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BALLOON LOGGING WITH THE INVERTED SKYLINE

C. Frank Mosher*

ABSTRACT: There is a gap in aerial logging techniques that has to be filled. The need for a simple, safe, sizeable system has to be developed before aerial logging will become effective and accepted in the logging industry. This paper presents such a system designed expressly on the K.I.S.S. (Keep It Simple Stupid) principle, and with realistic cost and ecological benefits.

INTRODUCTION AND OBJECTIVE

Today, in my mind, we have the best potential mountain-logging system only with balloon transportation techniques. This is particularly true as we are having to face the most difficult and inaccessible areas in this coming generation of logging. With the constant increase in timber value, the requirement of recovering every last fiber of wood is becoming an absolute business and forestry necessity. Mountain-logging is creating serious problems at present, but surely we have the technology and brains to accomplish what has to be done for the future, within a reasonable cost, and within the constantly-increasing ecological requirements.

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I am pleased to have been involved in the old steam-donkey logging operations of the Pacific coast, as well as many other operations in the past 25 years, but to me, balloon logging has now evolved as an essential development for future logging operations. The necessary objective is brutally simple: to lift the full "tree package" off the stump, out of the woods, and down to the landing.

Thinking deeply of the future, it is not logically possible for us to continue to send high-priced cutters or fallers into the mountains to unavoidably shatter 10% to 20%, or more, of the total timber volume on rock bluffs, canyons, stumps and steep sidehills. It is also not possible that we can continue to yard, or drag, the remainder of that volume over similar bluffs, canyons, etc. for another 10% or 20% loss. This waste is far too valuable to be destroyed by slash fires or left to rot. Surely we can do better, and I believe the balloon system can provide us with the means.

Since 1960, when I first started thinking of balloon potential, I have been involved in most of the balloon logging developments, to try personally, as much as physically possible, to insure their relative success. As a result, I have probably accumulated more direct hours of daily balloon logging operation and supervision than anyone I know of. Balloon operations are now working in several areas of the Pacific Northwest, Alaska and Canada. The present system is driven by yarding machines which pull the balloons back and forth with lines known as the mainline and haulback. In rather short yarding distances, this system has worked, and along with the other two main aerial logging systems (skyline and helicopter), it is being utilized to the best of its capability.

Skylines and helicopters are excellent systems for logging in certain areas and under certain conditions, but they now have, and always will have, inherent problems that limit their usefulness. Balloon logging, however, is the only technologically-free system of transportation available to us to meet the necessary objective of "standing-tree logging." That is to say, properly developed, it has no inherent restrictions as to topography, deflection, lift, yarding distance, weather, future development, and most important, cost per thousand board feet (MBF).

The purpose of this report is to familiarize you with the systems-improvement proposal by my company to help make balloons and balloon transportation a hard reality in the hard world of competitive logging.

INHERENT PROBLEMS WITH PRESENT AERIAL SYSTEMS

Skyline System

Skyline logging is one of the oldest cable methods in the Pacific Northwest. For years we have utilized the system to log the concave or "good-deflection" valleys with ever-increasing efficiency. However, as a result, we have now reached a point where this process has caught up with us and we have fewer and fewer areas where adequate deflection is satisfactory. This problem, combined with the requirements of longer yarding distances over rougher terrain, and the need for doing a better job of lifting, has caused the skyline system to become less useful over the years.

Helicopter System

Helicopter logging is the newest system in the West. In the past few years there has been much emphasis on the merits of this method because of its speed and versatility. However, the problems of its disaster-factor, limited lifting capacity, weather limitations and ever-increasing costs have dampened enthusiasm quite markedly. Yarding costs in the $140-$160/MBF range have been quoted, and with future Sikorsky Flying Cranes costing as much as 3.3 million dollars, who can predict where the costs will end? Certain areas of high value or scattered wood that cannot be logged by any other methods should be removed by helicopter. However, indiscriminate layouts for helicopters on normal timbered slopes, merely because it's easy, create a serious concern, as stumpage loss has to be accepted in order to keep these vehicles in business.

Present Balloon System

The present high-lead balloon system has developed gradually since 1964 into a workable method. Chronic yarder problems are being improved and with maximized daytime, good-weather production, annual yarding costs in the $40-$60/MBF range are possible.

However, in my mind, the critical problems with the system are snow on the natural-shaped balloon and a high drag co-efficient in relative wind conditions over 20 knots. The snow situation creates a disaster-factor that, similar to the helicopter operation, is far too high. During a heavy snowstorm, men have to climb on top of the balloon and remove the snow with brooms and shovels. Needless to say, this is an unnerving and hazardous job.

Similarly, wind problems, on many occasions, have given us serious periods of concern trying to get the balloons to safety before damage occurred.

What happens is that the front of the balloon flattens, as the wind builds up, and the co-efficient of drag jumps from approximately 0.5 to 1.1 or higher (similar to a circular disc). Then, suddenly, you have a serious increase in drag (approximately twice as much), which is difficult to handle for normal logging operations and hazardous for transportation to the bedding area.

As a result of the problems and limitations of the present balloon system, I believe it is essential to offer an improved balloon configuration and system that will lend itself to safe and ea handling in these critical situations and reduce the disaster factor to an absolute minimum.

IMPROVEMENTS POSSIBLE IN BALLOON SYSTEMS

Balloon Design

Several years ago I was gratified to discover the work being done in balloon design and development at the Range Measurements Laboratory, Patrick Air Force Base, Florida. Through their Family II Program and contractors, they were attempting to develop a balloon that would survive 90 knot winds. The significance of the effort impressed me a great deal. If these men could perfect that sort of vehicle, it had to be a breakthrough in balloon engineering and a significant breakthrough in potential industrial applications. (See attached drawing, Exhibit "A".)

Since then I have been steadily encouraged to find that they have persisted to the point where six or eight units have been built and flown, and 85 knot winds have been successfully survived. Not only that, but the configuration of the cigar-shape or blimp-shape with the round top and possible adaptation of an inverted "Y" empennage would provide us with an excellent start in our efforts to improve on the snow problems described above. Simple rolling of the vehicle, both in the air and on the ground, is a good initial action that we could readily adapt to our rigging techniques. Other actions also come to mind that could be easily and safely utilized with this vehicle to minimize the chronic snow problems.

Wind problems have already been significantly reduced when we consider that the balloon is safe aloft to at least 70 knots. Any winds exceeding that would be in the Columbus Day storm bracket that developed in the Pacific Northwest in 1962, and would be preceded by ample warning to move the balloon to a protected bedding area.

The key design factors that allow this balloon to meet these conditions are the pressurized blimp-shape and a very low co-efficient of drag (approximately 0.11 at 0° angle of attack). (See attached picture, Exhibit "B".)

The cost of the balloon, for the size needed to do the job, would be high - in the $800,000 to $1,000,000 bracket. However, for 50,000 pounds net lift to the turns, and the other advantages mentioned and to be described, it provides a much cheaper lifting vehicle than the S-64 Flying Crane at only 20,000 pounds approximate lift and a 3.3 million dollar price tag. If other balloon designs or improvements come along that will do the job better or cheaper, we will be looking at them immediately.

Equipment Design

The first major change planned in the logging equipment is to go to a powerful carriage mounted on an inverted skyline. The carriage will be operated by a person inside and will be held aloft by the balloon to travel back and forth on the inverted skyline by a traction drive system. The carriage will contain a power propeller, or "power-prop", to aid in sideways movement while hooking onto the turns. The skyline will be stored on a line horse at the landing end and will be attached to a ridge or sidehill at the other end by a "mountain-grabber" system of equally distributed load straps. There will be a powered winch in the carriage to reach directly down to the trees. (See attached drawing, Exhibit "C".)

The engineering and design of the carriage is progressing favorably. Every effort is being made to keep the design and construction as simple as possible. Weight, of course, is being watched closely, and readily accessible component parts will be used almost exclusively. Tentatively, the carriage will have approximately 1,500 h.p. and weigh in the neighborhood of 10,000 pounds. Serious consideration is being given to multiple engines of the rotary or "Wankel" design for simplicity, continuity of operation (if one should fail), ease of replacement, and satisfactory power-to-weigh ratio. (See attached drawings, Exhibits "D" and "E".)

The traction system will be the multiple wheel and tire drive system with its own disc brakes. These will hold to the skyline while picking up a turn or in case of an emergency. This system, I feel, is a breakthrough for us because it allows the further use of already engineered components in a simple traction system. The skyline, which can be "regular lay" or "lang's lay", is rougher than a cob, so to speak, and can be utilized by standard tires for ready traction. We plan approximately 16 drive wheels squeezing on the skyline, which is twice as many as are used on the largest trucks for traction, and much more surface area than any locomotive ever had.

METHOD OF OPERATION

The secret of the whole operation lies in the large (1-3/4") inverted skyline which hangs up there doing most of the heavy work. If the mathematics of the operation are reviewed, it is readily apparent from the force diagrams, that the skyline is always keeping the complete system in stable equilibrium while supplying more than adequate safety factor.

In my mind, this big, strong, inert skyline replaces and does a better job than the complicated, mechanical, hydraulic, interlock, yarder systems that have yet been developed. It also reaches out any desired distance, with no running lines and no running blocks. The simplicity has to make sense, and it is simple.

Eventually, it may be possible to use a grapple to hook the trees and even uproot them, as indicated by Exhibit "C". However, for initial operation, plans are to climb the trees, choke them high, then snap the stump-cut as the balloon takes the load and creates a lead and leverage toward the landing. At the landing, the branches will be burned, dumped or utilized, depending on the situation, but the trees can be custom-bucked to quality grade for maximum utilization. The object of using chokers is to allow for more than one tree to be yarded at a time, if so desired. Oversize trees will have to be felled and a portion bucked off before they can go to the landing.

Conservative production estimates are approximately 17.5/MBF (gross) per prime (or yarding) hour, with annual production of between 25MM and 100MM, depending on how the operation is run. Cost figures of approximately $26/M have resulted from an eight hour day, 200 days a year and $15/M from a 20 hour day, 350 days a year. The detailed cost analysis follows.

COST ANALYSIS

	Information	Cost
Balloon		
Balloon - 1.5 MM ft.^{3}; 65,000# net lift at hard point	1.5MM@$.50/ft.^{3}	$750,000
- Weight of balloon	20,000#	
- Survivability in air	70 knots	
- Survivability on ground	90 knots plus	
- Snow survivability (inverted "Y" tail)	Excellent	
Helium - @ $.05/ft.^{3}	1.4MM (05)	70,000
Rigging - Balloon & bedding area	Blocks, lines, etc.	10,000
Subtotal Balloon		$830,000
Carriage		
Multiple engines (Wankle type) up to 2,000 h.p.		$200,000
- Approximate weight	10,000#	
Line-Horse		
Line-horse - combination transfer vehicle		$150,000
Line - 10,000 ft., 1-3/4" diam.; 300,000# b.s.; 5.5#/ft.	10,000 ft. @ $4/ft.	40,000
Rigging - blocks, chokers, straps, etc.		10,000
Subtotal Line-Horse		$200,000
Subtotal Package		$1,230,000
Company Markup		
Development, consulting, training, start-up, patent licensing	20%	$240,000

	Information	Cost
Total Price of Package		$1,470,000
Depreciation		
Write-off in five years (average)	$1,470,000/ 5 years	$294,000/yr
	8 hours/day 200 days/year	20 hours/day 350 days/year
Production Hours Available		
Normal lost time - maintenance & repair 5%		
- weather 5%		
- moving & misc. 5%		
- total 15%		
∴Availability is 85%		
∴Actual yarding or prime hours/day is	.85(8)=6.8 hrs/day	.85(20)=17 hrs/day
∴Actual prime hours/year is	6.8(200)= 1360 hrs/yr	17(350)= 5950 hrs/yr
Production Per Prime Hour		
Lift available = 65,000# less 10,000# (carriage) & 5,000# (line)	50,000#	50,000#
Average turn weight = 70% (50,000#)	35,000#	35,000#
Average turn size @ 10#/bd.ft. = 35,000/10 =	3.5 M gross	3.5 M gross
Average turns per prime hour (0 to 5000')	5 turns/hour	5 turns/hour
∴Production/prime hour = 5 (3.5) =	17.5 M/hour	17.5 M/hour
∴Production/day	17.5(6.8) = 120 M/day	17.5(17) = 300 M/day
∴Production/year	17.5(1360) = 24 MM/ yr	17.5(5950) = 104 MM/year

	8 hours/day 200 days/year	20 hours/day 350 days/year
Cost/M Gross		
Depreciation	$294,000/24 = $12.30/M	$294,000/104 = $2.80/M
Operating labor - 10 men @ $10/hr	100/17.5 = 5.50/M	5.50/M
Operating supplies - previous figures	4.00/M	3.00/M
Maintenance & repairs - previous figures	4.00/M	3.00/M
Total yarding/M gross	$25.80/M	$14.30/M

ADVANTAGES AND DISADVANTAGES

Advantages

I would like to list the obvious and not-so-obvious advantages I feel this system encompasses:

- Standing tree logging is possible for the first time in logging history, and is recommended. The necessary objective of maximum logging utilization is finally attainable.

- Safety in operation, wind, and snow is excellent. The disaster factor has quite factually been reduced to a minimum.

- Cost per/M is realistic.

- No expensive falling and bucking is required on the sidehills.

- The high capital cost and fire risk of felled and bucked inventories is eliminated.

- Maximum tree utilization is possible by bucking the trees to quality grades at the landing.

- Safety for the crew is improved with no dangerous felled and bucked logs hanging above them while they are logging.

- Night time logging is possible, and advisable, to take advantage of calmer weather usually prevailing.

- Maximum year-round logging is possible as standing trees are not buried by the snow; whereas, felled and bucked timber can be buried for many months.

- The production capability of the operation represents the equivalent of numerous normal high-lead sides if maximum annual hours are utilized.

- There are no running lines, running blocks and complicated layouts to be concerned with. Much rigging time and cost can be eliminated and the fire hazard can be reduced substantially.

- Yarding distances of up to 10,000 feet or more are possible if desired. Think what could be done with 10,000 foot corners instead of 1,000 foot corners in setting layout. Present road systems could probably be reactivated and road construction minimized or eliminated for many years, depending on planning flexibility within an operation.

- One combination landing and bedding area could replace many expensive landings on the sidehill or ridge tops.

- Future road construction could also be minimized. Two-thirds to three-quarters of the very expensive sidehill and ridge top roads could eventually be eliminated. Alternate drainage development could be followed.

- Savings in hauling costs can be realized due to less sidehill truck hauling.

- Uphill as well as downhill logging is possible, although downhill logging is recommended for reasons which will be discussed in the section, Future Potential.

- Minimum slash will be left on the sidehill.

- Slash burning will be minimized or eliminated, thereby reducing air pollution and the hazard of fire escapes.

- Valuable understory of saplings and seedlings will be preserved. Reforestation by fill-in with larger seedling stock could well be possible.

- Soil erosion is minimized.

- Clean creeks are a natural consequence of the system. Trees are not toppled and broken into the stream beds, causing muddy waters and fish-kill.

Disadvantages

- The main disadvantage of this system is the high capital cost. However, these are the prices that I have necessarily had to work with because of quotes from the various manufacturers. There may be savings in some areas and increases in others, but we're certainly in the ball park if we estimate logging costs at $30/M gross, and lower, depending on how the operation is run. When the time comes for getting down to more detail in setting up this system, I will obtain more exact quotes from each of the balloon manufacturers and other manufacturers involved.

- The second disadvantage of the system, that bothers some people, is the man in the carriage. However, he is necessary to monitor all of the functions taking place up there and can do something if a tire blows, or engine quits, etc. The safety of this man is excellent because we have allowed high safety factors in all areas. The main concern would be the lines breaking between the carriage and balloon. This has never happened to us in ten years of balloon logging, using two lines in there at all times. This carriage is being designed for four 1-1/8" lines for the 250' between the balloon and carriage and each is strong enough to hold the balloon within the working stress of the individual lines.

  If the inverted skyline itself should break, it will most likely happen in the back section (where most use and wear takes place), and in this event, the carriage will be clamped to the line and be brought in by the line horse or crawl down the line itself in low gear. If by the remotest possibility the balloon and carriage should get away from the skyline, they will at least go up instead of down and the operator can jump with a parachute. In ten years of balloon logging we have never had any of our balloons go up and get away from us. I would feel much safer and be much safer in that carriage than driving to the job each day and back. I will be the first operator on this rig, and train the other men as required. I have never asked any of my men to do anything I wouldn't do myself as long as I have been in the woods, and will continue to follow this practice in the development of this system.

FUTURE POTENTIAL

Energy on the Sidehills

For a number of years now, I have been concerned with how to ultimately utilize the natural energy clearly visible in the woods in the form of trees covering the mountains. Each of these trees is a certain weight and a certain distance above the landing. By taking these two basic facts, we can quite accurately calculate the natural energy per tree as so many foot-pounds energy (P.E.), available to us, if we can put it to work. A 3,300 board foot tree weighing 33,000 pounds (at 10 pounds per board foot) and standing 1000' vertically above the landing, has a P.E. of 33,000 (1000) or 33 million foot pounds. When we allow that tree to move through the 1000 feet, in one minute, we change the P.E. to kenetic energy (K.E.) and can actually calculate the work, in horsepower, that is available. In this example, 33,000,000 ft. lb. per min. divided by 33,000 ft. lb. per min. per h.p. equals 1,000 h.p. generated in a single minute. That's a lot of power, and we have to learn to use it.

Energy Utilization

With the inverted skyline, carriage, and a fast balloon (with very minimum drag), we can finally put this natural asset to work. As the empty balloon goes back with 50,000 pounds lift, "energy of retardation" has to be dissipated through engi retardation (like going downhill in first gear), or through brake retardation (by brake application and heat loss). Now, rather than let this energy get away, there has recently been developed a super-flywheel, of very high performance, that could readily be adapted to the carriage for downhill logging. On the trip back to the woods, the flywheel could be "wound-up" by the retardation energy and have more than ample energy to bring in a normal turn. This is possible because the weight and movement of the turn downhill offsets most of the balloon lift and energy requirements, as previously described. In fact, my basic calculations indicate that under normal logging conditions, there is enough retardation energy on one run out to bring in two normal turns, or more, depending on the conditions. In other words, we have enough P.E. in those sidehill trees to run the entire operation continuously, and we've been looking at them and cursing them for years.

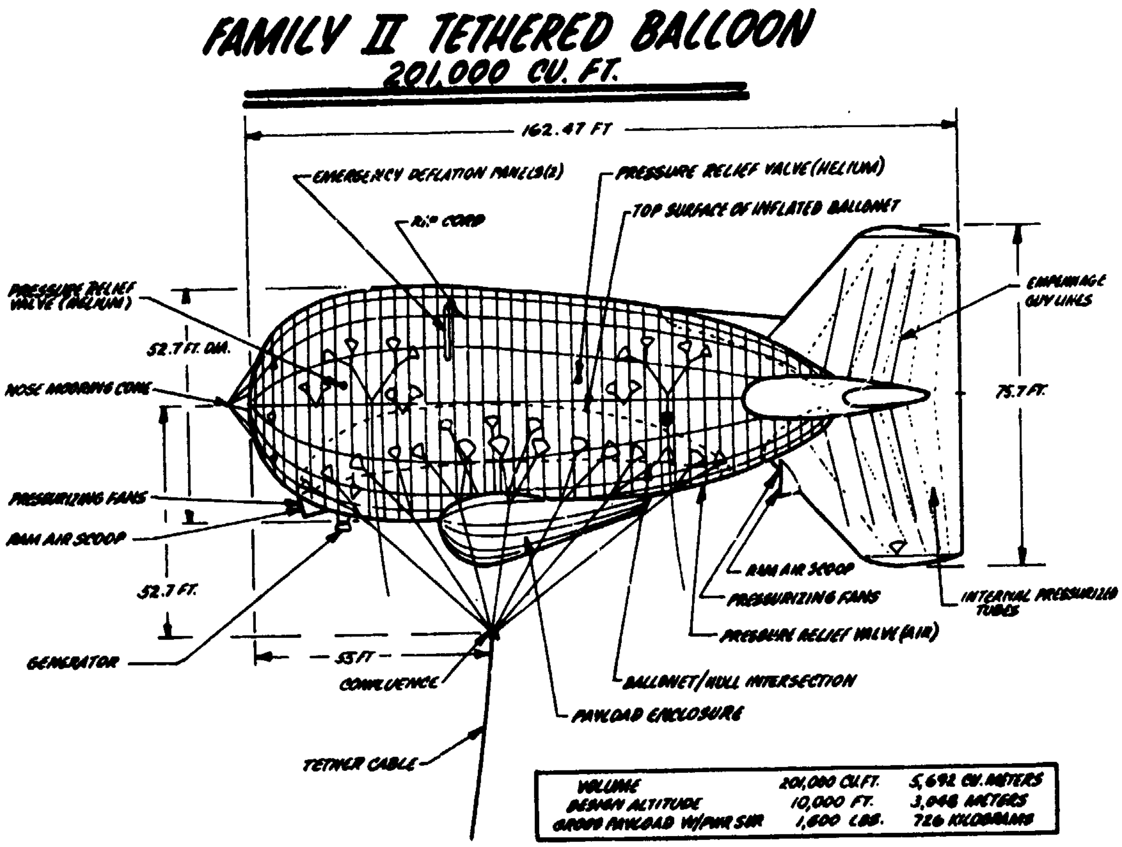
I would judge that within a very short period, after getting the first inverted skyline and carriage operational, we will have this flywheel carriage developed and available. It has to make sense, particularly with the growing need for energy conservation that we have been hearing about for some time now.

Future Potential Beyond the Flywheel

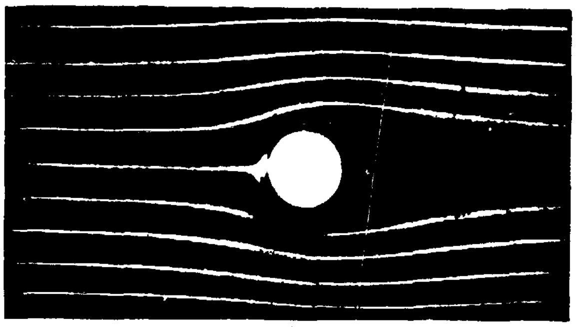
One of the continuing advantages of this balloon concept is that there is more that we can do in the future. Eventually, we will be looking at the retardation energy for electrical generation of hydrogen and oxygen through the electrolysis of water in the carriage. This will supply us with our operational fuels (hydrogen with oxygen in the air) and balloon lifting gas (hydrogen). There are a number of companies now developing hydrogen engines because of maximum efficiency, cleanliness, and a ready supply of fuel. Also, balloon lift by hydrogen is the maximum efficient gas, and free, by this system. However, there is a fear of its use to overcome and problems to work out. But the excess retardation energy and resultant excess gas can then be compressed and stored for some level or uphill logging operations and some extra balloon gas. This system could be very simple and very neat, if we don't run into unforeseen obstacles.

SUMMARY

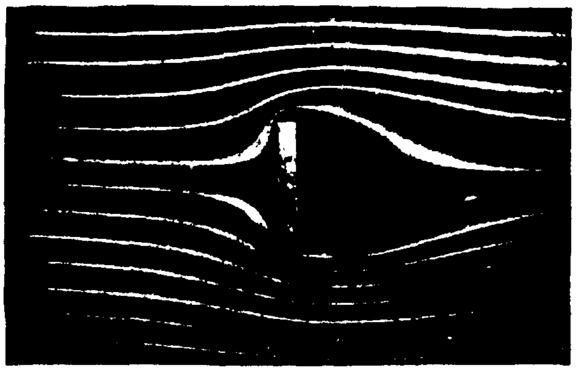
Throughout this paper, I have talked in terms of mountain logging operations exclusively. However, it should be mentioned that the advantages for other aerial transportation requirements are directly applicable; e.g., swamp logging, ship-to-shore transportation, etc. The simplicity and safety possible, along with good potential production and reasonable cost per production unit, would indicate that the method is worth pursuing.



<u>EXHIBIT "A"</u>
(Small Family II balloon. Larger ones now being built.)



(a)



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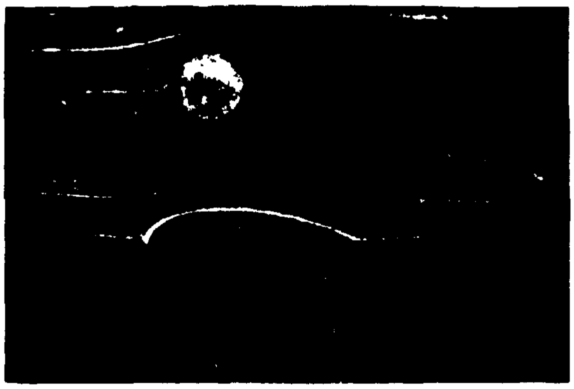


(c)

EXHIBIT "B"

"A picture is worth a thousand words." This picture is included just to give some idea of airflow (left to right), around (a) cylinder; (b) flat plate (similar to circular disc); (c) cylinder (similar to sphere) and streamlined body. This is from "Fluid Mechanics" by R. C. Binder, Ph.D. His comment was "the examples show that the phenomena giving rise to resistance are markedly affected by the rear of the body as well as by the front of the body."

Feb. 20, 1968 C. F. MOSHER 3,369,673

Tree Harvesting, Lifting and Transportation Apparatus

Filed Jan. 12, 1965

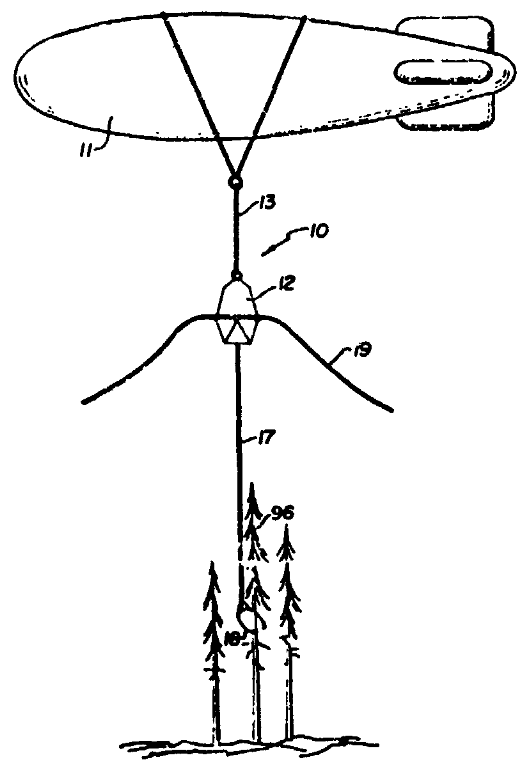
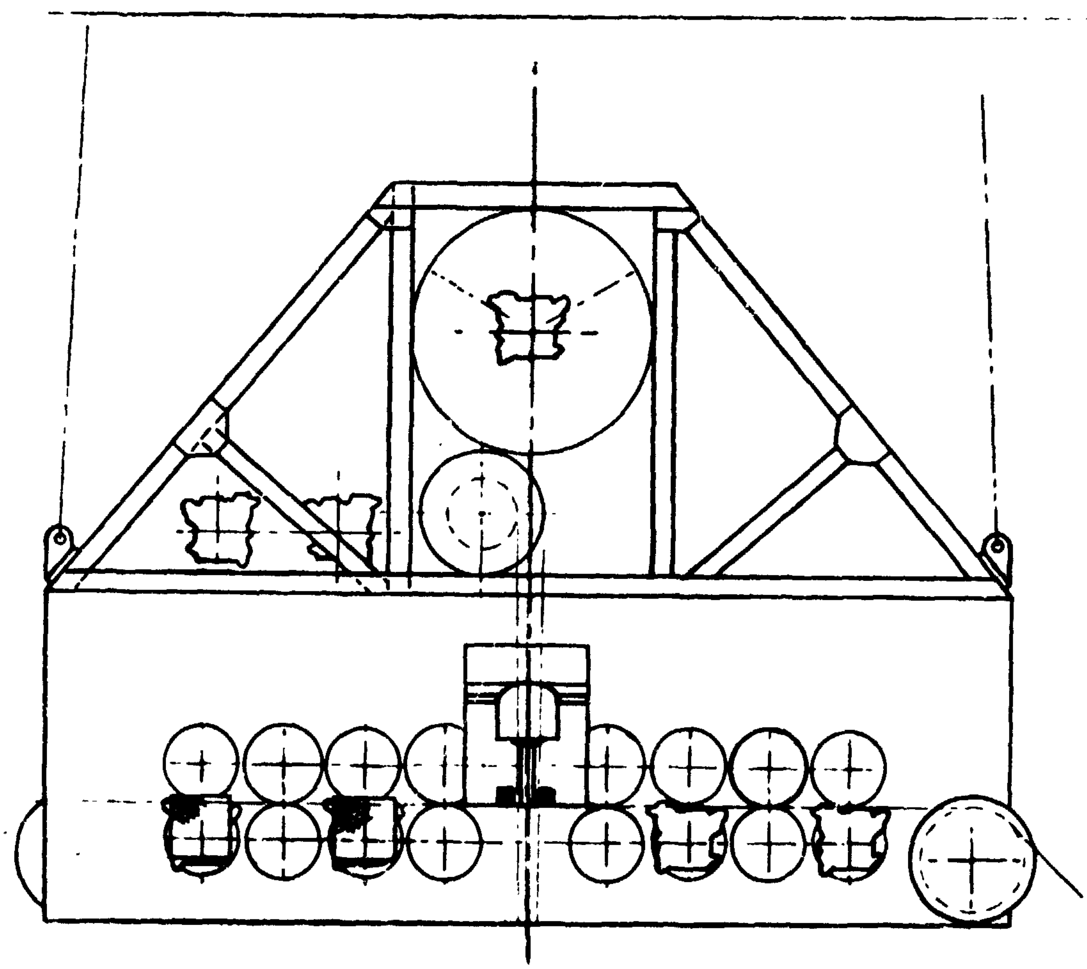


EXHIBIT "C"

INVENTOR
CLIFFORD F. MOSHER
BY
[signature]
ATTORNEYS

BALLOON CARRIAGE FCR INVERTED SKYLINE
(side view)



SCALE 1/4" = 1'

9-5-74

EXHIBIT "D"

BALLOON CARRIAGE FOR INVERTED SKYLINE
(End view)

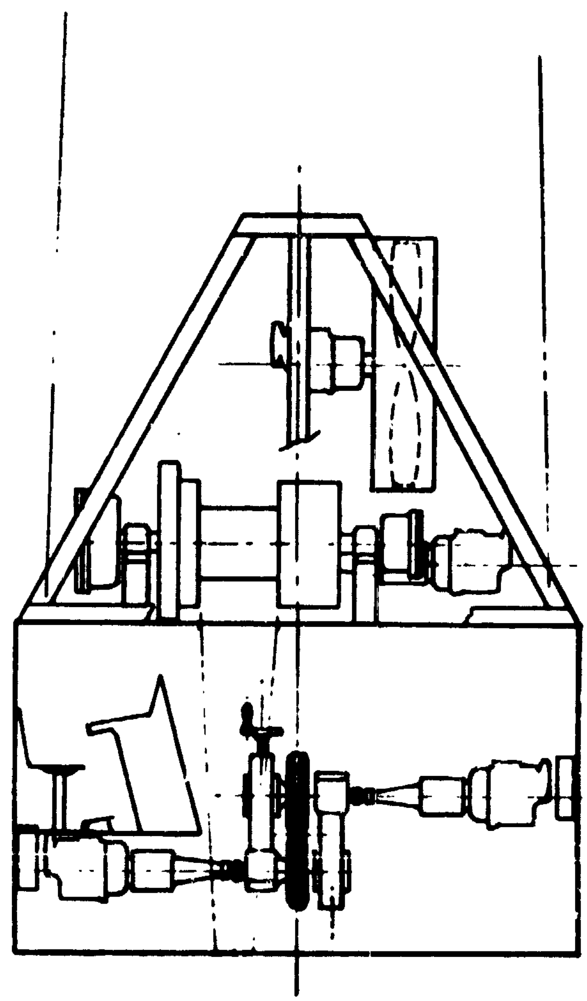


EXHIBIT "E"