the final design phase and obtain the contracting officers approval to start fabrication of the tooling prior to approval of the final design. The only other item which requires lead time is the mold for fabrication of the plastic body. The brackets, shafts, etc. needed for this vehicle will be made in the Studebaker experimental machine shops. The final assembly will be made in the experimental garage by experienced mechanics.

Phase IV - Test Program

The test program will consist of two types of tests. One will be laboratory tests on those components that are new and have not been used on other similar applications. The new components are primarily the track grousers. The other components have been used on many other applications and can best be checked out for this application by the test program of the entire vehicle.

The laboratory program on the grousers can start very early by obtaining samples of the proposed materials. These samples will simulate the grousers and the tests run in the Mechanical Laboratory subjecting the material to impact, strength and the effects of temperature that are expected in actual use. This will give sufficient information during the preliminary design phase to permit selection of the needed material in time to allow the lead time for procuring the required tools for fabrication.

The tests of the complete vehicle will be run at the Studebaker Proving Grounds over various types of terrain from hard surfaced roads to soft mud, to cross country, to swimming and to various grade climbing. This will demonstrate compliance to the performance requirements of the specification. The following tests are proposed to demonstrate this compliance and would be conducted with the vehicle fully loaded.

1. The vehicle will be driven over smooth pavement, rough pavement, unimproved county roads, and soft terrain such as grass, turf, etc.

2. It will then be driven over soft mud.

3. Next, watery mud 4-6" deep.

4. Next, it would be floated, and propelled in water.

5. The vehicle would be driven on a 30% side slope, and driven up a hort 60% slope.

The test program will be completely detailed during the design phases and submitted for approval prior to conduct of any of the tests.

Deficiencies found during the testing program will be corrected on the vehicles and drawings altered prior to delivery to the Army.

Phase V. - Delivery

The following items will be delivered to the Army as fulfillment of the contract:

(a) Complete vehicle.

(b) Preliminary design report.

(c) Final design report.

(d) Set of drawings on Studebaker format.

(e) Operating instructions.

(f) Monthly progress reports.

D. Major Problem Areas

While the preliminary analysis indicates a device described in the RFQ can be designed and built it is recognized that there are some problem areas that will be encountered during the program. The ones that will be most difficult to solve will be:

(a) The overall weight limitation of 250 pounds is exceedingly tight. It will be necessary to eliminate every frill or "nice-to-have" feature and get down to the bare essentials if this weight is to be held. By careful design and selection of light materials, a 300 pound weight can be met by the concept proposed using a 4 cycle engine. However, Studebaker's past experience using a 2 cycle engine on the "Turtle" vehicle has proven unsatisfactory for this type operation because of the following factors:

1. Piston seizure after 5 minutes to 5 hours running time. This was either due to the amount of load applied to the engine or manufacturing quality.

2. Excessive smoke due to mixing the oil and gasoline. None of the present 2 cycle engine manufacturers have developed a successful independent lubrication system. Several have designs available that could be developed, if warranted.

3. High noise level which can be reduced by a large and expensive muffler system.

If the specified weight requirement of 250 pounds for the vehicle is mandatory, then development work must be done by the 2 cycle engine manufacturer to overcome the above shortcomings.

(b) Because of the weight limitation, it will be necessary to develop an extremely light weight track. (A tracked vehicle is deemed necessary to obtain a satisfactorily low ground pressure). No known track is in existence that will meet the strength - weight requirements. The track and track drive concept proposed has the characteristics which the preliminary analysis shows has an excellent chance to attain the strength to weight ratio required.

It is recognized that the proposed track construction may give problems with regard to non-uniform ground pressure.

The foam block used as a filler between tracks can be used to provide a load on the center portion of the track span if this becomes too great a problem. The need for this can be ascertained from the test program.

(c) The proposed design concept visualizes the use of rigid connections between frame and tracks, i.e., no spring suspension. This is being proposed in an effort to keep the weight as low as possible and the design as simple and economical to build as possible. While a spring suspension is a nice to have feature, it is our judgment that with this low speed vehicle the ride afforded the cargo will be satisfactory without such a suspension. If tests prove that springs are required these can be incorporated between the body and the pallet carrying the load.

E. Interpretations or Exceptions to Specifications

Most features of the proposed design have been developed to meet the light weight requirement of the vehicle. Most of these features are not believed to be seriously effected by this light weight. In fact, our experience has shown that the design is workable except for the tracks which have not been tested. There are two features that we have included that add weight to the vehicle which are:

(a) 4 cycle engine - As stated in previous paragraphs our experience has led us to recommend the 4 cycle engine over the 2 cycle even though this puts the weight considerably over the specification requirement. This is done to increase life expectance and reliability. If the 250 lbs. must be met, we recommend that a development program be negotiated to carry out the completion of one of the lubrication systems for the engine. This program is not included in this proposal, but could be negotiated.

(b) Quick disassembly into components - The requirement for disassembly for transport has been provided, however, this adds complication and weight. A better simpler design could be achieved by eliminating this requirement.

Our proposed design can easily provide for knock down of the vehicle into five subassemblies for transport when desired. Weights of the five pieces would be 60 lbs. each. Further disassembly into smaller pieces could be accomplished with a greater amount of complication and increased weight. Our interpretation of the requirements suggests that this further breakdown would not be warranted.

F. Degree of Success Expected.

While there are problems and limitations that may be encountered as discussed above, the expectations, based on our preliminary analysis and the experience gained on the development of the "Turtle" vehicle, are that the vehicle designed and built in accordance with the proposed concept will be successful in meeting the requirement. The vehicle weight can be held within that specified while vehicle performance will be such that two men can carry their equipment over terrain that could not be traversed on foot due to excessive sinkage.

III. EXPERIENCE AND CAPABILITIES

A. Corporate

The Studebaker Corporation is the oldest manufacturer of wheeled vehicles in the world. Its progressive engineering and quality of manufacturing, unique in the field, is well known, and reflects the experience gained throughout these years.

The present staff has, during and since World War II, designed, developed, and produced, in addition to the commercial line of cars and trucks, such items for defense as the light track-laying-vehicle known as the "Weasel" and a wide variety of military trucks and special-purpose vehicles. Mass production of reciprocating and turbine aircraft power plants has also been accomplished.

Numerous special and classified assignments have been performed for the Air Force, the Army Ordnance and Signal Corps, and the Office of Scientific Research and Development. Much development work was done on a 5000 h. p. liquid-cooled aircraft engine which was subsequently terminated by cessation of hostilities. The Studebaker proving ground served as the test sight for many types of armored cars, mobile gun mounts, and meteorological equipment.

In both World War II and the Korean Conflict, Studebaker planned and executed the acquisition and installation of facilities and machine tools, developed new sources of supply, originated and/or processed engineering changes, carried out the mass production and precision assembly required by the supply contracts, experimented, developed and performed special services for the Government, met delivery schedules and all other requirements in an efficient and businesslike manner.

In the past few years Studebaker has produced approximately 15-20,000, 2-1/2 ton military trucks as a subcontractor for Curtiss-Wright Corporation. Studebaker, as a prime contractor since August 16, 1961, has produced several thousand more of these vehicles.

All of the activities described above have been accomplished at a cost which was either well below, or compared favorably with the cost to the Government of similar services purchased from other contractors.

The Corporation's history demonstrates its ability to produce quality products in accordance with the exacting specifications of the Government, successfully meet delivery schedules, and perform at or below original contract estimates.

The Studebaker Corporation has a most enviable and successful record of performance in all contracts with the Government, either large or small, whether involving engineering development, experimental and research work, or mass production of material.

Prior to the Corporation's reorganization in 1956, its principal commercial activities were concentrated in the automotive field. Subsequent to the reorganization, a program of acquisition and diversification to broaden product lines and provide a more stable operating base has been followed. The Corporation today is composed of several divisions and wholly owned subsidiaries, as shown on Figure 9.

B. Related Projects

1. Turtle Vehicle

Studebaker has built, tested, and demonstrated six prototype vehicles with modifications and improvements as results warranted.

(a) Development of the first Turtle vehicle began in September, 1961, based on evaluation of the Army requirements for a front-line transporter.

Design studies were made for a vehicle to meet all the performance requirements and using only "off-the-shelf" components. Since time was valuable, the program for this vehicle was placed on a "hurry-up" basis and it was developed by using existing equipment and components with the understanding that subsequent design effort would be required.

The first vehicle, Figure 2, was made using a complete engine and transmission package available from Studebaker's Gravely Tractor Division. This Gravely unit provided an air-cooled 4-cycle engine rated at 6.6 hp at 2600 rpm and a transmission consisting of gears and splined shafts which gave two speeds forward and two in reverse. The cargo compartment and hull was fabricated from 18 gage aluminum sheet and 11 gage aluminum reinforcing strips (Figure 3).

The controls for the vehicle were located at each end in order that tests could be conducted with the driving wheels (2) to the front or to the rear. From the test results it was found that the two driving wheels should be forward and use two 24x12x10R Terra Tires and the third wheel to the rear, this being a smooth Terra Tire 12x12x64.

After considerable testing and demonstration, it was learned that the aluminum hull was very susceptible to piercing damage, the over-all weight was too great, maneuverability was not quite what was expected. The cargo area was too small and noise level was too high.

(b) After further design studies were made, it was decided to build and test another prototype using "Expanded Royalite" (a fiber impregnated rubber compound by U. S. Rubber Co.) for the water tight hull but making it basically similar to the previous aluminum model.

The over-all vehicle had basic dimensions of 72"x36"x35" with cargo area of 65"x35". It was three-wheeled (terra tires), with the two forward wheels being powered mechanically with the same Gravely power transmision driven by a light weight 2-cycle engine with a rating of 8 hp at 7200 rpm.

The time spent testing this prototype was rather short due to the fact that under load there was practically no engine life due to piston seizure. Also, the high noise level and smoke, which is characteristic with this type engine, made it impracticable for military use.

Figure 2
Aluminum Body - Dual Controls

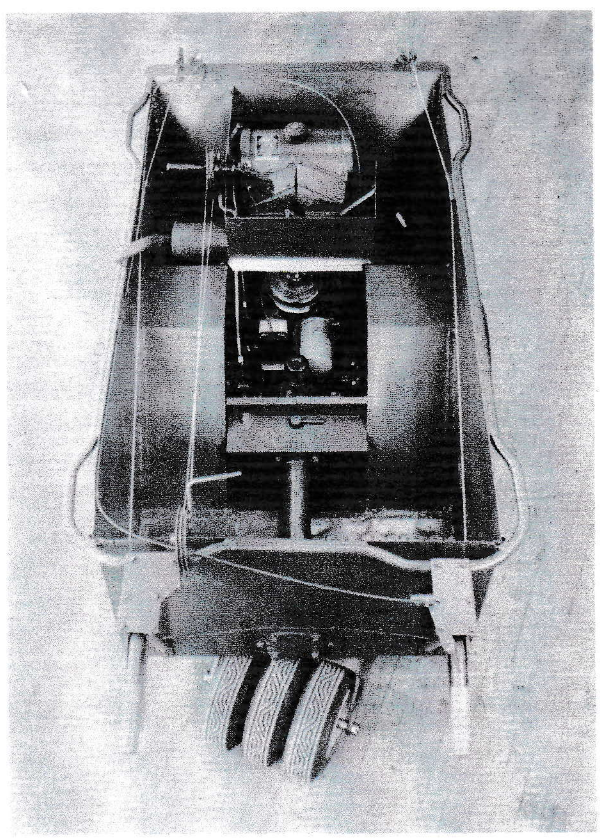


Figure 3
Aluminum Body with Gravely Engine
and Power Unit

(c) The next change came by installing a 4-cycle Onan engine (5.5 hp at 3600 rpm) belt driving the Gravely power transmission with a 1:1 ratio.

Considerable time was spent in test and demonstration of this concept with very good results being shown in maneuverability, slope climbing capabilities, floatability, and load carrying ability (up to 1000 lbs.). However, the engine size in combination with the mechanical transmission was too high and large for the engine compartment, therefore requiring a greater hull height to accomodate this combination. Also, it was determined that the over-all weight (unloaded) of the vehicle and difficulty of access for maintenance in the field made it impractable for a front-line military vehicle.

(d) Based on the experience gained on these prototypes, Studebaker decided to investigate the same basic hull design with three wheels (2 powered), but using a hydro-static transmission, to cut down on over-all weight and simplify field maintenance (Figure 4).

Design studies revealed that simple off-the-shelf hydraulic components were available.

A vehicle was built-up using a 2-cycle engine, a variable displacement pump and 2-wheel drive motors (Figure 5).

Basic tests revealed that the vehicle was excellent on load carrying, maneuverability, weight and field maintenance, but the 2-cycle engine would not stand the load, due to the high rpm, and again piston seizure was encountered.

(e) The small size of the hydro-static transmission allows the use of several choices of 4-cycle engine in this engine compartment, so a change back to the Onan AJ series 4-cycle engine was made. See Figure 6.

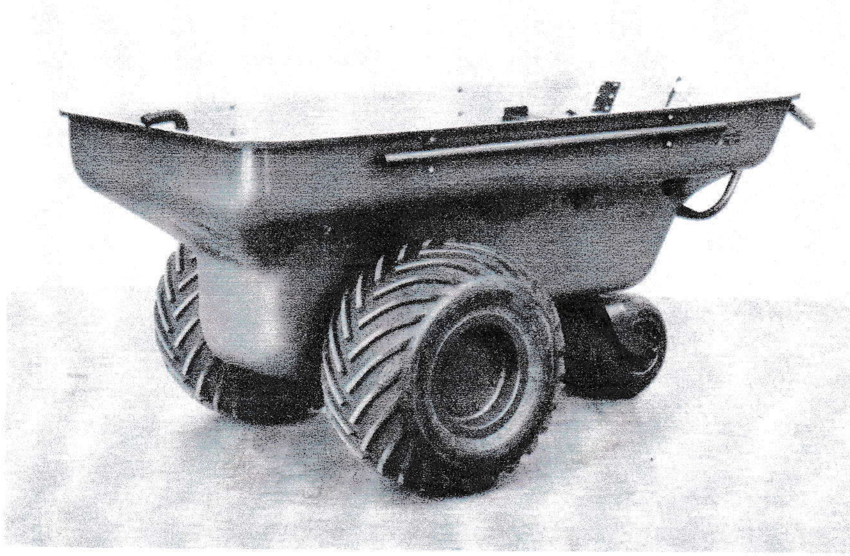


Figure 4

Royalite Body with 2-cycle Engine and
Gravely Power Unit

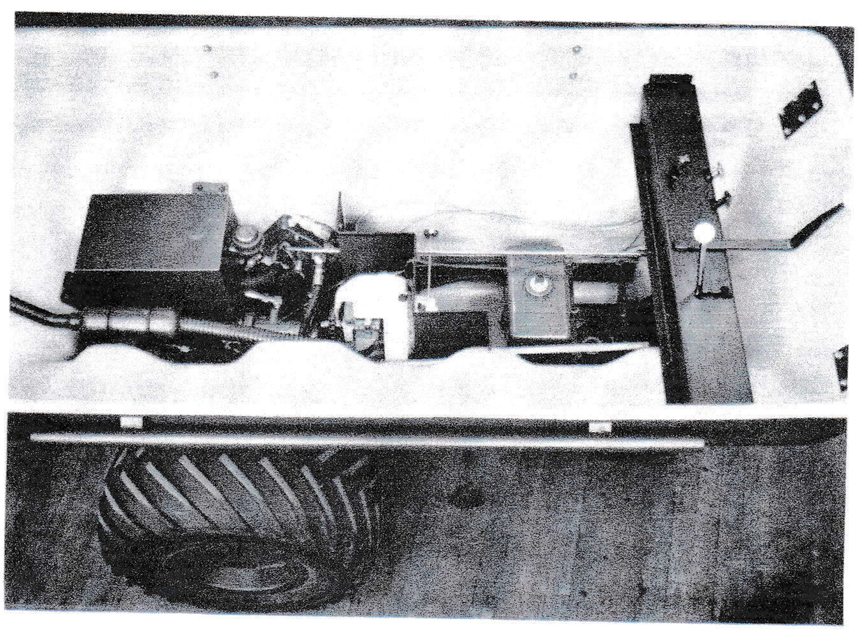


Figure 5

Royalite Body with 2-cycle Engine and
Hydrostatic Transmission

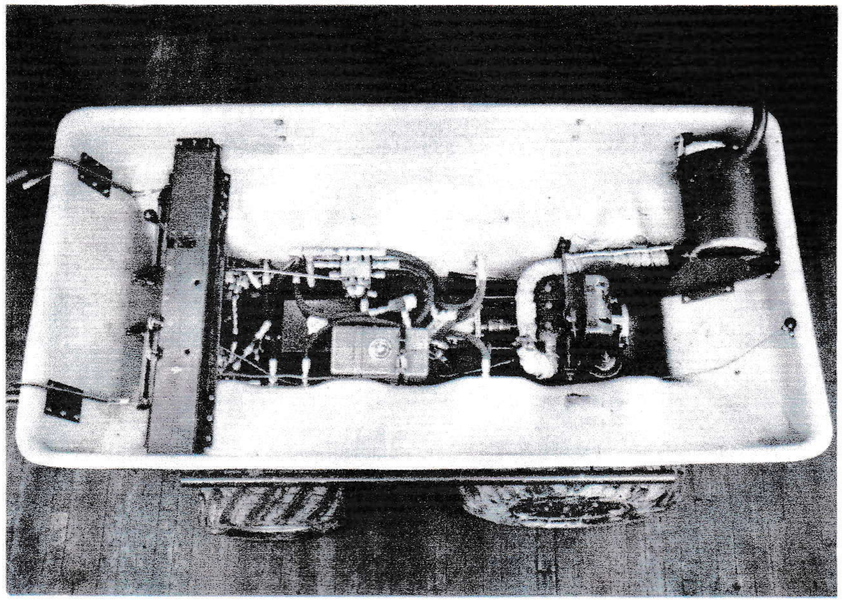


Figure 6
Four Cycle Engine and Hydrostatic Transmission

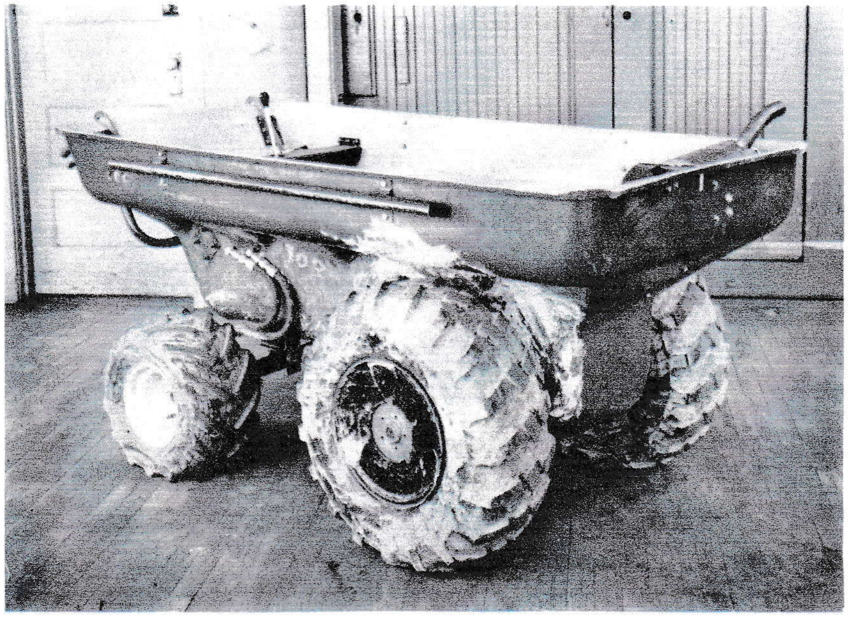


Figure 7
Four Powered Wheel, Hydrostatic Transmission and Four Cycle (after military demonstrations)

Again tests and demonstrations were made in various areas and terrain which showed that we had a vehicle that could accomplish most military requirements. The vehicle had good maneuverability, weight ratio to load, simple field maintenance, standard off-the-shelf components, but the third wheel (caster wheel) caused difficulty in handling and was not in a rolling attitude at all times.

During a demonstration to the military it was determined that four wheels (all powered) were necessary for stability, as well as the need to assure military operating requirements, such as being able to traverse 60% forward slopes and 40% side slopes (Figure 7).

(f) The vehicle now on hand at Studebaker, which has been tested and demonstrated, has utilized four (4) powered wheels with grouser tread tires. (Various tire sizes have been tested to afford good flotation and traction comparable to the 24x12x10R Terra Tire and still allow for a lower tire cost in comparison with the Terra Tire. The results of these tests have brought us to the use of 27"x 10" tire with a grouser tread.) Also, during this test period the vehicle body was subjected to hot and cold impact tests in the Studebaker engineering lab with the results being that this hull construction can stand -40° F. to +160° F. without any physical damage. These results indicate that this prototype will accomplish most military requirements desired in this type of front-line transporter.

SUMMARY:

The following data summarizes the present "Turtle" vehicle design, Figure 8.

a. Hull - Expanded Royalite
b. Engine - 4 cycle, 7.25 hp at 3600 rpm (standard engine).
c. Transmission - hydro-static (off-the-shelf component)

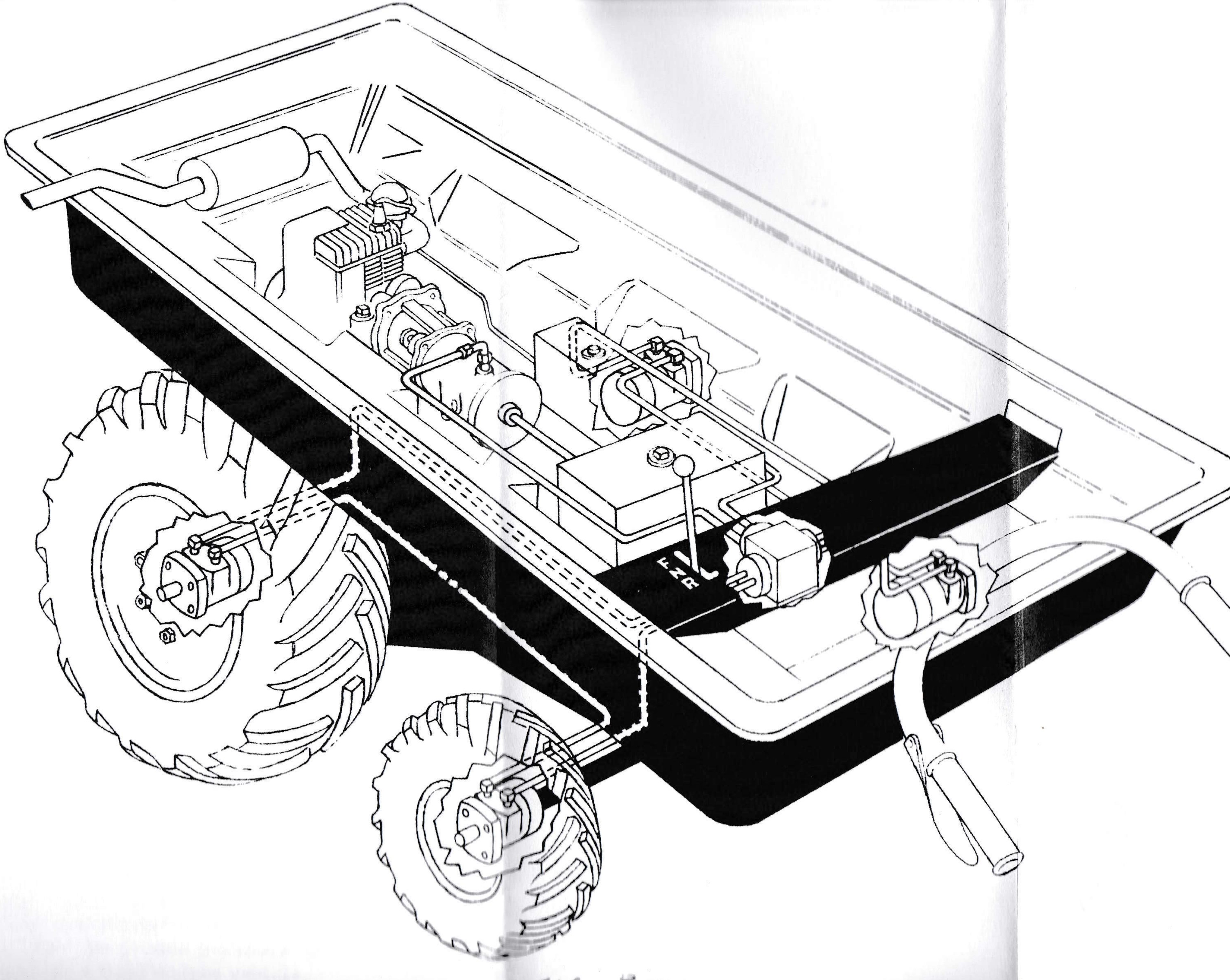


FIG. 8

d. Control - speed governed by pump displacement which is adjusted by motorcycle type throttle in handle bar grip.

e. Tires - 27 x 12 x 10 front
- 9:50 x 8 rear

f. Steering - bicycle type handle bar arrangement that links rear axle pivot to two (2) bevel gears, one of which is integral with the handle bar for turning. This also actuates the hydraulic valve from open to closed to open position and allows for flow changes to each set (left or right) of wheel motors.

g. Weight - 300 to 315 pounds.

h. Payload - 500 to 750 pounds.

i. Speed - 10 mph maximum
4 mph normal
2-4 mph in water

j. Gradeability - 60% forward slope
40% side slope

B. (2) Development Experience of Tracked Amphibious Carrier - Weasel.

During World War II, Studebaker developed on a crash basis a small amphibious personnel carrier which was originally intended for use in snow covered Arctic regions. This program was closely coordinated between Studebaker and the mobility experts at Aberdeen Proving Grounds. It was recognized early in the program that low ground pressure tracks would be necessary to allow performance over the snow. The results of this development was the Weasel as produced in quantity (some 15,000) by Studebaker. The Weasel proved to be an extremely good vehicle not only for the original purpose, but also for swampy, muddy, or any soft terrain. The track development was the principal contributor to the outstanding performance of this vehicle. The low ground pressure of 1-1/2 psi obtained by using a wide track on a light weight vehicle, together with the aggressive grousers, gave performance that is just now being equalled by newer vehicle designs.

During the Korean Conflict, Studebaker did some further development work on Weasel type vehicles. The Army's primary interest at this time was in larger vehicles. The scale up of the Weasel for these larger vehicles did not carry a commensurate increase in track area so that mobility suffered. Later extensions of this program, at another company, led to the development and production of the M116 vehicle which was intended to be the replacement for the Weasel, but is now considered too large for this objective.

Many of the features and principles developed during the Weasel program are still good today. This knowledge is still available at Studebaker and will be utilized for this vehicle. Mr. H. E. Churchill was in charge of Weasel development and is active as a consultant to the Corporation. Other members of the original Weasel team are also available for consultant purposes.

C. Facilities and Equipment

Production Facility

The vehicle being proposed for manufacture and assembly by the Studebaker Corporation would have the work accomplished in the Automotive Division Experimental and Engineering Shop. This area is located in the Engineering Building and has a work space of approximately 50' x 90' to be used for this prototype build-up.

The personnel assigned to this area each have over 20 years of experience doing this type mechanical and fabricating work. Also, the engineering experimental and machine shop, and certified welding area, which is located adjacent to the build-up area, will fabricate all the Studebaker manufactured parts.

Test Facility

The following laboratories, which provide support to all research and development activities in the South Bend Complex, will be used as a test area for the proposed vehicle.

1. Mechanical Laboratory --- This laboratory provides the test facility and equipment for evaluation and destructive testing (both load-

deflection and resonant) for all components, such as brake systems, clutch mechanisms, steering systems and other miscellaneous components, supports, hinges, etc.

2. Low and high temperature test Laboratory - Temperature testing operations from — 50° to +185° are accomplished in this laboratory. Also included in this facility is an electrically controlled dynamometer roll.

3. Proving ground -- This test facility is layed out to simulate all types of terrain, both on and off road, and/or road surface conditions that may be encountered by any vehicle. The following listed areas would be used for test and evaluation of the proposed vehicle:

   a. Grades - 12%, 15%, 30% and 60%.

   b. Side Slopes - 20%, 30% and 60% -- all concrete.

   c. Fording Basin - 72" maximum water depth.

   d. Cross-country roads - approximately seven (7) miles of unimproved cross-country roads, trails, and off-road brush and trees, slopes, grades. (This area was used during 1943-1945 for test of track-laying and multiple drive military vehicles.)

Equipment

The equipment to be used for fabricating the proposed vehicles is listed as follows and is now on hand:

1. Assembly cradle for holding body.

2. Overhead chain falls.

3. Bins for subassembly storage by part number

4. Body mold.

5. Track assembly tools and fixture.

D. Project Management

It is recognized that the design, construction, and testing of the "1/4 ton payload capacity cargo load carrying device" is a small, short term R&D project that could get lost in a large organization unless the necessary steps are taken to insure expeditious handling. Studebaker will assign this project to the Applied Research Division, a corporate staff organization. A project engineer/manager will be placed in charge of the complete program to assure that the project is accomplished in an efficient and expeditious manner.

The project engineer/manager system of management will accomplish these objectives:

1. Provide centralized control of establishment of the plans and schedules for insuring accomplishment of the design, fabrication, and testing within the time and funds of the contract,

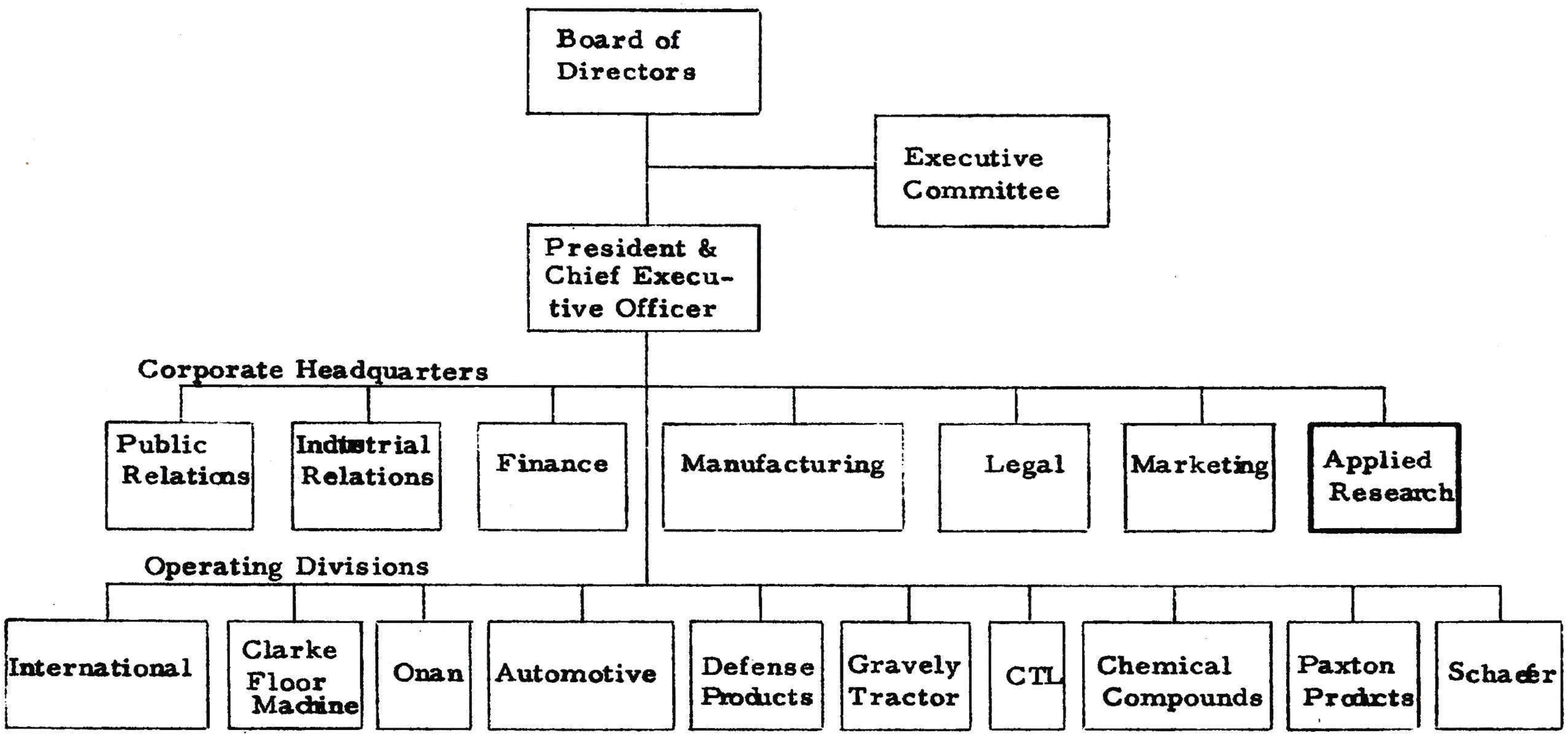
2. Provide a direct channel for communication with the procuring agency, thus assuring rapid response to technical and/or management direction.

3. Provide direct controls of the project that will assure adherence to the schedules and estimated costs by early detection and timely resolution of problem areas.

4. Provide the means to monitor and implement changes in personnel strength required for the various phases of the project.

The implementation of this management system can best be understood by examining its position in the over-all organization. The Studebaker Corporate Organization, shown on Figure 9, consists of the Corporate Headquarters and the Operating Divisions. Each division operates as an entity with its own products and program management. Approximately 11,000 persons are employed throughout the Corporation. Each division manager reports and is accountable directly to the president of the Corporation.

The Applied Research staff was established to bring the technological advances of today's "space age" to Studebaker's civilian and military customers. The staff is composed of scientists and engineers



STUDEBAKER CORPORATE STRUCTURE
FIG. 9

with experience ranging from ballistic missiles and spacecraft to commercial trucks to construction machinery. This staff has technical and managerial capabilities to supply a strongly directed well organized program on this project without interference with other work. The organization is shown on Figure 10. The project engineer/manager reports to the Chief of Applied Research and has the authority and responsibility to direct all activities of the assigned project. Individuals assigned to this program by their parent organization receive all project direction from the Project Engineer/Manager and are accountable to him for program performance. These individuals continue to receive policy and administrative direction from their parent organizations.

The project organization is shown in Figure 11. The Project Engineer/Manager will integrate and coordinate all functions to assure over-all program performance. This will entail executing these duties and responsibilities:

1. Represent Studebaker to the government procuring agency on all matters effecting the project.

2. Establish the plan for design, fabrication, and test of the device.

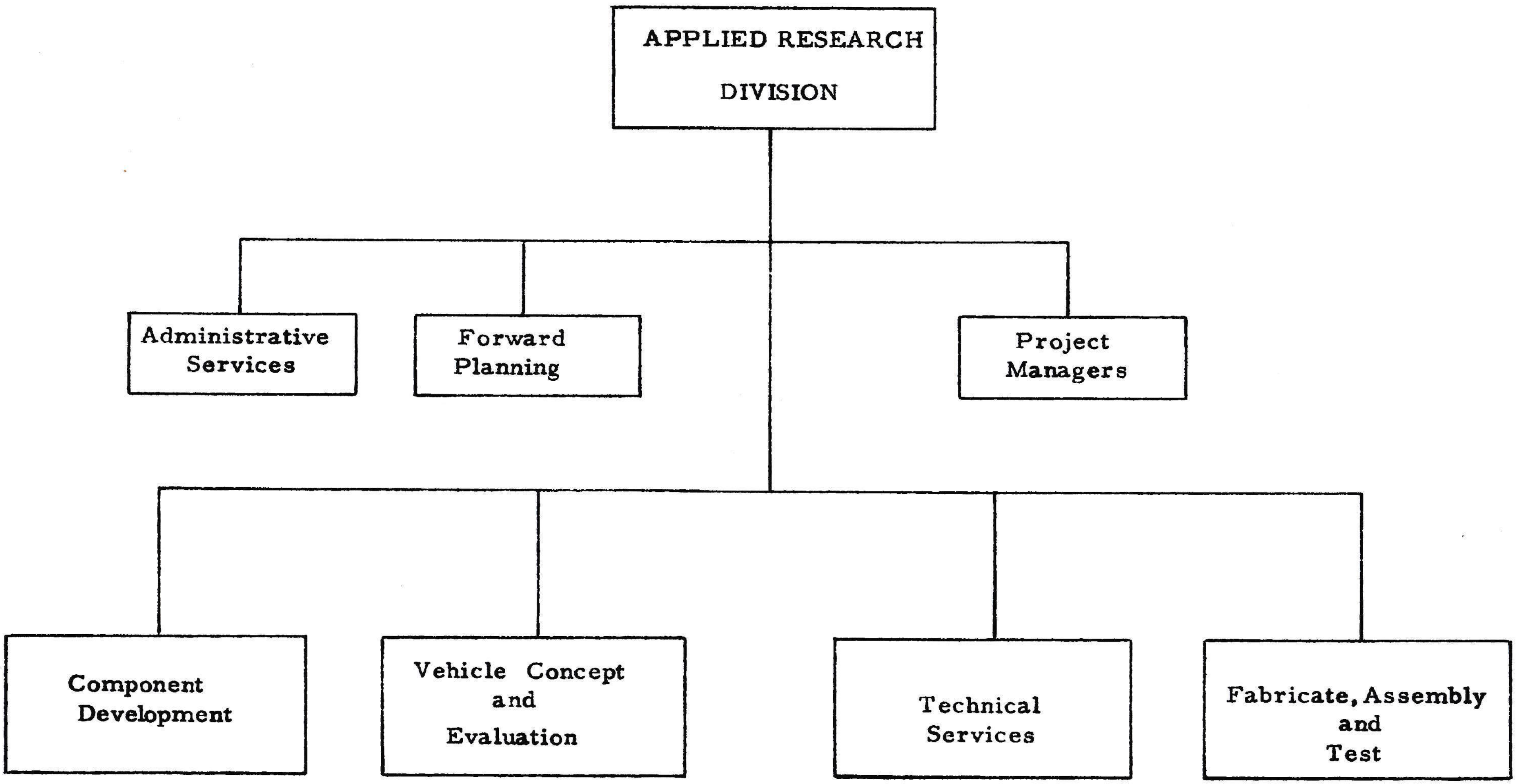
3. Implement and direct the accomplishment of the plan.

4. Exercise effective surveillance and control over program activities including schedule and cost performance.

5. Establish and implement the system for creating and supplying the reports and drawings to the procuring agency.

6. Provide program policy and direction for functional line organizations.

The design activity will be closely supervised by the Project Engineer/Manager and will be accomplished by the services of an engineer, a layout designer and detailer assigned to the project for the period indicated by the schedule. Subsequent phases of the project will be similarly supervised by the Project Engineer/Manager, who will be assisted as needed by an assigned



APPLIED RESEARCH DIV. ORGANIZATION

FIG. 10

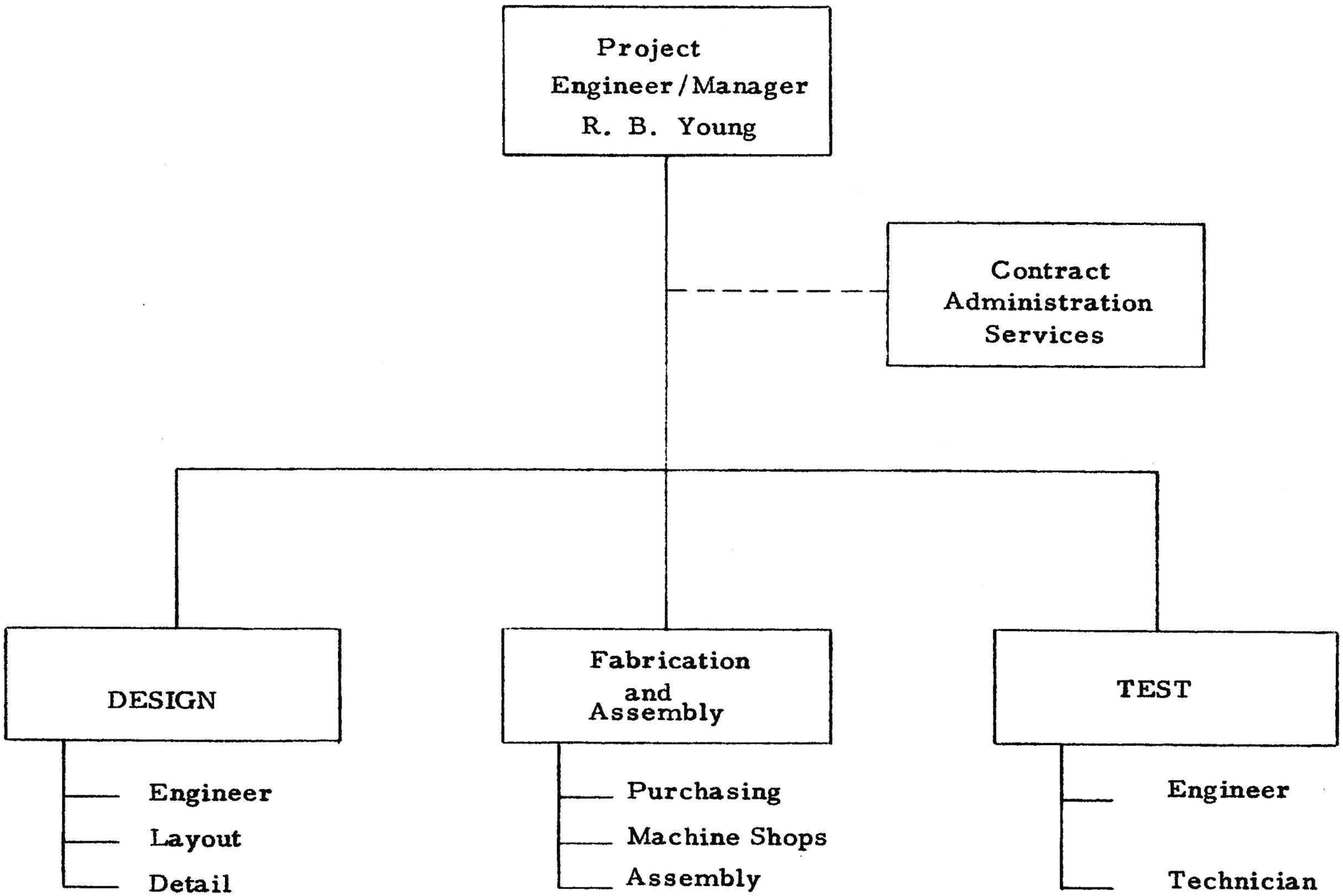

Project
Engineer/Manager
R. B. Young
Contract
Administration
Services
DESIGN
Engineer
Layout
Detail
Fabrication
and
Assembly
Purchasing
Machine Shops
Assembly
TEST
Engineer
Technician

FIG. 11

purchasing agent, by the experimental machine shop, and the experimental garage for assembly of the vehicles. Testing will be accomplished at the Studebaker Proving Grounds by an experimental engineer and mechanic-technician.

E. Personnel Resumes

The following persons will be responsible in the management and engineering activities of this project. Mr. R. B. Young will direct the project as engineer/manager. Mr. M. J. Isley is responsible for all activities of the Applied Research Division. Mr. K. W. Parsons will be available on a part time basis for design and development consultation and assistance.

R. B. Young - Research Engineer

Mr. Young has over ten years experience in research, production engineering, and manufacturing engineering in both aircraft and the automotive fields. His engineering and manufacturing experience was in the automotive field at Chrysler Corporation on the 3-speed automatic transmission, and production engineering experience in aircraft at Lockheed of Georgia as production Engineer of the Controls and Equipment Group on the C-130 aircraft. Mr. Young was formerly Chief Product Engineer for Curtiss-Wright Corporation's J-57 jet engine division. At Studebaker Corporation he has 1-1/2 years experience as Project Engineer/Manager for the "Turtle" program, with complete responsibility for design, fabrication, testing, and demonstration to the military. He spent eleven years in the Service, attaining the rank of Captain in the U. S. Army Ordnance Corps, with 2-1/2 years spent at Aberdeen Proving Ground. Mr. Young is a member of the SAE, AUSA, and American Ordnance Association.

M. J. Isley - Chief of Applied Research

Mr. Isley has over 30 years experience in engineering research and development of automotive products, aircraft engines - both turbine and reciprocating, air conditioning equipment, and ballistic missile systems. The missile experience included management responsibility for the development and production of special vehicles for ground support of two weapon systems. Technical work in the automotive field has included fluid dynamic, heat transfer and mechanical developments for brakes, engines, heating and ventilating, steering, and torque converters.

In his present position Mr. Isley is responsible for developing advanced ideas into useful products for the Corporation's military and commercial vehicles and other products.

Mr. Isley has both a Bachelor's and Master's degree in Mechanical and Automotive Engineering. He is a member of the Society of Automotive Engineers and the American Ordnance Association.

K. W. Parsons - Research Engineer

Mr. Parsons has twenty-six years of experience in engineering, having contributed basic designs in dairy equipment, photo-mapping equipment, fork-lift trucks, and light weight metal structures for aircraft. His specialty is automotive chassis design and development, including frames, exhaust and fuel systems, brakes, wheels, and tires, having designed these components for several models for four major manufacturers. He has participated in noise and vibration elimination studies in connection with the introduction of several unitized new cars, and has supervised several government contracts for trailers. Recently, he was supervisor for research and development of the design and testing of a line of commercial trailers. Mr. Parsons received his BSME and Administration and has been a member of the Society of Automotive Engineers since 1950.

IV. SCHEDULE

The proposed preliminary design phase covers approximately four weeks of design, layout, and detailing. The report of the first phase will be presented to the Contracting Agency. After an agreement between Studebaker and the Contracting Officer on desirable features of the preliminary design has been reached, work will proceed on the final design. The final design will be completed by the seventh week, at which time the final design report will be submitted.

Fabrication of the prototype will begin in the eighth week after final decisions, although the long lead-time item procurement will have begun earlier. Final parts procurement will be complete in time for the beginning of assembly of the prototype during the fifteenth week.

Final assembly of the prototype will be finished by the beginning of the seventeenth week, which will allow a week of test trials during the seventeenth week, after the go-ahead. Modifications, as indicated, can be completed and retest in the twentieth week.

Representative tests suggested to prove compliance with requirements are outlined in the test procedure.

During the twenty-first week, close liaison between Studebaker and the Contracting Officer and his project engineer will assure that the vehicles are built to specifications, so that final test runs for acceptance during the twenty-second and early part of the twenty-fourth weeks can be made.

Acceptance will be accomplished the twenty-fourth week.

The accomplishment of this schedule will be attained by the efforts of the Project Engineer/Manager with the part time assistance, at the times indicated by the schedule Figure 12, of an engineer, a layout draftsman, a detailer, and an experimental mechanic. The estimated time for each of these is ---

Engineer	590 hours
Layout Draftsman	220 hours
Detailer	120 hours
Experimental Mechanic	210 hours

1/4 TON VEHICLE

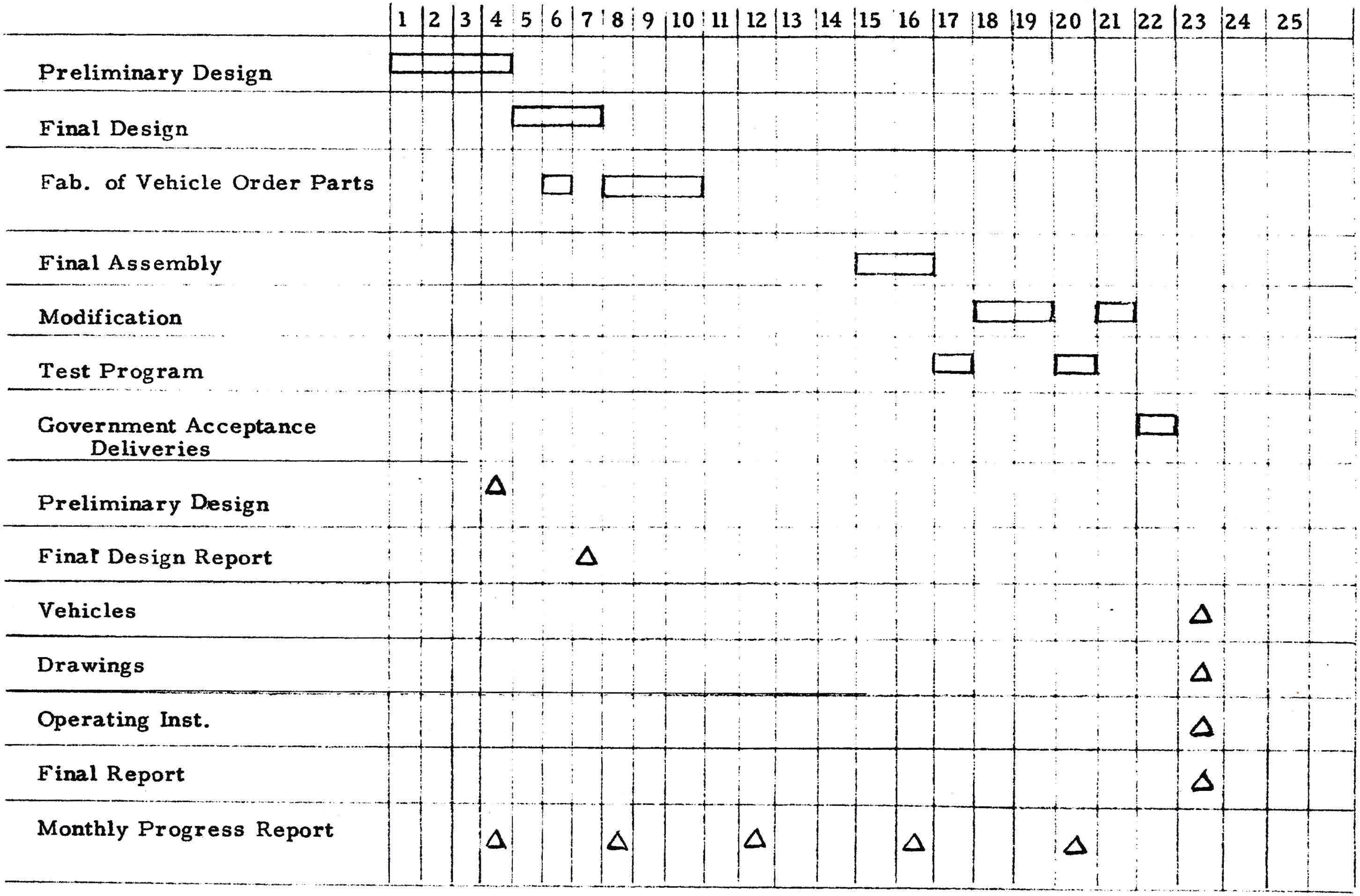


FIG. 12