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CL-215 AIR TANKER MODIFICATIONS IMPROVE DROP PATTERN

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E. Stechishen

FOREST FIRE INSTITUTE
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E. Stechishen

Forest Fire Research Institute
Canadian Forestry Service
Department of the Environment
240 Bank Street
Ottawa, Ontario
K1A 0H3

ABSTRACT

Modifications to the CL-215 air tanker tanking were made and the Fire-Trac installation and Fire-Trac plus other modifications were evaluated and ranked in terms of drop pattern concentration distribution and pattern configuration. The relative differences between the basic tank drop pattern and each of the modified tank patterns are discussed. The analysis deals with 19 water and 5 Tenogum drop tests for single tank payloads of 2673 ℓ.

RESUME

Des modifications ont été effectuées aux réservoirs de l'avion citerne CL-215 et l'efficacité du système "Fire-Trac" et du "Fire-Trac" plus d'autres modifications à été évalué. Les résultats ont été classés selon la concentration au sol et la forme de la zone arrosée. Le rapport traite des différences entre la distribution au sol avec réservoirs non-modifiés comparativement à chaque essai avec réservoirs modifiés. Le contenu d'un seul réservoir (2673 ℓ) à été largué à chaque essai et 19 largages ne contenaient que de l'eau alors que 5 contenaient un mélange d'eau et de produit retardant "Tenogum".

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Introduction

The initial objective in the development of air tankers was to provide the forest protection agencies with an aerial system of suppressant delivery. In equipping aircraft with the tanking and associated mechanisms, the main concern was to have a system which would enable the pilot to eject his load safely on a specific target. Aerial suppression flourished and cascading of water and fire retardant materials gained acceptance throughout North America but the concept of a "flying bucket" was not improved upon for many years. The trend was to increase the payload (use larger aircraft) to enhance air tanker capabilities but little was done to improve the tanking other than the totally new revolutionary approach undertaken by Field Aviation in the design and fabrication of the membrane tank. Although the concept of a programmed release of the payload gained acceptance, the user agencies were not convinced that the membrane tank system was an economical alternative. The next innovation to emerge from the Field Aviation Workshops was the Fire-Trac system. Although this grill-work type removable installation was originally designed and built for use in the Ontario Tracker air tankers, one unit was fabricated and installed in one of Quebec's CL-215's (CF-TXB). The test series at St. Honoré, Québec, in September 1974 was executed to determine the degree of load modification attained by using this Fire-Trac installation and to determine whether other modifications would enhance the load redistribution initiated by the Fire-Trac unit. Tenogum[1] was used in seven of the 30 tests to determine distribution changes between a viscous product and non-viscose water after passage through the Fire-Trac unit. Single tank capabilities (2673 ℓ payload) were evaluated in all but three of the tests.

The modifications, the screening attached to the Fire-Trac, the water head divider, and the vent airflow controller, were evaluated individually and in different combinations, however, the Fire-Trac installation was present at all times. The effect any of these modifications on load redistribution without the Fire-Trac was not determined. On-site determination of the degree of success achieved by using any of these installations was done by comparing the 0.1 cm application contour coverage.

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[1]Tenogum, sold in Canada by Charles Tennant & Co. Ltd., is a blend of water soluble vegetable colloids which when mixed with water yields a viscous gel.

The criteria used were the total length of the 0.1 cm contour and the portion of this contour having a minimum width of 9 m. For a more detailed analysis it was necessary to consider: the total area within the 0.005 cm contour; the overall length of the drop pattern within the 0.005 cm contour; the coverage (area) between the 0.005 cm contour and the 0.4 cm contour; the area within the 0.05 cm contour; the area within the 0.1 contour; the overall length of the 0.1 cm contour; and the length of the 0.1 cm contour having the specified minimum width (9 m).

Methods and Results

The Forest Fire Protection Service of the Quebec Department of Lands and Forests established a 61 x 244 m catch cup grid at St. Honoré, Québec, with the interior 36.6 x 152.4 m of the grid having a cup spacing of 3.05 x 6.1 m and the periphery a 6.1 x 6.1 m spacing. A field office was established adjacent to the grid to facilitate immediate weighing of the capped catch cups after each drop. The weights were simultaneously converted to depth in centimetres and entries were made directly on a grid map and were also recorded on tape.

The air tanker's drop height above grid and its air speed were 30.5 m and 185 km/h respectively for the 24 tests discussed herein.

In the text, reference will be made simply to Screen, Divider and Vent to mean the screening attached to the Fire-Trac, the head divider, and the vent air flow controller respectively.

During the trials the objective was to determine which modification maximized the 0.1 cm coverage, that is, which one yielded a pattern having the largest area within the 0.1 cm contour having the greatest length with a minimum coverage width of 9 m. On later examination it became evident that other parameters had to be considered in a comprehensive evaluation. Although it was desirable to maximize the area, the total length, and the minimum-width length of the 0.1 cm contour, it was also desirable to reduce or eliminate the peak concentrations that were so prevalent when the basic tank was used. Furthermore, an increase in total coverage was futile if this areal increase was primarily in the less than 0.05 cm application coverage. On examining the 0.1 cm contour lengths it appeared that comparisons with an arbitrary acceptable minimum length of 50 m were a just reflection on the effectiveness of a given modification in redistributing the payload. Using these criteria, the following ratios were deemed appropriate for inclusion in a rating equation:

$\frac{A}{B}$ = Ratio of area within the 0.1 cm contour (A) to the total area within the 0.005 cm contour (B),

$\frac{C}{B}$ = Ratio of area between 0.005 and 0.4 cm contours (C) to the total area within the 0.005 cm contour (B).

$\frac{D}{B}$ = Ratio of area within the 0.05 cm contour (D) to the total area within the 0.005 cm contour (B).

$\frac{E}{G}$ = Ratio of length of the 0.1 cm contour (E) to the total length of the 0.05 cm contour (G).

$\frac{F}{E}$ = Ratio of length of given width of the 0.1 cm contour (F) to the total length of this contour (E).

$\frac{E}{50}$ = Ratio of the 0.1 cm contour length (E) to acceptable contour length of 50 m.

These areas and lengths are identified in Figures 1 and 2. The drop pattern rating equation derived from these ratios,

$$DPR = \left(\frac{A}{B} + \frac{C}{B} + \frac{D}{B} + \frac{E}{G} + \frac{F}{E} + \frac{E}{50}\right) 1/5,$$

numerically categorizes these patterns. Pattern superiority increases as the value of the dimensionless DPR number increases. The data used in the DPR determination and the derived values for each type of tank configuration are presented in numerical form in Tables 1, 2 and 3 and in pictorial form in Figure 3. The rating system ranks the individual patterns primarily on their own merits to determine which combination of modifications yields the best overall distribution. Some degree of normalization was obtained by incorporating 50 m as the arbitrary standard for the 0.1 cm contour length in the equation.

To demonstrate the effects of deleting F/E from the equation, 9 m minimum width criterion, adjusted rating values (ADPR) were calculated and are also included in these tables and figure.

The position of each installation is indicated in Figure 4 and sample drop pattern diagrams for each type of tank configuration are presented in Figures 5 to 18 inclusive with five cross-section profiles appearing in Figures 19 to 23.

Discussion

Water Drop Patterns

The basis of comparison for the percentage changes tabulated in Table 2 are the values derived for the unmodified tank output. These percentages indicate the degree of redistribution obtained by using the modifications singly or in combination. The only negative changes in Area B that occurred was when Fire-Trac plus Vent were used; the decrease in area within the 0.005 cm contour was 5 %. It (Area B) increased from 9% for Fire-Trac + Screen + Divider to 41% when only the Fire-Trac was used but in spite of the area changes, the overall pattern length (G) variations were negligible in all cases, +4 to -8%. Not only did this indicate that the area increase was due primarily to an increase in pattern width, but the time interval for the 2673 ℓ load to exit remained relatively constant irrespective of the tank configuration. In the situation where Area B increase was 41 %, Area A (within 0.1 cm contour) and Area D (within 0.05 cm contour) increases were only 13 and 20% respectively. The major increase in coverage unfortunately was in the below 0.05 cm application range which is the relative ineffective application zone. The combination that produced the next largest increase in Area B (36%) was Fire-Trac plus Divider but the respective increases in areas A and D were 17 and 30%, which is not too impressive either. Maximization of Area A was achieved by incorporating all the tank modifications, 43 % increase, but maximum increase in Area D, 52%, and in length E (length of 0.1 cm contour), 61%, was attained when all but the Screen were used. In the ADPR ranking process wherein no width limitations for the 0.1 cm contour were imposed, the Fire-Trac, Divider and Vent combination ranked No. 1 (Table 3) but when the 9 m width criteria was imposed, it ranked No. 3 (DPR). Fire-Trac plus Vent patterns ranked No. 1 on the DPR scale primarily because of the highest increase in length F (length of 0.1 cm contour having a minimum width of 9 m), i.e. 61%.

The most striking evidence that the Fire-Trac installation was functioning and was modifying water bulk-flow was the lack of high concentration peaks for these drops. This is born out in the drop pattern profiles in Figures 19 and 20 where the peak maximum for Drop #25 (unmodified) was 1.540 cm and for Drop #5 (Fire-Trac) the maximum depth was 0.599 cm. Coupled with this peak decrease was an increase of 28% in the overall length of the 0.1 cm contour. The addition of the Screen to the Fire-Trac enhanced tanker performance as noted in the patterns by increasing area A by another 5% and lengths E and F by 5 and 37 % respectively. Area D was unchanged but Area B was reduced by 13 %. By using the Divider with the Fire-Trac, no appreciable pattern improvements were noted but by including the Screen as well, the overall length of the 0.1 cm contour (E) was elongated by an additional 17%.

The most important factor in payload manipulation proved to be the Vent. This airflow controller created a throttling effect during payload discharge such that a programmed release of the water was attained when it was used in any combination with other installations. The highest increases in areas A and D and in lengths E and F were recorded for those patterns when the Vent was in use. The Vent was instrumental in providing the desired load distribution required for meeting the drop pattern rating criteria; consequently, its presence in the system in ranks 1, 2 and 3 in the DPR and ADPR ratings is not accidental. Although the influx of air into the tank to displace the exiting water was restricted, the entrance rate did not alter the time interval normally required for the 2673 load to leave the air tanker.

The rating number separations between the respective DPR values for the different tank configurations identify four groupings: 0.808 - 0.820 for configurations ranked No. 1 and 2; 0.771 for that ranked No. 3; 0.730 - 0.739 for those ranked No. 4, 5 and 6; and 0.665 - 0.681 for those ranked No. 7, 8 and 9. The spread between these apparent groups is 49, 32 and 37 units respectively, the within group spread is 12, 0, 9 and 16 units. The 16 unit spread between the DPR numbers for those ranked No. 7, 8 and 9 indicates that the Fire-Trac afforded some measure of improvement but not as significant as when it was used in combination with modifications other than just the Divider. The lack of notable differences among ranks No. 4, 5 and 6 indicated that, on the whole, using either combination produced relatively similar patterns but in reality one's choice would depend on optimization of a specific application concentration, greatest areal coverage and/or greatest length.

By deleting the 9 m width criterion (F/E) from the rating derivation, the new rank designations according to the ADPR numbers remained identical except for the reversal of ranks No. 1 and 3. The ADPR unit spread distribution confirmed that any modification produced a drop pattern which on the whole was superior to that of the unmodified tank. Fire-Trac and Fire-Trac plus Divider both rated 55 units higher than the ADPR for the basic tank. Furthermore, the Divider did not make any worthwhile contribution unless it was used in combination with either the Screen and/or the Vent.

Tenogum Drop Patterns

The expectations were that overall pattern sizes would decrease when an inspissator was used but load transformations would be relatively similar to those for water drops. Since the prime purpose of the Tenogum tests was to determine whether the gravity-feed injector functioned properly and whether increasing the Tenogrum concentration from 0.25% to 0.35 % would yield an adequately viscous product, only several one-of-a-kind drops were made.

The drop patterns for Tenogum thickened water having a viscosity ranging from 536 to 864 mPa s (Brookfield, spindle No. 3 @ 30 rpm) when mixed in the ratio of 2.5 g Tenogum to 1.0 kg water (0.25%) were reduced in total area from 10 to 35 % for unmodified to fully modified tank compared to parallel water drop patterns. Although the overall area had decreased, the area within the 0.05 cm contour (D), the area (A) and length (E) of 0.1 cm contour, the minimum-width length (F) and the total pattern length (G) were not appreciably different. The areal decrease was primarily due to a reduction in pattern width. Whether or not the minimum width criteria is applied, the modified tank out-performed the basic air tanker tank: the respective increases for areas A and D and length E were 16, 17 and 34% countered by decreases in areas B and C and lengths F and G of 7, 6, 38 and 4%. The Fire-Trac, Screen, Divider and Vent combination modified bulk flow by reducing high concentration peaks from 1.08 cm to 0.599 cm and by utilizing this excess to extend the 0.1 cm contour.

The advantages of utlizing these tank modification was further demonstrated when the mixing ratio for Tenogrum was increased to 0.35%. Erosion of the more viscous gel (996 to 1128 mPa s viscosity) was reduced, consequently the pattern for the unmodified tank was very compact and the proportion of the area within 0.5 cm to 0.9 cm contours was more than twice as large as when a 0.25% mix was used. Nevertheless, by using Fire-Trac, the peak concentrations were reduced below 0.5 cm in depth and this volume was redistributed over the entire pattern. Inclusion of the Screen, Divider and Vent with the Fire-Trac resulted in further improvements in pattern distribution: the 0.1 cm contour area (A) increased by 32% and its length (E) by 68%; the 0.05 cm contour area increase was 39%; and the 9 m minimum-width length (F) of the 0.1 cm contour increased by 57 %. Much of the enhancement of the foremertioned was achieved by reducing the coverage in the less than 0.1 cm and greater than 0.3 cm coverage zones. Under the DPR and ADPR ratings the fully modified tank performance was ranked No. 1 (0.682 and 0.587) and the unmodified tank placed 3rd with ratings of 0.648 and 0.511, respectively.

The modified tank improved the drop distribution as seen in the resultant drop patterns irrespective of the viscosity of the payload.

Remarks

Manipulation of payload discharge by the installation of simple flow controllers was an attempt to attain a programmed release of the load to best meet the desired ground distribution. The basic CL-215 tank deposits miniature mountains of suppressant on the ground as indicated in the longitudinal cross-section profile. Any change in reducing these high peaks and spreading the excess material to deficient areas is a noteworthy achievement. Each of the installations that were tested had an impact on controlling load release and when used in combination with each other they provided some very encouraging drop patterns.

The three crude innovations that were used with the Fire-Trac during these tests have been replaced with prototype units and field use during 1976 should indicate effectiveness attained by using these installations in air tanker CF-TXB.

TABLE 1: DROP PATTERN RATING DATA

CONFIGURATION	(DROP NO)	A (m^2)	$\bar{A}$ (m^2)	B (m^2)	$\bar{B}$ (m^2)	C (m^2)	$\bar{C}$ (m^2)	D (m^2)	$\bar{D}$ (m^2)	E (m)	$\bar{E}$ (m)	F (m)	$\bar{F}$ (m)	G (m)	$\bar{G}$ (m)
WATER															
BASIC TANK	(15)	555		3475		3389		1049		41		33		171	
	(24)	511		3252		3169		853		43		35		171	
	(25)	534	533	3631	3453	3630	3363	972	958	55	46	25	31	134	159
FIRE - TRAC	(2)	617		4296		4291		1127		52		30		140	
" "	(5)	592	604	5455	4875	5394	4842	1174	1150	66	59	28	29	183	161
FIRE - TRAC + SCREEN	(16)	659		4415		4329		1151		66		42		165	
"	(17)	596	627	4400	4407	4354	4341	1148	1149	57	61	39	40	165	165
FIRE - TRAC + DIVIDER	(10)	605		4081		4070		1168		54		18		152	
"	(12)	643	624	5329	4705	5324	4697	1331	1249	62	58	34	26	180	166
FIRE - TRAC + VENT	(8)	714		3203		3198		1194		77		55		155	
" "	(9)	656	685	3360	3281	3331	3264	1057	1125	66	66	45	50	148	151
FIRE - TRAC + SCREEN	(20)	727		3646		3607		1117		67		37		158	
+ DIVIDER	(21)	538	632	3854	3750	3843	3725	1074	1095	65	66	25	29	134	146
FIRE - TRAC + SCREEN	(22)	713		4079		4060		1297		83		43		160	
+ VENT	(23)	706	710	3736	3907	3706	3883	1289	1293	62	72	46	44	158	159
FIRE - TRAC + DIVIDER	(13)	839		4161		4147		1435		76		40		158	
+ VENT	(14)	626	733	4610	4385	4595	4371	1477	1456	72	74	21	30	158	158
FIRE - TRAC + SCREEN	(18)	665		4285		4271		1361		52		30		149	
+ DIVIDER + VENT	(19)	857	761	4763	4524	4729	4500	1328	1344	74	63	40	35	180	164
TENOSUM (0.25 %)															
BASIC TANK	(27)	572		3094		3020		959		59		40		166	
FIRE - TRAC + SCREEN + DIVIDER + VENT	(29)	662		2876		2833		1124		79		25		180	
TENOSUM (0.36 %)															
BASIC TANK	(26)	517		2865		2745		935		41		28		146	
FIRE - TRAC	(3)	496		3397		3397		1056		57		27		167	
FIRE - TRAC + SCREEN + DIVIDER + VENT	(28)	684		3513		3510		1297		69		44		171	

TABLE 2. **Percentage areal and length changes for patterns for specific tank configurations based on drop pattern data for the unmodified tank.**

CONFIGURATION	$\bar{A}$ (m^2)	Increase (%)	$\bar{B}$ (m^2)	Increase (%)	$\bar{C}$ (m^2)	Increase (%)	$\bar{D}$ (m^2)	Increase (%)	$\bar{E}$ (m)	Increase (%)	$\bar{F}$ (m)	Increase (%)	$\bar{G}$ (m)	Increase (%)
WATER														
BASIC TANK	533		3453		3363		958		46		31		159	
FIRE - TRAC	604	13	4875	41	4842	44	1150	20	59	28	29	-8	161	1
FIRE - TRAC + SCREEN	627	18	4407	28	4341	29	1149	20	61	33	40	29	165	4
FIRE - TRAC + DIVIDER	624	17	4705	36	4697	40	1249	30	58	26	26	-16	166	4
FIRE - TRAC + VENT	685	28	3281	-5	3264	-3	1125	17	68	48	50	61	151	-5
FIRE - TRAC + SCREEN + DIVIDER	632	19	3750	9	3725	11	1095	14	66	43	29	-8	146	-8
FIRE - TRAC + SCREEN + VENT	710	33	3907	13	3883	15	1293	35	72	56	44	42	159	0
FIRE - TRAC + DIVIDER + VENT	733	37	4385	27	4371	30	1456	52	74	61	30	3	158	0
FIRE - TRAC + SCREEN + DIVIDER + VENT	761	43	4524	31	4500	34	1344	40	63	37	35	13	164	3
TENOGUM (0.28 %)														
BASIC TANK	572		3084		3020		959		59		40		166	
FIRE - TRAC + SCREEN + DIVIDER + VENT	662	16	2876	-7	2833	-6	1124	17	79	34	25	-38	160	-4
TENOGUM (0.35 %)														
BASIC TANK	517		2885		2745		935		41		28		146	
FIRE - TRAC	496	-4	3397	18	3392	24	1056	13	57	39	27	-4	167	14
FIRE - TRAC + SCREEN + DIVIDER + VENT	684	32	3513	22	3510	28	1297	39	69	68	44	57	171	17

TABLE 3. DERIVED PATTERN RATING VALUES

CONFIGURATION	(DROP NO.)	DPR	$\overline{DPR}$	RANK (DPR)	ADPR	$\overline{ADPR}$	RANK (ADPR)
WATER							
BASIC TANK	(15)	0.660			0.499		
	(24)	0.664			0.501		
	(25)	0.670	0.665	9	0.579	0.526	9
FIRE - TRAC	(2)	0.679			0.564		
" "	(5)	0.683	0.681	7	0.598	0.581	8
FIRE - TRAC + SCREEN	(16)	0.749			0.622		
" "	(17)	0.711	0.730	6	0.574	0.598	6
FIRE - TRAC + DIVIDER	(10)	0.640			0.573		
" "	(12)	0.700	0.670	8	0.590	0.581	7
FIRE - TRAC + VENT	(8)	0.869			0.726		
" "	(9)	0.771	0.820	1	0.621	0.673	3
FIRE - TRAC + SCREEN	(20)	0.762			0.652		
+ DIVIDER	(21)	0.717	0.739	4	0.640	0.646	4
FIRE - TRAC + SCREEN	(22)	0.837			0.733		
+ VENT	(23)	0.780	0.808	2	0.632	0.682	2
FIRE - TRAC + DIVIDER	(13)	0.814			0.709		
+ VENT	(14)	0.728	0.771	3	0.670	0.689	1
FIRE - TRAC + SCREEN	(18)	0.687			0.572		
+ DIVIDER + VENT	(19)	0.777	0.732	5	0.669	0.620	5
TENOGUM (0.25 %)							
BASIC TANK	(27)	0.737		2	0.601		2
FIRE - TRAC + SCREEN	(29)	0.799		1	0.736		1
+ DIVIDER + VENT							
TENOGUM (0.35 %)							
BASIC TANK	(26)	0.648		3	0.511		3
FIRE - TRAC	(3)	0.682		2	0.587		2
FIRE - TRAC + SCREEN	(28)	0.797		1	0.699		1
+ DIVIDER + VENT							

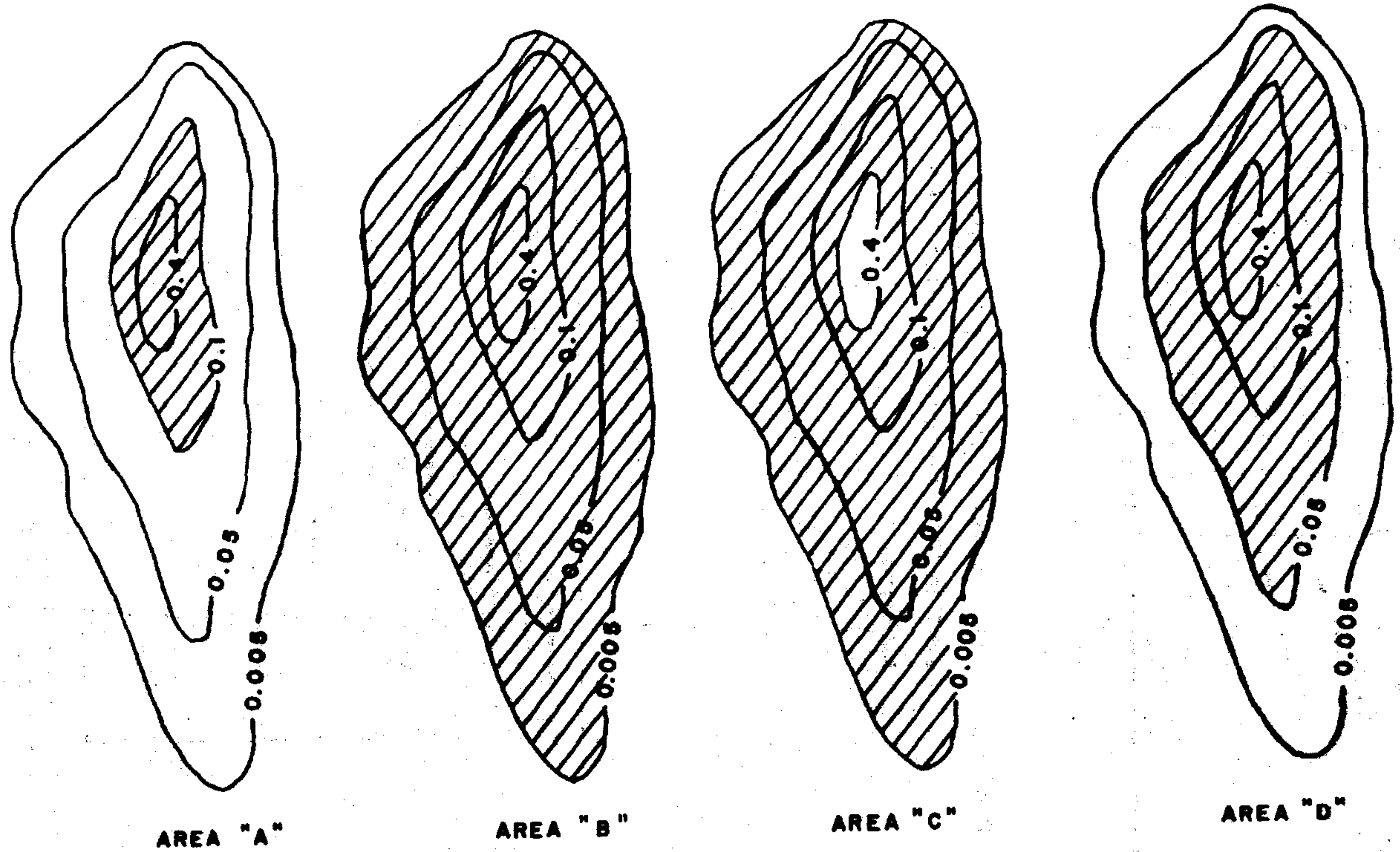


FIGURE 1. Areas represented by the symbols (crosshatched) used in the drop pattern rating (DPR) equation.

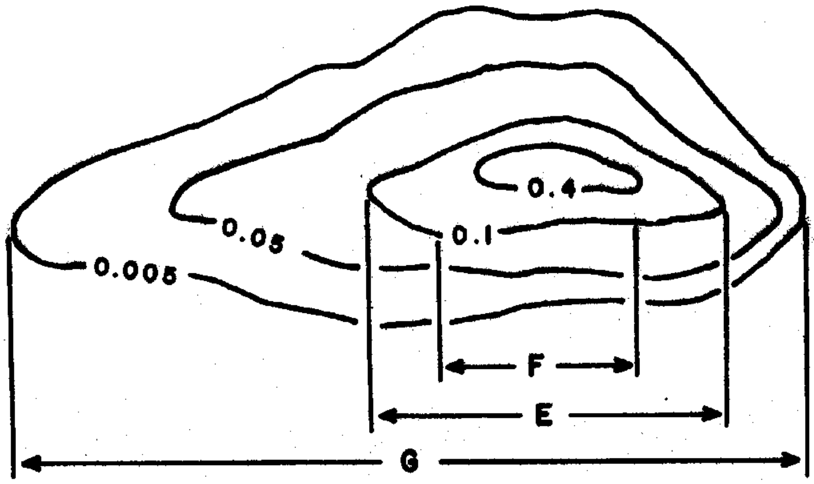


FIGURE 2. Lengths represented by the symbols used in the drop pattern rating (DPR) equation.

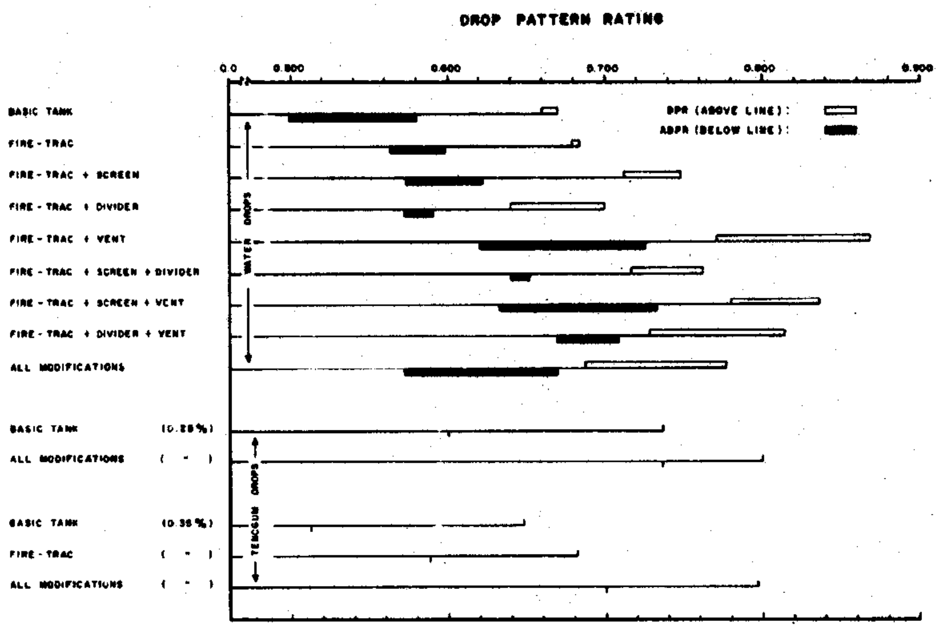
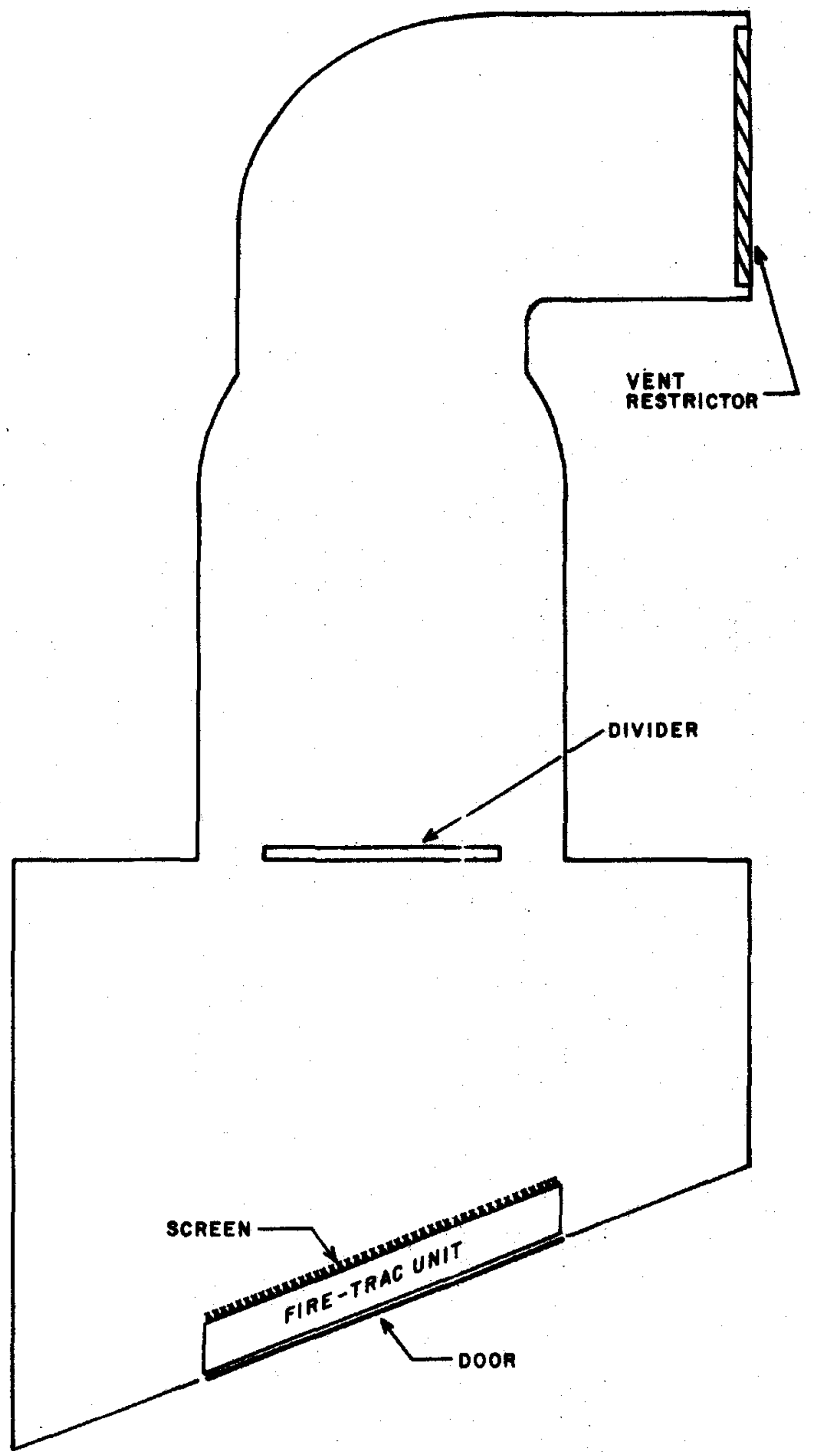


FIGURE 3. Drop pattern rating ranges for different tanker tank configurations for water drops and for tenogum drops having 0.25 and 0.35 per cent concentrations.



(NOT TO SCALE)

FIGURE 4. Sketch of tank cross-section showing positions of fire-trac unit, screen, head divider and vent restrictor.

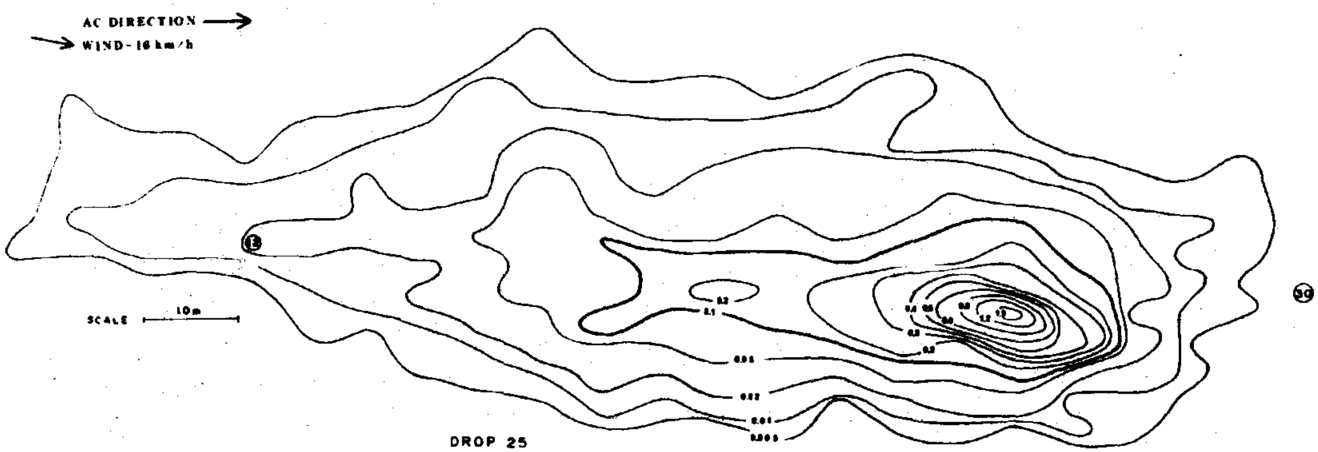


Figure 5. Water drop pattern for unmodified CL-215 tank (contours in cm).

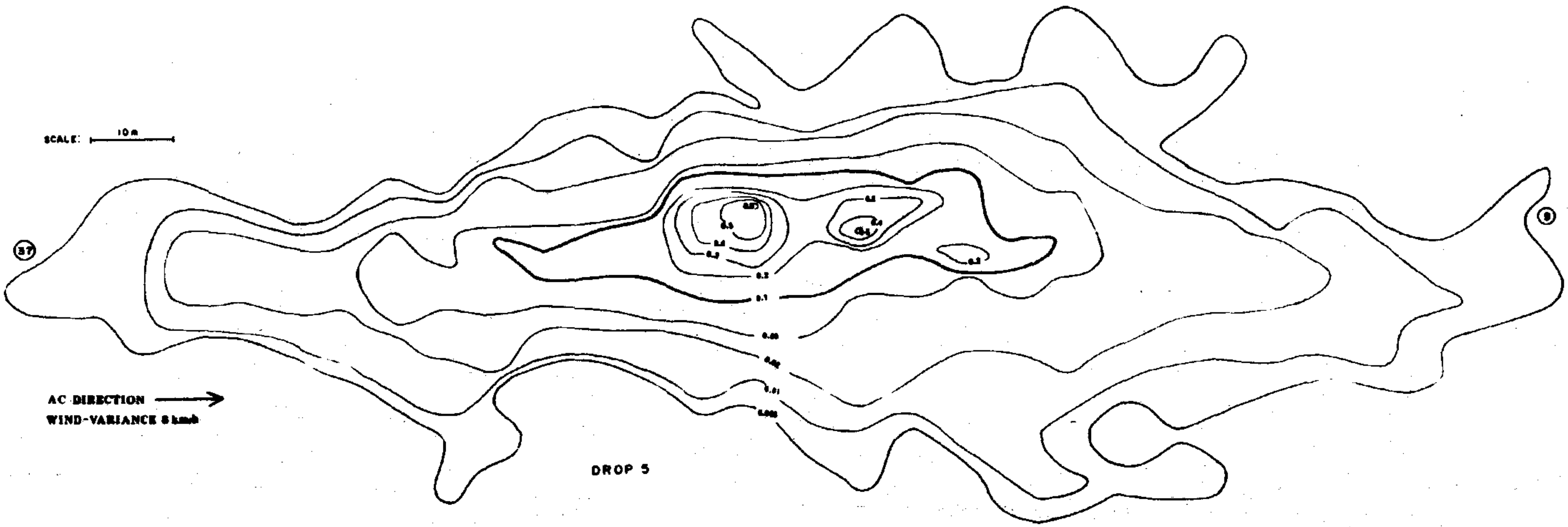


Figure 6. Resultant water drop pattern for tank equipped with Fire-Trac unit (contours in cm).

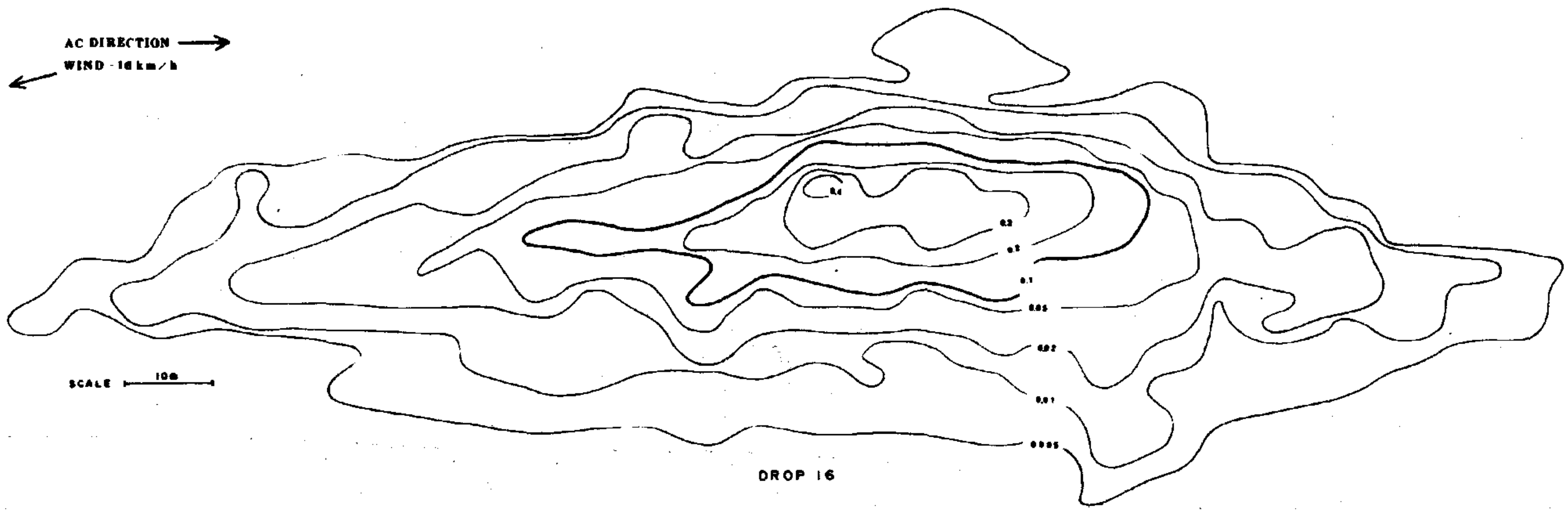


Figure 7. **Resultant water drop pattern for tank equipped with Fire-Trac and Screen (contours in cm).**

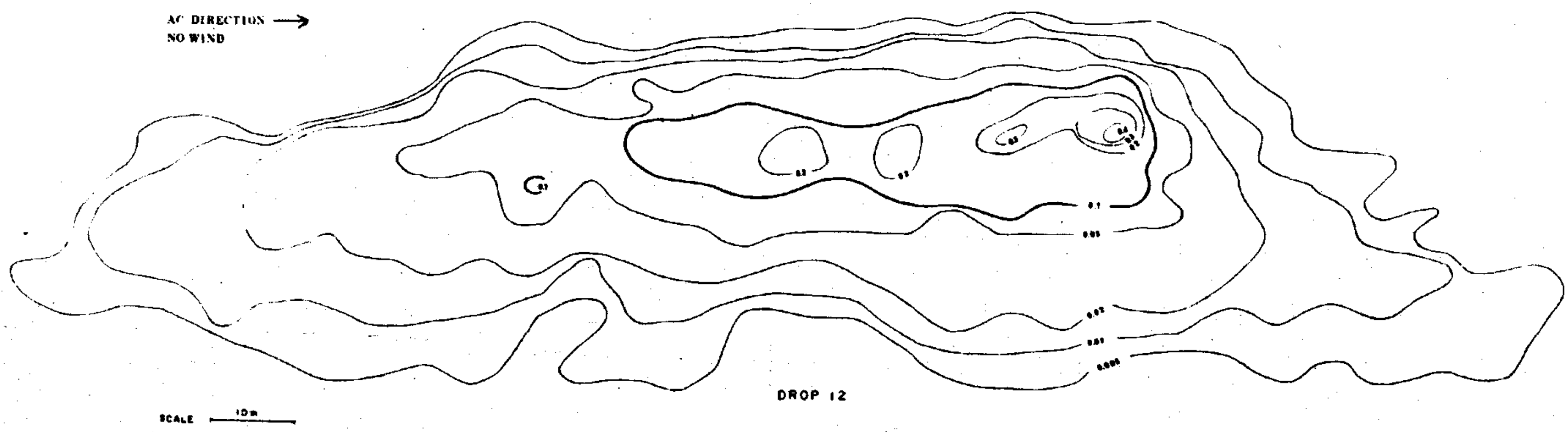


Figure 8. **Resultant water drop pattern for tank equipped with Fire-Trac and Divider (contours in cm).**

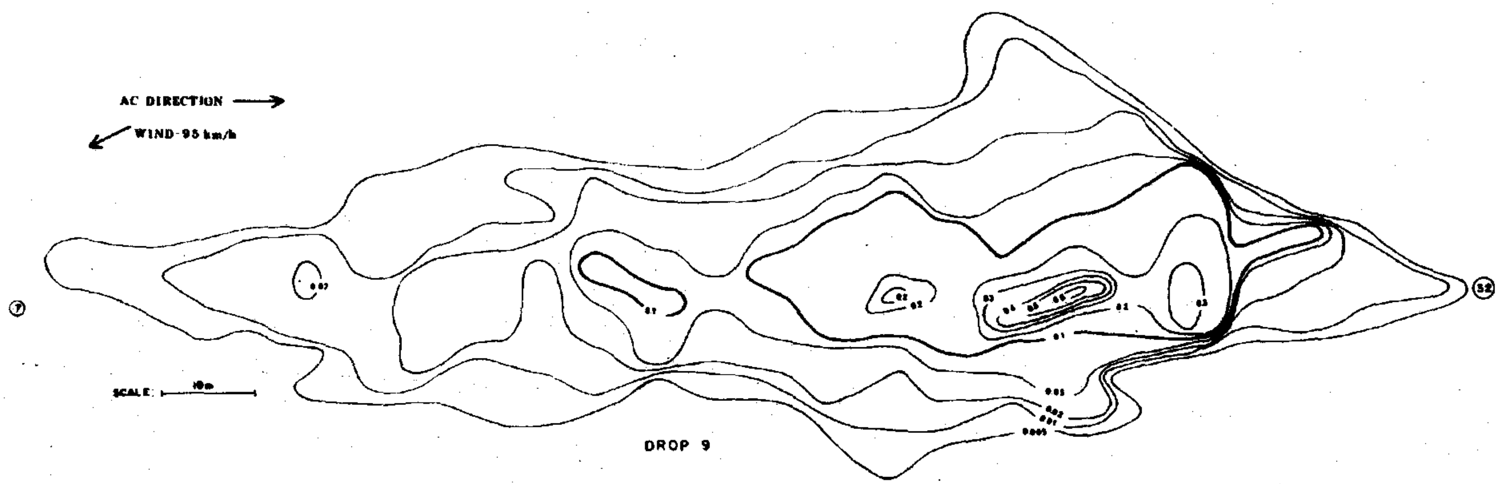


Figure 9. **Resultant water drop pattern for tank equipped with Fire-Trac and Vent (contours in cm).**

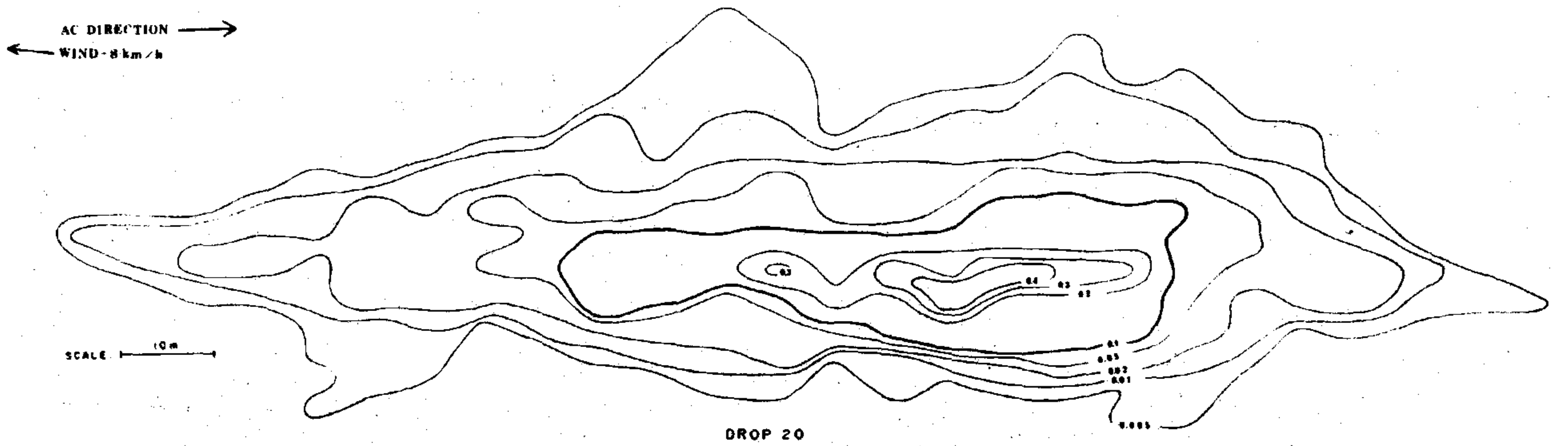


Figure 10. **Resultant water drop pattern for tank equipped with Fire-Trac, Screen and Divider (contours in cm).**

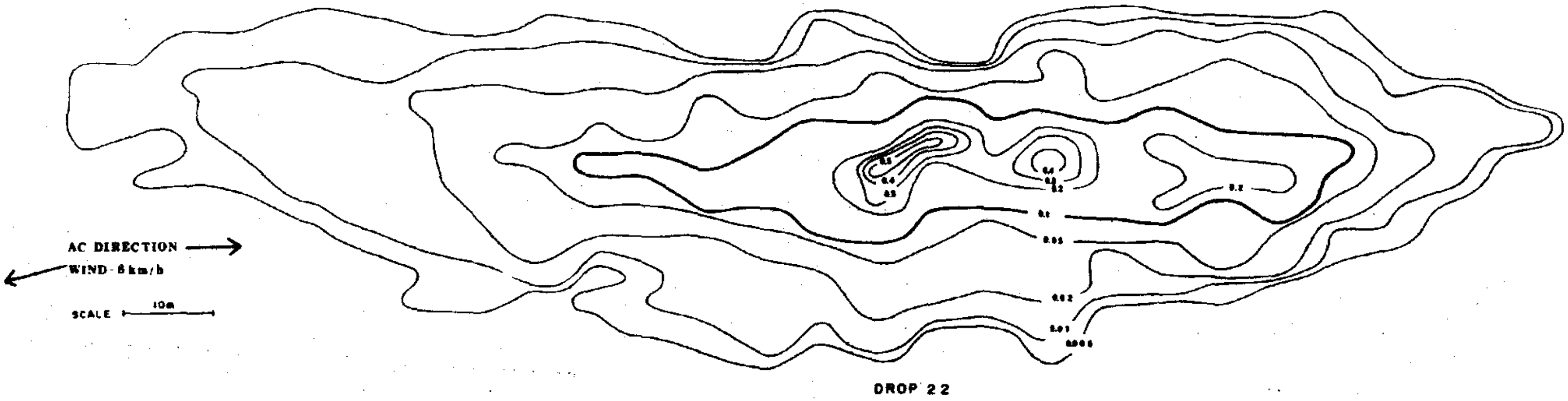


Figure 11. **Resultant water drop pattern for tank equipped with Fire-Trac, Screen and Vent (contours in cm).**

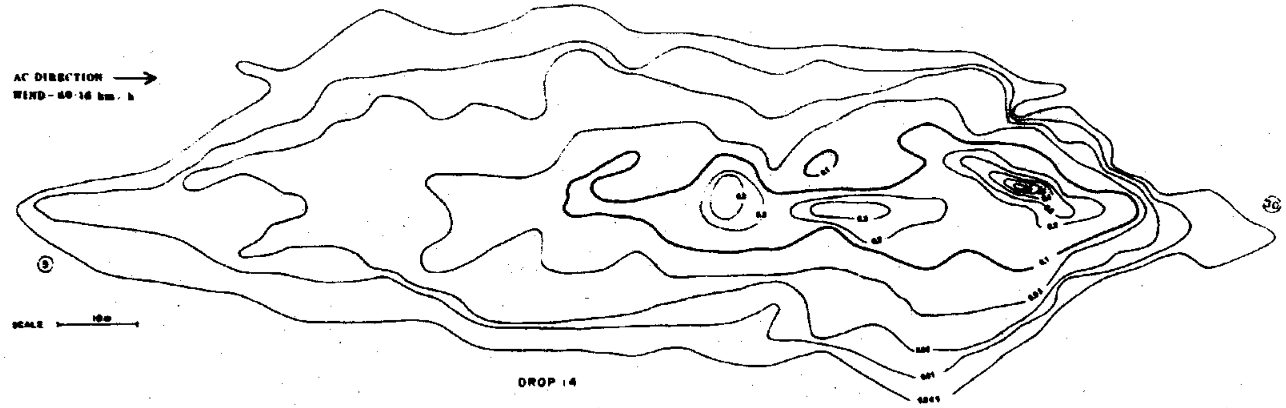


Figure 12. **Resultant water drop pattern for tank equipped with Fire-Trac, Divider and Vent (contours in cm).**

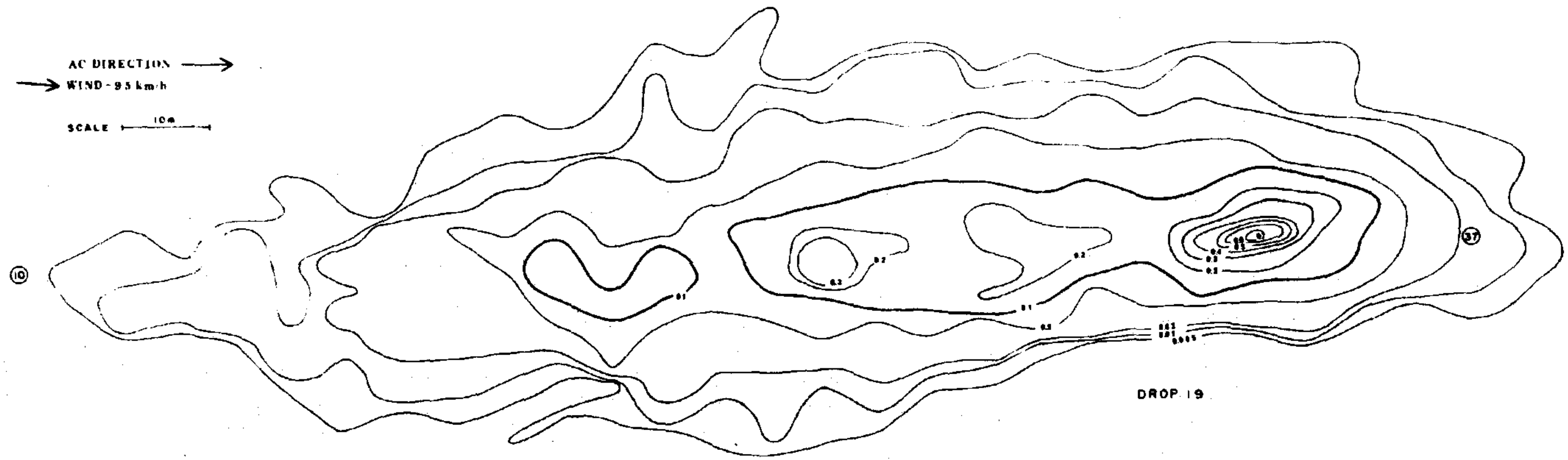


Figure 13. **Resultant water drop pattern for tank equipped with Fire-Trac, Screen, Divider and Vent (contours in cm).**

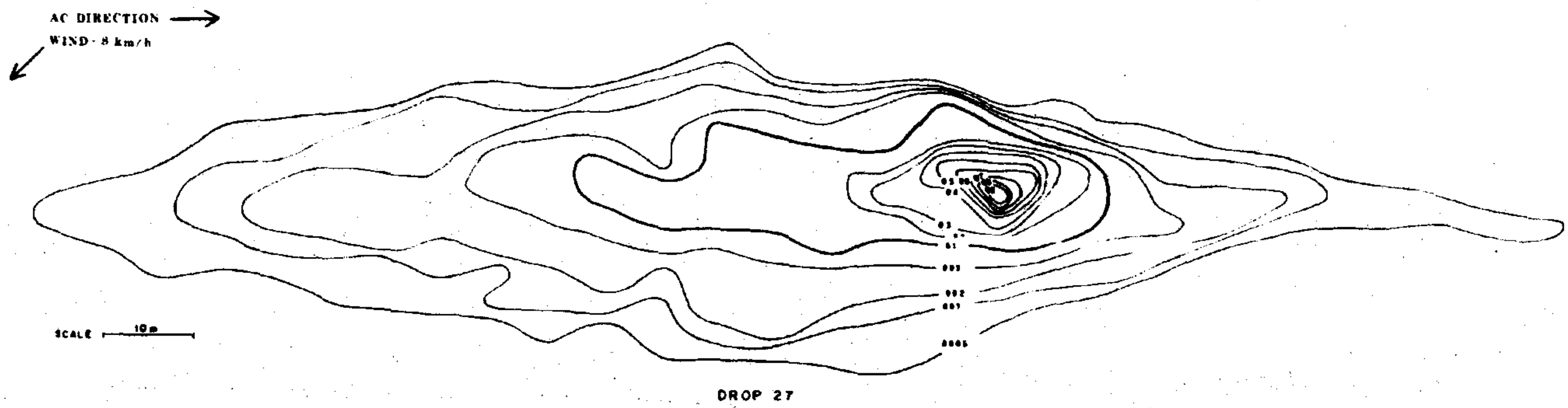


Figure 14. Tenogum (0.25%) drop pattern for unmodified tank (contours in cm).

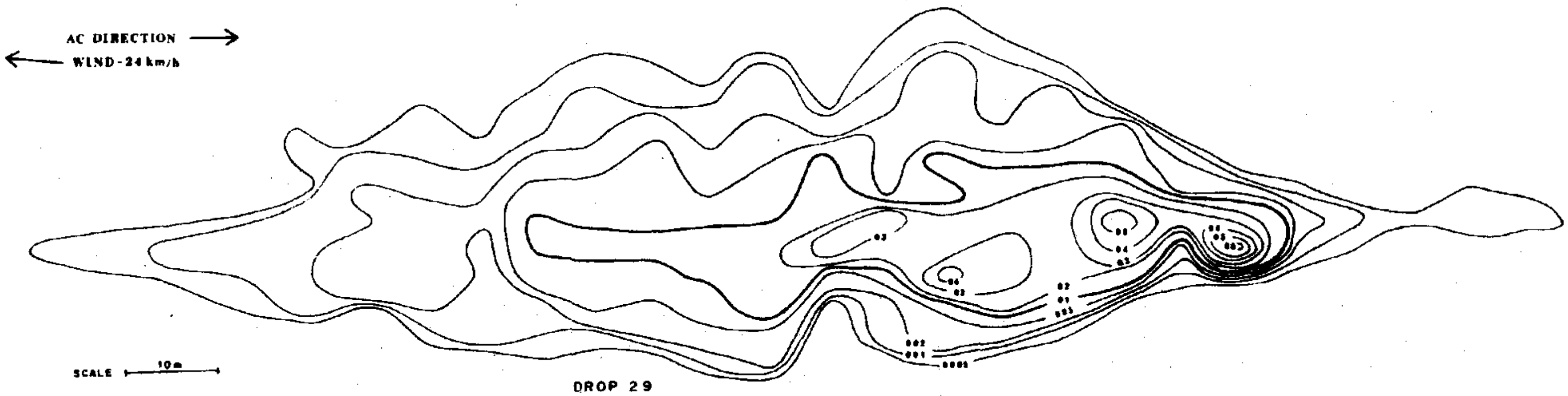


Figure 15. **Resultant Tenogum (0.25%) drop pattern for tank equipped with Fire-Trac, Screen, Divider and Vent (contours in cm).**

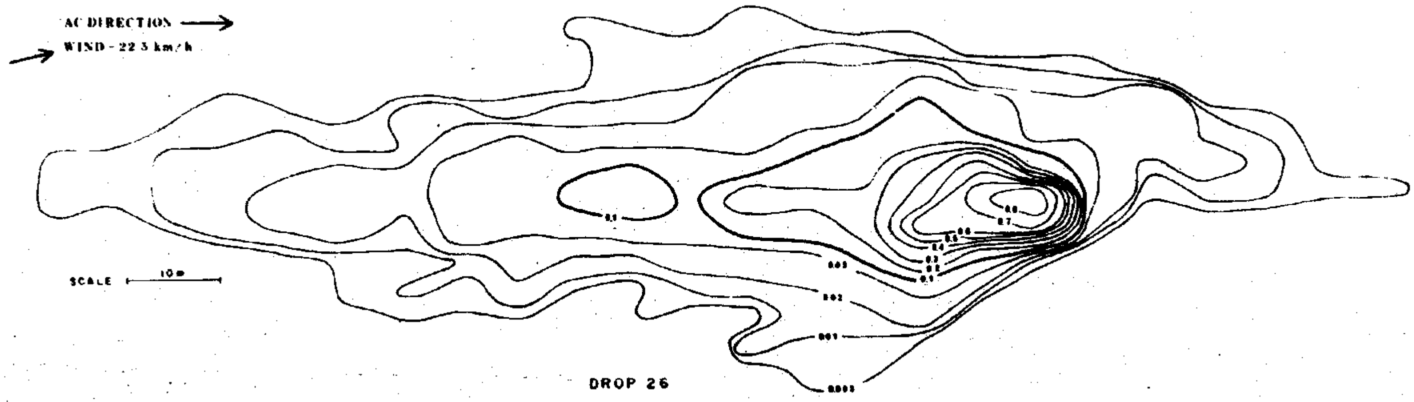


Figure 16. **Tenogum (0.35%) drop pattern for unmodified tank (contours in cm).**

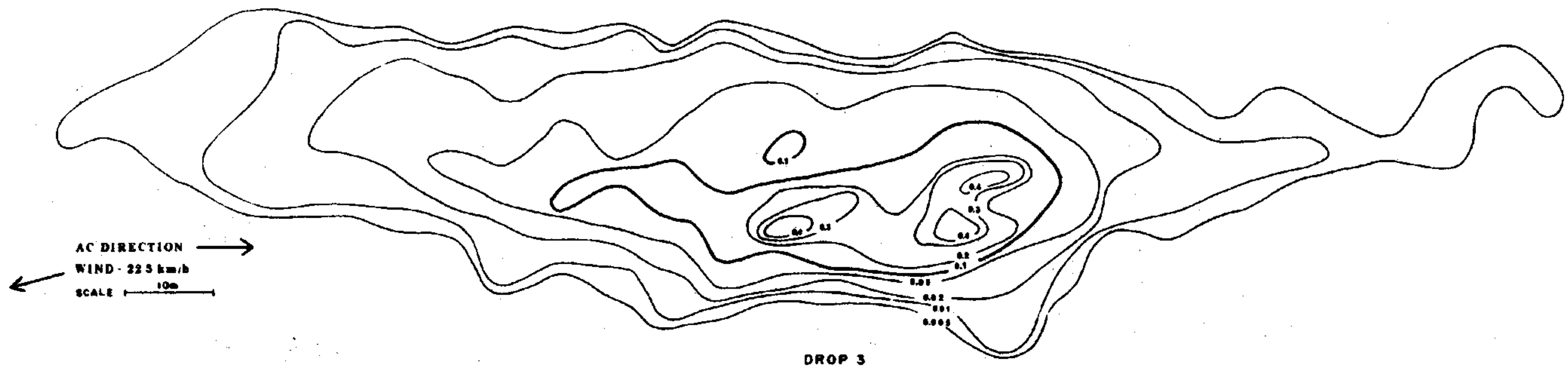


Figure 17. **Resultant Tenogum (0.35%) drop pattern for tank equipped with Fire-Trac unit (contours in cm).**

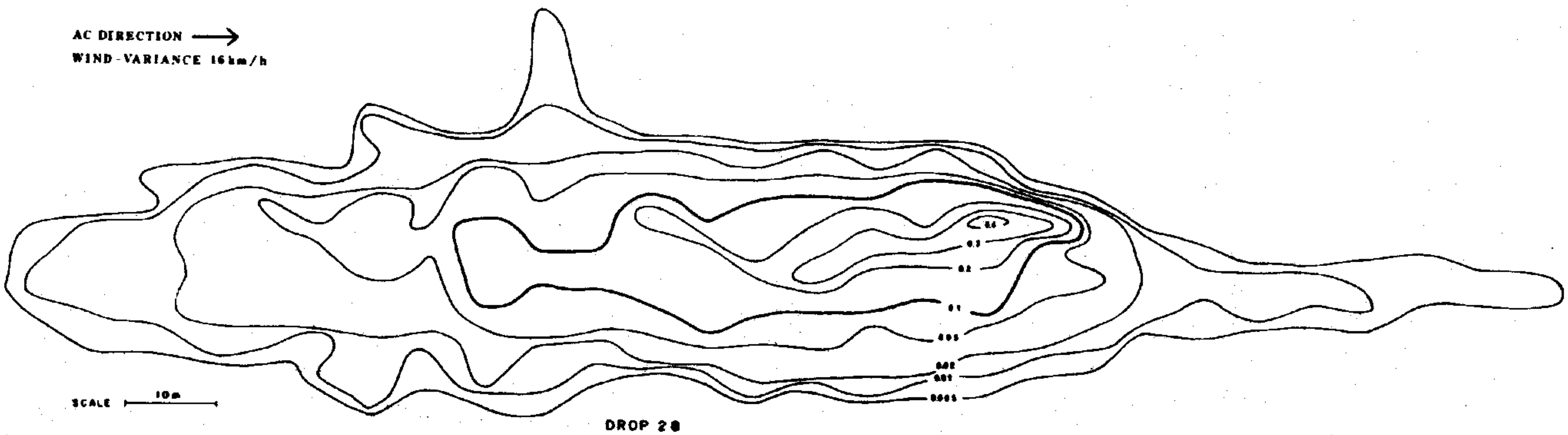


Figure 18. **Resultant Tenagum (0.35%) drop pattern for tank equipped with Fire-Trac, Screen, Divider and Vent (contours in cm).**

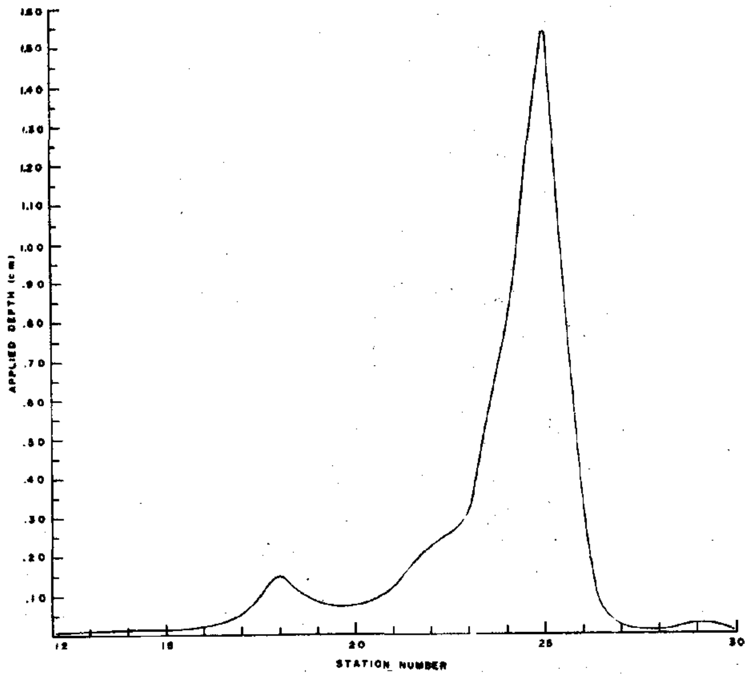


Figure 19. **Cross-section profile for Drop No. 25 from Stations No. 12 to 30; and stations identified in Figure 5.**

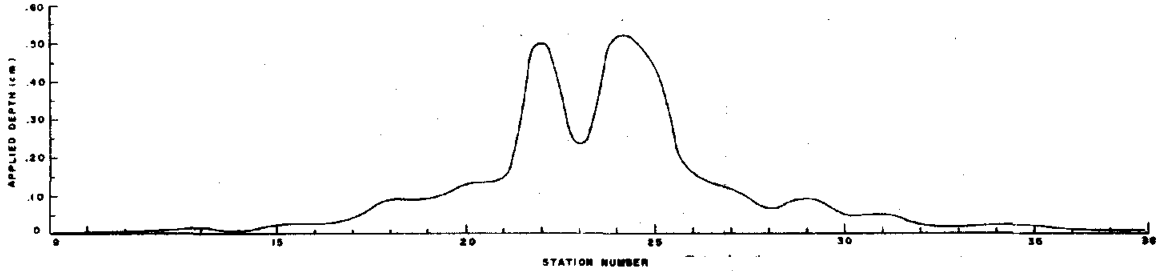


Figure 20. **Cross-section profile for Drop No. 5 from Stations No. 9 to 37; and stations identified in Figure 6.**

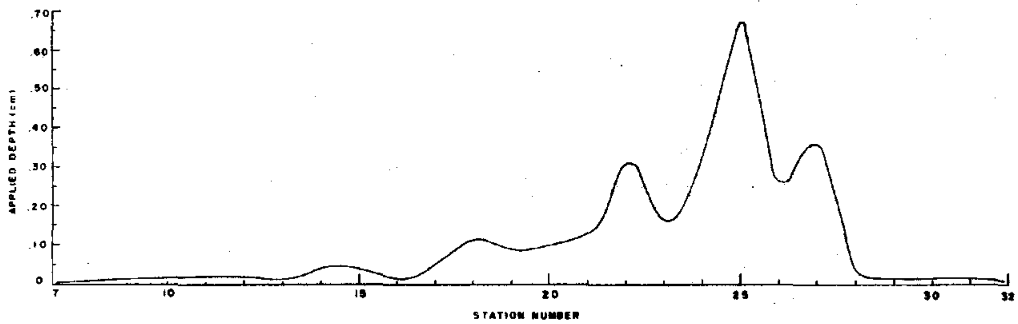


Figure 21. **Cross-section profile for Drop No. 9 from Stations No. 7 to 32; and stations identified in Figure 9.**

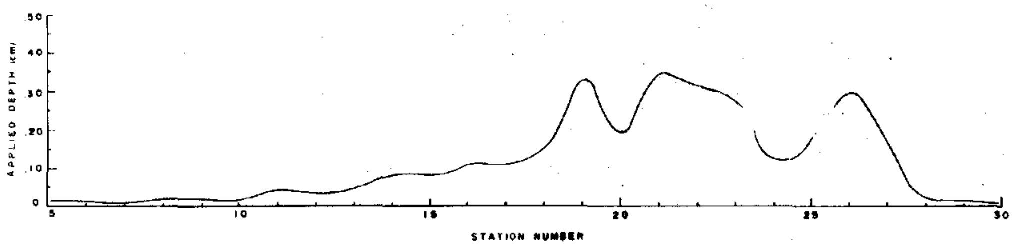


Figure 22. **Cross-section profile for Drop No. 14 from Stations No. 5 to 30; and stations identified in Figure 12.**

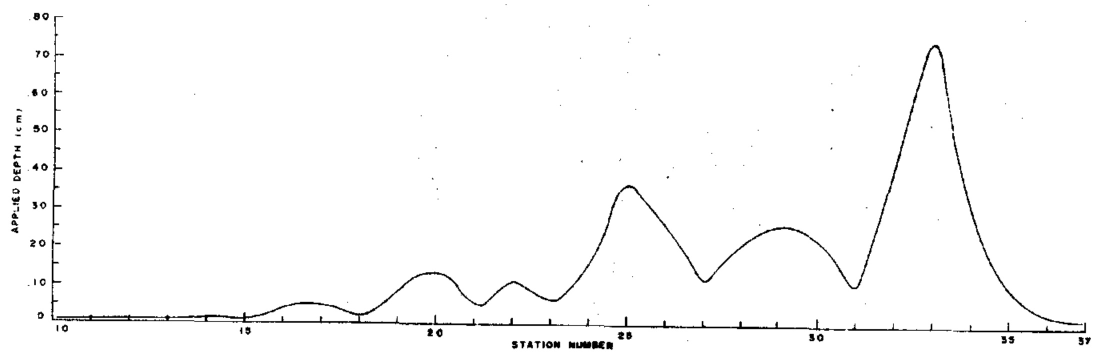


Figure 23. **Cross-section profile for Drop No. 19 from Stations No 10 to 37; and stations identified in Figure 13.**