A SAFE ICE LOAD METER AND A MOTOR-DRIVEN CORING TOOL FOR ESTIMATING THE BEARING CAPACITY OF AN ICE SHEET FOR TRANSPORTION PURPOSES

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ABSTRACT

The Safe Ice Load Meter is an inexpensive portable unit for use by vehicle drivers. Meter readings of safe load are obtained in terms of thickness of clear ice, thickness of white ice, crack conditions and number of days of thawing weather if any. The motor-driven coring tool, powered by the vehicle battery, provides 2 1/2 inch diameter cores in ice up to 4 feet thick.

INTRODUCTION

The Safe Ice Load Meter and the Coring Tool were developed to enable the driver of any vehicle to determine whether or not the ice on a frozen lake or river would carry his vehicle safely. Earlier estimates by people concerned with this problem, were generally based on ice thickness alone, sometimes with fatal results. In recent years both military and industrial needs in Canada, the U.S.A. and the USSR have resulted in the carrying out of research and the collection of experience data related to this problem. The information obtained showed that besides ice thickness there were several other factors having a significant effect on the bearing capacity of an ice sheet. However, the application of much of the information would have been beyond all but engineering specialists. Following an ice accident in which five Ontario Hydro linemen lost their lives at Minaki in 1957, the task of collating the best available information and presenting it in a form suitable for field use was undertaken. The requirements imposed on the manner of presentation were restrictive: any vehicle driver or foreman should be able to determine safe ice load without the use of mathematics and with little instruction; the method should be neither time-consuming nor laborious; all significant factors that can be readily recognized should be taken into account; there should be a built-in factor of safety to allow for variations in ice quality which are not readily recognized and to allow for human error.

The methods considered included sets of graphs, sets of tables, nomograms, and a special slide rule. All of these were rejected for various reasons including the possibility of error, and not omitting psychological aspects. The final decision was to build a "meter" which would give a reading of safe ice load in tons merely by setting controls in terms of readily determined conditions such as thickness of clear ice.

Operation of the SAFE ICE LOAD METER MODEL SL-1:

The resulting SAFE ICE LOAD METER is shown in Figure 1.

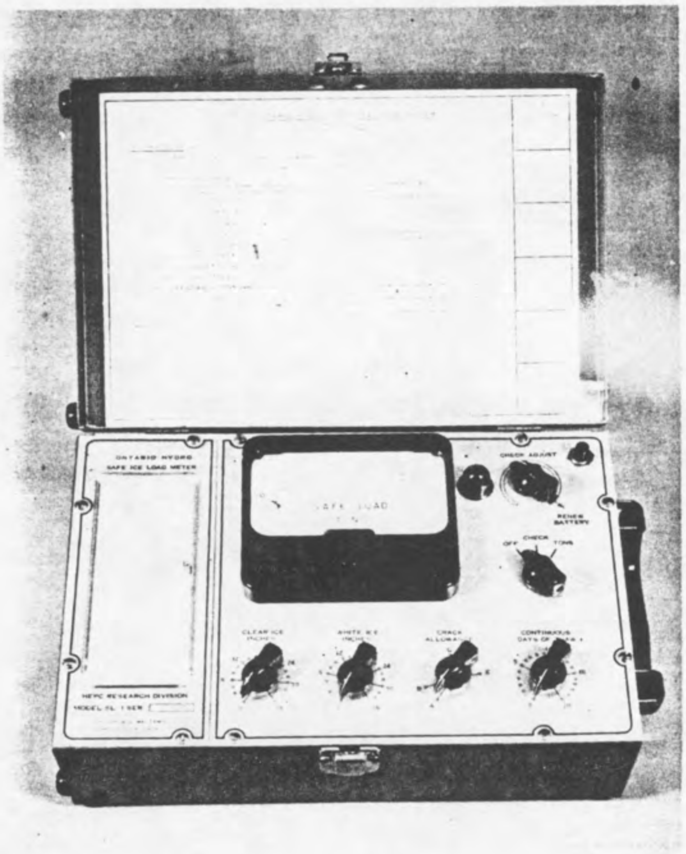


Fig. 1 - Ontario Hydro Safe Ice Load Meter Model SL-1

Step-by-step instructions for operation of the meter are contained in the l and are readily carried out. The instruction sheet is reproduced in Figure With the exception of vehicle speed, all of the principal conditions which determine safe ice load are accounted for by four controls across the botto of the panel. Starting from the left, the user sets the first control to t number of inches of clear ice, this information being found by obtaining an sample with the coring tool described later. A typical ice sample might ha 10 inches of clear ice with 4 inches of white ice on top. The clear ice is frozen lake water, and the white ice is frozen snow slush. After examining the proposed ice road for the presence of open cracks, and comparing the pa which the vehicle will follow with the crack situations lettered A to E sho at the right of the instruction sheet, the user sets the third control, CRA ALLOWANCE, to the appropriate lettered position.

The latter control is also used to allow for ice shrinkage. When wate

ONTARIO HYDRO SAFE ICE LOAD METER

MODEL SL-I

INSTRUCTIONS :

1. SET CLEAR ICE CONTROL TO THICKNESS OF TRANSPARENT ICE IN INCHES
2. SET WHITE ICE CONTROL TO THICKNESS OF MILKY ICE IN INCHES
3. SET CRACK ALLOWANCE
   - (A) UNTIL AIR TEMPERATURE RISES 10°F ABOVE LAST LOW, SET CRACK ALLOWANCE TO E THIS CONDITION USUALLY APPLIES TO EARLY MORNING AFTER A COLD NIGHT.
   - (B) AFTER AIR TEMPERATURE FALLS TO 10°F BELOW LAST HIGH, SET CRACK ALLOWANCE TO E THIS CONDITION USUALLY APPLIES FROM LATE AFTERNOON ONWARD.
   - (C) IF CRACK ALLOWANCE E IS NOT REQUIRED AS IN (A) OR (B) THEN SELECT A CRACK ALLOWANCE FROM THE SKETCHES OF VEHICLE AND CRACK SITUATIONS AT RIGHT. THESE ARE WET, OPEN, OR UNHEALED CRACKS. DISREGARD HAIR CRACKS AND HEALED CRACKS.
4. SET CONTINUCUS DAYS OF THAW TO NUMBER OF CONSECUTIVE DAYS THAT AIR TEMPERATURE HAS BEEN AT 32°F OR OVER. THIS CONDITION USUALLY APPLIES TO LATE WINTER. DURING MOST OF THE WINTER THERE IS NO THAW AND THE SETTING SHOULD BE O.
5. SET OFF SWITCH TO CHECK
6. SET CHECK ADJUST TO MAKE THE METER READ 40
7. SET CFF SWITCH TO TONS
8. READ SAFE LOAD IN TONS FROM METER
9. SET CFF SWITCH TO OFF
10. READ MAXIMUM SAFE SPEED FROM TABLE →

DEPTH OF WATER, FEET	1	2	4	8	16	32	64
MAX. SAFE SPEED MPH	2	3	5	7	10	14	20

NOTES :

1. THE SAFE ICE LOAD METER PROVIDES A FACTOR OF SAFETY OF 2.0 COMPARED TO COMMON PRACTICE IN THE LUMBER INDUSTRY. UNDER EMERGENCY CONDITIONS THE LOAD MAY BE DOUBLED AFTER A CAREFUL CHECK OF ICE THICKNESS AND CRACKS.
2. WHAT TO DO IF THE ICE CRACKS UNDER YOU
   - (A) SEVERAL CRACKS – VEHICLE STANDING STILL : MOVE IT, SLOWLY, IN LOW GEAR
   - (B) SEVERAL CRACKS – VEHICLE IN MOTION : SLOW DOWN TO 2 MPH. IF CRACKING CONTINUES HEAD FOR THICKER ICE AT 2 MPH
   - (C) ONE LONG CRACK – STRADDLE CRACK AS IN SKETCH B AND KEEP MOVING AT 2 MPH. IF THE SAFE LOAD METER INDICATES THAT THE ICE WILL SUPPORT YOUR VEHICLE USING CRACK ALLOWANCE E, THEN YOU CAN SAFELY DRIVE AWAY FROM THE CRACK. OTHERWISE, CONTINUE TO STRADDLE THE CRACK AND FOLLOW IT TO SHORE.

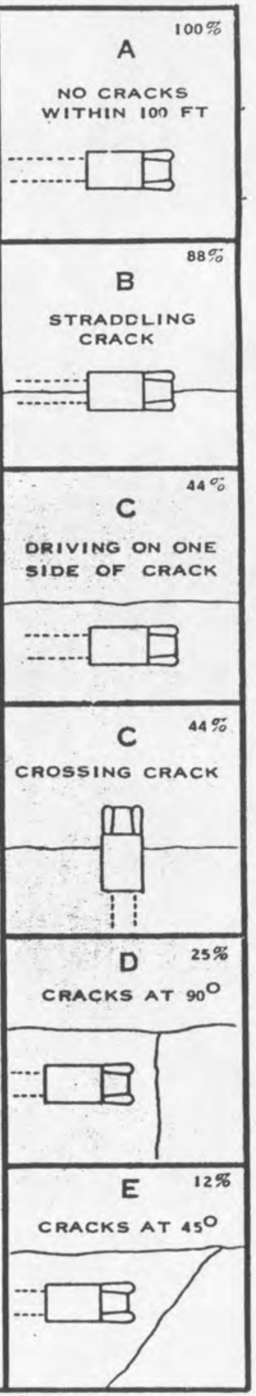


FIGURE 2

freezes, expansion takes place, but with cooling of the ice below the freezin point, contraction takes place. Falling air temperatures therefore cause the ice sheet to contract horizontally, and since the ice is frozen to the surrou ing shores and is weak in tension, it cracks. While the water entering the cracks may freeze and heal them, additional contraction and cracking will continue as long as the air temperature is falling. Further, while an East-West crack will relieve the tension in the North-South direction, it is likely tha additional cracks will form as a result of tension in other directions. Ther fore, during the period between the time when the air temperature has fallen about 10°F, until it has passed through a low and risen about 10°F from that low, it must be assumed that the ice either has cracked or is on the verge of cracking. It is therefore assumed that whether or not cracks are in evidence during the above temperature conditions it is likely that the vehicle could either come upon or trigger crack condition E, which is two cracks intersecti at an angle of 45° and which reduces the safe load to 12 per cent of the no crack safe load. The temperature conditions just described usually apply to the period from late afternoon on to 8 or 9 o'clock the following morning.

After setting the CRACK ALLOWANCE control either for the observed crack conditions or for falling air temperature effects as described above, the use then sets the fourth control, CONTINUOUS DAYS OF THAW, to the number of consecutive days that the air temperature has been at 32°F or over. This conditic usually applies to late winter only, and takes into account the gradual weake of the ice which occurs with mild weather.

This completes the control settings, viz.: thickness of clear ice, thick of white ice, crack allowance, and days of thaw. The user then sets the cent knob at the right to CHECK, standardizes the internal battery by setting the CHECK ADJUST control to make the meter read 40, and then sets the centre knob at the right to TONS. The meter then indicates the SAFE LOAD in TONS. The reading so obtained provides a factor of safety of at least 2.0 over values commonly used in the lumber industry.

A table of tare weights of vehicles used by the Ontario Hydro is provide as a slip-in card at the left of the meter panel.

Included in the instruction sheet is a table of water depths vs maximum safe vehicle speed. The need for this speed restriction comes from the fact that when a load is placed on the ice, the ice deflects downwards and produce a moving wave in the water beneath the ice. The speed of the wave is mainly dependent on the depth of the water and can be taken as

$$v = \sqrt{g\,h} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:

v = velocity of wave, feet per second
g = the acceleration due to gravity, i.e., 32 feet per second per sec
h = depth of water, feet

As the wave spreads out it diminishes in height both because of spreadin and because of frictional losses. When a vehicle moves, it continuously puts energy into the wave. Provided that the wave is moving substantially faster than the vehicle there is no dangerous build-up of wave height. If the vehi moves at or near the same speed as the wave, the wave will build up to such a height that it can cause the ice to break, usually beneath the rear wheels of the vehicle. Model tests performed by the author indicate that the downward deflection of the ice sheet increases rapidly when the speed of the vehicle exceeds two-thirds of the wave speed. The table of water depths and maximum safe speeds given in the instruction sheet limits the vehicle speed to two-thirds of the wave speed.

The instruction sheet also states what action should be taken in the event that the ice cracks beneath the vehicle. A parked vehicle should be moved slowly. When several cracks form under a vehicle moving on ice whose thickness has been measured and found adequate, the cracking is likely due to the wave action described above, and the driver should slow down. If a long crack forms under the vehicle, it is probably due to thermal contraction. Since the ice will support more load when the vehicle straddles the crack than if the vehicle is on one side of the crack only, the driver should continue to straddle the crack and follow it to shore. It would not be a good risk to attemps to drive away from the crack unless it was known beforehand that the ice was sufficiently thick to support the vehicle under crack condition E (i.e., two cracks intersecting at 45 degrees).

Principles and background of the SL-1

The METER is actually a form of analogue computer, a fact not normally mentioned since most prospective users know that they cannot operate a computer but that they can set a knob to the number of inches of clear ice. The equation solved is:

$$P = 0.042\ (h_c + 0.5h_w)^2 \times C_1 \times C_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where:

P = safe load in tons.

h_c = thickness of clear ice with values from 0 to 36 inches.

h_w = thickness of white ice with values from 0 to 36 inches

C_1 = crack factor with values between 1 and 0.12

C_2 = thaw factor with values between 1 and 0

The terms in equation (2) are arranged in the same order as the controls on the front panel of the METER. If there are no cracks and there has been no thawing weather, both C_1 and C_2 are equal to 1.0 and therefore have no effect on the first part of the equation. It is thus seen that in the absence of cracks and thaw the safe load is obtained by multiplying a constant (0.042) by the total effective thickness $(h_c + 0.5h_w)^2$. Since C_1 and C_2 are never greater than 1.0, it is also seen that the effect of cracks and/or thaw is to reduce the magnitude of the safe load determined by the first part of the equation.

It must be pointed out that the above equation is an approximation. Theoretical relationships intended to be exact have appeared in the literature but were rejected here because of their complexity which rendered them unsuitable for field use and, in view of the fact that because of the variable properties of ice, any computation of bearing capacity can be considered as an estimate only. The basic relationship consisting of multiplying a constant by the square of the effective ice thickness is recommended by Gold and by Korunov. The constant embraces the elastic properties of the ice, the strength of the ice, and the buoyant support of the water. If the strength of the ice could be readily determined in each situation, the constant could be appropriately adjusted to give the maximum safe ice load for that particular ice sheet. Korunov related the strength of the ice to the air content, with the resultir constant varying from a maximum of 0.12 for clear ice containing only small isolated air bubbles, to a minimum of 0.015 for granular sludge ice. The value 0.042 chosen for use in the SAFE ICE LOAD METER corresponds to clear ic having an air content midway between "thin short vertical air tubes" and "thick long vertical air tubes". As a result of this choice of constant, the user does not have to be a skilled judge of air content to determine safe ice load. The "thick long vertical air tubes" look like pencil stubs. Their presence makes it obvious that the ice should not be trusted. It should be reiterated that the SL-1 was designed for use by any vehicle driver. For applications where a more critical appraisal of the air content could be assured, either the safe load reading from the SL-1 could be scaled upwards for ice wi low air content, or the instrument could be modified to include a control whi would be set in terms of air content.

As evidence of the practicality of the 0.042 value of the equation cons as used in the SL-1, comparison can be made with ice failure data published l Gold. Of 45 instances of vehicles breaking either partly or completely thro the ice, 13 would have either certainly or likely occurred had the safe ice load been estimated using a constant of 0.042 without regard to any other factors. In 11 of these 13 cases, the data recorded indicate that the breakthr was due to the effects of speed, cold-weather contraction, cracks, or thaw. In the remaining two cases there were insufficient data to indicate the cause of failure. From this it is concluded that the combination of the 0.042 constant and the allowances made in the SL-1 for the above effects can result in ice travel with a high degree of safety.

The summation of the thickness of clear ice and one-half of the thicknes of white ice to give effective ice thickness is given by Gold as normal practice in the lumber industry although there is no indication that its accuracy has been verified by any laboratory tests.

The crack factor C_1 was taken from the work of Black who showed that if uncracked ice sheet had a load rating of 100 per cent, then 44 per cent load could be supported on one side of a long crack, approximately 25 per cent los could be supported between two cracks meeting at 90 degrees, and approximatel 12 per cent load could be supported between two cracks meeting at 45 degrees. The effect of falling air temperatures in producing cracks was obtained from observations made by the author in an investigation of ice pressure on dams.

The thaw factor C_2 consists of a reduction in strength of 5 per cent per day for every consecutive day of continuous air temperature at 32°F or over and appears in papers by Korunov and by Bergman and Proskuriakov.

How the SL-1 computes:

The component layout of the SL-1 is show in Fig. 3 and the circuit diagr is given in Fig. 4.

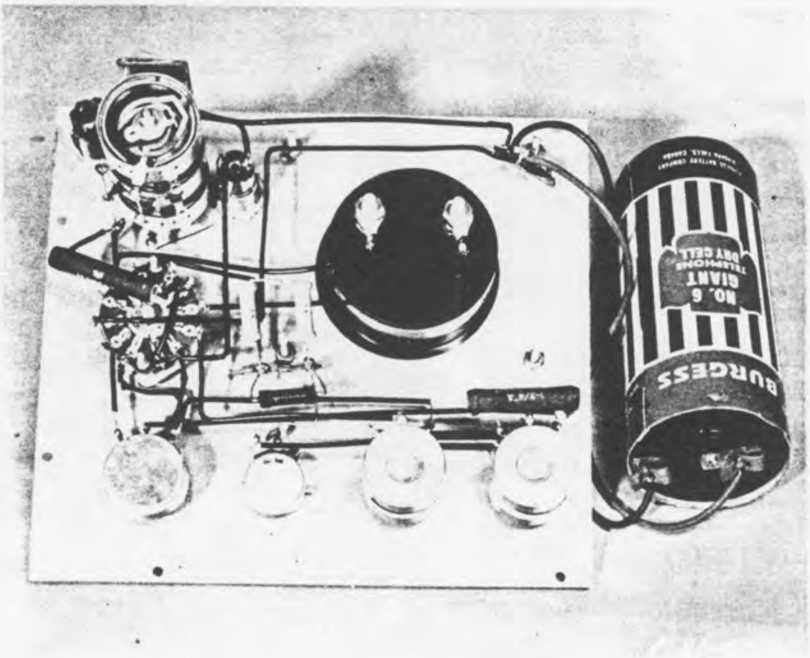
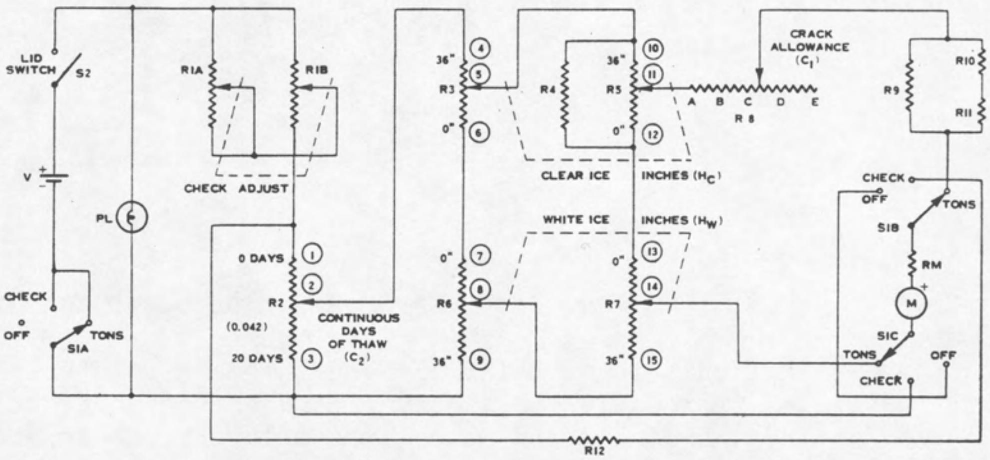


Fig. 3 - Arrangement of Components in the SL-1

The circuit is quite simple and the manner in which it adds, squares and multiplies is readily explained. There are no tubes or transistors. Aside from the battery, switches and meter, the only components are a few fixed and variable resistors. The order in which several quantities are multiplied together has no effect on the product. Therefore, for the sake of clarity, in the title to Fig. 4, the order of quantities in equation (2) has been changed to be in the same order as the operations performed by the circuit.

Current from the battery produces between points 1 and 3 a voltage drop which is equivalent to the 0.042 portion of the equation. Multiplication by the fractional constant C_2 is accomplished by adjusting point 2 to the number of days of thaw, the product $0.042 \times C_2$ appearing between points 2 and 3. Note that R_3 and R_5 are ganged, and constitute the inches of clear ice control. The desired value of R_5 was not commercially obtainable, and therefore R_4 was introduced to reduce the resistance of an available control to the desired value. Also note that R_6 and R_7 are ganged and constitute the white ice control. The $0.042 \times C_2$ voltage appears between points 4 and 9. If a fraction (a) of this voltage is taken between points 5 and 6, and a fraction (b) is taken between points 7 and 8, then the total voltage appearing between points 5 and 8, and hence between points 10 and 15, will be $0.042 \times C_2 \times (a + b)$. Because of the ganging of controls mentioned above, of the voltage between points 10 and 15, there will be a fraction (a) between points 11 and 12, and a fraction (b) between points 13 and 14. Hence the total voltage between points 11 and 14 will be $0.042 \times C_2 \times (a + b) \times (a) + 0.042 \times C_2 \times (a + b) \times (b)$, which is $0.042 \times C_2 \times (a + b)^2$. Here, of course, the fraction (a) is equivalent to h_c, and the fraction (b) is equivalent to $0.5h_w$. The reason why fraction (b) is equivalent to $0.5h_w$ even though R_3 and R_6 are both graduated from 0 to 36 inches, is that R_6 is chosen to have one-half of the



R1A, R1B, MALLORY M1PK 1.0 Ω WW
R2, IRC WPK2 2 Ω WW
R3, IRC WP20 200 Ω WW
R4, 2000 Ω WW

R5, IRC WM500, 500 Ω WW
R6, IRC WP10 10 Ω WW
R7, IRC WM200 200 Ω WW
R8, IRC Q13-128 100 K LOG TAPER

R9, R10, R11, 10K WW
R12, IRC 25K WW
RM 1500 Ω
V, 1.5 VOLT NO. 6 DRY CELL

S1A, S1B, S1C, 3P3T NON-SHORTING
S2, SPST MOMENTARY, NORMALLY CLOSED
PL NO. 222 PILOT LAMP, 2.2 V 0.25A
M. MARION MODEL 55 0-50 MICROAMPERE

FIGURE 4

SCHEMATIC DIAGRAM OF SAFE ICE LOAD METER MODEL SL-1

CIRCUIT SOLVES $P = 0.042 \times C2 \times \left(Hc + \frac{H_w}{2}\right)^2 \times C1$ TONS

resistance value of R_3. Similarly R_7 has one-half of the resistance of the R_4R_5 combination. Therefore, for a given rotation of the white ice controls, only one-half of the voltage is obtained that is obtained for the same rotation of the clear ice controls.

From points 11 and 14, the voltage is applied to the moving coil meter through R_8 which is the crack allowance control, and the R_9, R_{10}, R_{11} combination chosen to result in the desired meter sensitivity. When R_8 is at position A, ($C_1 = 1$), it has no effect on the circuit. When R_8 is at position E, ($C_1 = 0.12$), it reduces the meter sensitivity to 12 per cent. This completes the computation process.

During the actual reading, switch S_1 comprising S_{1A}, S_{1B}, S_{1C} is, of course, in the TONS position. Just prior to the reading, switch S_1 is set to the CHECK position which connects the meter across R_2 and permits the R_{1A}, R_{1B} combination to be adjusted to compensate for battery aging. The standard reading so obtained is 40 on the 0-50 scale of the meter, R_{12} having been selected to give that reading.

The Motorized Ice Coring Tool:

In any computation of safe ice load, adequate determinations of ice thickness and general quality are mandatory and therefore a coring tool is also mandatory. The requirements imposed on the design of the coring tool to be used with the SL-1 were that it should be easy to use so as to encourage thorough use, maintenance should be low and readily carried out with normal shop facilities, and parts should be easy to obtain.

Top and bottom views of the resulting tool are shown in Figs. 5 and 6. A core having 2 inches of white ice and 5 inches of clear ice is shown in Fig. 7. The coring tool cuts 2 1/2 inch diameter cores in ice up to 4 feet thick at a rate of 2 to 3 feet per minute.

During coring, some of the ice shavings enter the tube and usually some water enters the tube upon completion of the cut. In Fig. 7 a ramrod type clearing tool is shown being used to remove shavings frozen to the inside of the tube. In this connection it has also been found helpful to swab the inside of the tube with an oil-soaked rag before starting the day's coring operations.

The motor is a 12-volt automobile starter motor. Extension leads 50 feet long with battery clips are used to power the motor from the battery of a light vehicle used to survey the proposed ice road. A thumb switch and automobile starter solenoid are used to control the motor. To avoid inadvertent operation, a safety switch at the end of a 6-foot extension lead is connected in series with the thumb switch. A fish-eye bubble level mounted beside the motor assists the operator in keeping the tool plumb.

The spiral feed on the outside of the cutting tube brings the cuttings to the surface of the ice sheet. Details of the cutting head are shown in Fig. 8. Bottom cutter A which projects 1/8 inch inside the tube, makes the initial cut, and provides clearance between the core and the inside of the tube. The hole cut by A also provides a side-to-side bearing surface for the cutting head so as to eliminate side-to-side vibration. Top cutter C widens the cut to eliminate any possibility of jamming upon removal from the hole.

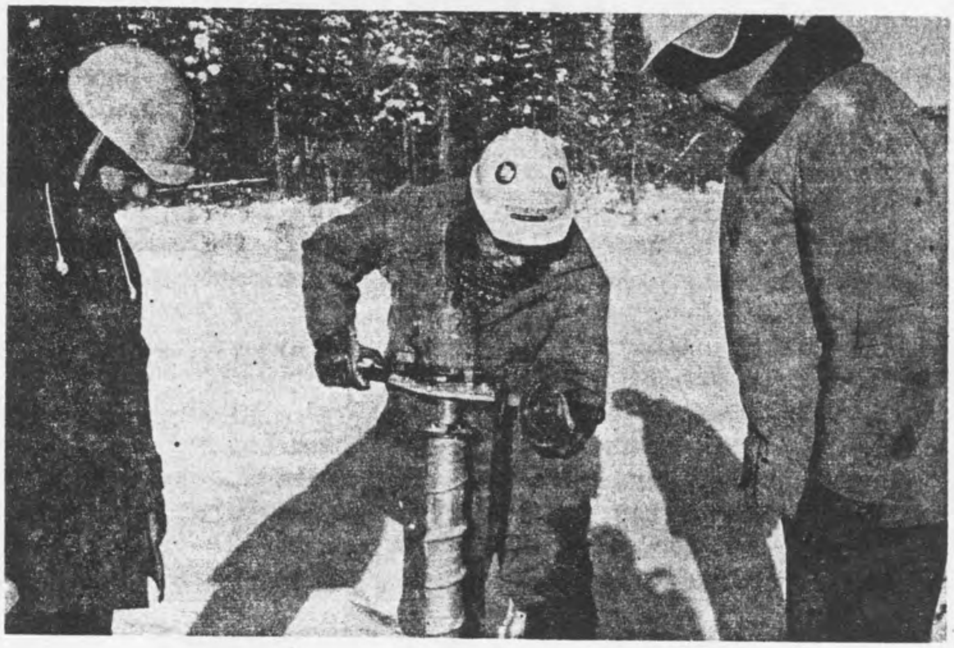


Fig. 5 - Top of coring tool. Automobile starter motor, solenoid, thumb switch and fisheye level are mounted on cross bar.

Fig. 6 - Coring tool entering ice. Safety man at right holds cord switch which overrides thumb switch on coring tool.

Fig. 7 - Ice core having 2 inches white ice and 5 inches clear ice. Clearing tool being used to remove ice cuttings from inside of tube.

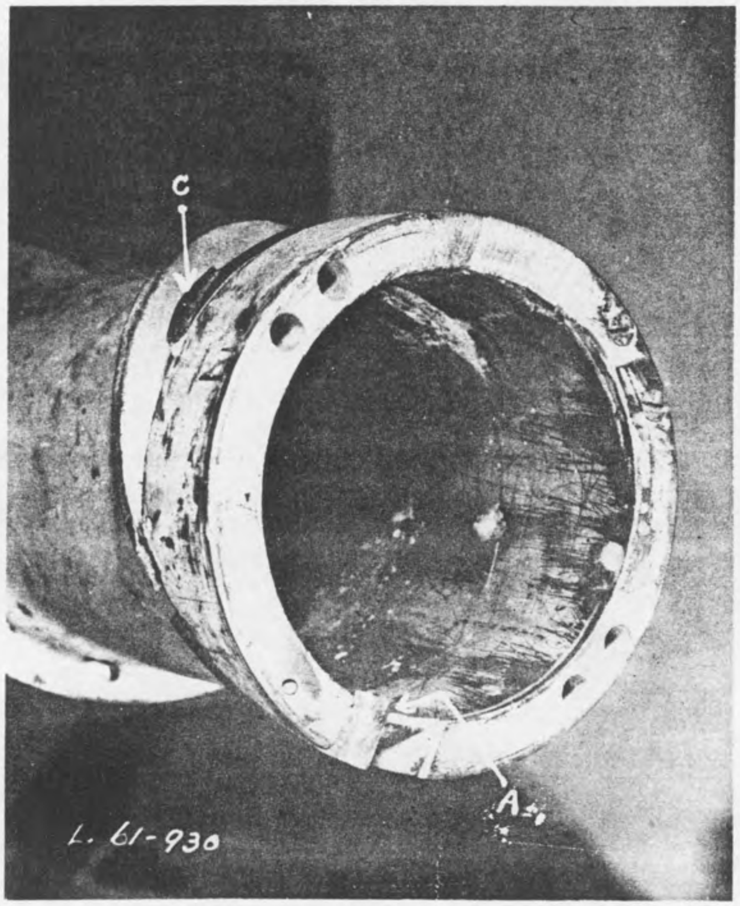


Fig. 8 - Details of cutting head of ice coring tool (see text).

Some slight differences will be noticed between the photographs and the reduced scale drawings of the ice coring tool as given in Figs. 9 and 10. Fig. 10 shows bottom cutters A and B, whereas Fig. 7 shows that bottom cutter B has been removed. Subsequent experience has shown that both bottom cutters are desirable. Further, Fig. 7 shows mounting holes for two top cutters C. However, as indicated by Fig. 10, only one top cutter is necessary Finally, as indicated by the spiral feed, the coring tool shown in the photogr was designed for conventional clockwise rotation. This feature was incorporat in the pilot model as a matter of safety since it was felt that at least until some operating experience had been gained, rotation should be in the direction which the operator would most likely expect. Experience showed that the corin tool was extremely easy to handle. Since clockwise rotation had required that the motor be reversed, which was a factory job, then both as an economy measur and to facilitate servicing, the second model was made as shown in Figure 10 for counterclockwise rotation using an off-the-shelf motor.

Acknowledgements:

The author wishes to acknowledge the contributions of the researchers whc names appear throughout the text and whose works are contained in the list of references. Particular tribute should be paid to the work of Mr. L. W. Gold c the National Research Council of Canada whose continuing efforts are doing muc to increase the available useful knowledge of ice travel. The author also wishes to acknowledge the work of Mr. J. T. McKinnon and those other members c the Ontario Hydro staff whose efforts and suggestions have contributed to the successful development of the equipment described in this paper.

References:

(1) "Field Study on the Load Bearing Capacity of Ice Covers".
L. W. Gold, Woodlands Review, Pulp and Paper Magazine of Canada, Volume 61, No. 5, May 1960.

(2) "Load-Carrying Capacity of Ice for Timber Transport".
M. M. Korunov, Lesnaia Prom. (11): 18-19, 1956. National Research Council Technical Translation 863.

(3) "Relative Strengths of Plates on Elastic Foundation".
L. D. Black, EIC Trans., Volume 2, No. 3, September 1958.

(4) "Investigation of Construction and Maintenance of Airdromes on Ice, 19 Selected Excerpts from Ice Crossings".
G. R. Bergman and B. V. Proskuriakov. Trudy Nauchno-Issledovatel'skil Uchreshdenii, Seriia IV, Gidrometeorizdat, Moscow, 1943. SIPRE transla tion distributed as PB 111688 by Office of Technical Services, United States Department of Commerce.

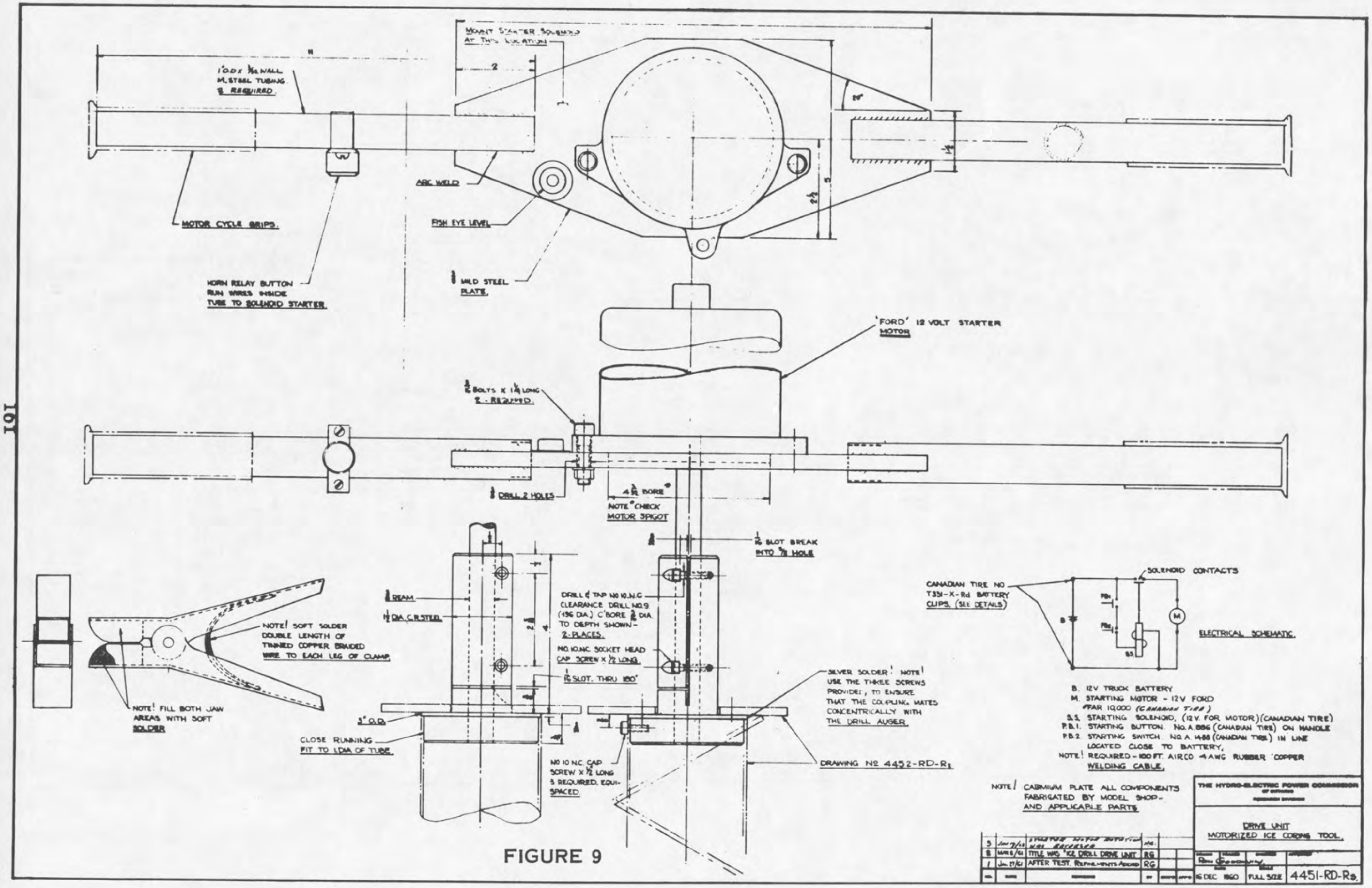

MOUNT STARTER SOLENOID AT THIS LOCATION
2
1" O.D × 1/16 WALL M. STEEL TUBING 2 REQUIRED.
MOTOR CYCLE GRIPS.
ARC WELD
FISH EYE LEVEL
HORN RELAY BUTTON RUN WIRES INSIDE TUBE TO SOLENOID STARTER.
3/8 MILD STEEL PLATE.
20°
5
'FORD' 12 VOLT STARTER MOTOR
5/16 BOLTS X 1 1/4 LONG 2 - REQUIRED.
3/8 DRILL 2 HOLES
4 3/32 BORE*
NOTE * CHECK MOTOR SPIGOT
1/16 SLOT BREAK INTO 5/8 HOLE
3/8 REAM
1/2 DIA. C.R.STEEL
DRILL & TAP NO 10 N.C. CLEARANCE DRILL NO.9 (.196 DIA.) C'BORE 3/8 DIA TO DEPTH SHOWN - 2-PLACES.
NO. 10.N.C. SOCKET HEAD CAP SCREW X 1/2 LONG.
1/16 SLOT. THRU 180°
3" O.D.
CLOSE RUNNING FIT TO I.DIA OF TUBE.
NO 10 N.C. CAP SCREW X 1/2 LONG 3 REQUIRED. EQUI-SPACED.
SILVER SOLDER! NOTE! USE THE THREE SCREWS PROVIDED, TO ENSURE THAT THE COUPLING MATES CONCENTRICALLY WITH THE DRILL AUGER.
DRAWING No 4452-RD-R1
NOTE! SOFT SOLDER DOUBLE LENGTH OF TINNED COPPER BRAIDED WIRE TO EACH LEG OF CLAMP.
NOTE! FILL BOTH JAW AREAS WITH SOFT SOLDER
CANADIAN TIRE NO T331-X-Rd BATTERY CLIPS. (SEE DETAILS)
SOLENOID CONTACTS
B
PB1
PB2
SS
M
ELECTRICAL SCHEMATIC.
B. 12V TRUCK BATTERY
M. STARTING MOTOR - 12V FORD #FAR 10,000 (CANADIAN TIRE)
S.S. STARTING SOLENOID, (12V. FOR MOTOR)(CANADIAN TIRE)
P.B.1. STARTING BUTTON. No. A.886 (CANADIAN TIRE) ON HANDLE
P.B.2. STARTING SWITCH. No. A. 1488 (CANADIAN TIRE) IN LINE LOCATED CLOSE TO BATTERY,
NOTE! REQUIRED - 100 FT. AIRCO 4 AWG RUBBER COPPER WELDING CABLE.
NOTE! CADMIUM PLATE ALL COMPONENTS FABRICATED BY MODEL SHOP - AND APPLICABLE PARTS
THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO
DRIVE UNIT
MOTORIZED ICE CORING TOOL.
3 | STARTER MOTOR SUPPLIER WAS REFERENCE
2 | MAR 6/61 | TITLE WAS 'ICE DRILL DRIVE UNIT' | RG
1 | Jan 27/61 | AFTER TEST. REFINEMENTS ADDED | RG
16 DEC 1960
FULL SIZE
4451-RD-R3.

FIGURE 9

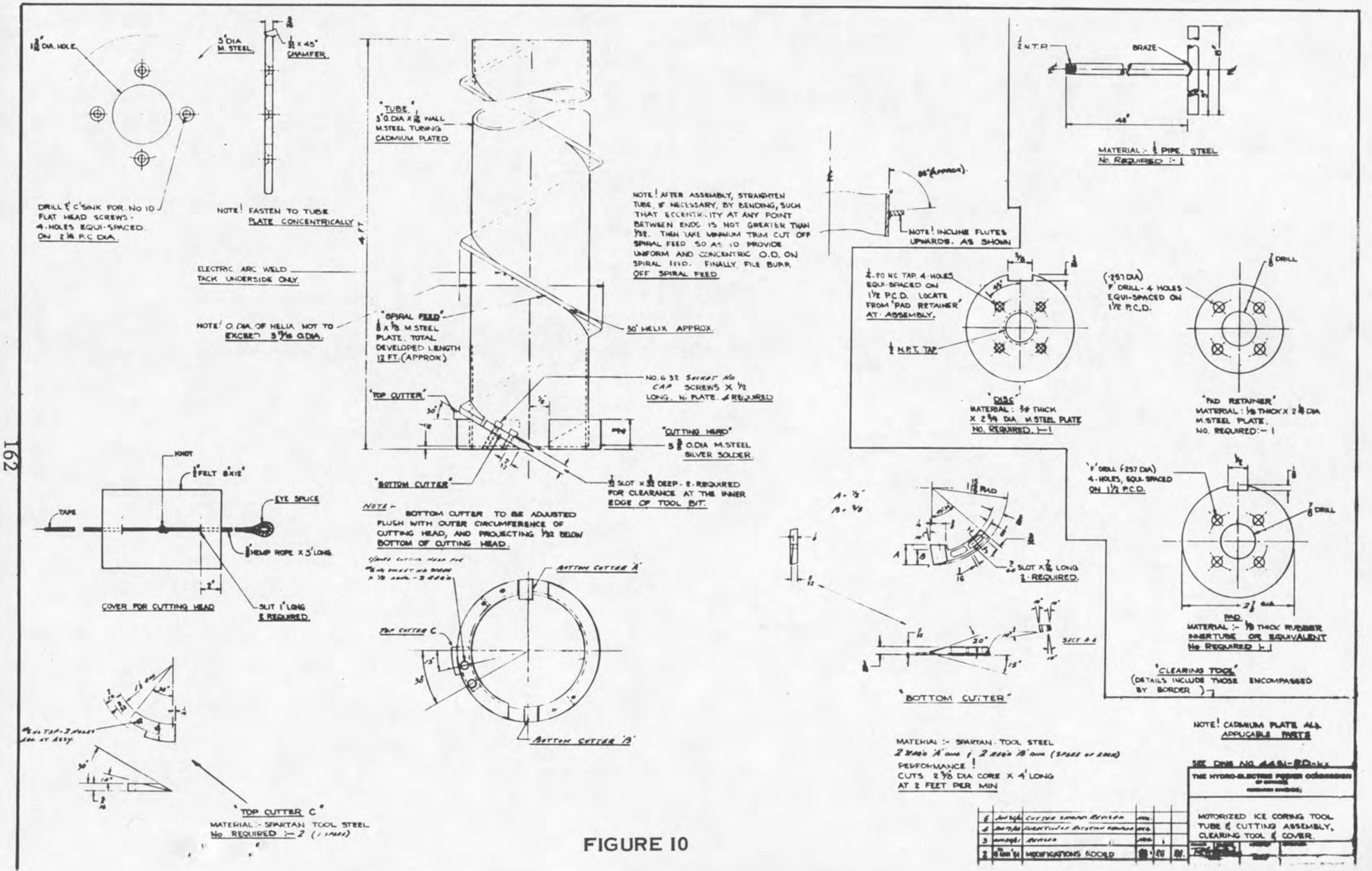

1 3/8" DIA. HOLE
DRILL & C'SINK FOR No 10 FLAT HEAD SCREWS - 4-HOLES EQUI-SPACED ON 2 1/4 P.C DIA.
3" DIA M. STEEL
1/32 X 45° CHAMFER
NOTE! FASTEN TO TUBE PLATE CONCENTRICALLY
ELECTRIC ARC WELD TACK UNDERSIDE ONLY.
NOTE! O. DIA. OF HELIX NOT TO EXCEED 3 5/16 O.DIA.
'TUBE' 3" O.DIA X 1/16 WALL M.STEEL TUBING CADMIUM PLATED
4 FT
'SPIRAL FEED' 1/8 X 3/8 M.STEEL PLATE. TOTAL DEVELOPED LENGTH 12 FT. (APPROX)
30° HELIX APPROX
NOTE! AFTER ASSEMBLY, STRAIGHTEN TUBE, IF NECESSARY, BY BENDING, SUCH THAT ECCENTRICITY AT ANY POINT BETWEEN ENDS IS NOT GREATER THAN 1/32. THEN TAKE MINIMUM TRIM CUT OFF SPIRAL FEED SO AS TO PROVIDE UNIFORM AND CONCENTRIC O.D. ON SPIRAL FEED. FINALLY FILE BURR OFF SPIRAL FEED
'TOP CUTTER'
30°
NO. 6 32 Socket Hd CAP SCREWS X 1/2 LONG. Ni PLATE. 4 REQUIRED
'CUTTING HEAD' 3 5/8 O.DIA M.STEEL SILVER SOLDER.
'BOTTOM CUTTER'
1/32 SLOT X 3/32 DEEP - 2 - REQUIRED FOR CLEARANCE AT THE INNER EDGE OF TOOL BIT.
NOTE - BOTTOM CUTTER TO BE ADJUSTED FLUSH WITH OUTER CIRCUMFERENCE OF CUTTING HEAD, AND PROJECTING 1/32 BELOW BOTTOM OF CUTTING HEAD.
KNOT
1/8" FELT 8"X12"
TAPE
EYE SPLICE
1/8" HEMP ROPE X 5' LONG.
2"
COVER FOR CUTTING HEAD
SLIT 1" LONG 2 REQUIRED.
BOTTOM CUTTER 'A'
TOP CUTTER C
BOTTOM CUTTER 'B'
'TOP CUTTER C'
MATERIAL :- SPARTAN TOOL STEEL
No REQUIRED :- 2 (1 SPARE)
1/2 N.T.P.
BRAZE
48"
MATERIAL :- 1/2 PIPE. STEEL
No. REQUIRED :- 1
85° (APPROX).
NOTE! INCLINE FLUTES UPWARDS. AS SHOWN
1/4-20 NC TAP. 4-HOLES EQUI-SPACED ON 1 1/2 P.C.D. LOCATE FROM 'PAD RETAINER' AT ASSEMBLY.
1/2 N.P.T. TAP
'DISC' MATERIAL : 3/8 THICK X 2 3/4 DIA. M.STEEL PLATE NO. REQUIRED :- 1
(.257 DIA) F DRILL - 4 HOLES EQUI-SPACED ON 1 1/2 P.C.D.
7/8 DRILL
'PAD RETAINER' MATERIAL : 1/8 THICK X 2 3/4 DIA M.STEEL PLATE. NO. REQUIRED :- 1
'F' DRILL (.257 DIA) 4-HOLES, EQUI-SPACED ON 1 1/2 P.C.D.
2 7/8 DIA
'PAD' MATERIAL :- 1/8 THICK RUBBER INNERTUBE OR EQUIVALENT No REQUIRED :- 1
'CLEARING TOOL' (DETAILS INCLUDE THOSE ENCOMPASSED BY BORDER)
A - 1/2"
B - 3/8"
1 15/16 RAD
3/64 SLOT X 7/8 LONG 2 - REQUIRED.
20°
15°
SECT A-A
'BOTTOM CUTTER'
MATERIAL :- SPARTAN - TOOL STEEL
2 REQ'D 'A' DIM ; 2 REQ'D 'B' DIM (SPARE OF EACH)
PERFORMANCE ! CUTS 2 3/8 DIA CORE X 4' LONG AT 2 FEET PER MIN
NOTE! CADMIUM PLATE ALL APPLICABLE PARTS
SEE DWG NO 4451-BD
THE HYDRO-ELECTRIC POWER COMMISSION
MOTORIZED ICE CORING TOOL TUBE & CUTTING ASSEMBLY, CLEARING TOOL & COVER.
6 CUTTER SHAPE REVISED
4 DIRECTION OF ROTATION CHANGED
3 REVISED
2 MODIFICATIONS ADDED

FIGURE 10