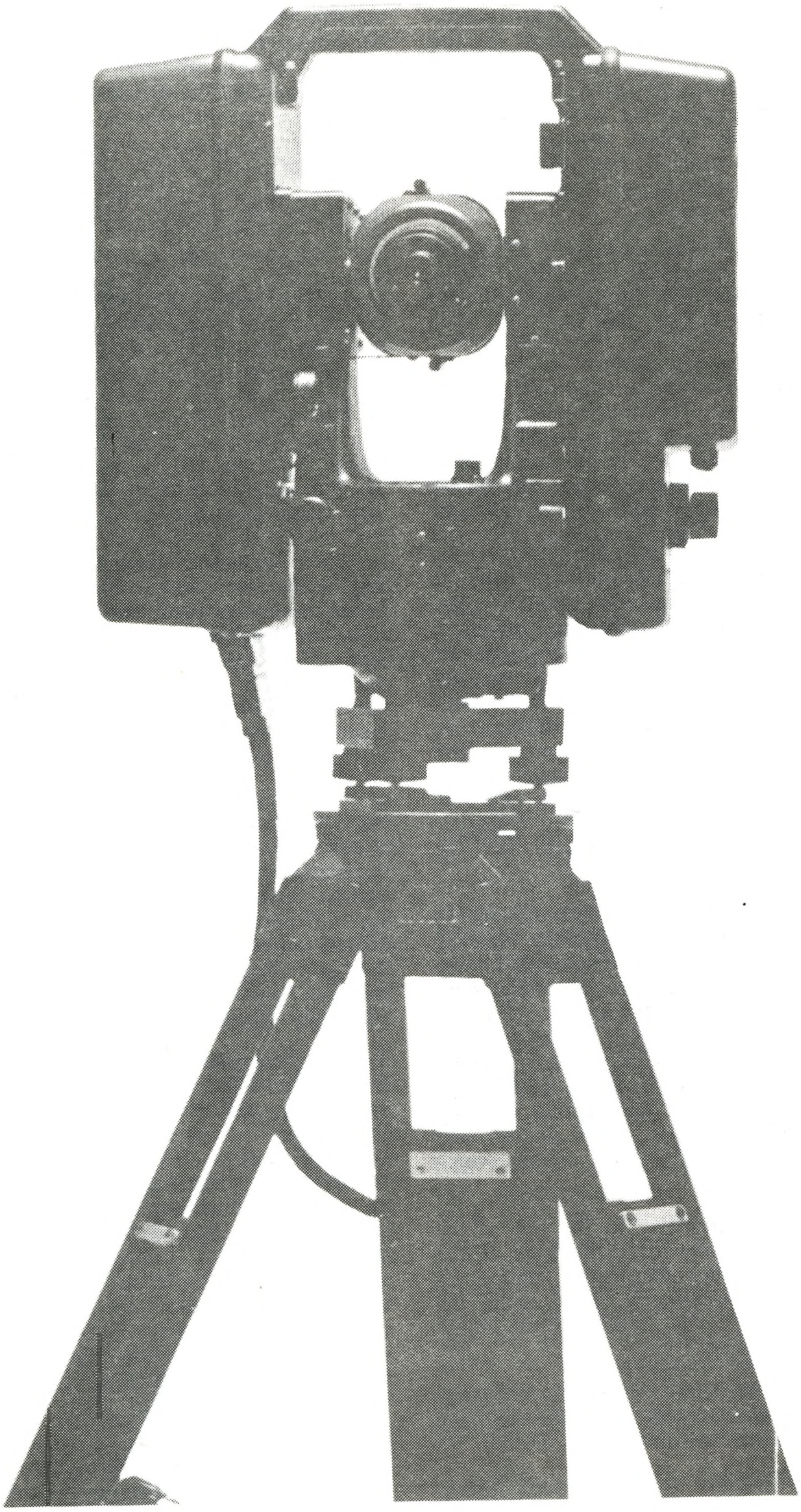
TECHNICAL REPORT —

The Geodimeter 710

THE TRANSIT WITH THE FRINGE INSIDE

BY TUDOR JONES



The Geodimeter 710 is a versatile survey instrument developed by Aga Geotronics of Lidingo, Sweden. It measures slope, horizontal and height distances, together with horizontal and vertical angles. All measurement data are presented in digital form.

The electromagnetic distance measuring part of the machine works with visible light. The source is a 1-mW He/Ne laser. The beam is modulated by means of a Kerr cell at precisely known frequencies, stabilized to within one part per million in a constant-temperature crystal oven within the measuring unit. It is claimed that distances are accurate to within plus or minus 5 mm + 1 mm/km.

The mean error of a direction measured in two telescope positions in the horizontal plane is two seconds of arc, and in the vertical plane, three seconds of arc. There is an automatic index for the vertical angle. This sort of accuracy puts the theodolite part of the device in the same class as the Wild T2 and the Kern DKM2, which you have got to admit is very high class indeed.

Independent tests carried out by the National Road Administration, Stockholm, Sweden, University College, London, England, and the Royal Institution of Chartered Surveyors appear to confirm the claims made by the company.

An optional attachment, the Aga Geodat, when connected in the field, keeps the field notes on paper or plastic tape. Point numbers, instrument height, eccentricities, and all other station information you want to record are punched manually via the instrument panel. Once the instrument is in operation and pointed on the reflector, it only remains to push a button. The horizontal angle, vertical angle, horizontal distance and slope distance are all registered automatically on tape within three seconds.

The information is punched in either of two standard formats, selected by the operator: (a) an eight channel code for direct input to a data processing computer, or (b) a teletype five channel code, for remote input to a distant processing centre.

The Geodat attachment comes complete with its own software!

This short article is to outline in absurdly elementary form the basic concept of the theodolite built into the machine, and to mention some of the obstacles that had to be overcome during its development.

The extremely high accuracy of the theodolite has been made possible in this particular instrument through the use of modern photolithographic processes in conjunction with the well established moire fringe effect.

To begin, let us suppose that an opaque disc be set up so that it is free to rotate around its centre in a horizontal plane. Short radial slits have been made around the circumference of the disc, so that the width of each slit is approximately equal to the width of material left between them. Now, if a very small light source is fixed in place below one of the slits on the edge of the disc, and a light detector is fixed just above the same slit, and therefore also above the light source, then as the disc is turned, the light intensity received by the detector will fluctuate as the slits pass between it and the light source.

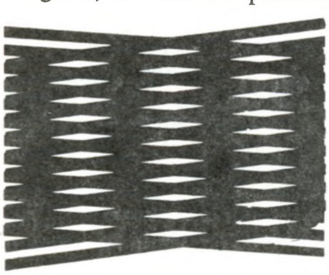
If these pulses could be counted, and if the values of the fluctuations could be interpolated, you will see that a fairly accurate angular measurement could be made.

The system would be limited to the diameter of the disc, the size of the slits, but more important of all to the size of the detector.

Quite obviously, a very large circle indeed would be needed to approach the accuracy being attained by this instrument today.

The french word "moire" (with an acute accent over the "e") translates as "watered or clouded (of silk, etc.)" and means the watered effect which can often be seen on silk.

How it is used in the "710" can best be illustrated by imagining two identical gratings each constructed of one set of parallel bars, so that the spaces between the bars look like very long rectangles. Let one grating be superimposed on the other over a light table, so that together they look like only one grating. Now if the top grating is rotated through a few degrees, so that its parallel bars cross the bars of the lower grating, rows of illuminated, elongated diamonds will appear, each row of diamonds being separated by bands of darkness.



This is the moiré fringe effect.

The size of the diamonds and the size of the dark bands will be dependent upon the width of the bars, the width of the spaces between them, and the angle of rotation.

If the top grating is now moved laterally across the bottom grating, maintaining the same angle between their respective parallel bars, the rows of light and dark will move up or down the gratings. Once the top grating has moved a distance equal to the combined width of a bar and a space, one cycle would have occurred, and the rows of light and dark would be in the same position as they were originally.

Imagine now, two transparent discs, each engraved around their edges with narrow, almost radial, opaque lines, and mounted one above the other on the same centre. If the lines on one disc are slanted slightly one way, and on the other they are slanted the same amount but the other way, then as the top disc is rotated over the lower stationary one, the same fringe effect would be evident.

If a light-emitting diode (L.E.D.) were positioned below the discs, then a detector or photo-sensor above could count and record the number of cycles or pulses of light, and the movement could be accurately measured.

What the Agatronics people have done is to go one important and clever step beyond this.

They have taken one 7 cm diameter circle and drawn on it some nearly radial lines at a spacing, believe it or not, of approximately 100 lines per millimetre, giving 20,000 lines around the full circle.

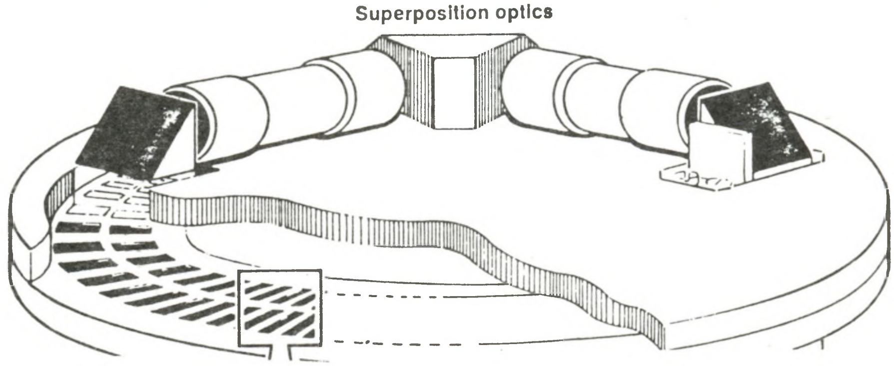
An optical arrangement superimposes one side of the circle onto the other, thus not only providing a system which eliminates eccentricity of the circle, but increases the resolution by effectively doubling the relative movement of the gratings.

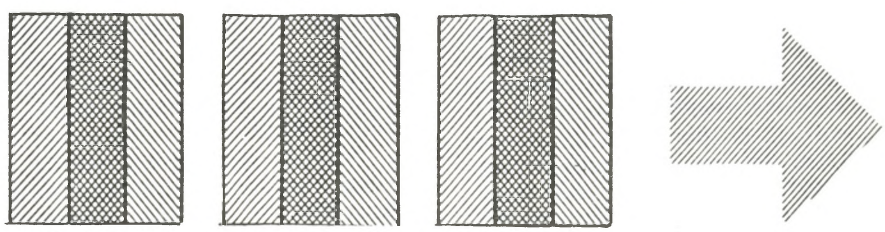
By pushing a beam of light through these gratings, no fewer than 40,000 sinusoidal cycles of light intensity are produced at the photosensor for every revolution of the circle. This corresponds to about thirty seconds of arc for each cycle.

From here on in, things start to get a bit complicated, and because of space limitations, and for other reasons that I leave you to guess at, no attempt will be made to delve into the back-up electronics.

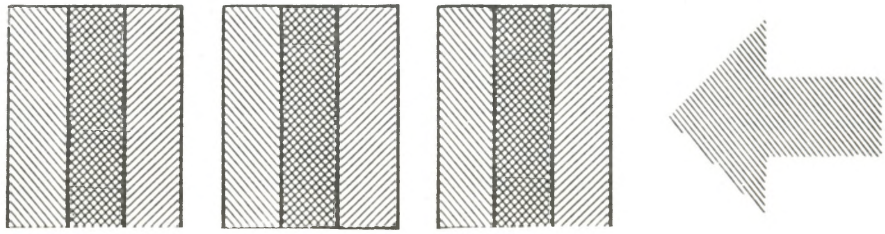
For example, to divide one cycle into, say, sixteen parts to reach the accuracy of two seconds of arc which is claimed, is not as easy as it sounds.

Superposition optics





The superimposed pulse-track images, moving in opposite directions, produce moiré closing-off and letting-in of light to the detectors.



Because the sine wave produced by the photosensor flattens out towards the peaks, to try and divide this would not give satisfactory results. In fact, there appears to be very little literature on this phase of the operation, and how it is done may well be a closely guarded industrial secret.

Also, to count the pulses, digital counting devices require square wave form input, and therefore the output from the photosensors has to be modified. This is done by passing the output through special trigger circuits that change quickly from one voltage to another whenever a certain threshold level is crossed.

The intensity of the light source is also subject to variation, and provision is made within the instrument to accommodate this by including two photosensors, one placed 180 degrees out of phase with the other on the moiré fringe pattern. L.E.D. fluctuations affect both photo-sensors equally; a combined output from both effectively negates any differences caused by variations in the light intensity.

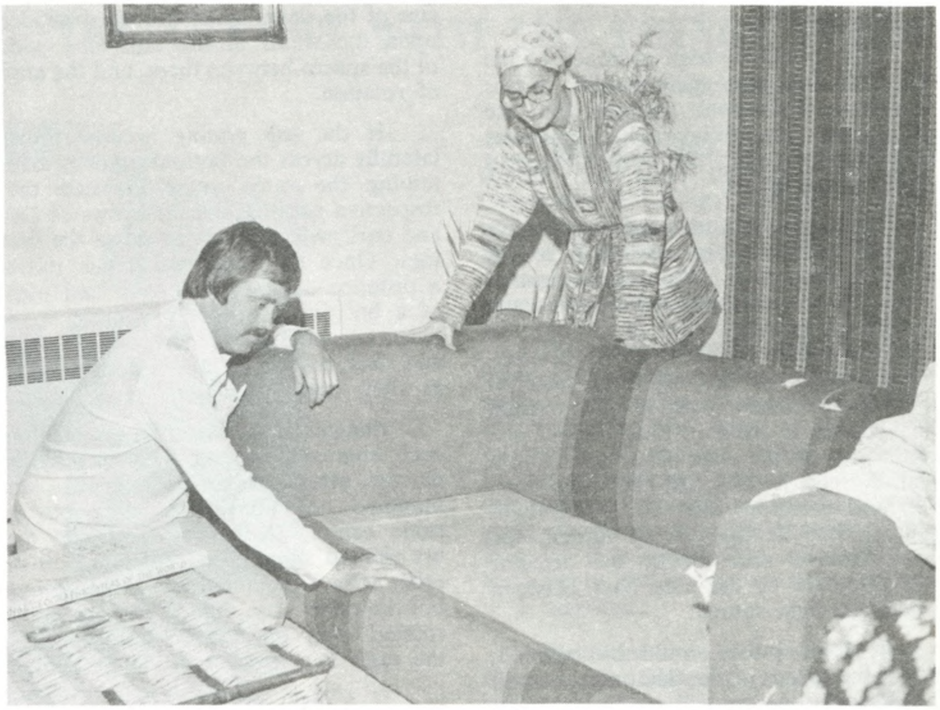
One last problem that has been overcome, is to cause the instrument to sense whether or not it is travelling in a clock-wise direction or not. You will appreciate that as the theodolite is rotated through an angle between two targets, the sense of direction must be known. Because if the foresight is inadvertently overshot, the counting system will have to deduct the excess pulses as the instrument is rotated back to the target.

To effect this, the pulse disc has in fact two concentric tracks of precision marks around its edge. They have been marked with opposite "slants" from the radial, and are shifted slightly with respect to one another. When the pulse marks from each side of the disc are superimposed, the tracks, or fringes, move in opposite directions to each other when the pulse disc is rotated. The light reaching the detectors will thus vary in accordance with two wavetrains. When these are compared using "simple" electronic logic, the counting mode is adjusted, and the information is passed on to the counting circuits.

What all of this comes down to is that if you feel you need one of these instruments for your day to day endeavours, and are suddenly confronted with its price, be tranquil. It's probably worth every penny of it.

The foregoing is based upon an article by C. Rawlinson in the April 1976 issue of the "Survey Review". Additional information was also kindly provided to me by Mr. I. H. Murray, Product Manager, Geodetic Instruments, of Agatronics Ltd. in Toronto, and I wish to thank him for his assistance in its preparation.

Survey of Foam in Home Leads to Hash Cache



(From the Leamington Post and News Nov. 10, 1976)

For six years the Wards have been technically breaking the law, and didn't know it.

And someone else is missing 50 pounds of an illegal drug, hashish.

And the RCMP is trying to fit the story together, at least they want to find out who 'stashed the hash', with a street value at over $450,000.00 estimate the Mersea Township police.

The story initially started at least six years ago, but we have to pick it up going back just 10 days.

John and Sharon Ward just moved to Mersea Township, 272 Seacliff Drive West about six weeks ago from Kingston.

He is articling at the Bill Setterington firm as an Ontario Land Surveyor. And Sharon is studying law at the University of Windsor.

On a Saturday evening recently, they decided it was time to recover a favourite couch, the one with the cushions that are both large and weighty.

As Sharon prepares the slip covers, John slits into the cushion material, and a package, neatly wrapped, weighing about a pound falls out from between the foam.

Not just one but 24 and on examination it doesn't take John long to realize what he is holding.

And the second cushion reveals just as many packages as the first.

"I knew the cushions were heavier than usual, but I just thought they were weighted to hold them in place", said John shortly after his discovery.

And when the Mersea police dropped by after his call, they were just as surprised at the uncut quality of the hash, probably from Lebanon, says Chief Ardell McIntyre.

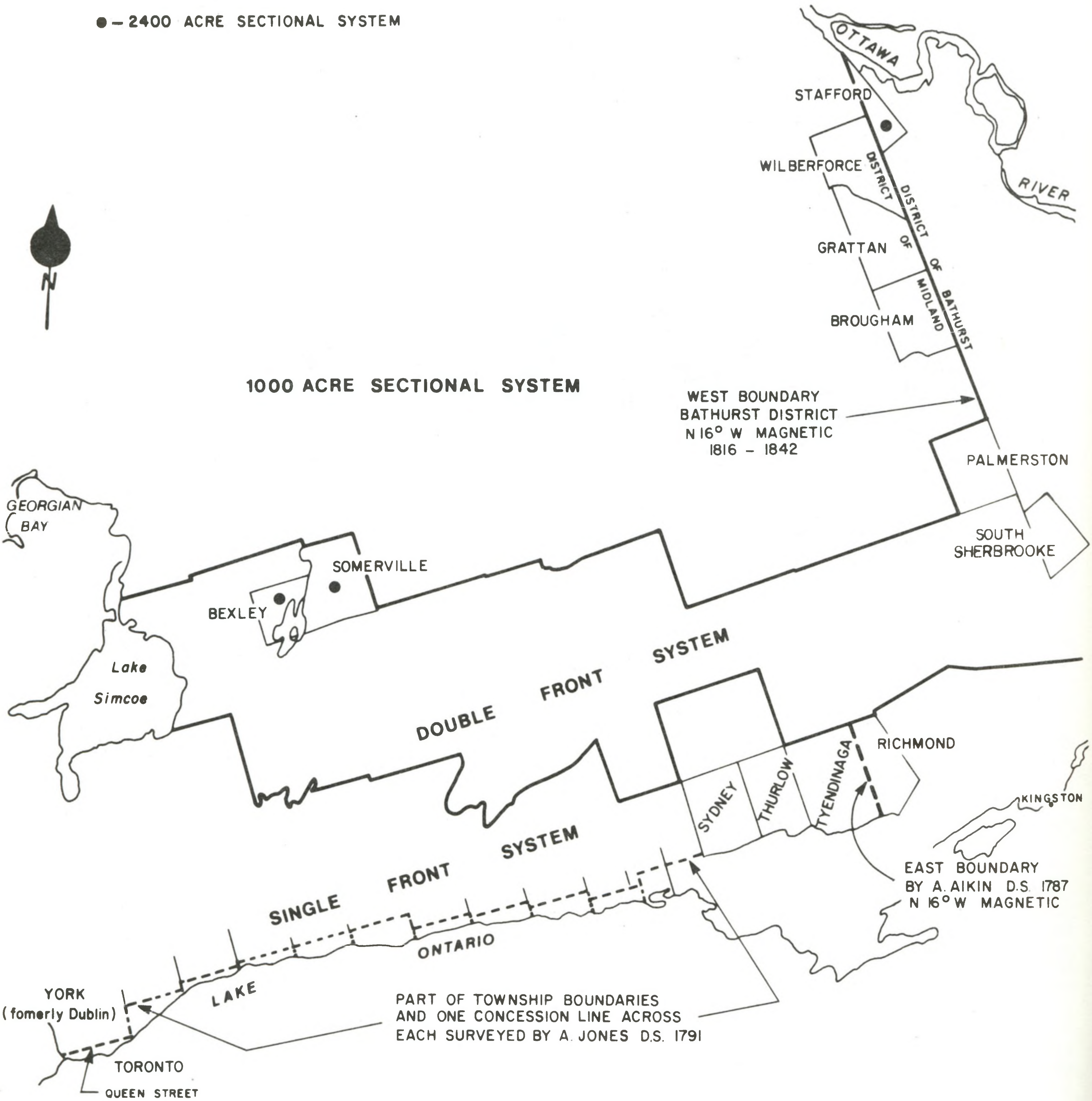
John and Sharon have moved at least five times in the last six years with the couch they bought at an auction sale for $40 near Barrie.

John says he can remember the day of the auction—"no one tried to outbid us and no one has bothered us either during the time we've had the couch", he added.

The couch is big and comfortable, with lots of padding and John said he checked the arms and other areas and could find nothing more, and the police checked it as well, but John said he had to be a little firm when they wanted to take it completely apart.

Whoever put it there, is probably dead or in jail, he says, also conclusion of a Mersea Police official, but RCMP officers are still checking into what is left of any leads in the Barrie area.

On the day they were interviewed the Wards were just waiting to get their cushions back, wondering what it will be like to sit on, without 50 pounds of hash.



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