"That is all I had remembered about the lecture," recalls Dr. Makow, "but when the Section sought a new way to measure length, it flashed back to me. I started to read up on it and soon got the idea of how this capacitor, together with a then newly-available precision ratio transformer, could lead to such a system."

The novel "Lincap", or linear capacitor system, measures length over a range of 25 centimetres (one centimetre equals about 0.4 inch) with an accuracy of better than one micrometre. In addition to speeding up map-making, the instrument can be used in astronomy, spectroscopy, atomic research, in the machine industry and other fields.

Patented by Canadian Patents and Development Limited, a subsidiary of NRC, the instrument has been licensed to R.A. Barkley and Associates Limited of Ottawa and Valeriote Electronics (Guelph) Limited. Both companies are exploring different aspects of the invention.

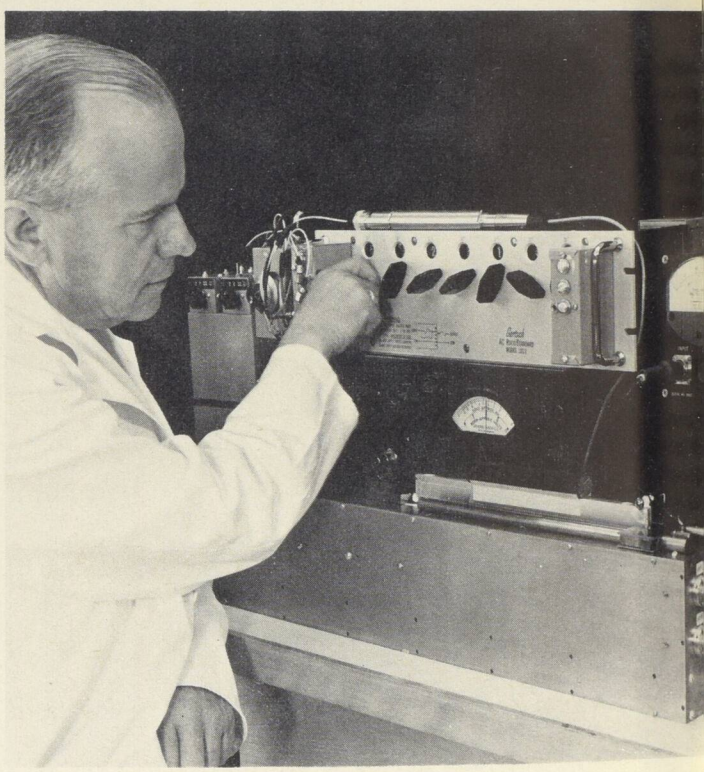
The device consists of two sets of four metal cylinders or quartz cylinders with metallic coating. The sets are insulated electrically from each other. A movable shield inserted between the cylinder shields a part of the cross-capacitance of two diagonally opposite cylinders of the first set and a complementary part of the second set. The shield is connected to the carriage on which the object to be measured, for example, a photographic transparency, is mounted. The first cylinder set forms one arm of an electrical bridge and the second set the other arm. The ratio of the voltages across the unshielded parts of the two sets of capacitors is then measured in the bridge against a precision ratio transformer. Two measurements are taken by electrically interchanging the cylinders. By taking the mean value of the two measurements, errors due to imperfect straightness or roundness of the cylinders or in the assembly, etc., cancel out. Therefore, very precise construction is not required. The mean value is then an accurate measure of position of the shield.

The instrument can work in two ways: the length measurement which is a difference between two positions of the shield can be made with an automatic readout or manually. The latter permits simplified instrumentation which is much cheaper than the automatic system. Measurements can be taken and read in less than a second using the automatic bridge which has an accuracy of one part in one million of the total range. With the manual bridge, accuracy is three parts in ten million and it can be improved using special instrumentation.

"There are few other systems where measurements can be made without electronic readout," says Dr. Makow. "With the laser, for example, it is impossible. The Lincap's manually balanced bridge is inexpensive, yet very accurate."

The instrument is not affected by fluctuations in supply voltage, humidity or pressure, since these factors cancel out in the measurement of ratio. It is also possible to match the temperature coefficient of the device to that of the object measured. Ambient conditions therefore, do not have to be rigidly controlled. In addition, very high mechanical accuracy of the instrument is not required which reduces the cost of the unit.

"This is an important factor," says Dr. Makow, "because usually cost and precision are closely related. For example, to improve accuracy by a factor of two in an already precise unit often results in more than doubling of the cost. And if it were improved by a factor of two again, cost could escalate quite quickly."



Albert Zuidhof of the photogrammetric Research Section balances the manual bridge of the Lincap. ● M. Albert Zuidhof, de la Section de recherches photogrammétriques, équilibre le pont manuel du "Lincap".

In the Lincap the moving elements do not touch the stationary parts and therefore there is no wear. Unlike incremental devices where length is defined by the number of counted pulses, the Lincap is an absolute system and the reading is always defined by the position without any doubt. In the incremental system, counts can be lost through a power failure, by moving too quickly, or by vibration of the instrument, which necessitates repetition of the measurement.

"I'm pleased by the fact that although I didn't know very much about measuring length before the project started, I was able to devise a new method for such measurements," says Dr. Makow. "This proves that you don't always have to be an expert in a particular field to make new contributions." □