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AN ARCTIC CALIBRATION OF THE VIDEOGRAPH

by

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ABSTRACT

The Videograph visibility sensor has been calibrated against the prevailing visibility observations of meteorological observers in a variety of temperate climate conditions by the Atmospheric Environment Service in 1970-1. Because this instrument is soon to be used at Canada's Meteorological Automated Reporting Stations in Arctic locations, we required additional calibration information for visibility restrictions experienced in colder climates. A Videograph was installed at Yellowknife Airport for the winter of 1975-6 to relate the daytime calibration in ice fog and ice crystals to that in snow. A graphical presentation of the data indicates no significant difference in the calibration for ice fog/crystals and snow.

ÉTALONNAGE DU VIDÉOGRAPHE POUR L'ARCTIQUE

par

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RÉSUMÉ

Le capteur de visibilité du vidéographe a été étalonné d'après les observations de la visibilité dominante effectuées en 1970-1971 par des observateurs du Service de l'Environnement atmosphérique dans diverses conditions de climat tempéré. Comme cet instrument doit bientôt être utilisé dans les stations météorologiques automatiques du Canada situées dans l'Arctique, il nous fallait plus de renseignements sur l'étalonnage relativement à la réduction de la visibilité que l'on trouve dans les climats froids. Un vidéographe a été installé à l'aéroport de Yellowknife pendant l'hiver de 1975-1976 pour comparer l'étalonnage effectué de jour dans le brouillard glacé ou les cristaux de glace à l'étalonnage effectué dans le neige. La représentation graphique des données n'indique aucune différence significative de l'étalonnage dans le brouillard glacé et les cristaux de glace d'une part et la neige d'autre part.

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Foreword

The "Videograph"* is the visibility sensor used in the second generation of Meteorological Automated Reporting Stations (MARS-II) currently being installed throughout Canada. With the expansion of the MARS network to northern sites, it was recognized that there was a lack of information on the performance, and notably the calibration of the Videograph in Arctic conditions. The calibration relationships applicable in more temperate regions were established during a field experiment at Toronto International Airport in 1970-71. These results have been reported previously in an AES Technical Memorandum (1), and more extensively in an Atmospheric Instrument Branch Technical Record (2). The test reported here is an extension of the Toronto experiment designed to provide similar calibration information in cold climate conditions. Of particular interest is the calibration during occurrences of ice fog and ice crystals which, at times, are the most common cause of reduced visibility in some parts of the Arctic (3).

1. Introduction

The Videograph is a "backscatter-type" visibility meter. There is no simple theoretical relationship between visibility through the atmosphere and the backscattering power of the air along a portion of the line of sight. Consequently, it is necessary to calibrate all types of backscatter meters empirically, i.e. to compare the instrument output to some visibility standard such as meteorological optical range, as determined from transmissivity measurements, or to the prevailing visibility reported by qualified meteorological observers. The Videograph has been calibrated in a number of experiments listed in reference 1. The test at Toronto International Airport in 1970-71 used the station observers as the standard.

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*"Videograph" is a trade name for a visibility meter developed by Dr. F. Früngel of Hamburg, Germany. His company, Impulsphysik, has licensed Sperry Ottawa to manufacture and distribute the instrument in Canada.

The results of such experiments have indicated that the Videograph calibration depends in part on the type of obstruction to vision present (e.g. fog, snow, rain, etc.). The visibility-backscatter relationship is affected by such properties of the scattering medium as constituent size, shape, state, distribution and refractive index. Considering the similar ice crystalline structures of snow, ice fog and ice crystals, we would also expect to find similar scattering properties. The calibration experiment at Yellowknife airport was intended to either confirm this hypothesis, or establish the relative differences in the scattering properties of these three obscurants as determined from Videograph measurements.

2. The Objective

The objective of this field calibration test was to establish the daytime calibration of the Videograph in ice fog and ice crystals relative to that in snow. By using the snow data as a reference we could relate the ice fog and ice crystal data directly to the Toronto International daytime calibration curves.

3. The Experiment

Yellowknife Airport was selected as a suitable location because of the frequent occurrence of ice fogs (4), the existing facilities for installation, and the presence of a meteorological station required to record surface observations for every hour of the day and night.

The Videograph used for this experiment was not the Impulsphysik instrument used in the Toronto International tests, but a newer Sperry model. The optics and electronics of this instrument were calibrated to match the Impulsphysik Videograph which is maintained at Toronto International Airport as the AES standard. Exact agreement between these instruments was not necessary, as we were only concerned with establishing relative daytime calibration differences between snow and ice fog or ice crystals.

The Videograph was completely enclosed in a plywood box, insulated with styrofoam. This housing was internally heated by three 80 watt "battery-blankets". The temperature was controlled by thermostat at 25°C. The heaters were capable of maintaining this temperature down to -40°C in still air.

The instrument was mounted on a pipe at the south end of runway 32 about one mile from the tower building (see Figure 1 and Photograph 1). It was oriented in an eastward direction so that it had an unobstructed view across the end of the runway. The 12 volt power source for the Videograph and heaters for the box operated from 115 VAC. Existing cabling was also used to carry the output signal from the Videograph site to the meteorological office in the tower building. The output was displayed on a digital panel meter (0 to 100 mV) and recorded on an Esterline Angus "Miniservo" recorder (0 to 100 mV).

The experimental procedure follows. The observer was supplied with a special form for recording data relevant to the calibration. For each regular hourly observation, the observer recorded the date and time, the Videograph output as displayed on the digital panel meter before and after his observation, his identification (initials), the weather and obstruction to vision, the prevailing visibility, and any comments pertinent to the spatial and temporal uniformity of the atmosphere.

The experiment continued in this manner from the beginning of November 1975 to the end of January 1976. At this time an interruption in the signal lines from the site to the meteorological office caused termination of the test. The Videograph and its heated box required no maintenance during this period.

4. Analysis

The data analysis was patterned after the Toronto International experiment. Again, the primary objective was to select the most suitable pairs of data for sensor calibration by rejecting instances of spatial or temporal variations in the atmosphere. These were identified by the observer's comments on the special form, and from inspection of the chart trace of the Videograph output. We also rejected transitional periods from one visibility extreme to the other, if the data indicated that the observer and Videograph were not "in phase". This situation may occur in the case of moving obscurants. Apart from these situations, when it was judged that the volume monitored by the sensor was representative of the atmosphere as viewed by the observer, we recorded one calibration point for every hourly observation.

Since the instrument's temperature was held nearly constant, the data required no normalization to compensate for instabilities caused by temperature changes, as was done in the Toronto International analysis.

The data was categorized according to day and night, and obscurant types. Day was defined from sunrise to sunset and night from one hour after sunset to one hour before sunrise. The obscurant type classifications were snow, ice fog, ice crystals, and any combination of these.

Two scatter diagrams similar in format to the Toronto International ones were plotted for the "Day" and "Night" observations (see Graphs 1 and 2 respectively). The Videograph output from 0 to 100% of full scale was plotted on the vertical axis and the prevailing visibility in statute miles on the horizontal logarithmic axis.

Prevailing visibilities were plotted at the arithmetic mean of the log of the reported value and the log of the next highest reportable value. If more than one observation occurred at the same point on the scatter diagrams, these were recorded by a horizontal string of symbols centered on the "visibility bin" at the appropriate Videograph output value. Each small symbol represents one observation and each large symbol five. This procedure gave a "visual density" to the point distribution on the scatter diagram. Symbols plotted to the left of the Videograph output axis represent prevailing visibility observations of 0 miles which on a log axis is negative infinity.

The ice fog and ice crystal observations were plotted as open triangles oriented in different directions to distinguish one from the other, and the simultaneous occurrence of both. Open circles represented a combination of snow and ice fog. Snow was represented by black dots. This representation aided in the visual comparison of the two distributions.

Best fit curves were then drawn by visual estimate through the day and night scatter diagrams. For comparison purposes these were transferred to the corresponding scatter diagrams for the Toronto International snow data shown on Graphs 3 and 4.

5. Conclusions

This experiment confirms the fundamental linear relationship between Videograph output and the log of prevailing visibility obtained from the Toronto International results. Graphs 1 and 2 both show that the distribution of ice fog/crystals and of snow form a single continuous linear distribution. Although the majority of snow observations occurred for visibilities above one mile, and most ice fog/crystals below one mile, the distribution at this boundary appears continuous.

Those ice fog/crystal points that did occur in the one to twenty mile range are randomly scattered through the snow distribution.

We conclude that, the relationship between backscatter, as measured by the Videograph, and prevailing visibility, as determined by the meteorological observer, is not significantly different in ice fog or ice crystals than it is in snow.

6. <u>Further Deductions</u>

In addition to the principle conclusion of this experiment, some serendipitous deductions result from a comparison of the Yellowknife and Toronto data.

The corresponding graphs for both day and night observations indicate a greater degree of scatter in the Yellowknife data. The major source of this uncertainty for both experiments is the non-representativeness of the sensor monitoring volume in the larger field as viewed by the meteorological observer. We expect the greater scatter at Yellowknife because of the greater separation of observer and Videograph. Nonetheless, the best fit curve drawn freehand through the Yellowknife <u>daytime</u> data and superimposed on the Toronto distribution (Graph 3) indicates close agreement over the entire visibility range.

This has important implications for the Videograph as a sensor in the MARS network. First it indicates that the calibration procedure used to match the Videograph at Yellowknife and the AES standard at Toronto has potential for successful application to the entire MARS system. Secondly, the good agreement between the two experiments indicates that the daytime visibility environment at Toronto International and Yellowknife airports were not significantly different. This would include the type of markers, the background against which they are viewed, and the general illumination levels at the two locations. From this we suggest that the daytime calibration relationships derived from the Toronto data might also be typical of other locations.

On the other hand, a comparison of the daytime best fit curve for the Yellowknife data and the nighttime scatter diagram for the Toronto data (Graph 4) indicates that there was a significant difference between the night visibility environments, namely the intensities and availability of the lights used as targets. Observers at Toronto International could see slightly further than at Yellowknife for the same atmospheric conditions as measured by the Videograph output. For example, an output of 50% represents an average prevailing visibility of $1\frac{1}{4}$ miles for night observations at Yellowknife and 1 3/4 miles at Toronto. This is reasonable if we recognize that the lights surrounding Toronto International are more numerous and probably more intense than at Yellowknife.

7. Acknowledgements

We thank the following for their contributions to this experiment. Mr. R.G. Catling, the O.I.C. at Yellowknife Airport, authorized his observing staff to record the visibility observations. Mr. R. J. Grauman of the AES Western Region installed the Videograph in the field at Yellowknife. Mr. W. G. Sutton and Mr. N. E. Case of the Telecommunications and Electronics Branch, M.O.T., assisted at the time of installation and monitored the experiment throughout.

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The number of each reference listed here, corresponds to its number in parentheses where referenced in the text.

1. Sheppard, B.E., 1975: Visibility Through Various Obscuring Media as Determined by the Videograph. Technical Memorandum No. 813, Atmospheric Environment Service, Department of the Environment.

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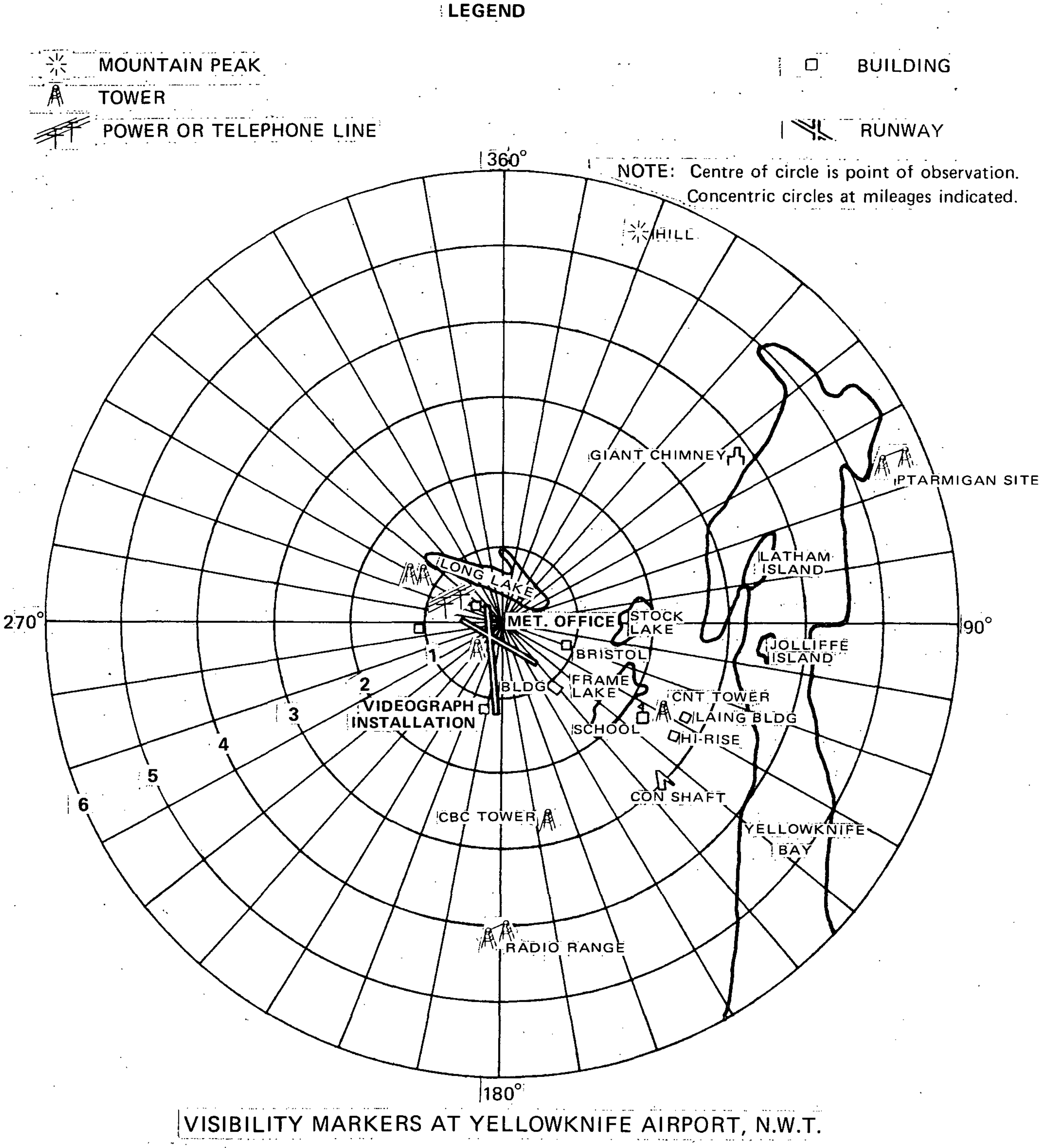
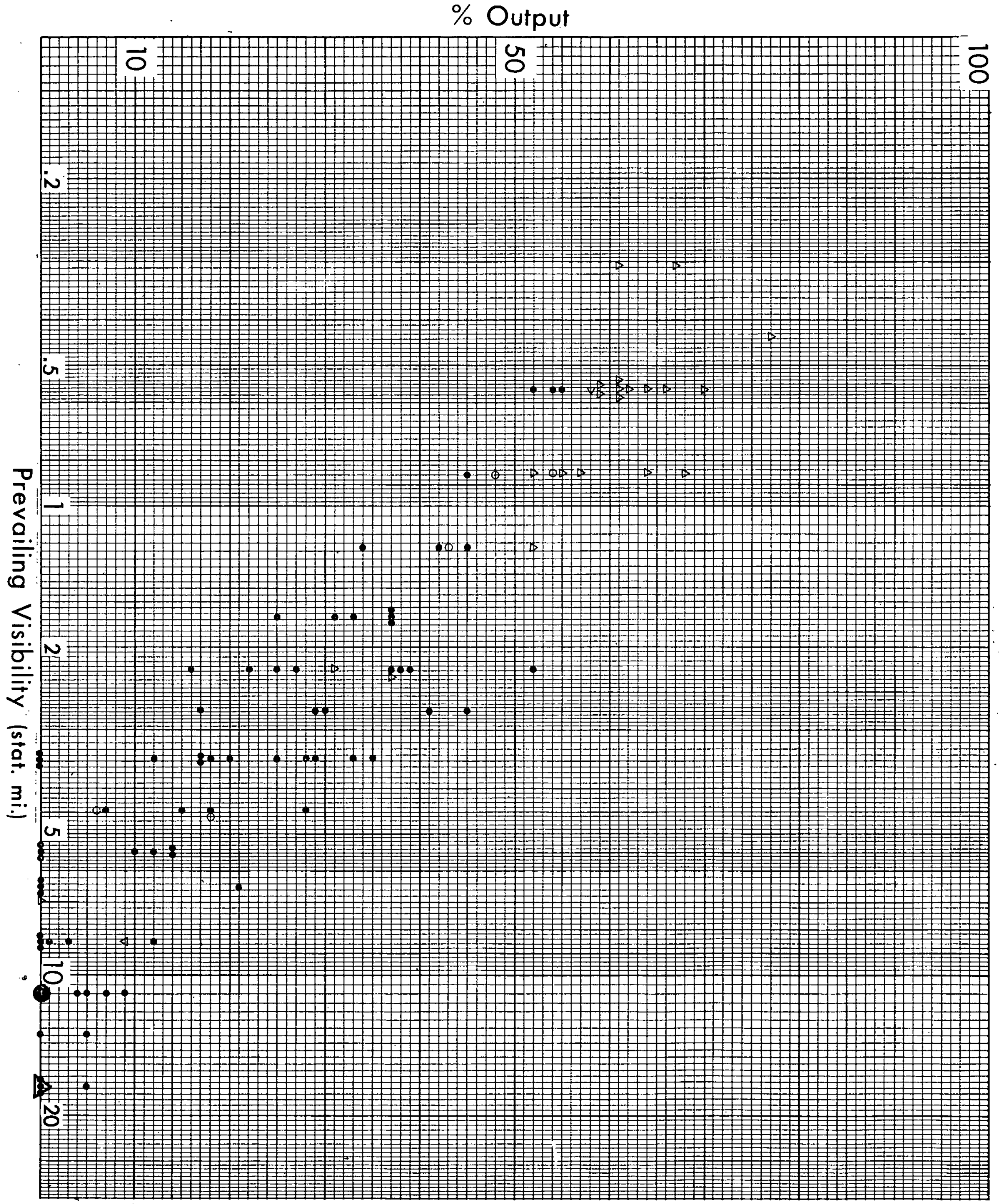


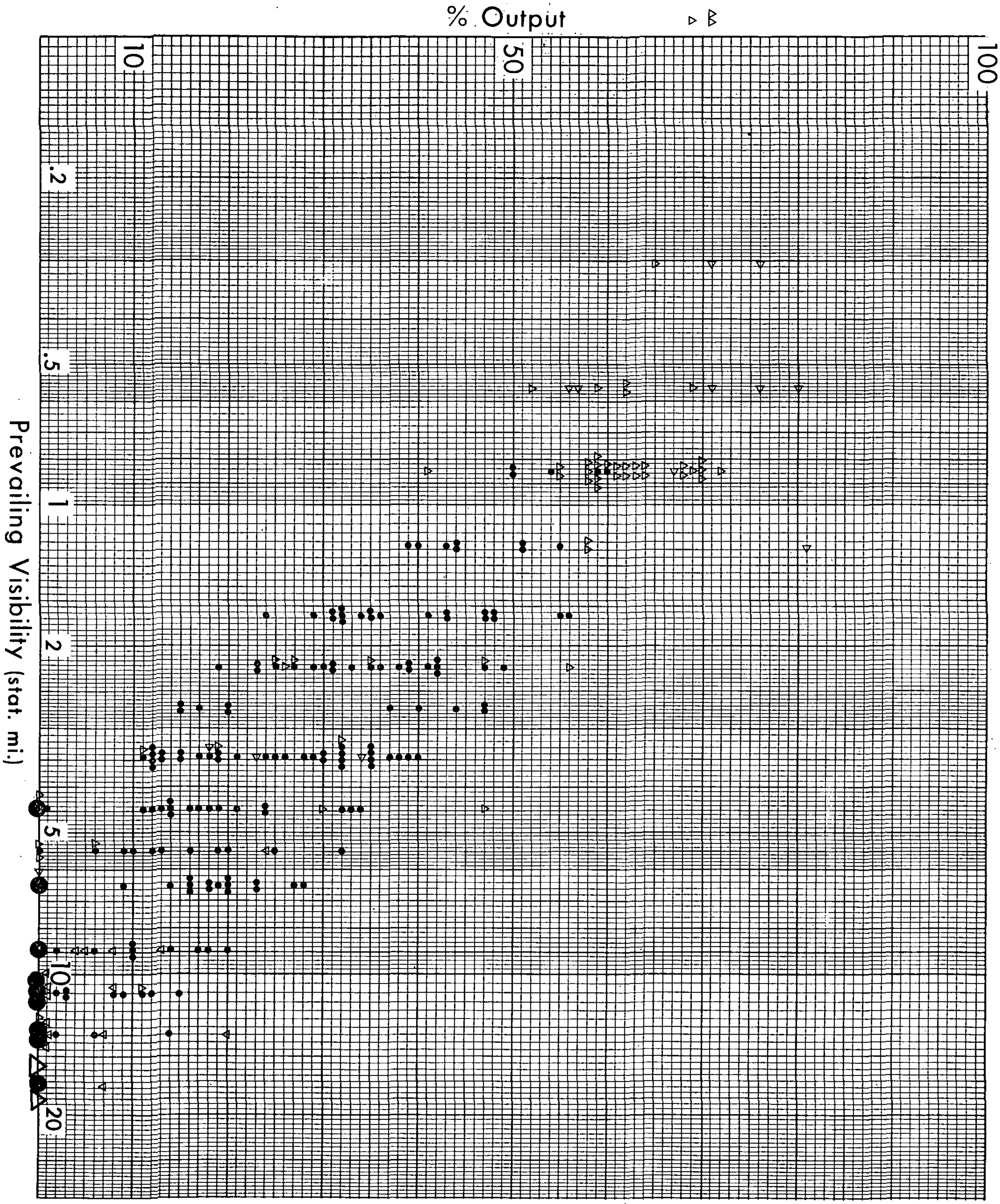
VISIBILITY MARKERS AT YELLOWKNIFE AIRPORT, N.W.T.

Figure 1



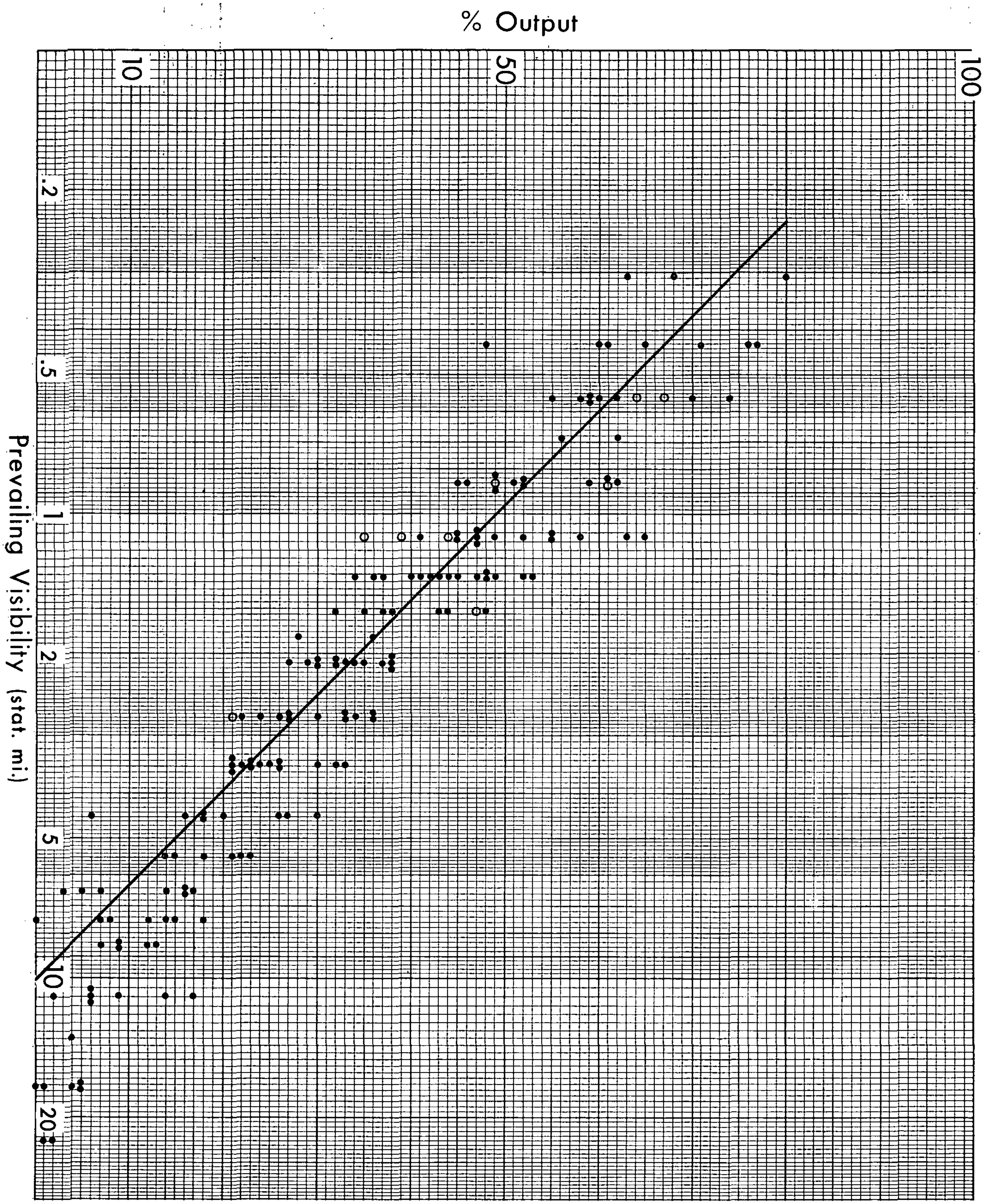
Graph 1

Scatter diagram of Videograph calibration data from Yellowknife for daytime observations showing the random distribution of ice fog/crystal occurrences (open triangles) throughout the more numerous snow occurrences (solid dots) and good continuity between the two distributions at one mile



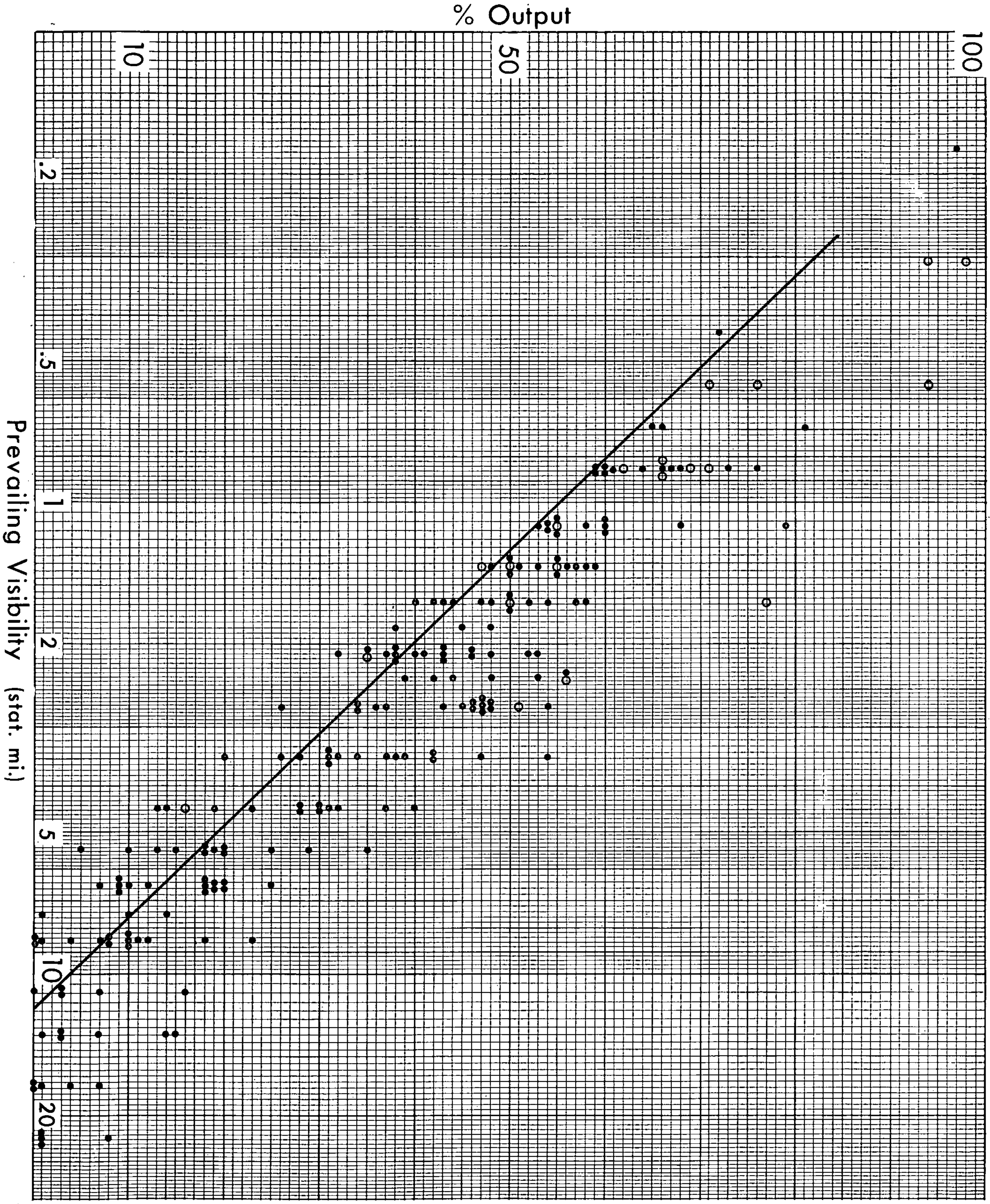
Graph 2

Scatter diagram of Videograph calibration data from Yellowknife for night-time observations. As for the daytime data, the ice fog/crystal points (open triangles) and the snow points (solid dots) appear to belong to a single continuous distribution



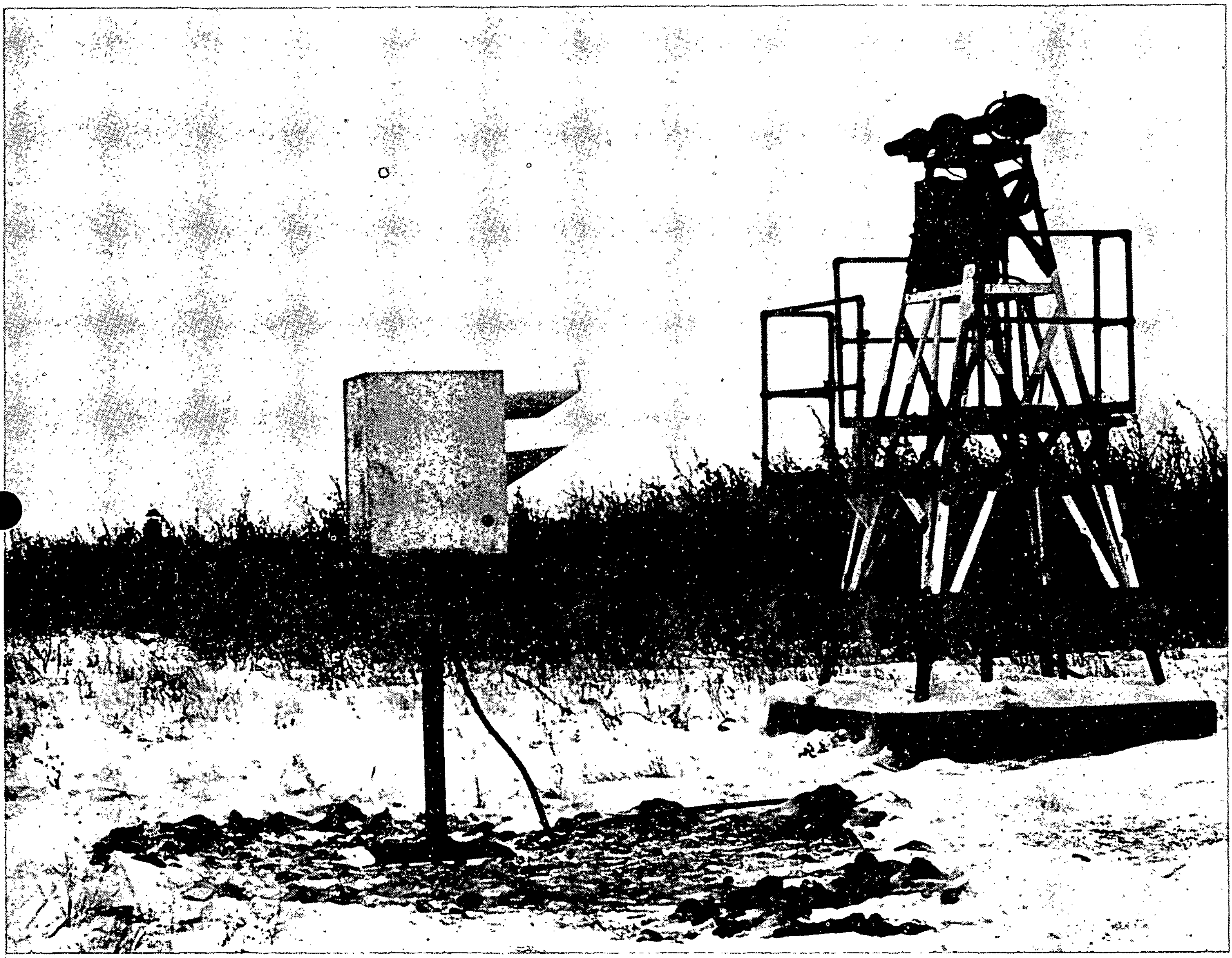
Graph 3

Scatter diagram of Videograph calibration data from Toronto International for daytime observations in snow (solid dots) and blowing snow (open circles). A visual best fit curve to the corresponding Yellowknife scatter diagram of Graph 1 is shown on this scatter diagram to illustrate the close agreement between the two distributions



Graph 4

Scatter diagram of Videograph calibration data from Toronto International for night-time observations in snow (solid dots) and blowing snow (open circles). A visual best fit curve to the corresponding Yellowknife scatter diagram of Graph 2 is shown on this scatter diagram. Unlike the daytime comparison in Graph 3, there is a significant difference in the two distributions. We conclude that the night-time visibility environment was different at Yellowknife and Toronto



Photograph 1

The Videograph Installed at Yellowknife Airport, N.W.T.

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