INSECT WIND TRAPS: IMPROVEMENTS AND PROBLEMS

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Some improvements to traps designed to catch insects flying upwind separately from those flying downwind are described. They include a redesigned funnel and catching bottle arrangement and a better wind vane. Field observations suggest that difficulties remain in interpreting flight direction from the catches. A summary of data obtained in 9 localities is given.

Nous décrivons des améliorations d'une trappe désignée à séparer les insectes volant avec le vent de ceux volant contre le vent. Ces améliorations incluent un nouveau arrangement d'un entonnoir et d'une bouteille de capture et un meilleur ventilateur. Les observations en nature suggèrent qu'il y a encore des problèmes dans l'interprétation de la direction du vol des insectes capturés. Nous présentons un exposé abrégé des données obtenues dans 9 localités.

INTRODUCTION

Two traps designed to catch insects flying with the wind separately from those flying against the wind have been described (Hocking, 1970). These traps, with and without minor modifications, have since been used for further studies near Edmonton, Alberta, at various localities near the east coast of Queensland, Australia, on the northeast coast and in the interior of New Guinea, on islands in the Caribbean, and on the east coast of Florida at Vero Beach. In 22,600 m^2hr of operation 64,700 insects were caught, giving a new total of 134,700 insects in 44,700 m^2hr.

IMPROVEMENTS

Two principal difficulties became apparent in the earlier work. Firstly, some insects were overcome by cyanide fumes before they went through the hole at the top of the funnel into the catching bottle, especially when this was freshly charged with cyanide. Such insects fell back into the bottom of the trap, where they usually recovered, or were retrieved when the trap was cleared. Secondly, the small, pivoted traps could not be kept in perfect balance primarily due to differences in moisture pick up from dew and rain; in a very light wind they therefore sometimes settled in a wrong position relative to wind direction and thus blurred the differences between catches of upwind flying and downwind flying insects. Also, in a light wind they settled with the vane in the wind shadow of one or other of the widely-spaced catching bottles.

CATCHING ARRANGEMENTS

The simplest solution to the loss of catch from cyanide fumes was to swtich to a slower acting insecticide; 3 cm squares of "Vapona no-pest strip"[2] (active ingredient dichlorvos, 2, 2-dichlorovinyl dimethyl phosphate) are now used. These remain active for months rather than days, and

1. Deceased.
2. Shell Chemical Company, New York.

are much safer and easier to handle. The tendency of large insects to remain active for some time results in damage to specimens and they may need killing separately when the traps are cleared.

Since it is desirable to be able to use any kind of insecticide in the traps this was not an entirely satisfactory solution. Accordingly, a different approach was tried, by changing the funnel and catching bottle arrangement from that shown in Fig. 1 (a) to that shown in Figs. 1 (b) and 2.

The new design introduces an additional funnel stage between the entrance to the net itself and the entrance to the killing bottle. In this intermediate funnel the direction of insect travel is turned from upwards to downwards. The intermediate funnel consists of a 45° cone, truncated at a diameter equal to the top outside diameter of the final funnel plus twice the inside diameter of its stem, and capped by the appropriate sector of a sphere. These intermediate funnels, here termed dome-cones, may be vacuum moulded from a variety of clear plastics, but Surlyn, a clear ionomer of ethylene was chosen as it is insoluble in the usual insect killing agents. The dome-cones used in the small traps measure 7 cm high by 11.5 cm O.D. at the base, and those used in the large ones 8.5 cm x 14.5 cm. The bottom edge of the dome-cone is stiffened by a small rim on which a circle of spring brass wire, sewn to the top of the tulle funnel, is supported. In some traps the tulle was glued permanently to the inside of the dome-cone, as in Figs. 2 and 5, but this practice was discontinued when it was found easier to pack the nets and the dome-cones separately.

The final funnel is a standard laboratory powder funnel of polypropylene with a wide parallel stem. The funnels used in the small traps have a base diameter of 8 cm and a stem diameter of 1.3 cm. In the funnels used in the large traps these dimensions are 10 cm and 1.7 cm. The funnel is suspended inside the dome-cone by three or four nylon threads from its rim tied to a ring in the end of a brass wire which runs through a reinforced hole in the top of the dome-cone to a support half the overall diameter of the dome-cone from the top centre of the trap. The height of the funnel is adjustable but its top should be level with the transition from dome to cone. This leaves a gap around it of width equal to the inside diameter of the stem of the funnel.

The killing bottle is a straight-sided clear polystyrene vial with white polyethylene screw-cap. Caps are permanently mounted as a press fit on the outside of the tops of the stems of the powder funnels. Vials are simply unscrewed, capped, and replaced by new ones when the traps are cleared; this eliminates the delays and hazards of field transfer of specimens to a second container. A 3 oz vial, 8.5 cm high x 4.5 cm diam. is used for the small traps, and a 4 oz vial 9 x 5 cm for the large ones. A disc of Vapona strip is threaded on the brass wire inside the top of the dome-cone and a ring of it around the stem of the powder funnel inside the vial.

By using standard supply items this type of catching arrangement is easier to construct and once the cost of a mould for dome-cones is covered, cheaper. It is light, easy to handle, and durable. It also solves the wind shadow problem, since the two wind shadows are combined into one in the central position.

Although both the chemical and physical changes greatly reduce the losses from premature poisoning with cyanide, neither change appears, from preliminary studies, to increase the catch significantly. A possible explanation is an attractant effect of cyanide at low concentrations, with or without a repellent effect of Vapona. Both have been reported in the literature, (Hocking, 1960). Catches do not appear to be qualitatively different either between the two poisons or the two structures.

A few tests were run with a catching arrangement more like that of the original Malaise trap, and shown in Fig. 3. When such a catching arrangement was paired with an original funnel on the same trap, reversed daily for upwind and downwind positions, it gave a small but significantly greater catch. The difficulty in making up curved cones, and more especially in assembling, packing and transporting them in the field led us to abandon this approach.

BALANCE

The second problem, that of balancing the small traps, has been reduced by several minor changes. The original vanes, of stiff acetate sheet supported by a central rib of 5 mm (3/16 inches) diameter aluminium alloy tubing were heavy and easily damaged. They have been replaced by a length of 3 mil clear tubular polyethylene sheet with a rounded, heat sealed end. This is supported on an ellipse of spring brass wire crimped into the end of the same 5 mm aluminium alloy tubing, and threaded anteriorly through a hole drilled in this. The polyethylene bag is threaded over this wire frame and kept taut by it (Fig. 4). It is rarely damaged and can easily be replaced in the field since the same tubular plastic is used in packing the traps. Notices warning of poison, in appropriate languages, can be placed within the bag where they remain dry and legible. These vanes are kept vertical by being bowed with a fine steel wire passing over the top of the centre post that supports the catching bottles. The wire then hooks into the anterior end of the 6 mm (1/4 inches) diameter tube that forms the top of the trap frame. This top tube projects 12.5 cm beyond the frame on each side, so that the vane can be easily switched from one side to the other to balance out inequalities between the sides. The addition of a further horizontal tube running at right angles to this one allows the vane to be set at the two remaining compass points for catching insects flying across the wind direction. Crosswind flight may be important in host finding (Hocking, 1971).

With the new, lighter vane most traps can be balanced either by moving of the mounting point on the bottom tube, or by a tube weighted at the upwind end sliding inside the bottom tube. If to these refinements of balance refinements of level are added, the results are very satisfactory. A plate of aluminium is added at the bottom of the bicycle pedal bearing large enough to carry a circular spirit level, which is adjusted accurately at right angles to the axis of the pedal bearing in two directions. Whenever the trap is visited it is checked for level as well as balance. Level is adjusted by manipulating sliders on the nylon guy lines which are kept as tight as possible and moored to trees or adequate pegs. The sliders have locking grooves in the sides to prevent slip.

OTHER MODIFICATIONS

Large traps can be set up with the eaves at ground level, pegged directly to the ground, and stones or pieces of wood holding the diaphragm net down. They may be best used this way when the wind is too strong for normal use. Some traps were made up like this, consisting of only the top triangle and a normal base of a standard large trap. The area of wind intercepted by these arrangements is 2 m^2, but the catching rate per m^2 is increased by a factor of about 3. In a trial near Edmonton in 1972, two large traps and two 2 m^2 traps were set up at similar sites in the same locale and ran for 8681 m^2hr and 1104 m^2hr respectively. This difference is attributed to the fall in insect flight density with increasing altitude.

Large and small traps were designed to operate at the same height of area-centre above the ground, 134 cm. Small traps can, however, be run at any height above ground from 80 cm upwards, either by driving the base tube into the ground or by using a longer one. Attempts to operate them from meteorological balloons, however, have not been too successful.

To avoid confusion in analyzing the catch, an upwind flying insect was identified by a red line, and a downwind flying insect by a blue line, along one end of the label. Since upwind fliers end up in the downwind side of the trap, (usually - see next section), catching bottles on the downwind sides of the traps were identified by red markings. Black lines on the other ends of labels indicate that the specimens came from small traps.

PROBLEMS

Field observations showed that insects, especially larger ones, could see the traps and take avoiding action. This explains the relative rarity in catches of Odonata, horseflies, and other common insects with good vision. Most of the captured predators probably were caught while seeking prey. Spiders' webs had to be removed from inside the fabric cones with such disturbing frequency that we formed a habit of feeling for them. In the light of the importance of vision one small trap was sprayed, when set up in the field, with black dye in a random "camouflage" manner. The effect has not yet been evaluated.

Under certain weather conditions in open bush country close to high tide line unexpectedly large catches were obtained in the seaward (flying downwind) sides of traps during daytime. This happened when wind speeds were rather steadily close to the upper limit for controlled flight, at least in the open. Since it seemed unlikely that these insects had actually come in off the ocean, some time was spent in watching the movements of insects near the traps. As expected, most of the flight was against the wind, but most insects made progress against the wind only by slipping sideways (across the wind) from wind shadow to wind shadow, where lower speeds allowed them to progress. Wind shadows (Lewis, 1968) used included those of trees and shrubs, and of course, traps. Insects which came up on the lee side of a trap, made their way round it by keeping low and close to the wall. Then, having run out of wind shadows and encountering the full force of the wind off the ocean, they entered the trap tail first - still flying upwind, but landing in the downwind flying side. These observations have been repeated many times and raise problems in interpreting the numbers caught in the upwind and downwind side respectively.

It is important to remember that with insects flying at an air speed of V in a wind speed of W, given equal densities of insects in each direction, it would be expected from mechanical considerations alone, that the ratio of specimens taken flying downwind to those flying upwind would be $\frac{V + W}{V - W}$ and hence to approach infinity as W approaches V. Also, insects flying upwind have progressively more time to observe the trap and avoid it as wind speed increases. These two factors thus give a double bias increasing the downwind numbers.

Whenever possible, wind speed immediately downwind of the centre of at least one trap is measured continuously with a Biram anemometer, so that total flow of air through it is known, and hence the flight density. These and other considerations all point to the desirability of using a trap fabric of maximum permeability for its mesh size, and of minimum visibility to insects. Modern textile technology could surely improve greatly on anything available now. Our nylon tulle had a permeability of about 80% at an average working wind speed.

RESULTS

A brief summary of the results of this work is given in Table 1, which follows the pattern of Table 1 in Hocking (1970). The human population densities for Devon and Whitemud, both near Edmonton, are derived from the 1971 populations of the four township sites adjacent to each study area. The human population densities for the other localities are derived from a variety of sources, and are mostly average figures for a larger area. In this paper and the previous one the total catch of insects per m^2 hr has been calculated from the expression $\frac{u + d}{at}$ where u = number caught flying upwind, d = number caught flying downwind, a = area of diaphragm and t = time in hours.

It is hoped that a more detailed breakdown and analysis of the data will be presented before too long. In the meantime it may be noted that the catching rate at Devon in 1971 was the highest obtained anywhere with the large traps, 5.19 $m^{-2} hr^{-1}$. Female mosquitoes made up 72% of this catch; 97.5% of them were *Aedes vexans* (Meigen).

ACKNOWLEDGEMENTS

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Table 1. Wind trap densities per m^2hr on islands of various sizes and continental North America, with latitudes, human population densities, insecticide use, and trapping times. Australia, Atlantic and Caribbean 1971 - 74.

Area	km^2	Latitude	Persons/km^2	Insecticide use rank	m^2hr	Total Catch insects/m^2hr
Australia, E. Coast	7.66 X 10^6	10-40°S	c.10	8	1012	1.14
New Guinea	6.57 X 10^5	0-10°S	c.1	2	3101	2.92
*N. Stradbroke Island	350	27°30′S	c.3	0=	881	1.53
**Heron Island	0.17	23°S	c.250	0=	1324	0.99
Devon, Alberta		53°32′N	8	3	5515	5.01
Whitemud Ck., Alberta						
May 1972		53°32′N	7	4	2820	2.90
June 1972					4018	2.69
July 1972					3456	1.26
***Tobago	2.95	11°15′N	150	6	179	1.89
San Salvador	155	24°35′N	3.8	5	124	1.56
Vero Beach, Florida	6.73 X 10^4	27°39′N	c.50	7	186	2.03
(Continental North America	2.67 X 10^7)					

* Sand island, close to mainland for most of its length.

** Great Barrier Reef, 60 km off shore.

*** 37 km from Trinidad which is 5 km from mainland S. America.

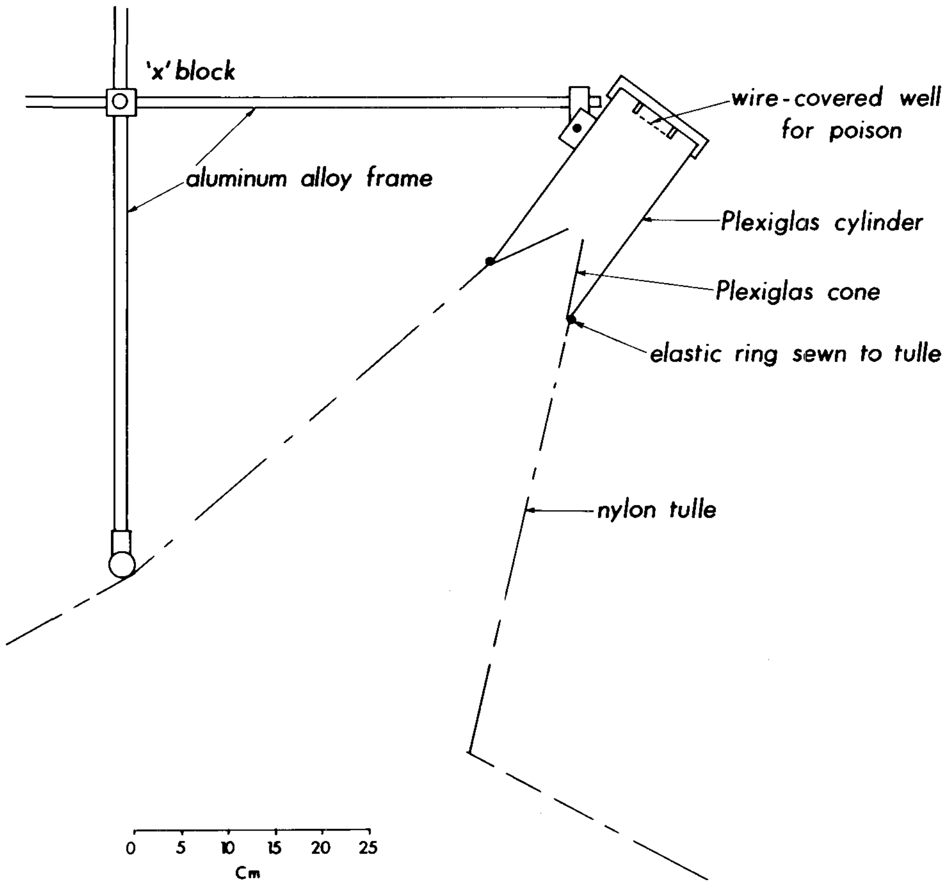

Fig. 1 (a). Vertical sections of catching heads of large (10 m^2) traps – old type.

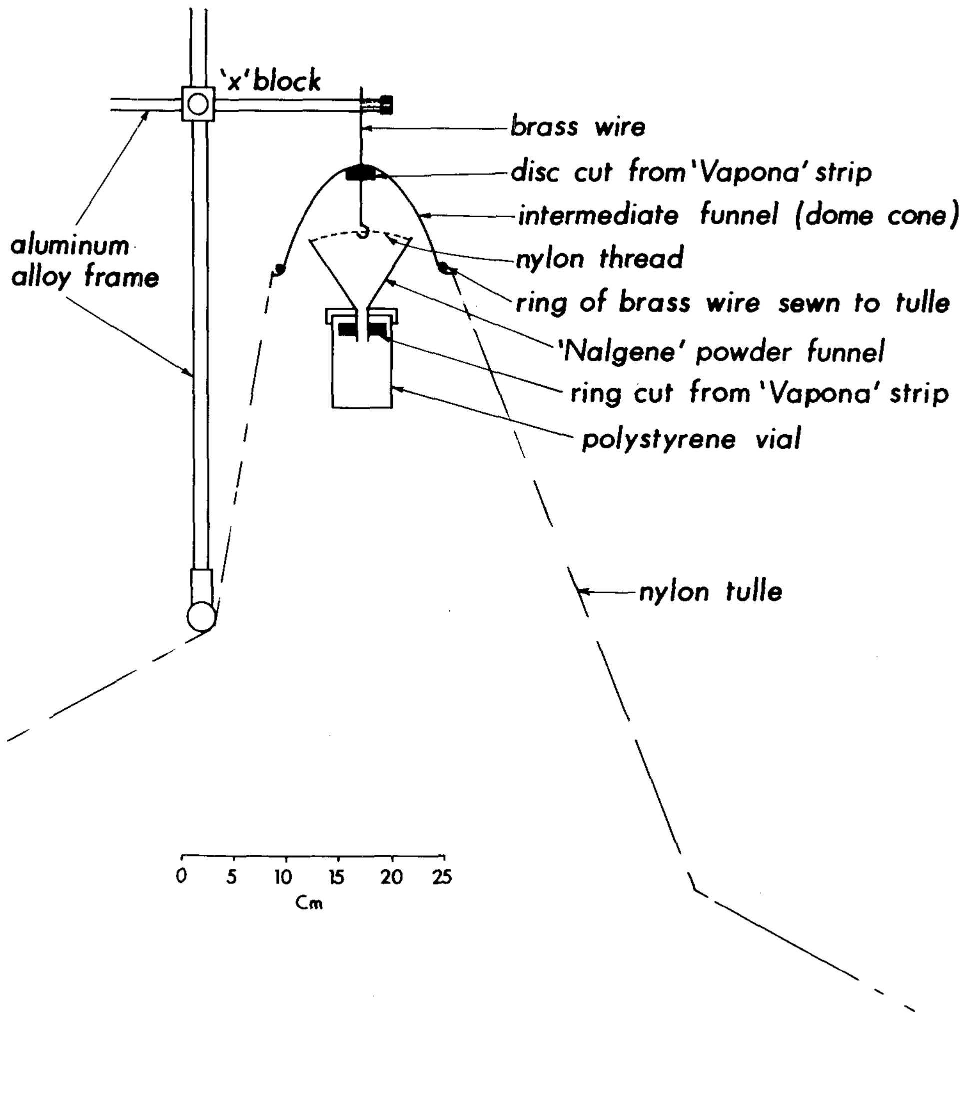

Fig. 1 (b). Vertical sections of catching heads of large (10 m^2) traps – new type.

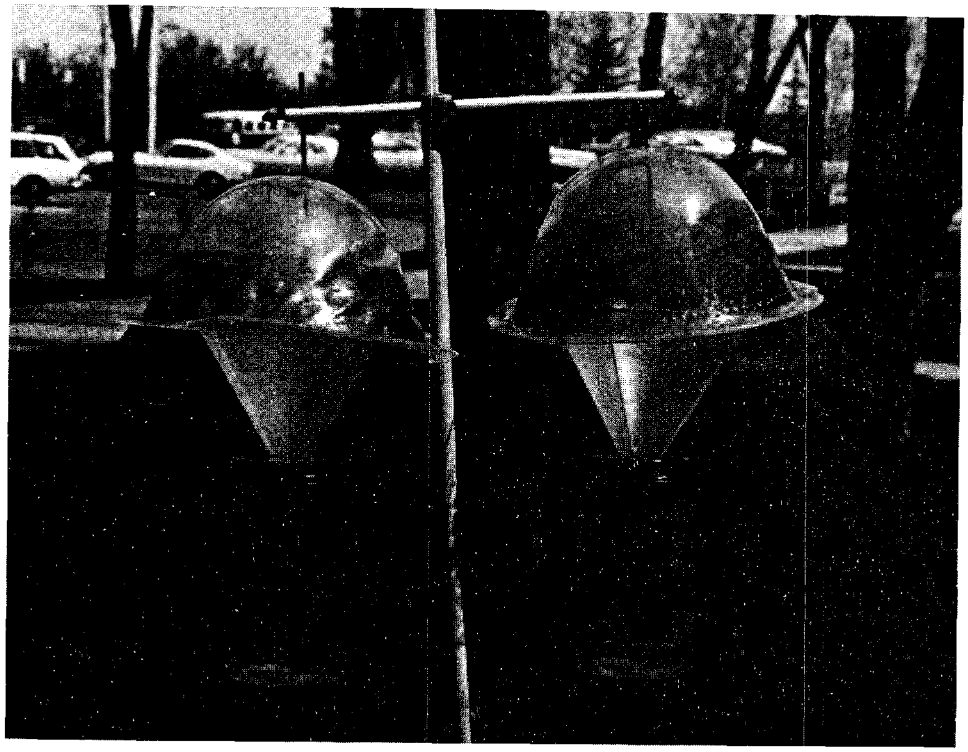

Fig. 2. New catching heads of 10 m^2 trap.

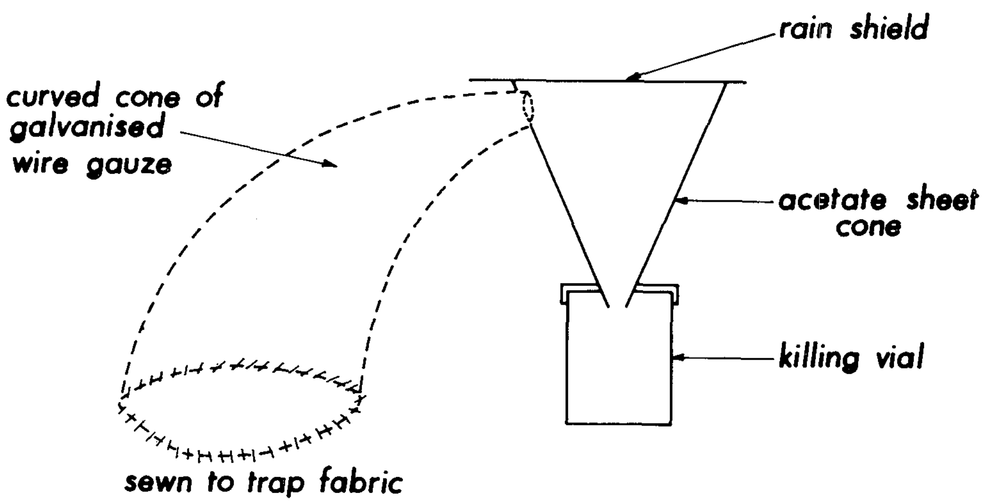

Fig. 3. Malaise type catching head used in some studies but later abandoned. Not to scale.

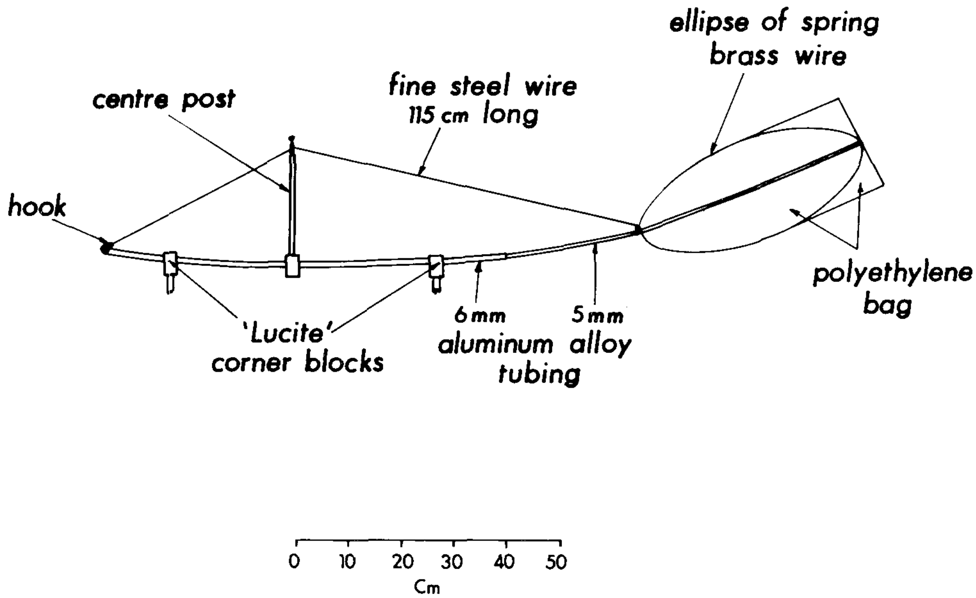

Fig. 4. Upper part of frame of small (0.5 m^2) trap, from the left, to show new wind vane. Net and catching heads omitted.

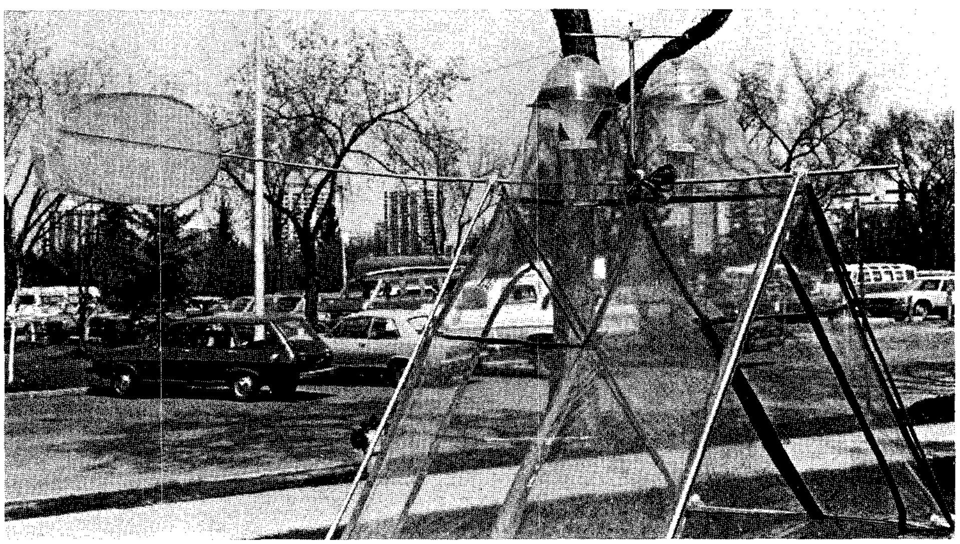

Fig. 5. 0.5 m^2 trap with new wind vane and catching heads.