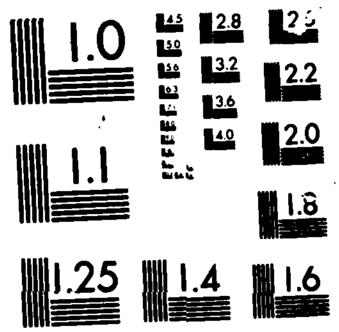
AD-A165 729 BURIAL OF UNDERSEA PIPES AND CABLES UNDERSEA TRENCHER CARRIER PART 2 CARR..(U) NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON DC CHESAPEAKE.. R LISTON 1976 1/1

UNCLASSIFIED CHES/NAVFAC-FPO-7620-PT-2 F/G 13/3 NL



MICROCOPY RESOLUTION TEST CHART

FPO
7620

AD-A165 729

1

Burial of Undersea Pipes and Cables

Undersea Trencher Carrier

Part II

86 3 18 015

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

AD-A165 729

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION AVAILABILITY OF REP. Approved for public release; distribution is unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER FPO 7620	5. MONITORING ORGANIZATION REPORT #
6a. NAME OF PERFORM. ORG. 6b. OFFICE SYM U.S. Army Cold Regions Research & Engineering Laboratory	7a. NAME OF MONITORING ORGANIZATION Ocean Engineering & Construction Project Office CHESNAVFACENGCOM
6c. ADDRESS (City, State, and Zip Code)	7b. ADDRESS (City, State, and Zip) BLDG. 212, Washington Navy Yard Washington, D.C. 20374-2121
8a. NAME OF FUNDING ORG. 8b. OFFICE SYM	9. PROCUREMENT INSTRUMENT INDENT #
8c. ADDRESS (City, State & Zip)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT # PROJECT # TASK # WORK UNIT ACCESS #

11. TITLE (Including Security Classification)
Burial of Undersea Pipes and Cables: Undersea Trencher Carrier Part II, Carrier Vehicle Design

12. PERSONAL AUTHOR(S)
Ronald Liston

13a. TYPE OF REPORT	13b. TIME COVERED FROM TO	14. DATE OF REP. (YYMMDD)	15. PAGES
		76	23

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if nec.)
FIELD	GROUP	SUB-GROUP	Pipes, Cables, Underwater construction Trenchers

19. ABSTRACT (Continue on reverse if necessary & identify by block number)
Operating Requirements for Trencher Carrier: The proposed operating environment for the vehicle includes a remarkable collection of challenges ranging from extremely soft soil to coral to rocky coast lines. The first design reaction to meet these requirements is to rely on displaced (Con't)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT SAME AS RPT.	21. ABSTRACT SECURITY CLASSIFICATION
22a. NAME OF RESPONSIBLE INDIVIDUAL Jacqueline B. Riley	22b. TELEPHONE 202-433-3881 22c. OFFICE SYMBOL

DD FORM 1473, 84MAR SECURITY CLASSIFICATION OF THIS PAGE

BLOCK 19 (Con't)

water for buoyancy and simply drift over the rough spots. However, the demand that a significant drawbar pull be available for the trenching operation eliminates buoyancy as an aid to mobility. The design concept was required therefore, to meet many of the constraints acting on its land-based counterparts and , in addition, accommodate additional constraints unique to the undersea environment. The various operating requirements and other criteria discussed in the following with appropriate comments concerning either the impact of the requirement or ways in which the requirement restricts design options.

Keywords: seabottom crawlers; automatic carriers,

(1)

Burial of Undersea Pipes and Cables

Undersea Trencher Carrier

Part II

Carrier Vehicle Design

Ronald Liston

U.S.Army Cold Regions Research and Engineering Laboratory

for

1976

Naval Facilities Engineering Command

CONTENTS

1. Introduction

1.1. Existing Sea-bottom Crawlers: The development of devices to operate on or close to ocean bottoms is by no means a recent activity. Simon Lake, who was a leader in the development of submarines, was also a forerunner in the construction of successful sea floor vehicles beginning in the mid-1890's. His early efforts, and those of others, had goals that apply to current programs: submarine salvage, mining, harvesting of marine products, laying submarine foundations, dredging, excavating, and scientific exploration. The machines built by Lake were semi-submarines depending on displaced water for buoyancy and on wheels for directional control and part of propulsion forces. Design emphasis was shifted at an early date to submarines for both military and exploratory applications with the result that few, if any, sea floor vehicles were built between the early 1900's and the 1960's when damage to transatlantic telephone cable prompted the development of systems to bury cable.

An answer to the cable burying problem developed and used successfully by Bell Telephone, was the Bell Sea Plow. This vehicle used four sled runners for support on the sea bottom and depended on a tow cable for propulsion. The plow buried cable in a 4-inch wide, 28-inch deep trench. The vehicle and plow system was obviously not designed to bury the cable in surfaces consisting of hard materials such as rock or coral, although it may have been feasible to use the sled as a carrier and replace the plow with a rock cutting device.

A device similar in concept to Bell Sea Plow is the Harmstorf Sled which was built for operation in the North Sea. This sled is much larger than Bell's and relies on wheels rather than runners for support. However, it is similarly propelled by means of a towing cable. The apparatus to bury cables is distinctly different in that it depends on high pressure water jets to create a fluidized trench into which the cable sinks because of its weight.

There have also been several recent attempts, with varying degrees of success, to develop self-propelled sea floor vehicles. The carrier portion of the Remote Underwater Manipulators (RUMs I and II) utilized the off-the-shelf suspension system of the Army's M56 personnel carrier and the Marine Corps' Ontos. The two versions of the RUM were in reality the same basic vehicle which appeared as RUM and later, after renovation, as RUM II. The vehicle was built for the Scripps Institution of Oceanography and received mixed reviews with the strongest criticism directed at its inability to cope with sea-bottom obstacles. Despite its drawbacks, the machine was considered to be successful enough to be considered a prototype for follow-on sea-bottom crawlers to serve in a variety of roles.

The Seacat built either by or for California Eastern Engineering was somewhat similar to the RUM II but used a heavier tracked suspension system. The suspension appears to be equivalent to that of a Caterpillar D-7 tractor. Details concerning the Seacat are sketchy so that its degree of success is a matter of conjecture. However, judging from photographs, the automotive components appear sound.

The British proposed a rather sophisticated 4x4 wheeled Heavy Duty Sea Bed Work Vehicle in the late 60's. The vehicle was to use 8-foot diameter, 3-foot wide, watertight, individually suspended wheels. The proposed dimensions of the vehicle were an impressive 44 feet long, 20 feet wide and a deck height of about 12 feet. The very large dimensions coupled with an ingenious system of varying wheel loading were hoped to provide a high level of mobility.

The Tracked Diving Bell is a unique vehicle of limited application but considerable interest. The bell is neutrally buoyant and has continuous chains mounted on each side of the vehicle. The chains lie partially on the sea floor and are driven in a mode similar to a track by sprockets located at each corner of the craft. The amount of chain lying on the sea bottom is controlled by the buoyancy of the bell. The more chain lying on the bottom, the more traction that can be developed. The idea is most interesting but is only useful in providing modest levels of traction so that it cannot be of much use as a trencher carrier.

The Komatsu Underwater Bulldozer, which is in reality an underwater tractor with a bulldozer blade as one of its attachments, is similar in perfomance, size, and function as the undersea trencher carrier. It is too large to fit into a C141 since it is 28 feet long, 12.6 feet wide, and 9.5 feet high, thus exceeding both the width and height limits of that aircraft thereby eliminating it as a candidate trencher carrier vehicle. The vehicle has apparently performed successfully, if not extensively, in depths up to 197 feet. During the period March 1970 to August 1973, the vehicle operated in four different locations for a period of not more than six months. The Underwater Bulldozer is evidently a straightforward conversion for sub-surface operations of a conventional land tractor and its apparent success is encouraging to the idea of utilizing off-the-shelf components.

A similar approach was taken by the Naval Civil Engineering Laboratory in their solution to the undersea trenching problem. They modified a Vermeer T-600 unit by replacing the diesel engine with a hydraulic motor and were able to operate with some success. The operating difficulties that have been attributed to the system involve vehicle size relative to that of obstacles encountered rather than to crippling mechanical problems.

1.2. Operating Requirements for Trencher Carrier: The proposed operating environment for the vehicle includes a remarkable collection of challenges ranging from extremely soft soil to coral to rocky coast lines. The first design reaction to meet these requirements is to rely on displaced water for buoyancy and simply drift over the rough spots. However, the demand that a significant drawbar pull be available for the trenching operation eliminates buoyancy as an aid to mobility. The design concept was required, therefore, to meet many of the constraints acting on its land-based counterparts and, in addition, accommodate additional constraints unique to the undersea environment. The various operating requirements and other criteria will be discussed in the following with appropriate comments concerning either the impact of the requirement or ways in which the requirement restricts design options.

1.2.1. Operating Depth: The vehicle will be required to operate at water depths to 150 feet. In that the Komatsu machine performed in water more than 190 feet deep, no extreme mechanical problems appear to be associated with operations at 150 feet. The hydraulic systems will be operating at pressures high enough that ambient water pressures can be ignored. The fact that scuba divers can operate at 150 feet has double significance: 1) the pressures are not so severe that sealing water out, if necessary, is of particular difficulty and 2) on-board control of the vehicle will be possible although it may be necessary for the operator to use conventional diving gear rather than scuba gear during extended operations.

1.2.2. Power: Adequate vehicle power must be provided to permit an embedment speed of at least 2 feet per minute and a transit speed over typical beaches of 50 fpm. To establish power needs, the maximum drawbar pull that must be provided was established as 16,000 pounds. In addition, the beach slope was as great as 02%, a figure which seems very low based on observations of sandy beaches. A more realistic number of 25% slope was taken to compute power requirements.

1.2.3. Soil or surface conditions: It was assumed that three sets of conditions would represent the extremes of surfaces to be anticipated: a weak silt-like material; a hard, undeformable, rock surface; and a typical beach sand.

The weakest silts that have been measured on ocean bottoms have a zero friction angle and a cohesion of 0.5 psi. Using the Terzaghi bearing capacity equation, it was established that this material would have a bearing capacity of 2.6 psi. A nominal wheel or track loading much in excess of 2.6 psi would result in sinkage until other elements of the suspension or vehicle came in contact with the soil surface to provide additional support.

The sand was characterized by the following parameters:

(Bekker) $k_c = 0$ $k_\phi = 4$ $n = 0.77$

(Coulomb) $c = 0$ $\phi = 35^\circ$ Density $= \gamma = 0.6$

(Terzaghi) $N_c = 60$ $N_q = N_\gamma = 40$

The coefficient of friction between the rocky surface and the steel track was assumed to be 0.3.

1.2.4. Geometric Obstacles: There appeared to be a distinct difference between oral comments by some knowledgeable Naval personnel and the written statements of obstacle severity. The written requirement established a need to negotiate a five-foot wide, three-foot deep trench and to climb a one-foot vertical step. Oral representations of expected surface obstacles were of ten-foot wide, deep trenches and of huge boulders strewn in a vehicle's path. It is evident that two sets of obstacle crossing requirements may be needed: one set appropriate to vehicle operation while trenching is in progress and a second set for the trencher in a raised position. For example, the five-foot wide trench would require about a fifteen-foot long vehicle to accommodate both the trenching operation and trench crossing while crossing the trench without concern over vehicle attitude would be possible with a ten-foot long vehicle.

A rather similar argument can be made concerning the vertical obstacle. To absorb a one-foot vertical rise without affecting the trenching operation would require a relatively large vehicle. If vehicle attitude were not a factor, five-foot vertical obstacles could be and have been negotiated by some articulated vehicles with ease.

Side slope operations were not addressed at all in the statement of requirements and it is assumed the trenching operations would not be conducted on side slopes. It is evident that even modest side slopes would pose serious, unplanned loading on the trenching apparatus and could result in damage or stop the trenching operation.

1.2.5. Other Requirements:

1.2.5.1. The vehicle and supporting equipment must be transportable in a C-141 or larger aircraft. The loading opening of the C-141 is 123 inches wide and 109 inches high. The maximum payload is 170,493 pounds.

1.2.5.2. The system is to be capable of trenching through a four-foot surf. Initially, this appears a relatively modest requirement until it is recognized that the trenching operation is not at the mercy of weather and the surf area can be avoided until conditions are the most favorable. It is recognized that some circumstances may require that surf in excess of four feet may have to be negotiated, although not while the trencher is in operation. Therefore, the operator station on the front unit should provide protection to the operator in such a way that he is safe from the surf and cannot be dislodged from his position and thrown into the path of the second unit.

1.2.5.3. It is required that the vehicle and its components utilize existing technology. Neither time nor funds are available for the development of new technology.

2. Proposed Vehicle Concept

2.1. General Description of Vehicle: The combination of a good soft soil performance requirement, the ability to negotiate severe geometric obstacles, and the modest forward and maneuver speed requirements led to the selection of an articulated concept. Several wheeled vehicle configurations were considered but rejected because of the soft soil performance requirement. The introduction of the radial ply tire allows wheeled vehicles to operate at very low inflation pressures, nonetheless, excessively large diameter wheels would be required to provide sufficient contact area to support the vehicles. In addition, the low spring rates associated with soft tires would be incompatible with the operation of a trenching device which makes a stiff, uncompliant suspension desirable. Finally, the problems involved with the operation of pneumatic tires in deep water have not been examined and would likely not be solved using off-the-shelf hardware.

Thus, the decision to opt for a tracked suspension was reached — based as much on the problems surrounding use of wheels as on the advantages of tracks. However, the tracked suspension, despite its high initial and operating costs and its complexity, does have several characteristics which make it a particularly attractive match with the articulated vehicle form. Perhaps the most significant factor is the ability to use optimum track geometry. Both theory and experience have established the fact that a long, narrow contact area with the long axis oriented in the direction of vehicle motion is capable of producing a given traction level with minimum motion resistance. However, when using skid steering, the length-to-width ratio of tracked vehicles is restricted to 2:1 or less. When articulated steering is used, the length-to-width ratio becomes controlled by other considerations which normally become operative well after the optimum soft soil performance has been achieved.

In addition to good soft soil performance, the tracked suspension allows a relatively low configuration for a given amount of track on the ground. Finally, when coupled with a means to control the pitch attitude of the two units of an articulated vehicle, the tracked suspension has a remarkable ability to negotiate rough terrain. It is evident that a variety of reasons drove inexorably to the selection of a tracked, articulated vehicle having an articulation joint that included positive control of the intra-vehicular pitch and yaw angles.

The proposed vehicle concept is depicted in Figure 1 in a semi-schematic form. The concept is based on the Model 200 logging vehicle manufactured by the Food Machinery Corporation (FMC). After wheeled vehicle concepts had been rejected, available tracked systems were investigated with the conclusion that military or military-like vehicles had the greatest potential of meeting the performance requirements of the sea-bottom crawler. A primary shared design criterion is the necessity to transport heavy loads over rough terrain. Because the vehicle would have to operate in surf, a low silhouette and minimum hull side area were dictated. Initially, the M113 Armored Personnel Carrier appeared an excellent candidate since it has a long production life, leading to a high degree of reliability and, in addition, because of the extensive use of the vehicle, spare parts would be available well into the forseeable future. Discussions with FMC engineers responsible for M113 production indicated that the logging vehicle would be a better selection for several reasons: the hull configuration is more adaptable to provide the desired low silhouette; the track contact area is eight inches longer and seven inches wider than that of the M113; except for the differential housing which is magnesium, the suspension, hull, and drive line components are all steel which reduces the danger of corrosion induced by the interaction of dissimilar metals; both the weight and reliability of the components are greater than their M113 counterparts; and, finally, the suspension of the logger vehicle was designed to accept significantly higher loading than that of the M113.

The proposed specifications of the carrier are as follows:

Vehicle Dimensions:

Front Unit: 195" long
103" wide
102" high
40" bed height

Rear Unit: 195" long
103" wide
57" maximum bed height

Distance Between Units: Approximately 70"

Overall Length: 460"

Weight:

Front Unit: Normal GVW: 24,500 lbs.
Maximum GVW: 29,000 lbs. (4500 lbs. ballast)

Rear Unit: GVW: 24,500 lbs.

Track and Suspension:

Type of Suspension: Road wheels suspended by torsion bars, no support rollers, sprocket location either front or rear dependent upon design simplicity. The suspension can have the lock-out system shown in Figure 2 which can provide the completely stiff suspension which may be required when cutting hard rock or coral.

Type of Track: Forged steel grousers, single pin shoe with rubber bushed hinge pin, no track pad.

Track Shoe Width: 22"

Length of Track On Ground: 113"

Area of Track on Ground: 9944 in^2

Ground Pressure: Nominal 4.93 psi

Maximum, Front Unit: 5.83 psi

Road Wheels: Type: Solid Steel

Size: 24.5" diameter

Number per side (each unit): 5

Drive System:

Normal: Each unit driven by a 20 HP hydraulic motor which is fed by means of an umbilical from a surface support barge with hydraulic oil at a pressure of 2500 psi. The drive is through a speed reducer, another standard logger differential and final drive.

Extreme Soft Soil Conditions: The tracks are driven by the hydraulic motors to overcome internal and external rolling resistance while the vehicle is propelled with an on-board winch.

Steering:

The vehicle is steered by means of a hydraulically actuated articulation joint that can be controlled either on-board at the operator station or from a remote site. To assist in remote steering, vehicle attitude sensors will allow monitoring of the pitch angle, the roll angle, and the yaw angle between the two units. In addition a television camera system will permit visual monitoring of vehicle course, bottom profile, and vehicle attitude.

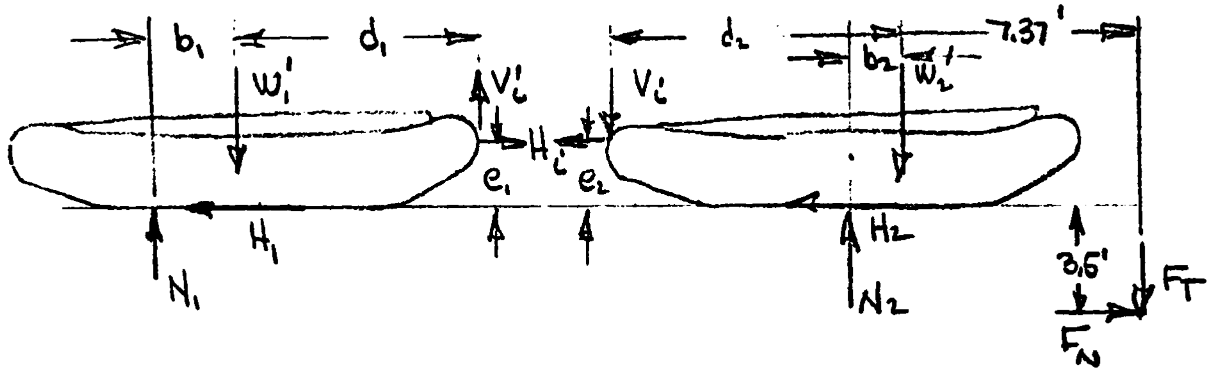
2.2. Description of Articulation Joint: A possible design for an articulation joint is shown in Figure 3. Yaw control is achieved with the yaw cylinders A which force the front and rear units to rotate about the yaw axis. The cylinders can be allowed to float when steering or yaw rigidity is not required. The cylinders have a six-inch bore and are rated at 70,675 pounds push and 58,400 pounds pull at a 2500 psi operating pressure.

The pitch angle between units can be controlled by means of the pitch cylinders B which have the same rating as the yaw control cylinders. The cylinders can serve two functions: 1) raise one unit relative to the other to assist in negotiating geometric obstacles or, 2) fix the units relative to each other so the articulated machine becomes the equivalent of a long, narrow conventional vehicle.

It may be necessary to limit the roll between units but the need is not obvious at this point in time. Roll freedom is provided by the arrangement to attach the joint to the rear unit. A large threaded cylinder, C, is screwed into a threaded plate mounted on the front hull section of the rear unit. The combination of a large diameter, long threaded area should provide both security of attachment and freedom of motion. The opposite end of the articulation joint is attached to the front unit by brackets D and E.

The proposed design is by no means the only way to achieve the desired motions. The design does, however, identify the types of motion that must be provided for successful operation of the trencher carrier.

2.3. Preliminary Design Calculations: A free body diagram of the vehicle-trencher system is shown below.



In completing design details, some dimensions were changed slightly but these changes would have little impact on the final results. The trenching device was moved closer to the vehicle so that the location of the center of gravity of the rear unit may be slightly closer to the bow than calculated. Because a forward shift would be beneficial, the calculations are conservative.

2.3.1. Determination of Required Weight for Each Unit:

Assumptions: Trenching Forces: F_T = 8000 lbs.

F_N = 16,000 lbs.

b_2 = 3.34' (This was to assure that the resultant of the ground reaction, N_2, would act at the geometric center of the contact area.)

d_1 = 8.125' d_2 = 11.465' $e_1 = e_2$ = 4.17'

W_2 = 24,500 lbs. (land weight)

$W'_2 = 0.85W_2$ = 20,825 (submerged weight)

μ = Traction Coefficient on hard surface = 0.3

Equilibrium Equations, Rear Unit:

$$V_i + V'_2 = F_T + N_2$$

$$H_i + H_2 = F_N \text{ and } H_2 = \mu N_2$$

$$H_i(e_2) + V_i(d_2) + F_N(3.5) = N_2(b_2) + F_T(7.37)$$

Solution of these equations using the assumed given above, provides the following results:

H_i = 4360 lbs.

V_i = 9975 lbs.

H_2 = 11,640 lbs.

N_2 = 38,800 lbs.

Equilibrium Equations, Front Unit:

$$H_1 = H_i = \mu N_1$$

$$N_1 + V_i = W'_2$$

$$N1\ b_1 + H_i\ e_1 = V_i\ d_i$$

Solution of these equations gives:

b_1 = 4.33'

N_1 = 14,533 lbs.

W'_1 = 24,508 lbs.

W_1 = 28,833 lbs.

The weights are:

W_1 = 28,833 lbs.

W_2 = 24,500 lbs.

2.3.1. Determination of Power Requirements:

2.3.1.1. Weak Soil

Soil Strength: $e = 0.5$ psi $\phi = 0$

Bearing Capacity: $q = 2.63$ psi

If nominal ground pressure exceeds the bearing capacity, the vehicle will sink until either stronger soild is reached or the belly of the vehicle provides buoyance.

Nominal ground pressure: $p = W/A$

Where A = contact area per unit = 4972 in^2

W = submerged weight of unit = 20,825 lbs.

$p = 4.2$ psi

Thus, the vehicle will sink to its belly; propulsion will be provided by the on-board winch and the normal propulsion system will be used to overcome internal rolling resistance and compaction of the soil.

Compaction Resistance = $R_c = b\ell q$

b = track width = 22 inches

ℓ = track length (taken as a unit length)

q = bearing capacity = 2.63 psi

R_c = 57.8 lbs/inch of travel

$(R_c)_T = 4\ R_c = 231$

Rolling Resistance = R_R = 120 lbs/ton

V = 10 ft/min

$HP = (R_c)_{T/550} \cdot\ V + R_R V/550 = 0.96$ HP

Resistance to towing:

$F = 0.5\ A$ Where A = area of belly = 14,946 in^2

F = 7473 lbs.

Trenching force:

F_N = 8000 lbs.

Total horsepower requirement:

$HP_T = 0.96 + 7473(10)/60(550) + 8000(10)/60(550) = 7.9$ HP

Assume an efficiency or 0.7 so that the total power requirement is 11.3 HP.

2.3.1.2. Power Required for Transiting Beaches at 50 fpm:

strength data of sound

$k\phi = 04.0 \quad n = 0.77 \quad C = 0$

$k_c = 0 \quad \phi = 350$

With maximum land weight:

$W_1 = 28,833$

$W_2 = 24,500$

Nominal contact pressures p_1 and p_2:

$p_1 = 11.6$ psi $\quad p_2 = 9.86$ psi

from $z = (p/k)\ 1/n$ where z = sinkage and $k = k_c/b + k_\phi$

$z_1 = 3.99" \quad z_2 = 3.23"$

Compaction Resistance, R_c/track:

$$R_c = \left[1/(n+1)(b \cdot k_\phi)^{1/n}\right] W/2 \cdot \ell^{(1+n/n)}$$

where ℓ = track contact length = 113 inches

$(R_{c_1})_T$ = Total Compaction Resistance = 234 lbs.

$(R_{c_2})_T$ = 160 lbs

Bulldozing Resistance, R_B/track:

$$R_B = \left[b\ k_\phi/(1+n)\right](z)^{1+n}$$

R_{B_1} = 576 lbs/track

R_{B_2} = 396 lbs/track

Rolling Resistance = R_R = 120 lbs/ton

$(R_{R_1}) = 120\ W_1/2000 = 1739$ lbs

$(R_{R_1}) = 1470$ lbs

Total Resistance = $R_T = R_{R_1} + R_{R_2} + (R_{c_1})_T + (R_{c_2})_T + (R_{B_1})_T + (R_{B_2})_T$

$R_T = 5547$ lbs

Power Required at V = 50 ft/min:

HP = 5547(50)/550(60) = 8.4 HP

Assuming an efficiency of 0.7, the total horsepower requirement is:

HP = 12 HP

Negotiating beach with 25% slope:

HP = W Sine (11.31°) (50)/(550)(60) + 8.4 = 28

with 0.7 efficiency

HP = 40

2.3.1.3 Power Required when trenching on land surface at 2 fpm:

Drawbar Required: 16,000 lbs

Rolling Resistance: (120) 45,335/2000 = 2720 lbs

HP: (2720 + 16,000)(2.)/550 (60) = 1.13

and at an efficiency of 0.7

HP Required = 1.6 HP

Recapitulation:

Condition	Required Horsepower
Soft Soil	11.3
Sandy Beach	12.0
Sandy Beach, 25% Slope	40
Hard Rock	1.6

3. Conclusion:

It is evident that the construction of an automotive carrier that can operate as a sea-bottom crawler is within the current automotive state of the art. Without question, there will be many conditions that will be beyond the capability of the vehicle but those conditions will not come as a surprise. The location of cables to be buried is well known and trenching routes can be clearly identified. Extreme conditions that would prevent trenching operations can therefore be clearly marked and thereby avoided. It may be that some trenching operations may produce conditions of low visibility that can make control difficult. However, the use of hydraulic drive and control systems which permits the use of on-board vehicle controls should minimize operating problems associated with low visibility. All in all, the outlook is clearly optimistic after examining the challenges to the vehicle and the automotive options available to meet those challenges.

END
FILMED
4-86
DTIC