The Gymo Gyro Theodolite

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Gymo Div., Plessey Canada Ltd.

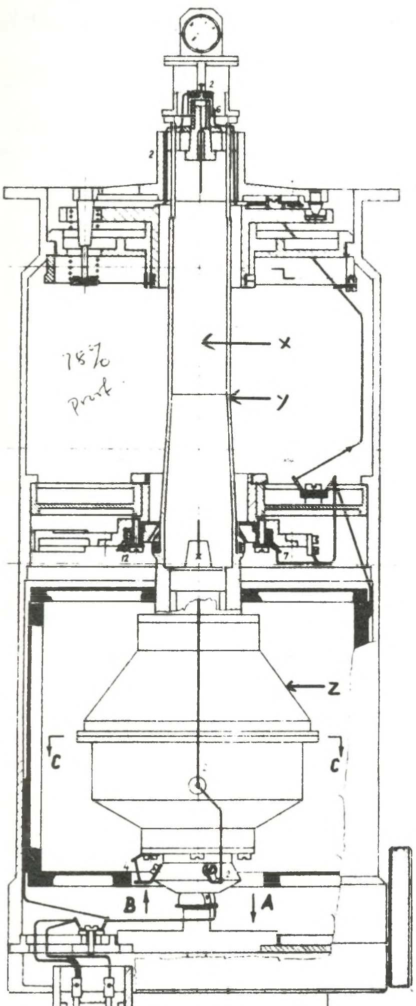

FIG 1

In theory, a suspended gyroscope with its spin axis horizontal will oscillate either side of the meridian and hence will enable one to determine True North. In practice most survey instruments of this type have an accuracy of about 20 seconds in comparison with astronomic determinations. In addition to the mechanical precision of the gyroscope assembly there are several factors which affect the ultimate accuracy. They are:

1. The frequency stability of the power supply that drives the gyro.
2. The stability of the set-up.
3. Internal magnetic influence.
4. External magnetic influence.
5. The resolution of the gyro scale.
6. Mislevelment.
7. The theodolite.
8. The changing physical dimensions of the components of the instrument.
9. The handling of the data obtained, and last, but not least —
10. The operator.

With the Gymo many of these factors have either been eliminated or compensated for, giving accuracies of + or — 3 seconds of arc and enabling azimuth determinations to be made as close as 8° from the North Pole.

The power supply converts the 12 volts DC to 3 phase AC which drives the gyro motor. The rotation of the motor must be very stable and the Polyphase Corporation of Ottawa designed and builds the power supply to meet our specification. Using digital circuits the phase angle between the three phases is maintained at 120 degrees with an accuracy of better than 1 degree and the frequency is maintained to within 1 cycle during the operating period. It also maintains a stable A.C. voltage output even though the DC voltage from the 12 volt input battery will be changing.

Safety features are built in so that, for example, the circuit for stopping the motor can not be operated unless the gyro is clamped.

The spinning gyro is affected by the rotation of the earth and this in turn gives us the determination of North. It is therefore most important for other external movement to be eliminated as far as possible and this entails a very rigid set-up for the tripod, a minimum of operator movement on the ground, and a wind-break if necessary.

There can be small residual magnetism in an instrument of this nature, caused by electric current flowing through wiring inside the gyro housing. The Gymo is designed so that demagnetisation takes place every time that the electronic braking circuit is activated. External magnetism could also be a problem operating near ore bodies in mines or near high voltage equipment in buildings, but this is eliminated by using several co-axial "cans" of mu metal around the inside of the gyro housing. Mu metal is a magnetic barrier and one can hold a magnet against the outside of the gyro housing with no effect on the gyroscope.

As with a theodolite one requires an accurate, easily readable scale if one is to obtain accurate readings. In the Gymo the scale is stationary and the operator observes it via a mirror secured to the gyro. However the fixed scale is divided horizontally and is viewed through a split, silvered prism. Inside this prism the bottom scale reflects off an additional mirrored surface which gives it a reversal. The effect to the operator is a view of a top scale going in one direction and the bottom one going in the opposite direction. The index on one scale is read against the other scale giving in effect a scale of double length.

A gyro hanging on a suspension tape behaves as a pendulum and if the readings are observed low down from the point of suspension it is most important that the entire instrument is level. If a gyro of this type is mounted above the theodolite, depending on the direction of mislevelment one can get an error of 3 seconds in azimuth for every 1 second of mislevelment. This problem is minimised in the Gymo by mounting the gyro unit below the theodolite. Around the outside of the suspension tape (X in figure 1) is a tube (Y in figure 1) one end of which is secured to the gyro motor (Z in figure 1). On the top of tube is mounted the mirror in which the readings are observed. When this assembly is mounted below the special theodolite the mirror is very close to the plane of the leveling screws and the maximum error one can expect is .3 of a second of arc for every 1 second of mislevelment.

The theodolite itself must be accurate of course, not only for precise leveling of the system but it is difficult to observe a reference object with an accuracy of 1 second with a 20 second theodolite. Also, the mating of the gyro assembly to the theodolite must be precise, with the collimation of the two units being maintained.

Heat is generated by any spinning motor and the gyro is no exception. The very nature of a gyroscope forces a manufacturer to use different metals with different rates of expansion, and in using an instrument of this type to obtain the maximum possible accuracy one should allow enough running time for the internal dimensions to stabilize. The sus-

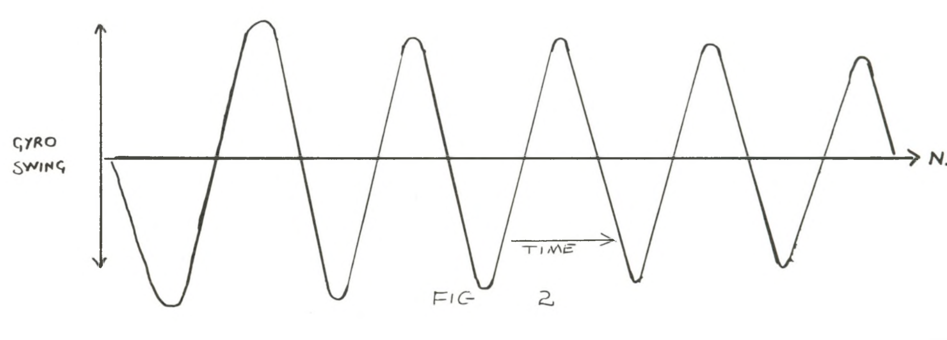

FIG 2

pension tape is particularly susceptible to this problem as it is one of the three conductors taking power to the gyro motor. All suspension tapes twist slightly when warm — only a few microns but enough to be noticeable when one is observing to one or two seconds of arc. In theory a series of gyro swings should produce a declining oscillation as shown in Figure 2, but in practice this slight twisting of the suspension tape produces an effect similar to Figure 3 which is exaggerated to emphasize the point. On switching off the gyro motor, the suspension tape will cool and revert to its original point of equilibrium. As we are now aware of this phenomenom, we can compensate for it in the computation. To maintain the suspension tape under as stable a condition as possible it is always maintained under constant tension. The gyro is clamped by lifting it until it engages on a shoulder in the housing but when this is done on the Gymo, springs lift the top end of the suspension tape keeping it under the same tension as when the gyro is hanging on it. This not only prevents it being bent lengthwise but it also minimizes the risk of breakage under shock conditions.

The effect of the suspension is minimized in the Gymo by the method of operating and the subsequent computation. Assuming that the instrument is approximately on North, a series of swings is observed with the gyro spinning, followed by a series of swings with the motor off.

Figure 3 shows graphically in exaggerated form the overall effect. The calculation on the field sheet projects to the point of switching off the motor, where the gyro influenced by the suspension tape indicates North. The swings with the motor off are projected mathematically in the reverse direction to indicate the effect of the suspension tape at the time of turning off the motor. By subtracting the tape effect from the combined gyro-and-tape indication we are left with the gyro indication only.

To obtain the 3 seconds of accuracy one must also have a well trained, careful operator. Unfortunately the technology of gyro determination of a precise azimuth is not like the present generation of EDM instruments where on pressing a button one gets an answer. But as an indication of what can be done I would like to quote the results obtained on a Gymo course conducted in Ottawa. Twelve students who had not used a Gymo before, on completion of the course observed a known azimuth using two different instruments. The results obtained were as follows:

	Group A Instrument A	Group B Instrument B
	157-01-40.8	157-01-49.9
	46.9	44.8
	44.3	51.4
	41.8	46.5
	46.6	50.8
	46.8	49.4
Mean	157-01-44.5	157-01-48.8
	Group C Instrument A	Group D Instrument B
	157-01-48.9	157-01-47.5
	48.3	49.1
	43.3	43.9
	44.7	42.4
	44.8	48.0
		49.6
	157-01-46	157-01-46.75

The known azimuth was 157-01-46.4, and as a matter of interest the overall mean of all 23 observations was 157-01-46.53 an error of 0.12 seconds. These were inexperienced operators and will probably improve with practice!

In the several years of research many people have been involved but in particular we would like to express our gratitude to Dr. L. Gregerson for his invaluable work in evaluating the physical problems, operating techniques and computation methods involved in Gymo operations.

CLUES TO PUZZLE

A. One half of a micro-wave E.D.M. system.
B. Former instrument to find altitude of star, replaced by sextant.
C. That certain parcel of land.
D. In what manner or way to be caught in a shower.
E. The degree, etc. of interest or ownership in land.
F. A dynamo to produce electric sparks.
G. Point in an orbit furthest from the sun.
H. Actual existence.
J. Where you will sometimes find (2, 3, 3)
K. Be careful with this registered document.
L. Thrust.
M. Bring the chef set.
N. A short distance measured at right angles to the main line.
P. The gradual recession of a shore line, resulting in accretion.
Q. River forming boundary between Sweden and Finland.
R. Lines drawn on maps and plans, indicating slopes.
S. The going out of the tide.
T. Map projection with parallel meridians.
U. A finer conclusion.
V. A steamship on regular service on the Nile R.
W. At this culmination, Polaris' L.H.A. is 180°.
X. Carrier wave in most electro-optical E.D.M.'s.
Y. Kind of linen stipulated in Sec. 7, S.Sec. 9, Reg. 780, The Registry Act.
Z. This man's mother is my father's daughter.

Use clue answers to fill in squares to the right thereof. Then transfer each letter to corresponding numbered square in diagram, where black squares separate words formed. Completed diagram will be a quotation from a book. First letters of answers, reading down, will spell out title of said book.

SURVEYORS ON THE MOVE

David H. Richardson of Toronto and Chief Surveyor with Ontario Hydro retired on July 1, 1977.

Dan A. Cybulski was appointed Chief Surveyor with Ontario Hydro and has moved from Barrie to Toronto.

The following surveyors, all employed by Ontario Hydro, have moved from Ottawa due to the closing of the District Office: **Ron Preston** to Toronto, **Murray LeGris** to Barrie, **Rich Lees** to Barrie, **Ray Schan** to Barrie.

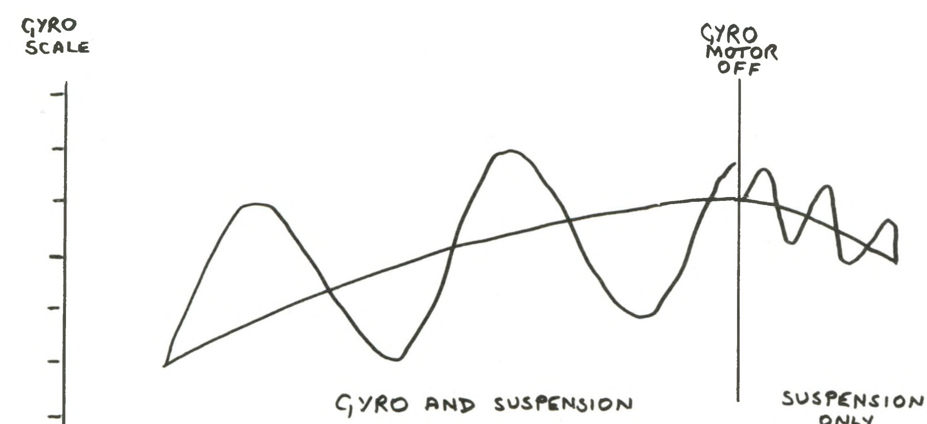

FIG 3