

# DISTANCE MEASUREMENT

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## DISTANCE MEASURING TECHNIQUES

- Pacing
  - Determined by repeatedly pacing between 2 marks set a distance apart
  - Careful pacing accuracy about 1:100



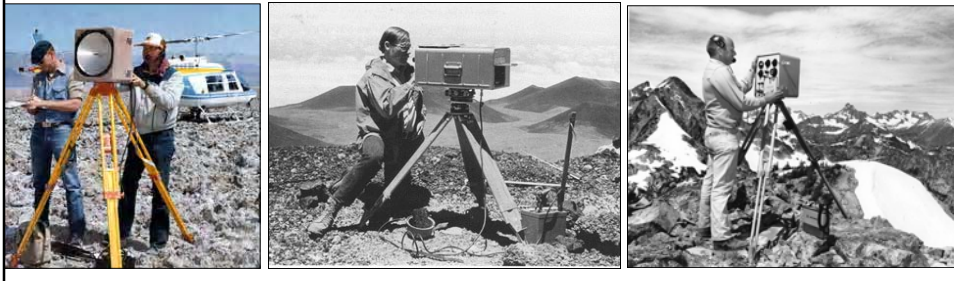
- Odometer
  - Automobile odometer or measuring wheel
  - 12" or 24" wheel with odometer



## DISTANCE MEASURING TECHNIQUES

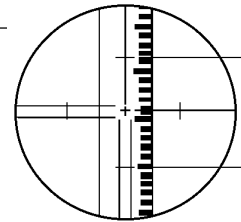
### □ Electronic Distance Measurement (EDM)

- Indirect measurement
- Two methods
  - Measure phase delay between transmitted and received light signal
  - Measure time of travel of pulsed light transmission



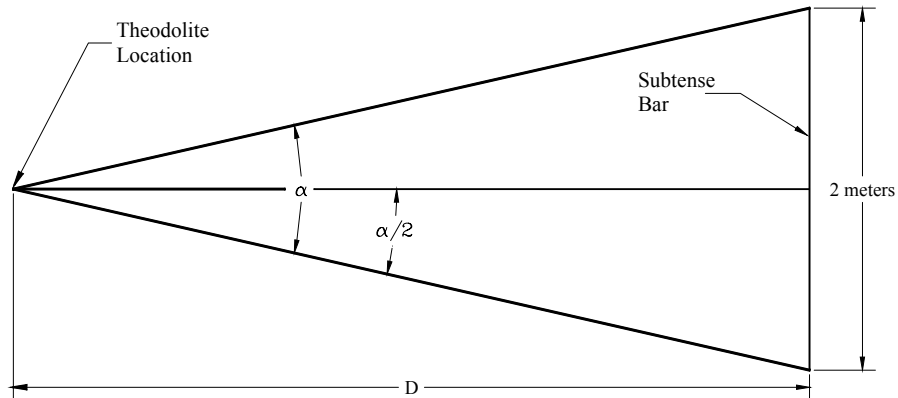
## DISTANCE MEASURING TECHNIQUES

- Stadia
  - Uses telescope cross-wire to determine distance
- Subtense bar
  - Tripod-mounted bar with targets 2.000m apart
  - Reasonably accurate over short distances
  - Distance measured is horizontal distance regardless of inclination of targets ( $\alpha$  measured between vertical planes)



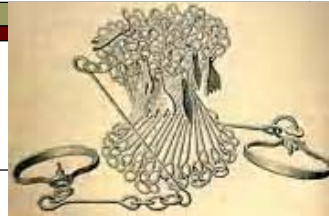
## SUBTENSE BAR

$$D = \frac{1}{\tan\left(\frac{1}{2}\alpha\right)} = \cot\frac{1}{2}\alpha$$



## DISTANCE MEASURING TECHNIQUES

- Gunter's Chain
  - 66' (22 yards) long comprised of 100 links
    - Each link 7.95"
  - Relationships:
    - 80 chains = 1 mile
    - 10 square chains = 1 acre
    - 4 rods = 1 chain
- Marked every 10 links by tags or tallies
- Number of points on tag denoted position in chain



Gunter Chain Tags



## EDMUND GUNTER (1581 – 10 Dec 1626)

- Received divinity degree
- 1619 appointed professor of astronomy in Gresham College, England
- Introduced words *cosine* and *cotangent*
- Invented Gunter's Chain
- Believed to be first to discover magnetic needle does not retain same declinations in same place all the time



## GUNTER'S CHAIN

- Used in U.S. from 1600s to end of 1800s
  - Sometimes 2-pole chain used for convenience
- Variations
  - Vara Chain
    - Used in Texas for Spanish land grants
    - 20 varas in length (60 Mexican feet, 55.556')
  - Ramsden's or Engineer's Chain
    - 100' long with 100 links
    - Jesse Ramsden (October 6, 1735 – November 5, 1800)
      - English astronomical and scientific instrument maker
      - Also constructed large theodolite for General Roy for survey between Greenwich, London and Paris



Jesse Ramsden

## GUNTER'S CHAIN - VARIATIONS

- Wing Chain
  - Described by English mathematician Vincent Wing in 1664
  - 66' long with 80 links
  - In U.S., W. & L. E. Gurley manufactured "Pennsylvania Chain" with either 40 or 80 links
- Grumman Chain
  - Josiah M. Grumman – city surveyor, Brooklyn, NY
  - Patent (April 15, 1859) for shorter Gunter Chain
    - 50 links measuring 33' (2 poles)
    - Links of tempered steel wire instead of iron
    - Formed link with circular eye at one end and oval eye at other
    - One end had spring balance and level
    - Other end had thermometer with Fahrenheit scale



## TAPING

- Fiberglass or cloth tapes
  - Used for less precise measurements
  - Cloth tend to stretch somewhat when wet
  - Some cloth have copper strand reinforcement
  - Fiberglass – rugged and consistent length



Fiberglass tapes: waterproof, dirt-resistant, washable, tough, more durable than steel

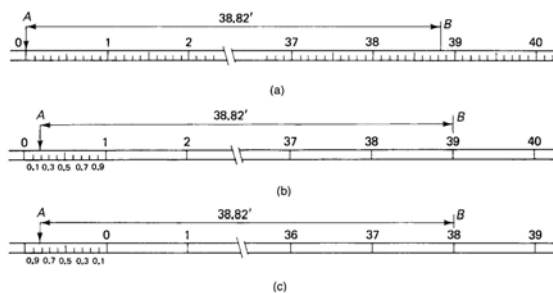
## STEEL TAPES

- 100' most common length
- 2 common cross sections
  - Heavy duty  $5/16'' \times 0.18''$  (8 mm x 0.45 mm)
    - Often used for route surveys – drag tape
  - Normal usage  $1/4'' \times 0.012''$  (6 mm x 0.30 mm)



## STEEL TAPE

- Graduations
  - Throughout (a) in feet and hundredths of a foot
  - Cut tape (b) – 1<sup>st</sup> and last foot graduated throughout
  - Add tape (c) – additional foot placed at beginning of tape





## IVAR STEEL TAPE

- ❑ Low coefficient of thermal expansion
- ❑ Nickel-steel alloy with thermal expansion ranging from 0.0000002 – 0.00000055 per degree Fahrenheit
- ❑ Generally attach thermometer to invar tapes



Base line and astro party of C. V. Hodgson, 1916



Crossing ravines on stands to keep line horizontal. Pasadena Base measurement. Base line party of Clement L. Garner, 1922

Traverse measurements in sub-zero conditions. Making front contact. Traverse party of Casper Durgin, Minnesota-Canada border, 1924.



Reading the Forward End of Tape

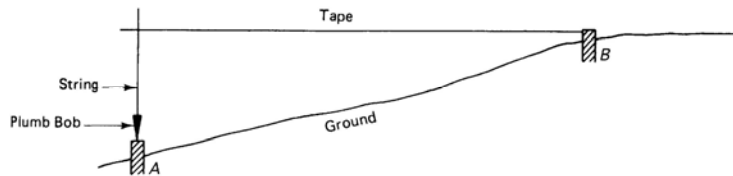
The tape was stretched under a tension of 15 kilograms (33 pounds), the tension being indicated by the spring balance. The heights of the tripods above the ice, which was assumed to be level, were obtained by the staves, graduated as shown, which were used in stretching the tape. The tape lengths were corrected for any inclination to the horizontal plane and temperature.

## TAPING ACCESSORIES



### □ Plumb bob

- Normally made of brass
- Permits surveyor to hold tape horizontal when ground sloping
- Markings on tape can be transferred down to point on ground with plumb bob
- Can also be used to provide precise line of sight

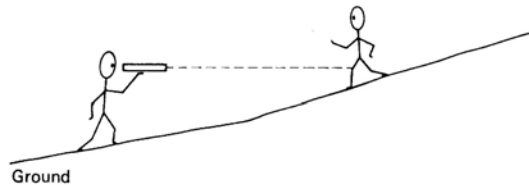


## TAPING ACCESSORIES



### □ Hand Level

- Permits surveyor to make low precision horizontal sightings
- Equipped with tubular bubbles and cross wires that can be viewed together
- Clinometer – hand level with attached protractor like Abney hand level



## TAPING ACCESSORIES



- Range Poles (line rods)
  - Usually painted alternately red and white in 1-ft. sections
  - Used to help in alignment for distances greater than 1 tape length
    - Rear-tape person keeps forward tape person on line by sighting on rod and telling forward person to move to right or left
  - Also can provide sighting for transit/theodolite angle measurements



## TAPING ACCESSORIES

- Chaining Pins (taping arrows, marking arrows)
  - Set of 11
  - Alternately painted red and white
  - Used to mark intermediate points on ground for long distances
  - Usually set at  $45^\circ$  angle and at right angles to direction of measurement
    - Sloping permits precise measurement with plumb bob



## TAPING ACCESSORIES



- Tape clamp handles
  - Helps surveyor grip tape at intermediate locations on tape
- Tension handle
  - For precise work, used to apply correct tension



Base line measurement with Invar tape. Off Launch ELSIE, Georgia, 1924

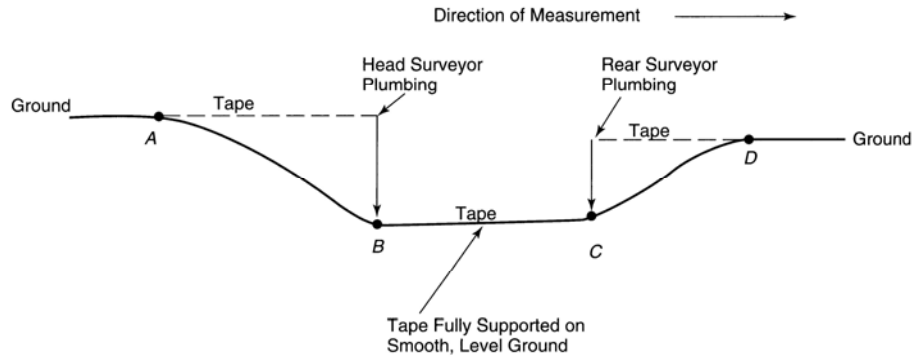
## TAPING TECHNIQUES



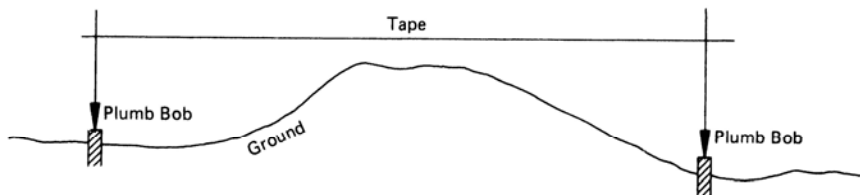
- “Front” part of tape is zero-foot end
- With drag tape, reel removed and leather straps inserted into eyelets at either end of tape
- Rear tape person puts front tape person on line using range pole (for precise measurements, theodolite/transit operator puts front tape person on line)
- Rear tape person puts 100’ (or 30m) end over point
- Front tape person makes sure tape is straight and applies proper amount of tension
- Rear tape person tells front tape person to “measure” when the rear tape person is correctly over the point
- Front tape person places chaining pin into ground at the zero end of the tape

## TAPING TECHNIQUES

- Taping over terrain that is not level
  - Use plumb bob



## HORIZONTAL TAPING USING PLUMB BOB AT BOTH ENDS



- Use hand level to establish height at which tape is suspended
  - Best to keep height at waist height or lower
  - Above shoulders increases chance of error
  - Hold plumb bob close to body such that arms are supported by the body itself

## USE OF CHAINING PINS TO MEASURE DISTANCE

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- ❑ Start by placing pin next to the initial point
- ❑ Front tape person extends tape full length, applies proper tension, is placed on line by back tape person
- ❑ When back tape person yells “mark”, front tape person places the pin in at the 100-ft distance
- ❑ Once front tape person is confident the pin is properly placed, they yell back to the rear tape person “good” and the rear tape person pull the chaining pin and puts it in their sheath or ring.
- ❑ Distance measured is the number of pins the rear tape person has in their possession – here 100’ since the rear tape person has one pin

## USE OF CHAINING PINS TO MEASURE DISTANCE

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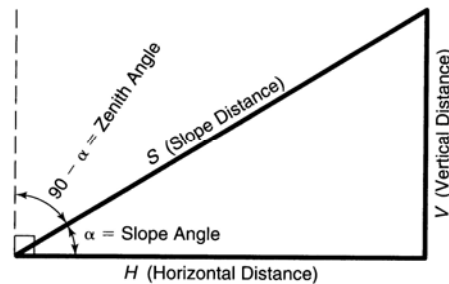
- ❑ Process continues until the front tape person has no pins in their possession.
- ❑ When that happens, front tape person yells “tally” and the rear tape person comes forward and hands front tape person their pins (10 pins since one is still in the ground)
- ❑ This is a tally = 1000’
- ❑ Taping continues until entire length is measured

## USE OF CHAINING PINS TO MEASURE DISTANCE

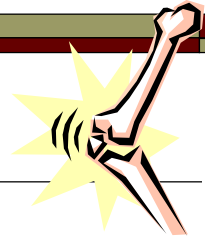
- At last segment, the front tape person reads the last segment of the distance and records that value in the field book.
- Front tape person asks the rear tape person how many pins they have in their possession (excluding the one still in the ground) and records that distance.
- Adds the number of tallies, number of pins and fractional tape length to obtain distance
- Once recorded, front tape person yells “good” and rear tape person pulls the pin and comes forward

## DISTANCE RELATIONSHIPS

- Horizontal, vertical, and slope distance relationships:
  - Solve using simple right triangles and basic trigonometry



## BREAKING TAPE (OR CHAIN)



- ❑ Lay tape out entire length
- ❑ Front tape person places a pin at the distance A-L and tells the rear tape person that foot marker
- ❑ Rear tape person comes forward, hands the front tape person a chaining pin and then holds that foot mark the front tape person measured to
- ❑ Front tape person sets pin at distance L-M and same procedure followed.
- ❑ At end of full tape, front tape person sets chain at point B after measuring distance M-B and rear tape person pulls the pin at M and keeps it in their possession – signifying one tape length measured

## REAR TAPE PERSON'S RESPONSIBILITIES

- ❑ Keeps front tape person on line during survey
- ❑ Holds back end of tape over point as front tape person applies proper tension and yells “mark” to indicate to the front tape person to mark the distance
- ❑ Keeps track of full tape lengths
- ❑ Maintains equipment
  - Cleans/wipes tape



## FRONT TAPE PERSON'S RESPONSIBILITIES

- ❑ Makes sure tape is straight with no loops or kinks
- ❑ Prepares ground surface by clearing away grass, leaves, snow, etc.
- ❑ Applies proper tension
- ❑ Marks the tape measurement
- ❑ Records distance measurement and other pertinent information in field book

