A Review of The International Ten-Twenty System of Electrode Placement and Application Methods

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OUTLINES

- What is the 10 - 20 System ?
- Designated Abbreviations for The 10-20 System
- Equipment necessary for the efficient use of the 10-20 system
- The sequence of measurement in the 10-20 system and Procedure
- Quick verification of the 10-20 system measurement
- Electrodes and Application Methodes.

What is The 10 - 20 System ?

- The International Ten-Twenty System of Electrode Placement is a procedure for the measured location of equally spaced electrode positions on the scalp, using identifiable skull landmarks as reference points. This system is based on the proven relationship between a measured electrode site and underlying cortical structures and areas.

- The system is termed “10 – 20” because electrodes are space either 10% or 20% of the total distance between a given pair of skull landmarks.

In The 10-20 System, electrodes are placed either 10% or 20% of the total distance between skull landmarks.

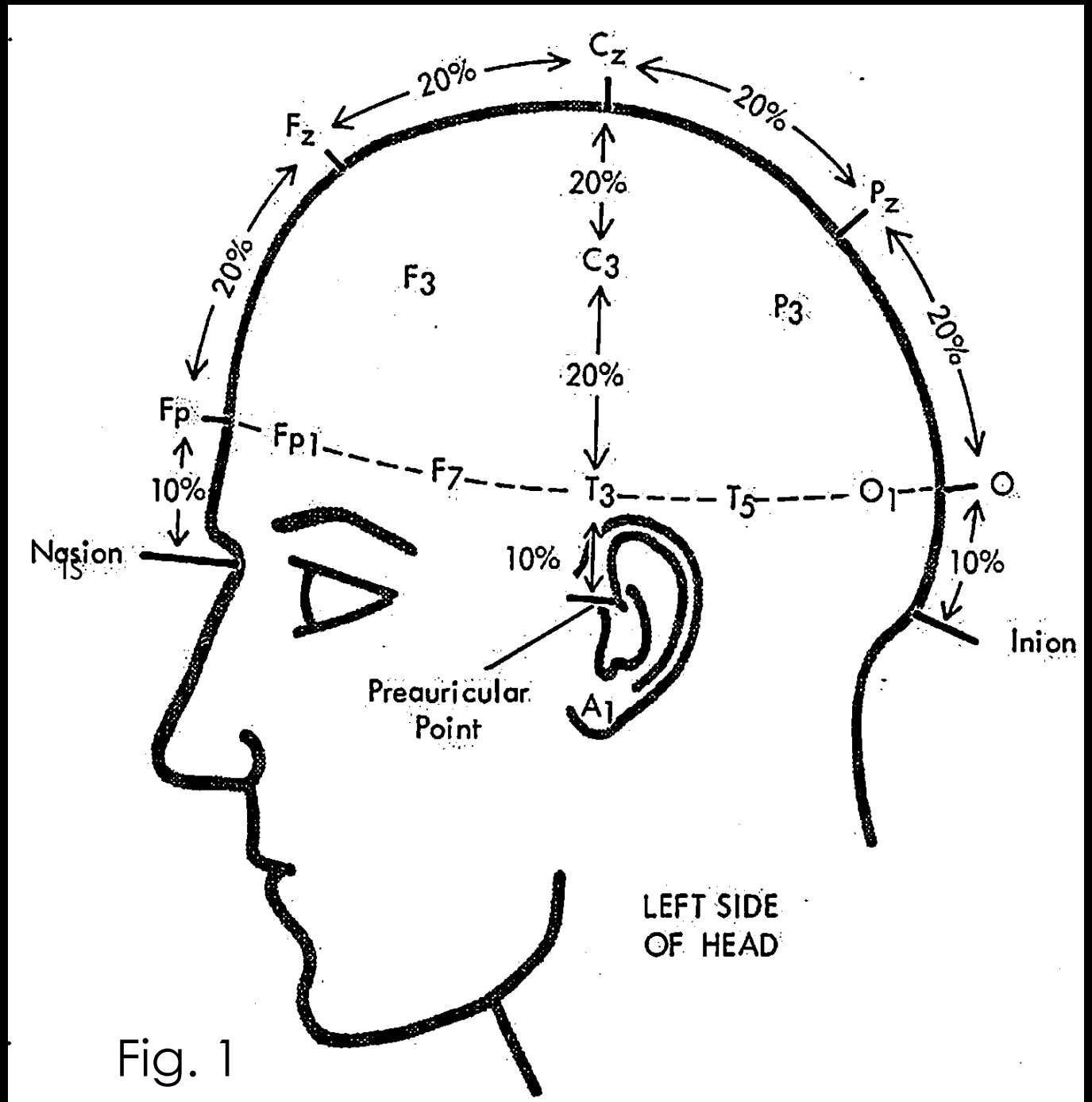


Fig. 1

ADVANTAGES OF THE TEN-TWENTY SYSTEM

The advantages establishes by the International 10-20 System are:

- on internationally accepted standard for format placing electrodes on the scalp.
- on anatomically proven correlate for each electrode which is consistent from patient to patient.
- uniform spacing of electrodes for accurate comparison of difference brain area.

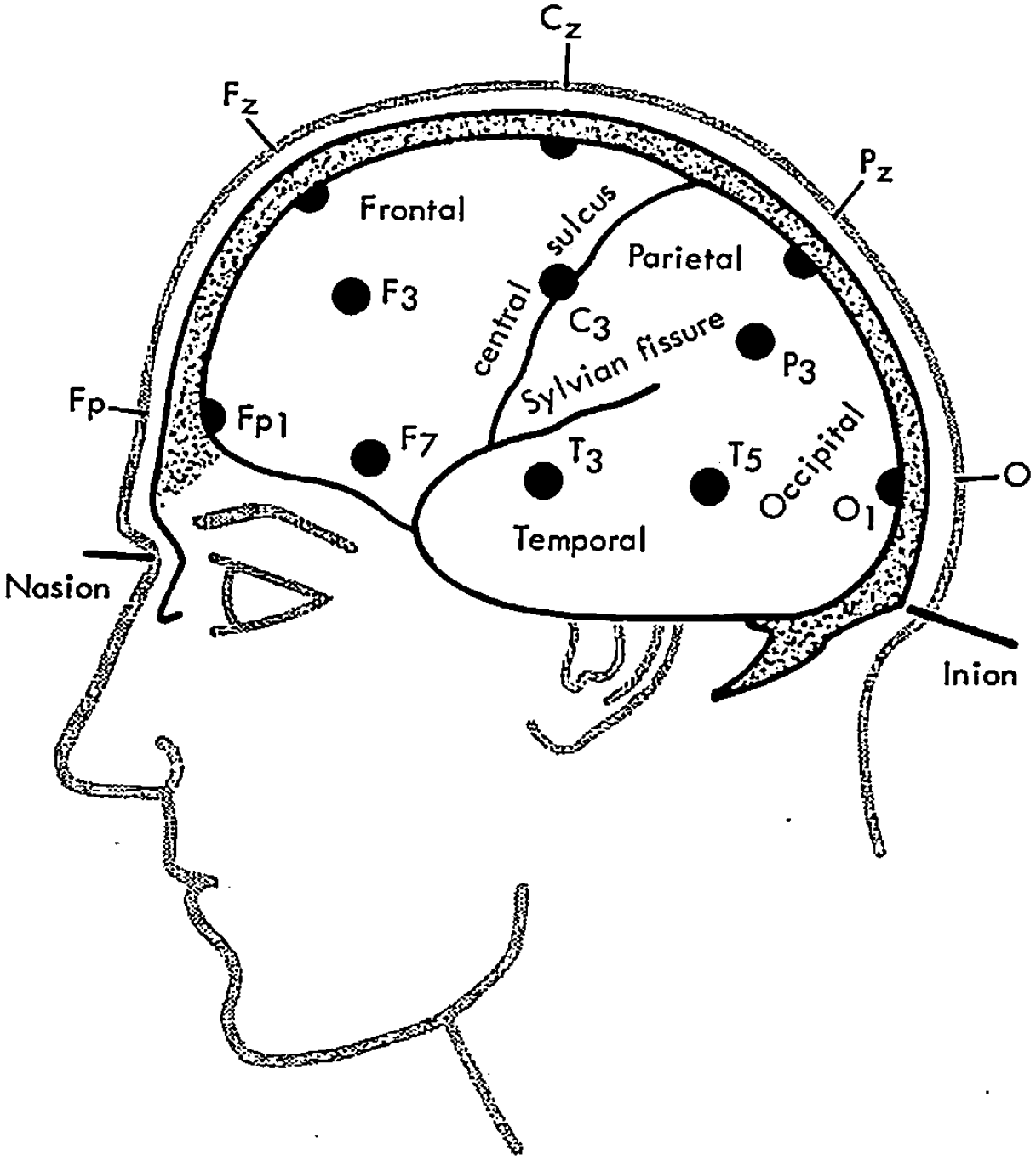
ADVANTAGES OF THE TEN-TWENTY SYSTEM [con]

- a system of labeling electrode locations which is identical in all languages.
- comparable data for the comparison of serial (follow-up) EEGs of the same patient in the same or in the different laboratories.
- a flexible system which provides adequate brain coverage and patients the additional electrodes is more detailed coverage is required.

Anatomical justification of The Ten-Twenty System

Relationship between central sulcus, sylvian fissure, lobes of the brain and electrode positions

Fig. 2



What are the skull landmarks in The Ten-Twenty System

There are four skull landmarks used in The 10-20 System: the nasion, the inion and the right and left preauricular points.

- The nasion is the indentation between the forehead and the nose.
- The inion is a ridge or knob that can be felt as you run your finger up the back of the neck to the skull.
- The preauricular points are indentations just above cartilage (tragus) which covers the external ear opening. Locate the point on both the right and left sides.

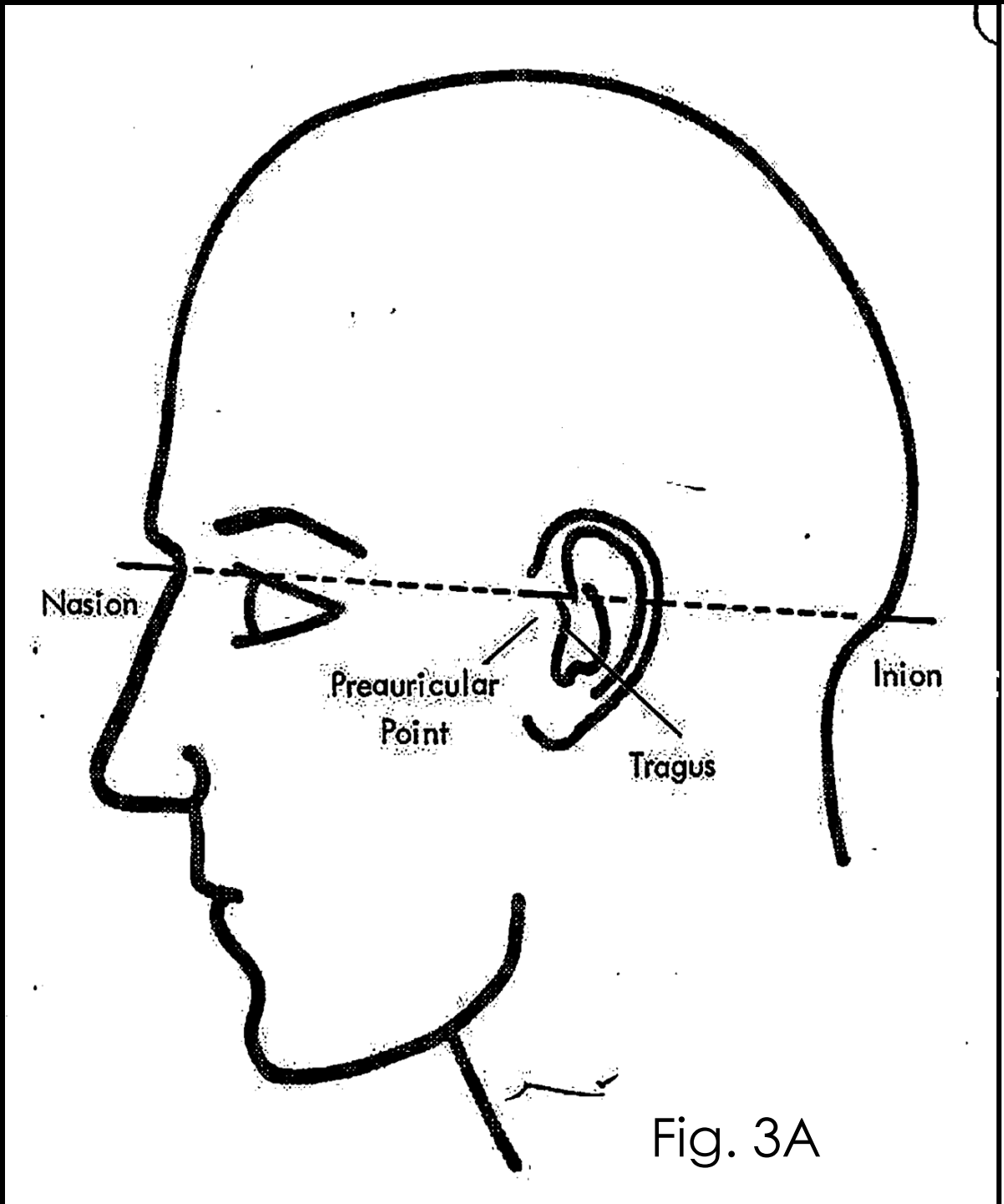


Fig. 3A

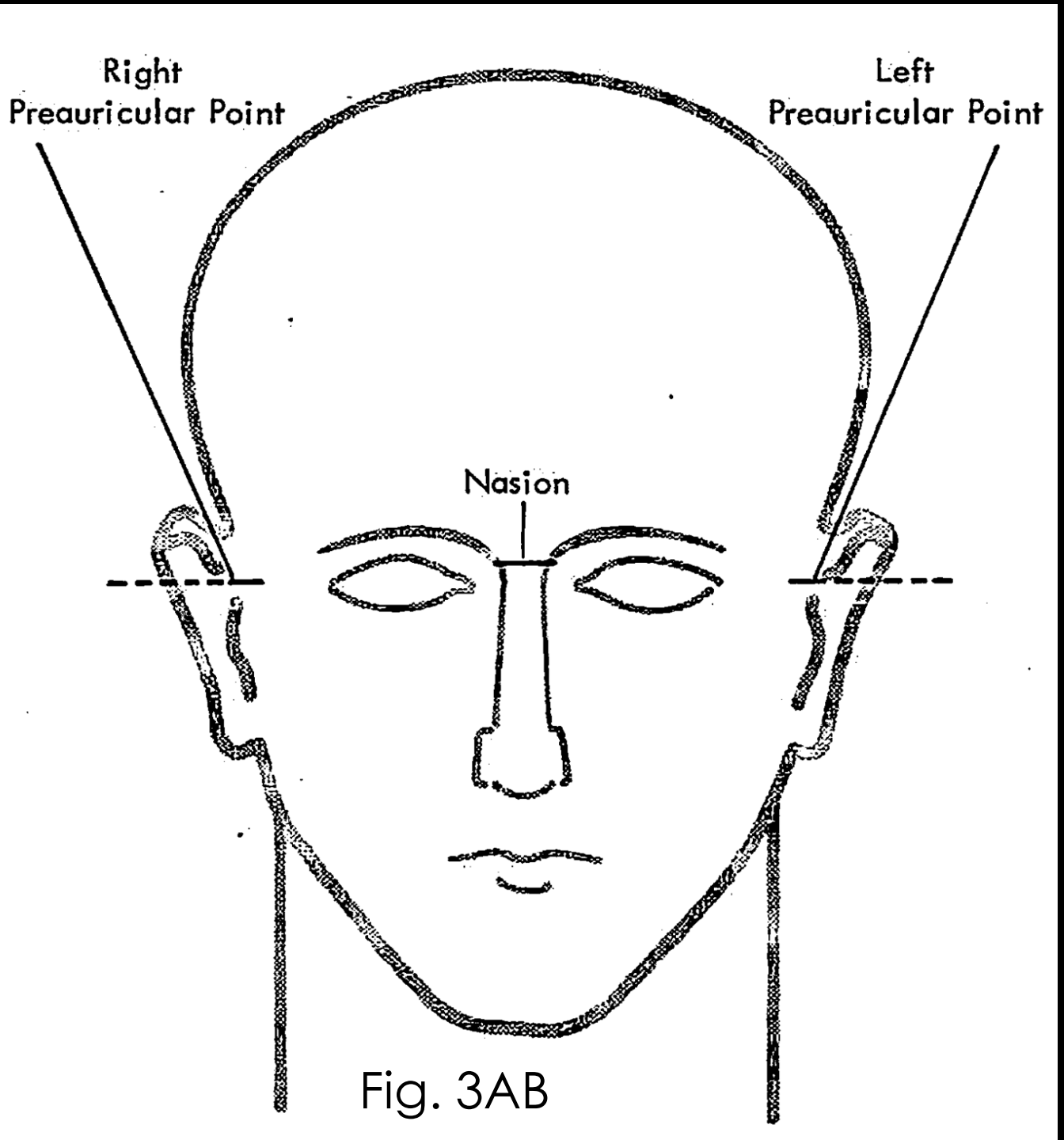


Fig. 3AB

How was the nomenclature for The International 10-20 System developed ?

The nomenclature was developed to give each electrode site a logical alphabetical abbreviation that immediately identifies it with the lobe or area of the brain to which its refers.

Terminology for scalp electrodes is such that:

- Each electrode has a two or three character component letters and numbers. The first character (s) indicate the general cerebral region and the last character indicates the area in that region.
- The regions for the first character are frontal pole (Fp), frontal (F), central (C), Temporal (T), parietal (P), occipital (O).

- For the second character, odd numbers are left hemisphere, even numbers are right hemisphere, and the lower-case “z” is midline.
- Ear (auricular) with left being A_1 and right being A_2
- Ground (GND) electrode.
- Referent (Ref) electrode.

Additional electrodes outside The10-20 System:

- Silverman “true” anterior temporal (T_1 and T_2) electrodes, to monitor anterior temporal activity,
- FT_9 and FT_{10} electrodes are placed, making them ideal for recording seizures with long-term monitoring.

Physiologic monitoring:

- EKG [ECG] is he most important and needs to be monitored in all patients.
- Additional electrodes for physiological monitoring need to be used predominantly in neonatal EEGs, in brain death recordings, and select situations, particularly for ICU recordings.

Designated Abbreviations for The 10-20 System

BRAIN AREA	LEFT HEMISPHERE	MIDLINE	RIGHT HEMISPHERE
Frontal pole	Fp1		Fp2
Frontal	F3		F4
Inferior Frontal	F7		F8
Mid-Frontal		F_z	
Anterior Temporal	T1		T2
Mid-Temporal	T3		T4
Posterior Temporal	T5		T6
Central	C3		C4
Vertex or Mid-Central		C_z	
Parietal	P3		P4
Mid-Parietal		P_z	
Occipital	O1		O2
NON SCALP LEADS			
Auricular	A1		A2
Nasopharyngeal	Pg1		Pg2

Equipment necessary for the efficient use of the 10-20 system

Centimeter Tape

Retractable tape

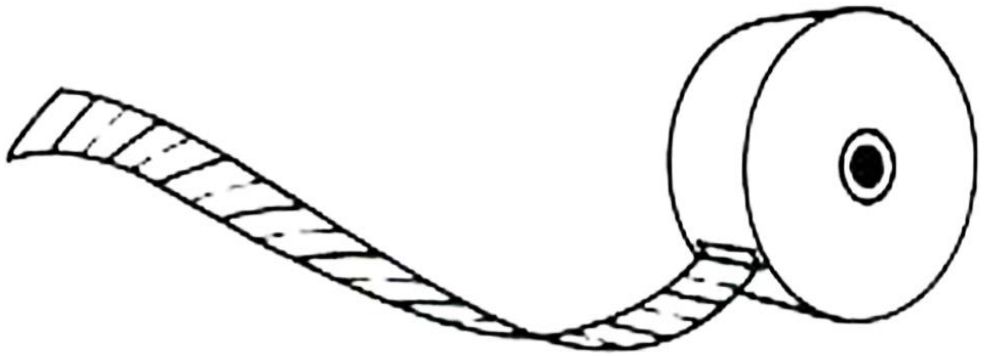


Fig. 4A

Flexible strip tape

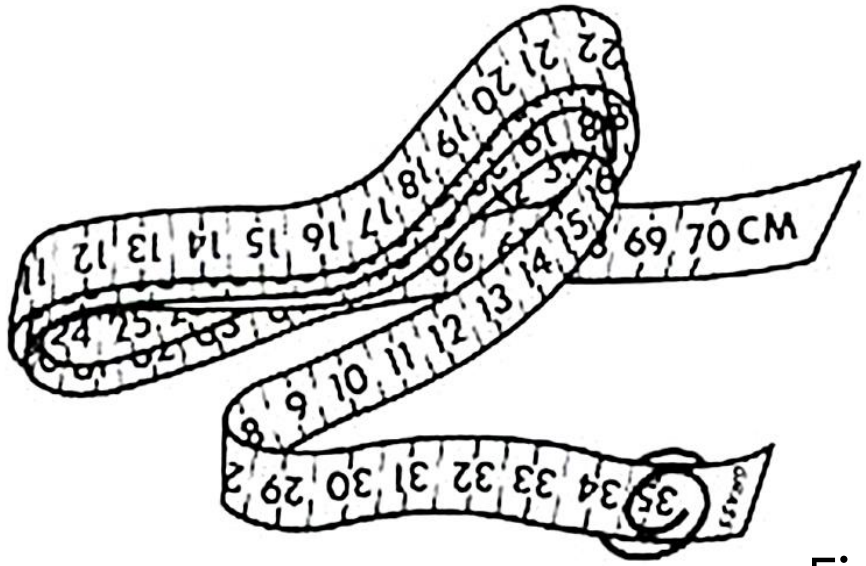


Fig. 4B

Non-toxic skin marking pencils

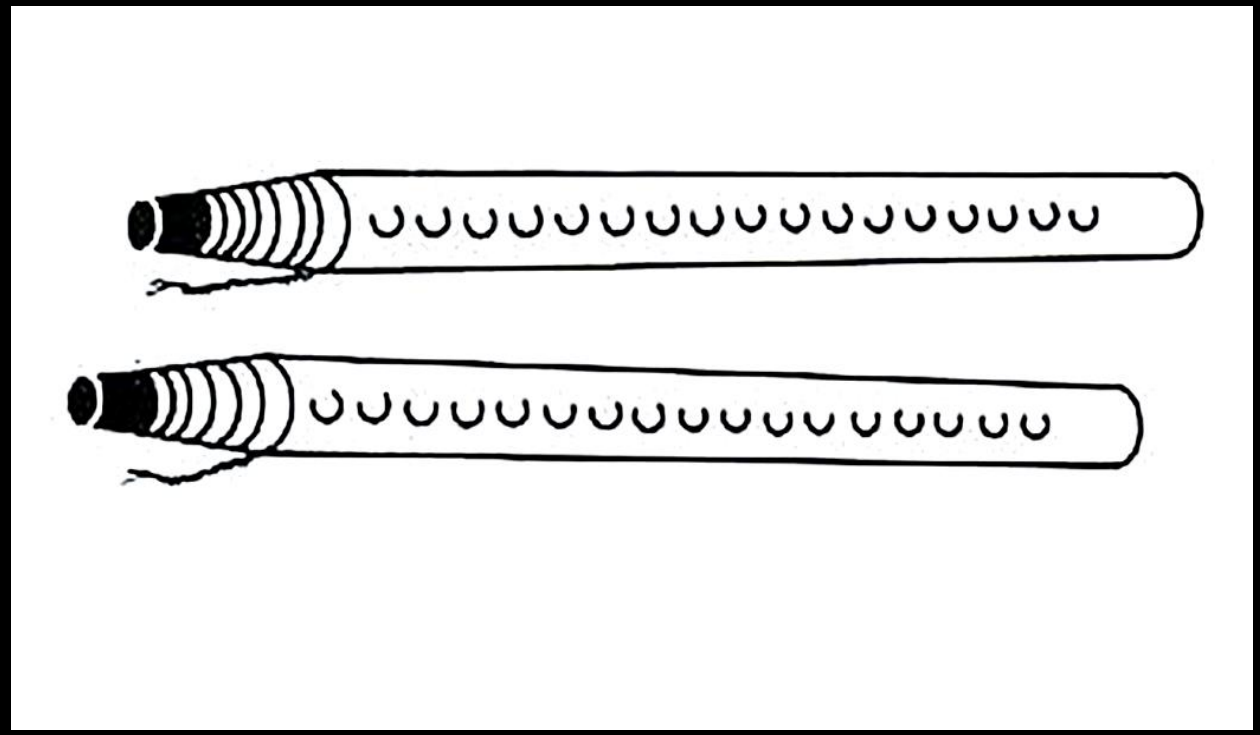


Fig. 4C

Dividers

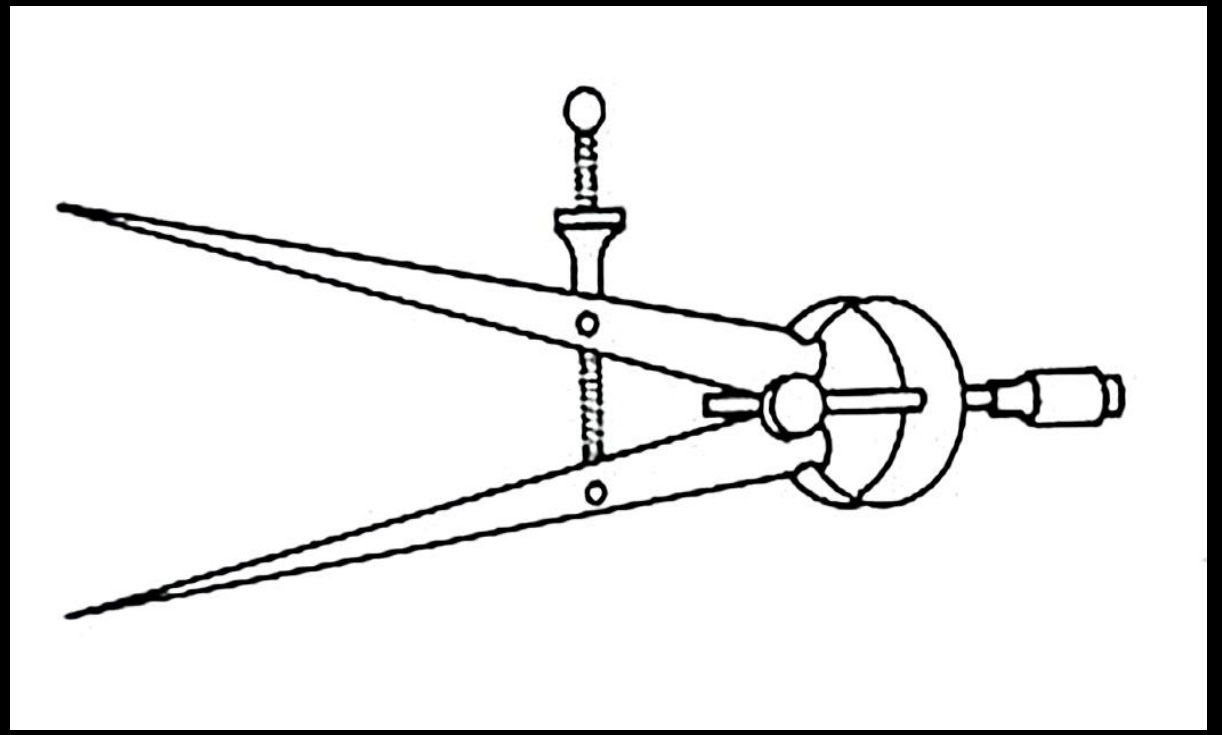


Fig. 4D


Fixomull stretch
5cm x 10m
Ten20
CONDUCTIVE
Nuprep
Skin Prep Gel
COTTON SWABS (L)
NON-STERILE
Collodion
UN 2059
Collodion Remover
No Acetone • Non-Irritating
Non-Flammable • Low Vapor
STERILE
PROCESSED+YELLOW
THAI GAUZE

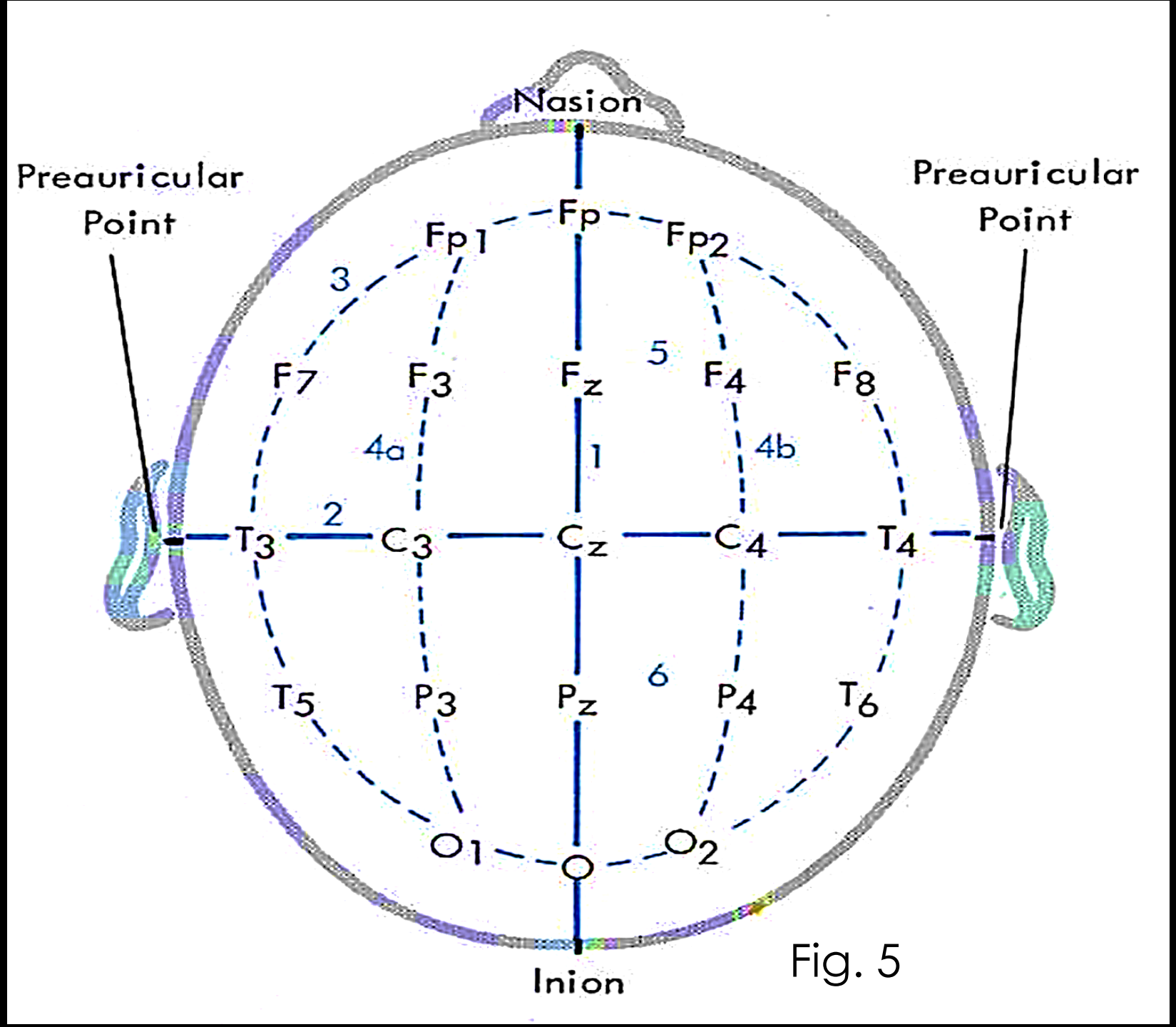
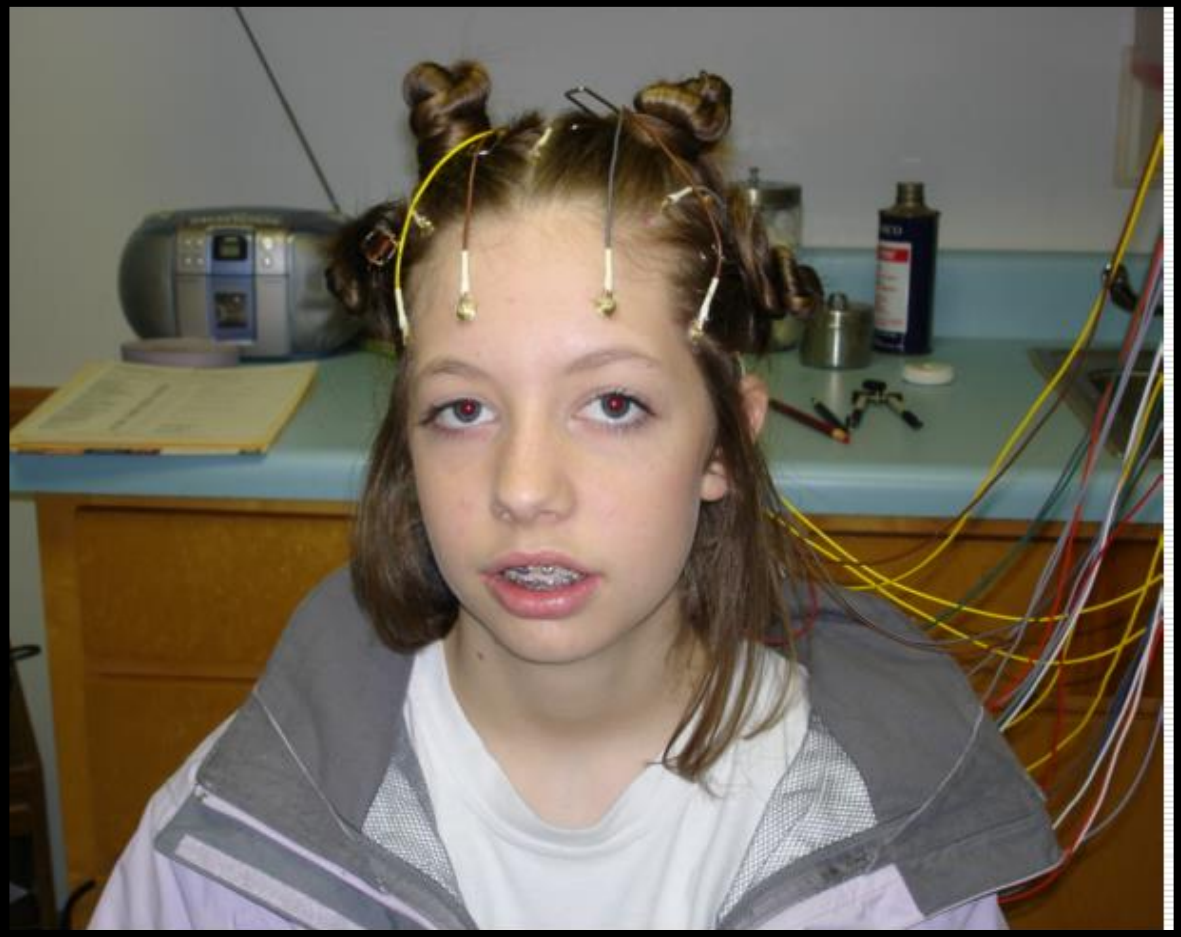

Nasion
Preauricular Point
Preauricular Point
Fp
Fp1
Fp2
3
5
F7
F3
Fz
F4
F8
4a
1
4b
2
T3
C3
Cz
C4
T4
6
T5
P3
Pz
P4
T6
O1
O
O2
Inion

Fig. 5

PATIENT PREPARATION

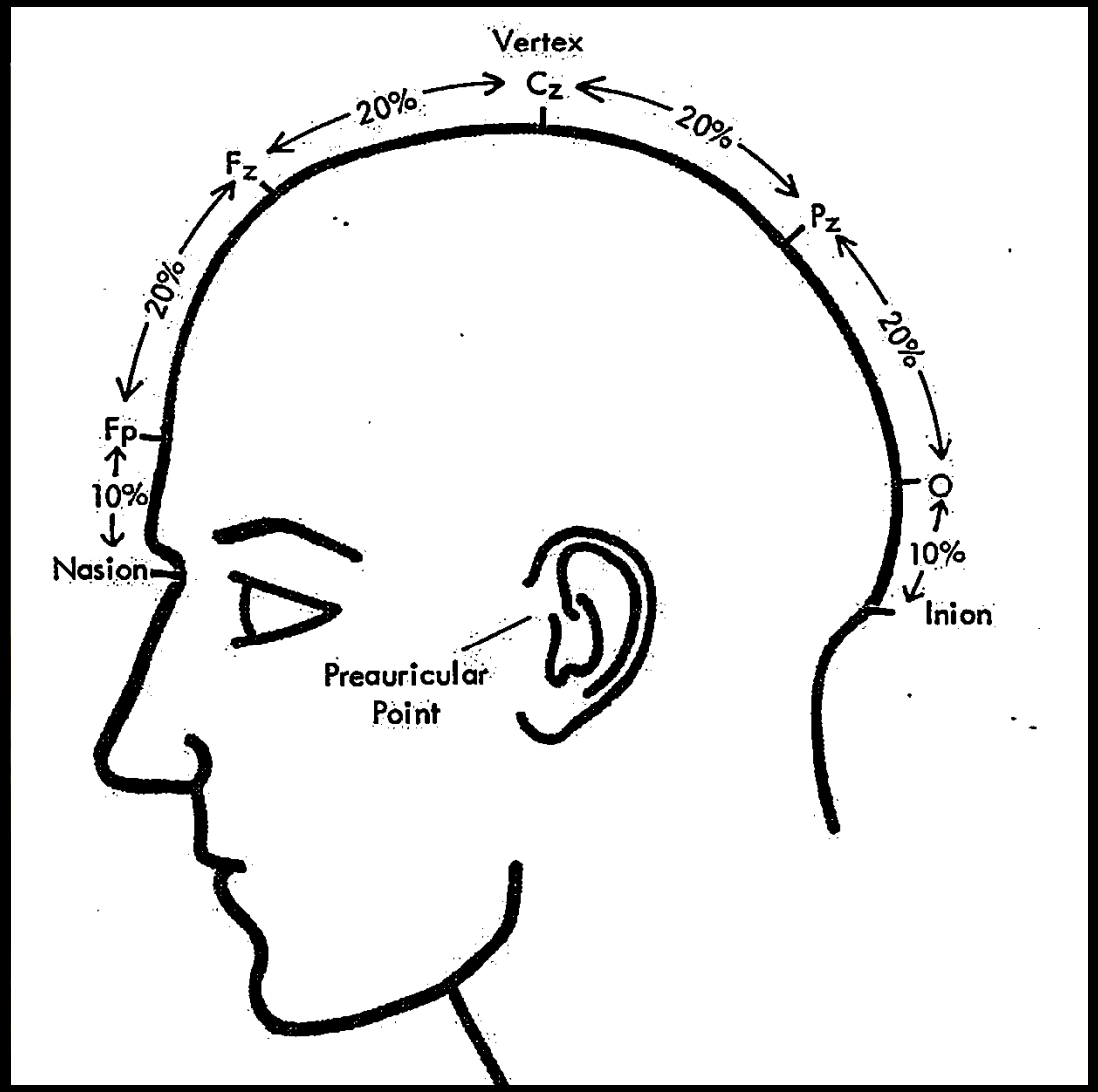
Patient preparation & Applying scalp electrodes

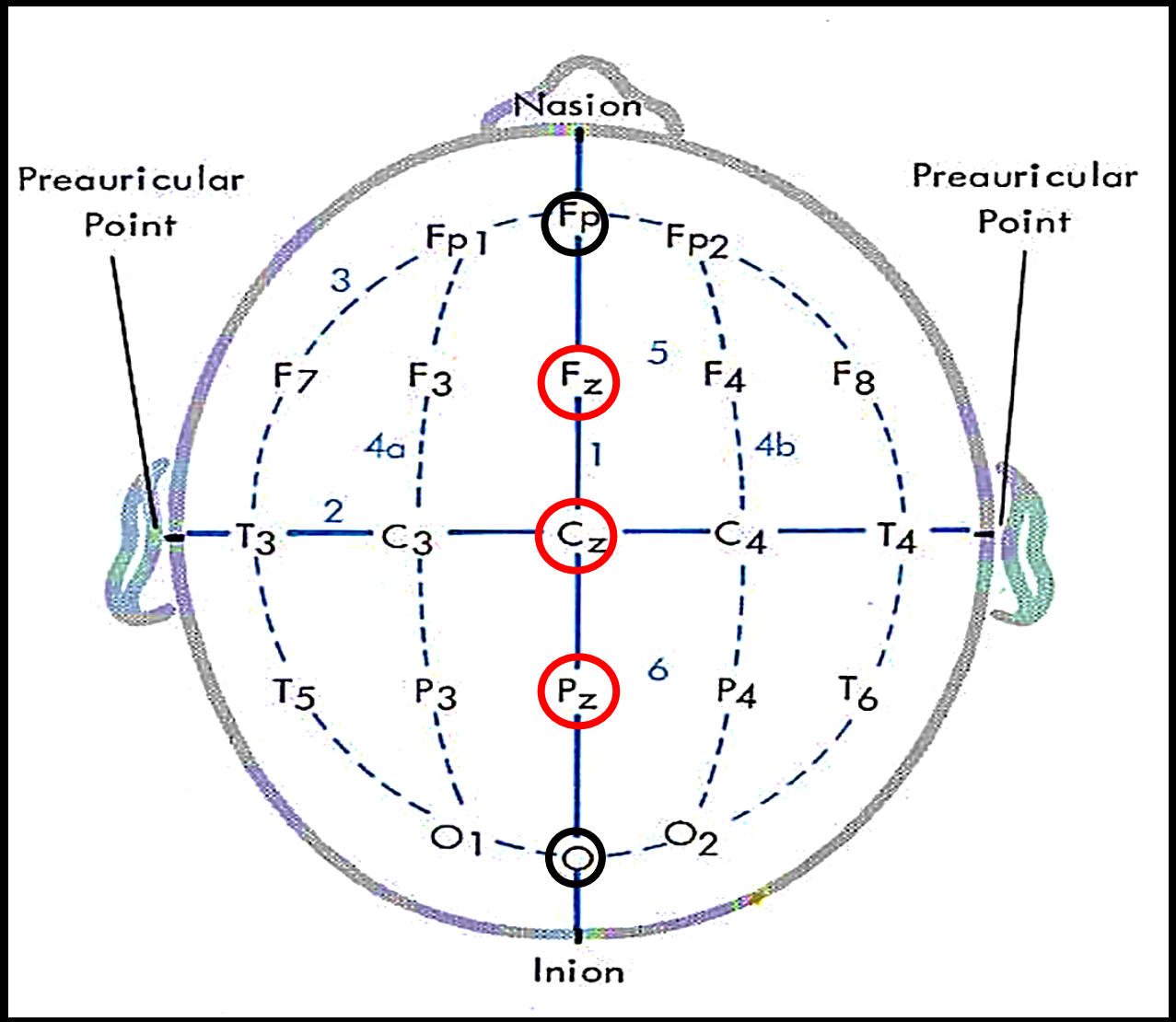


Briefly, the sequent of measurement is as follows:

- Nasion to inion measurement followed by subdivision for Fp, Fz, Cz, Pz, and O locations.
- Preauricular point to preauricular point through Cz – completing the Cz placement and locating one mark of T3, C3, C4 and T4
- Circumference measurement through O, Fp, T3 and T4 followed by the division of this total distance into 10 equal segments to locate the vertical mark for Fp1, F7, T3, T5, O1 and Fp2, F8, T4, T6 and O2 completing T3 and T4. Extend the O, Fp, T3 and T4 horizontal marks complete the other positions.

Nasion to inion measurement followed by subdivision for Fp, Fz, Cz, Pz, and O locations.





Preauricular point to preauricular point through Cz – completing the Cz placement and locating one mark of T3, C3, C4 and T4

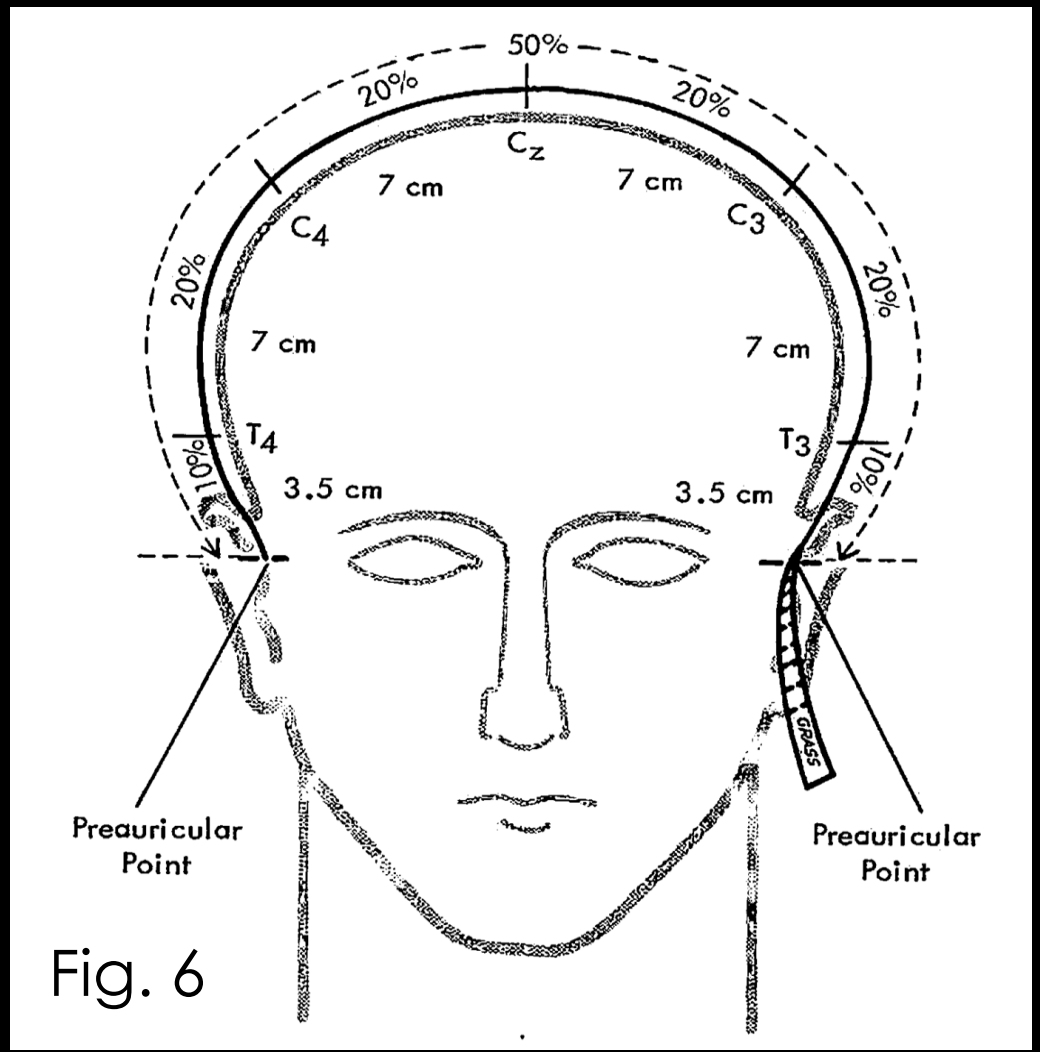
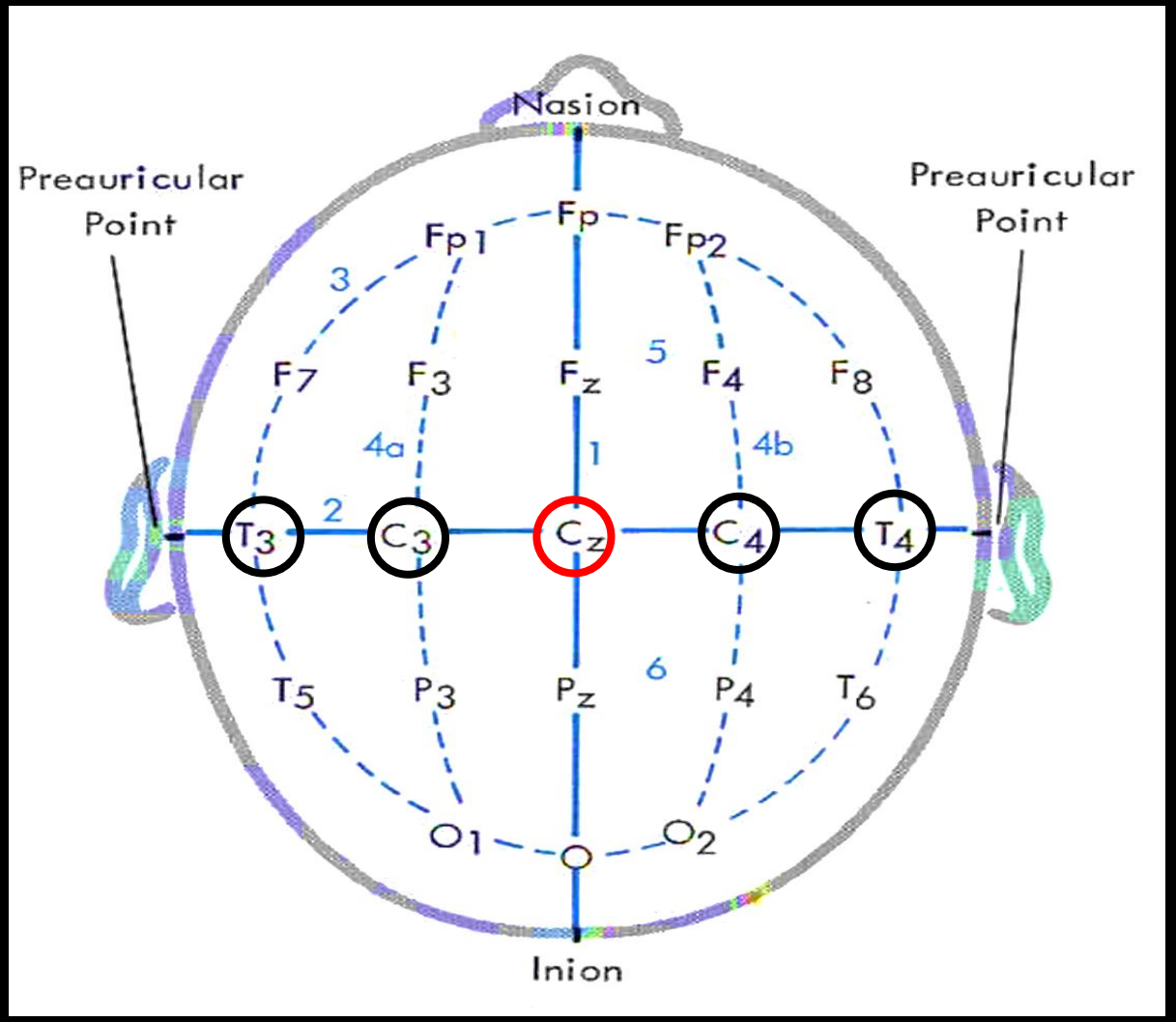


Fig. 6



Circumference measurement through Fp, O, T3 and T4 followed by the division of this total distance into 10 equal segments to locate the vertical mark for Fp1, F7, T3, T5, O1 and Fp2, F8, T4, T6 and O2 completing T3 and T4. Extend the O, Fp, T3 and T4 horizontal marks complete the other positions.

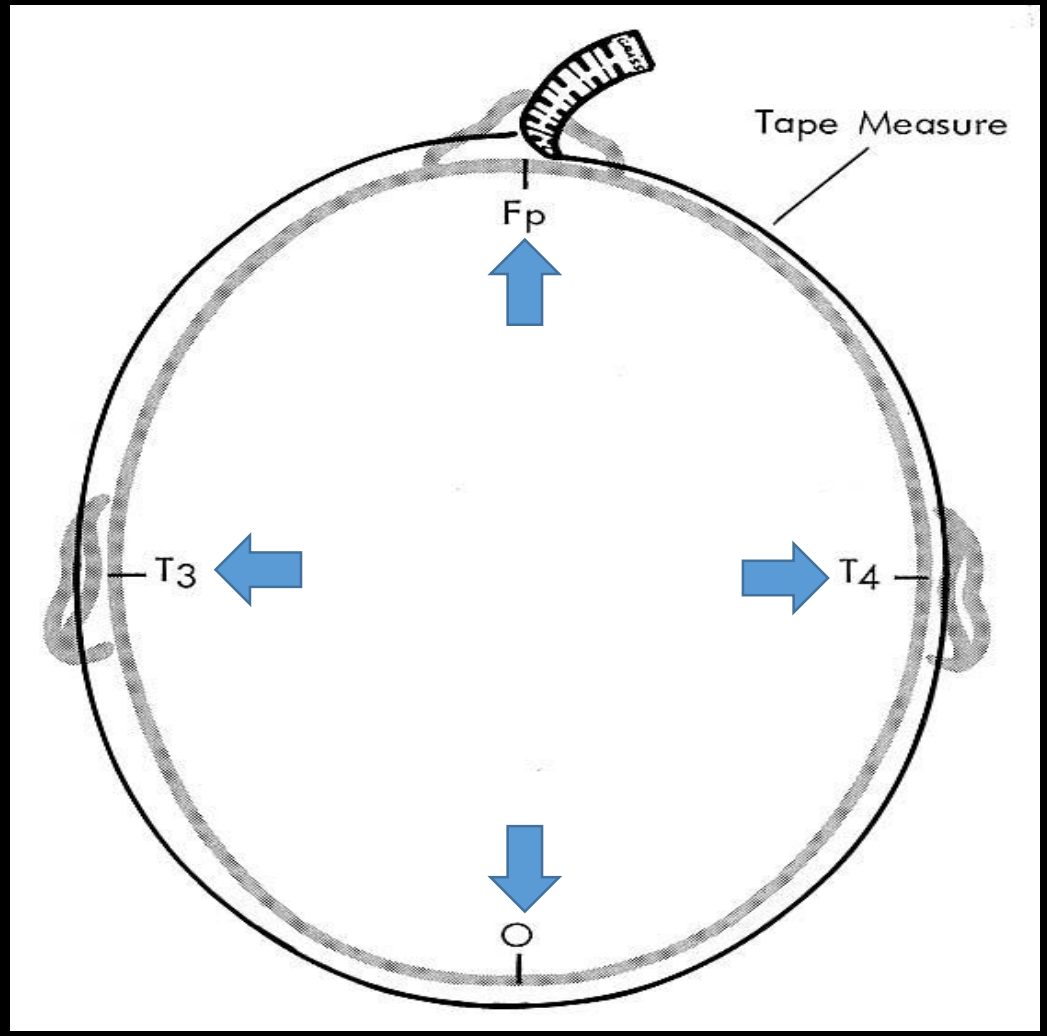
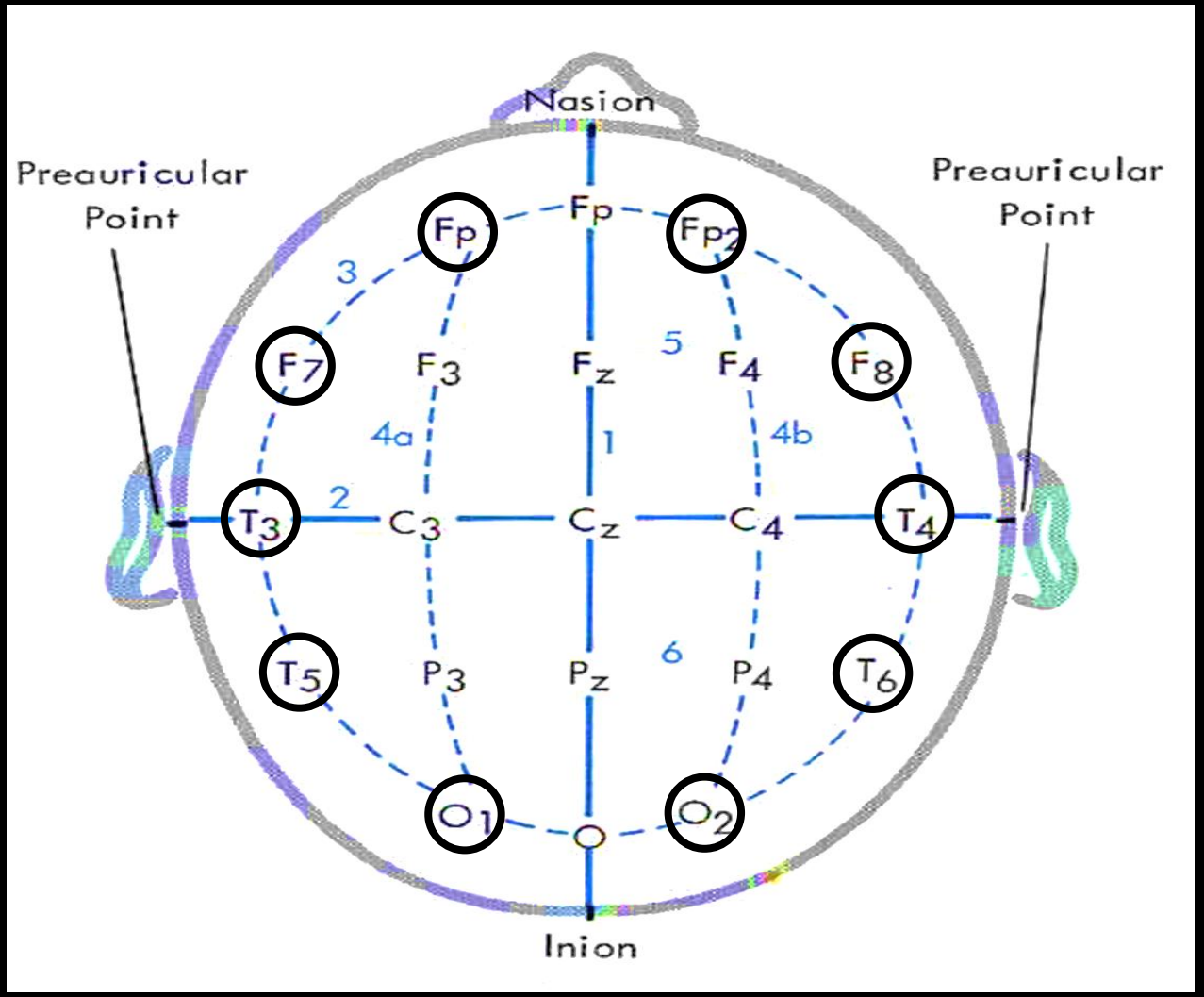


Fig. 7


Nasion
Preauricular Point
Preauricular Point
Fp1
Fp
Fp2
3
5
F7
F3
Fz
F4
F8
4a
1
4b
2
T3
C3
Cz
C4
T4
6
T5
P3
Pz
P4
T6
O1
O
O2
Inion

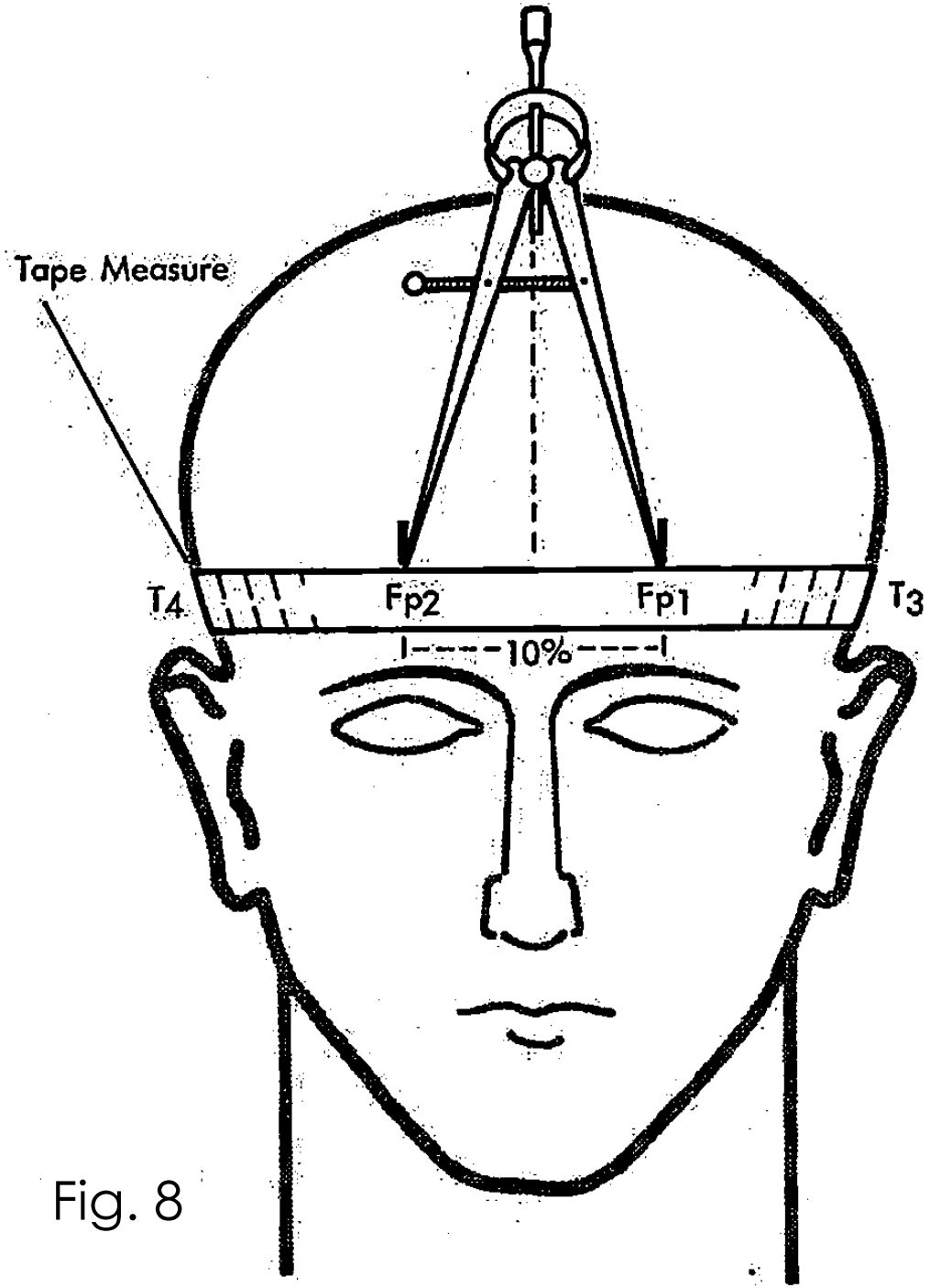

Tape Measure
T4
Fp2
Fp1
T3
10%

Fig. 8

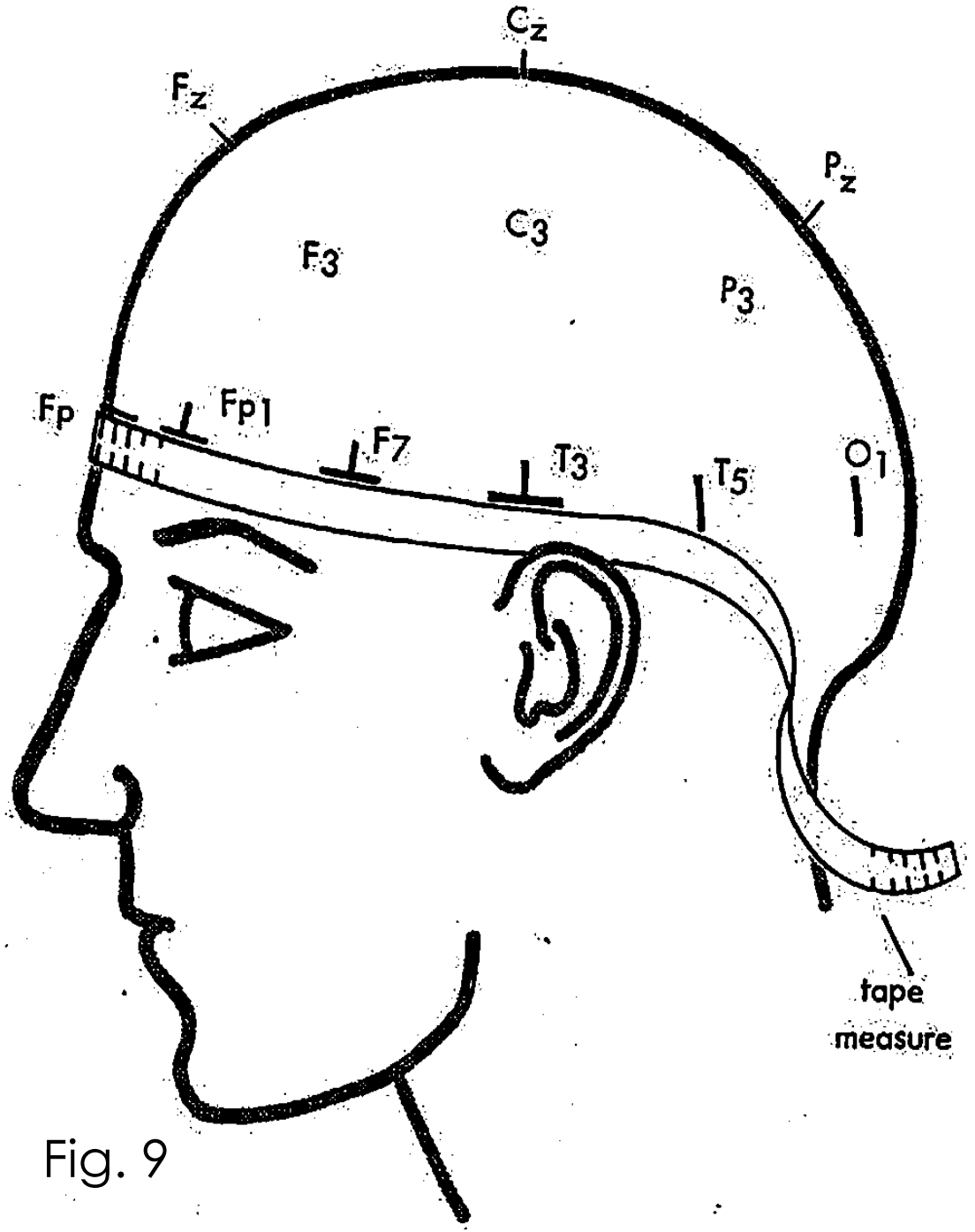

Cz
Fz
Pz
C3
F3
P3
Fp
Fp1
F7
T3
T5
O1
tape
measure

Fig. 9

Fp1 to O1 measurement through C3 on the left side of the head establishes the anterior-posterior marks of F3, C3, P3 and complete the C3 location.

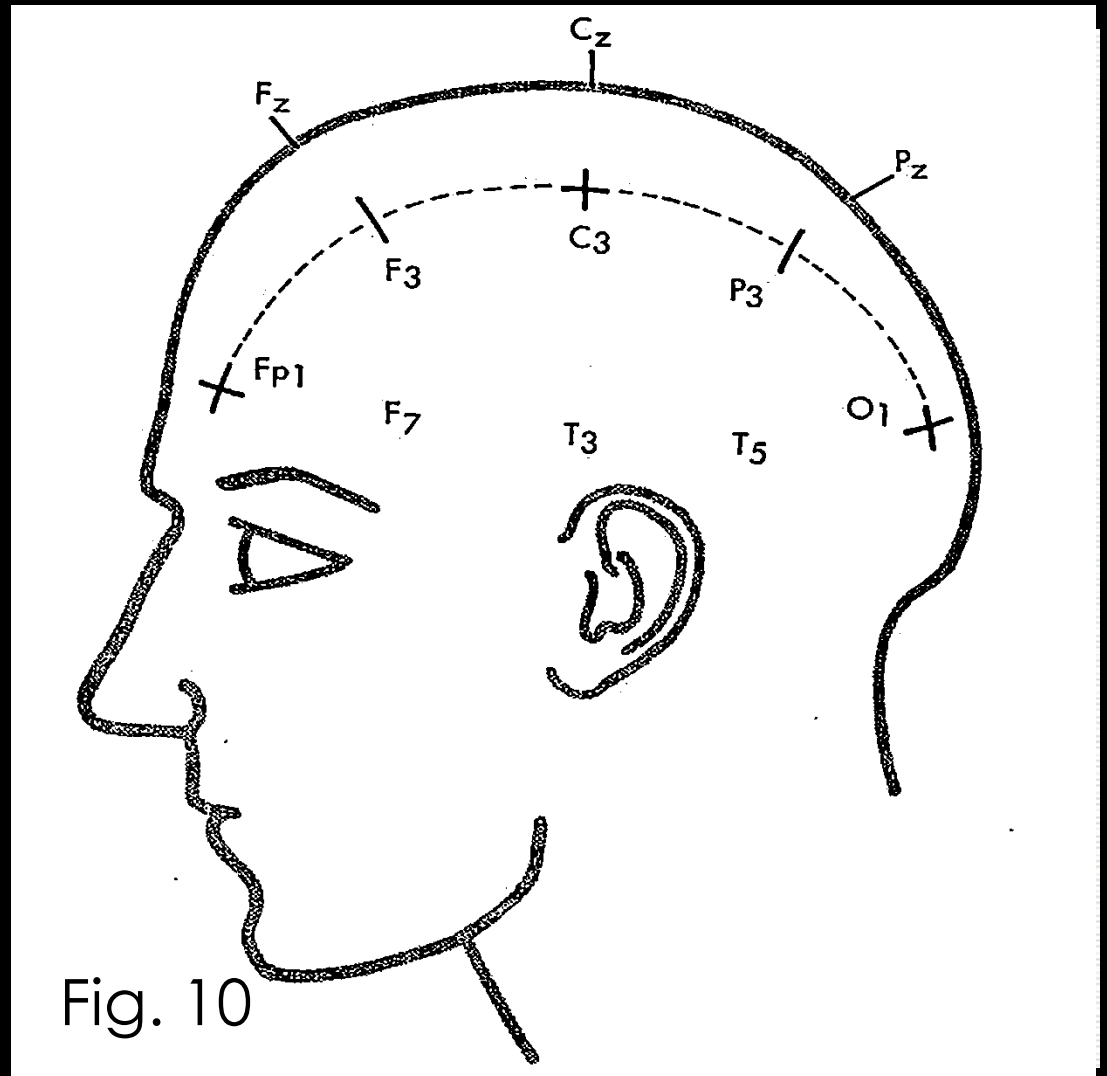
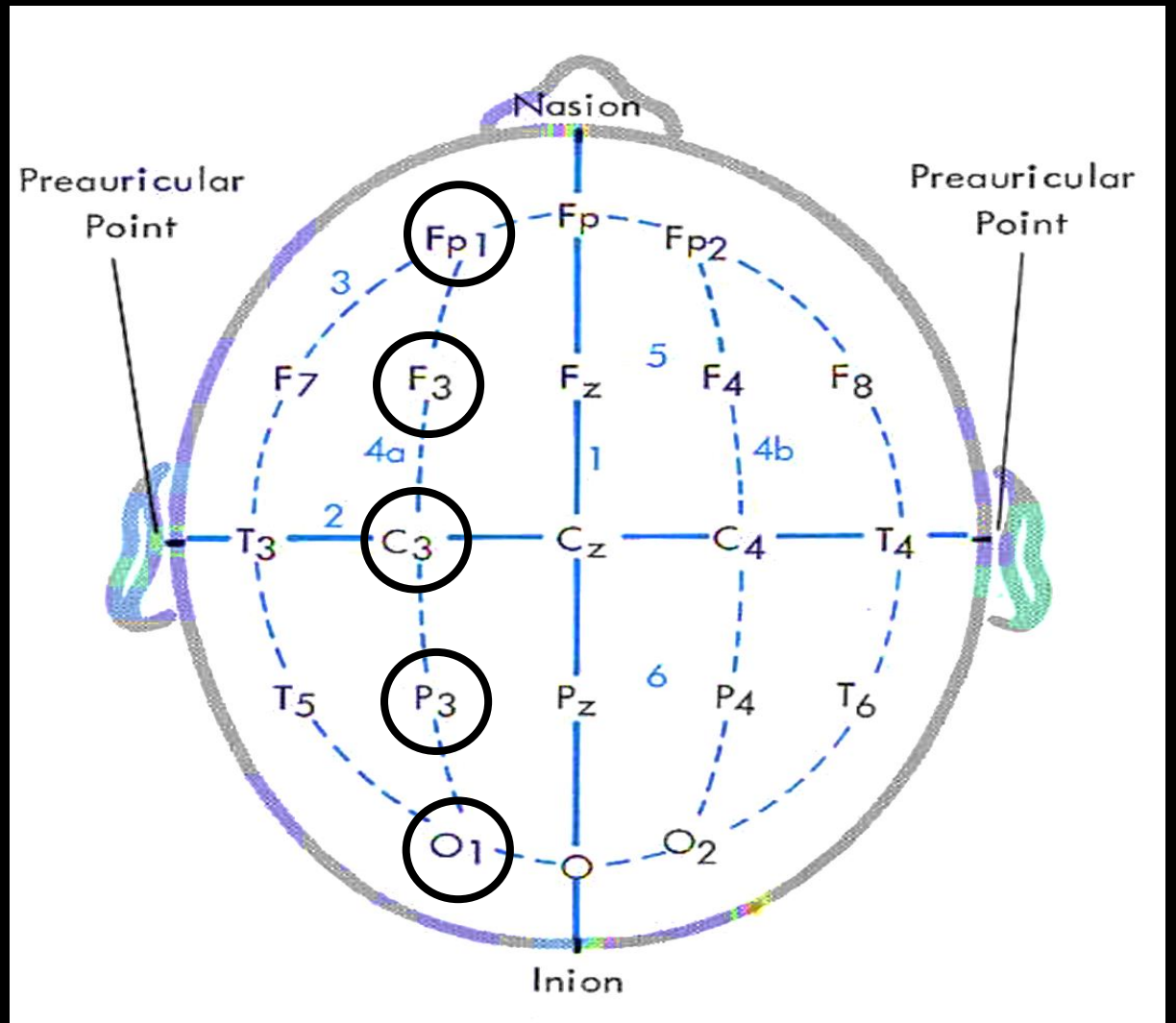
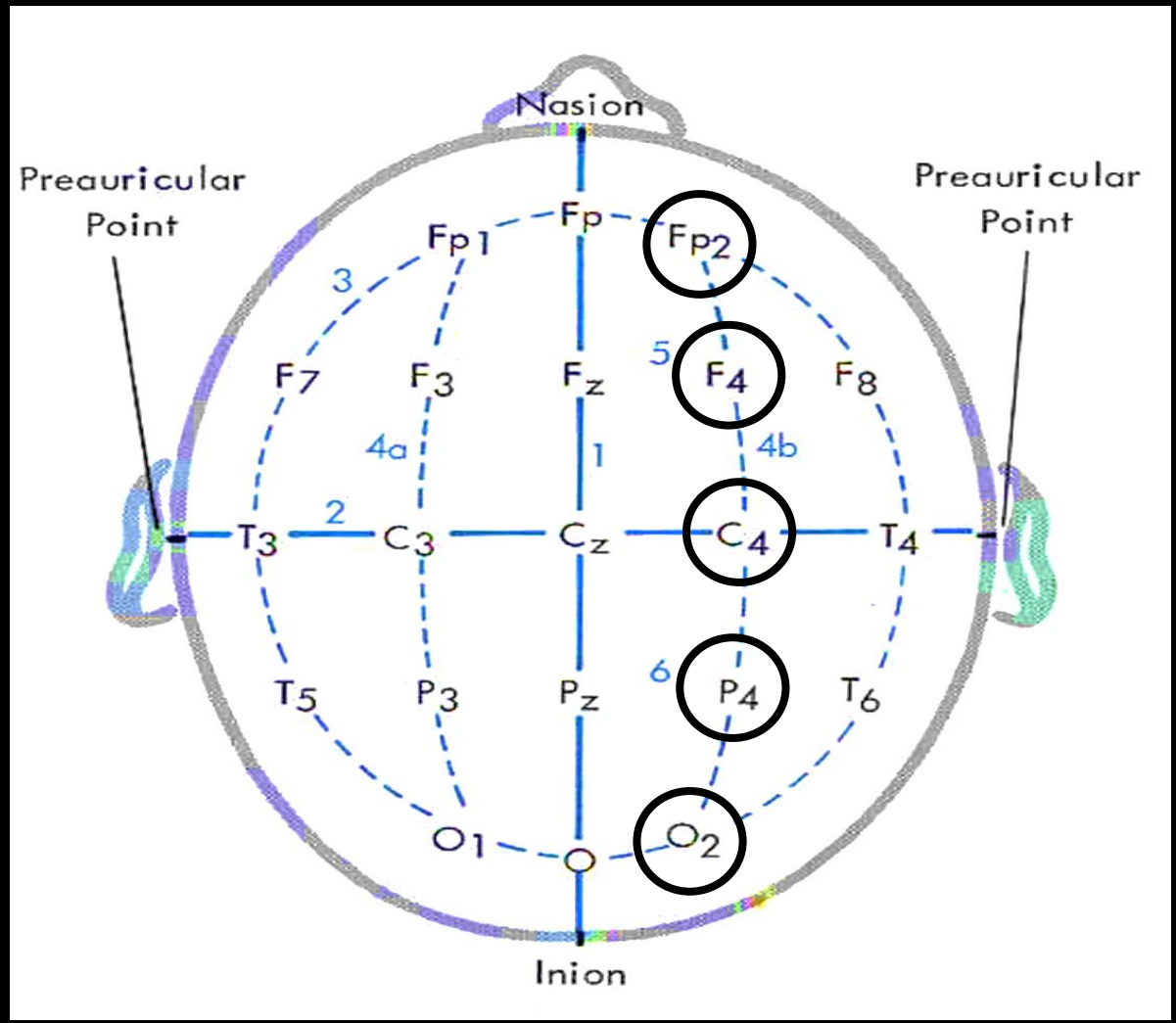


Fig. 10



Repeat for the right side of the head.



F7 to F8 measurement through Fz to complete electrode positions Fz, F3 and F4.

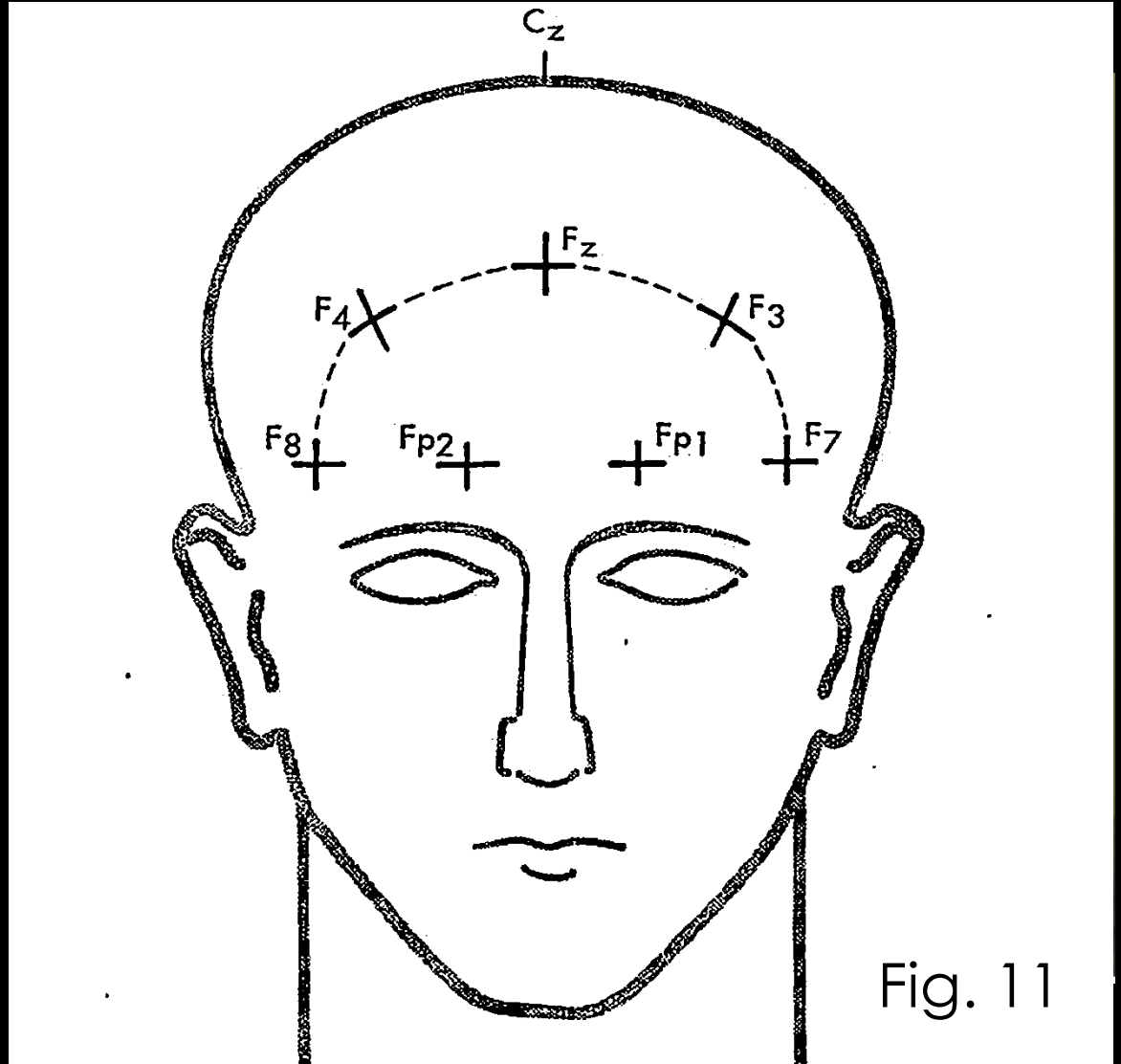
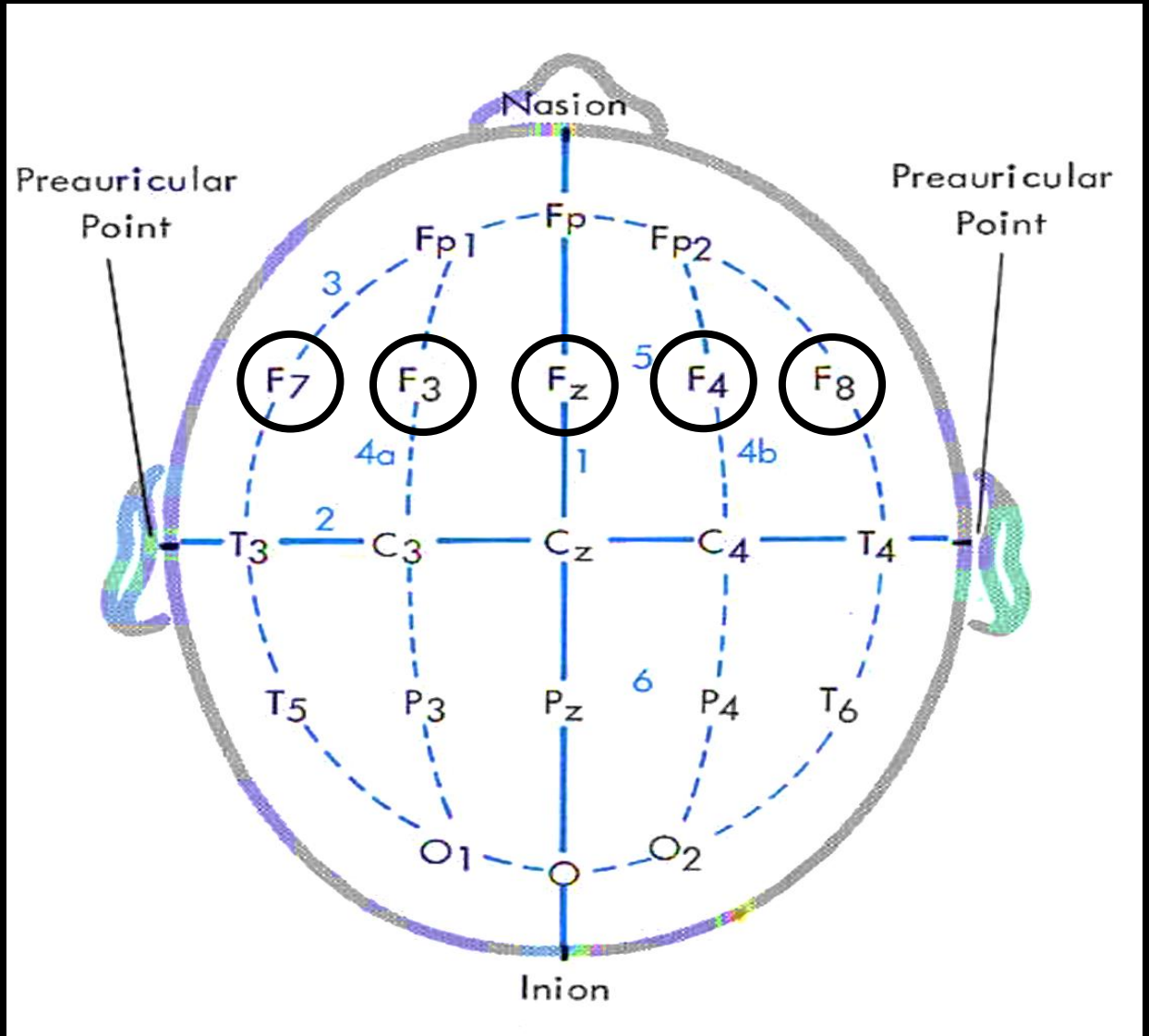


Fig. 11



T5 to T6 measurement through Pz to complete electrode positions Pz, P3 and P4.

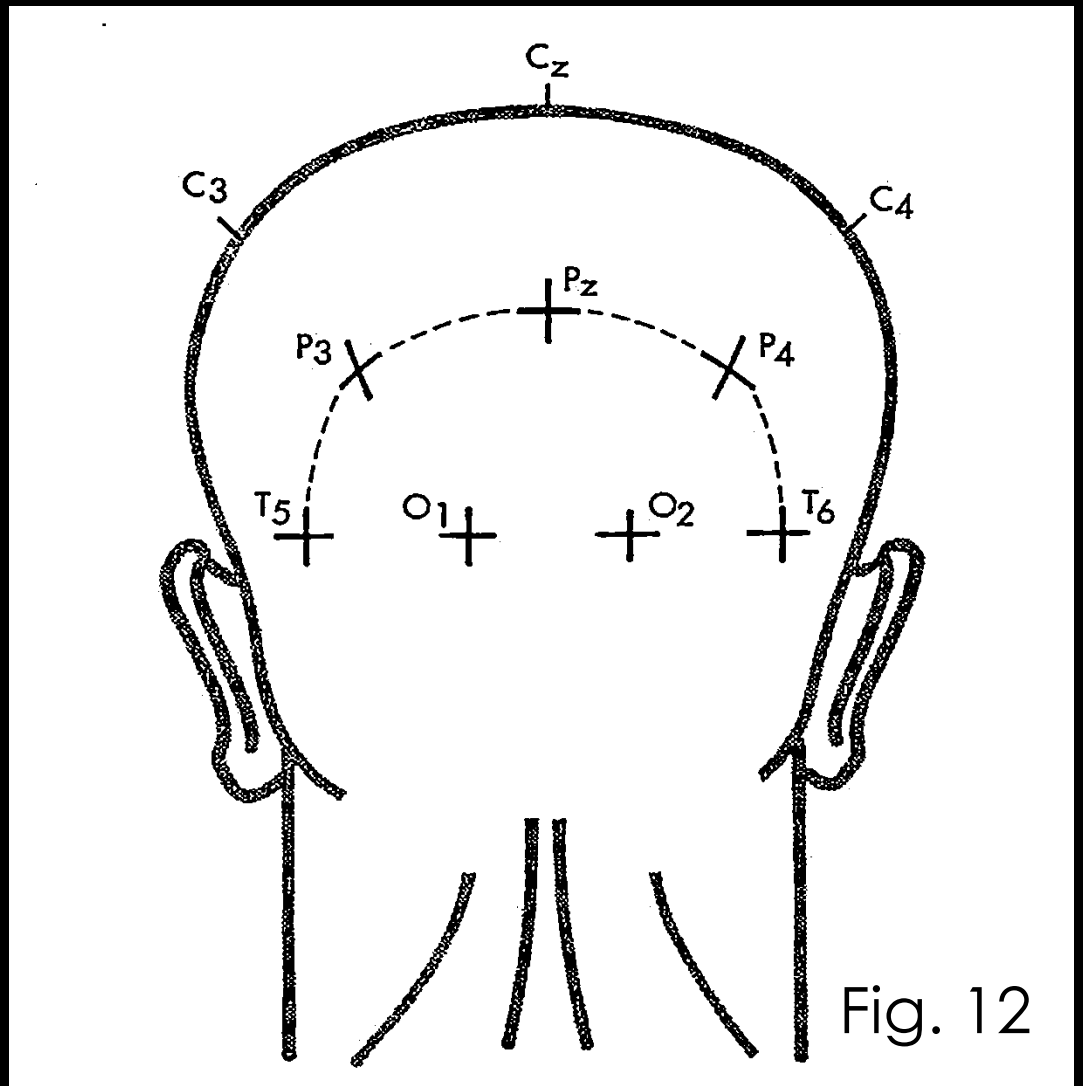
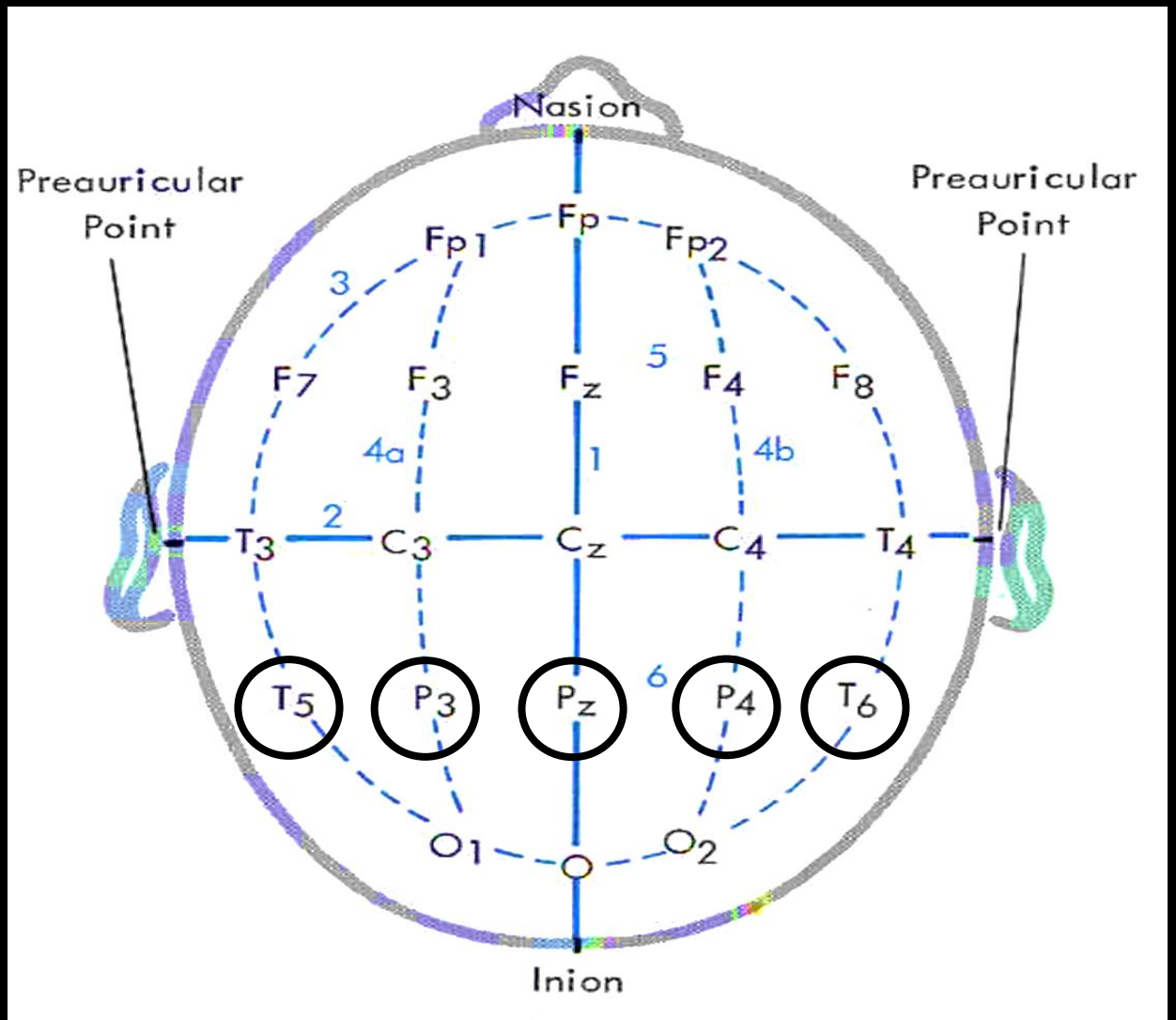
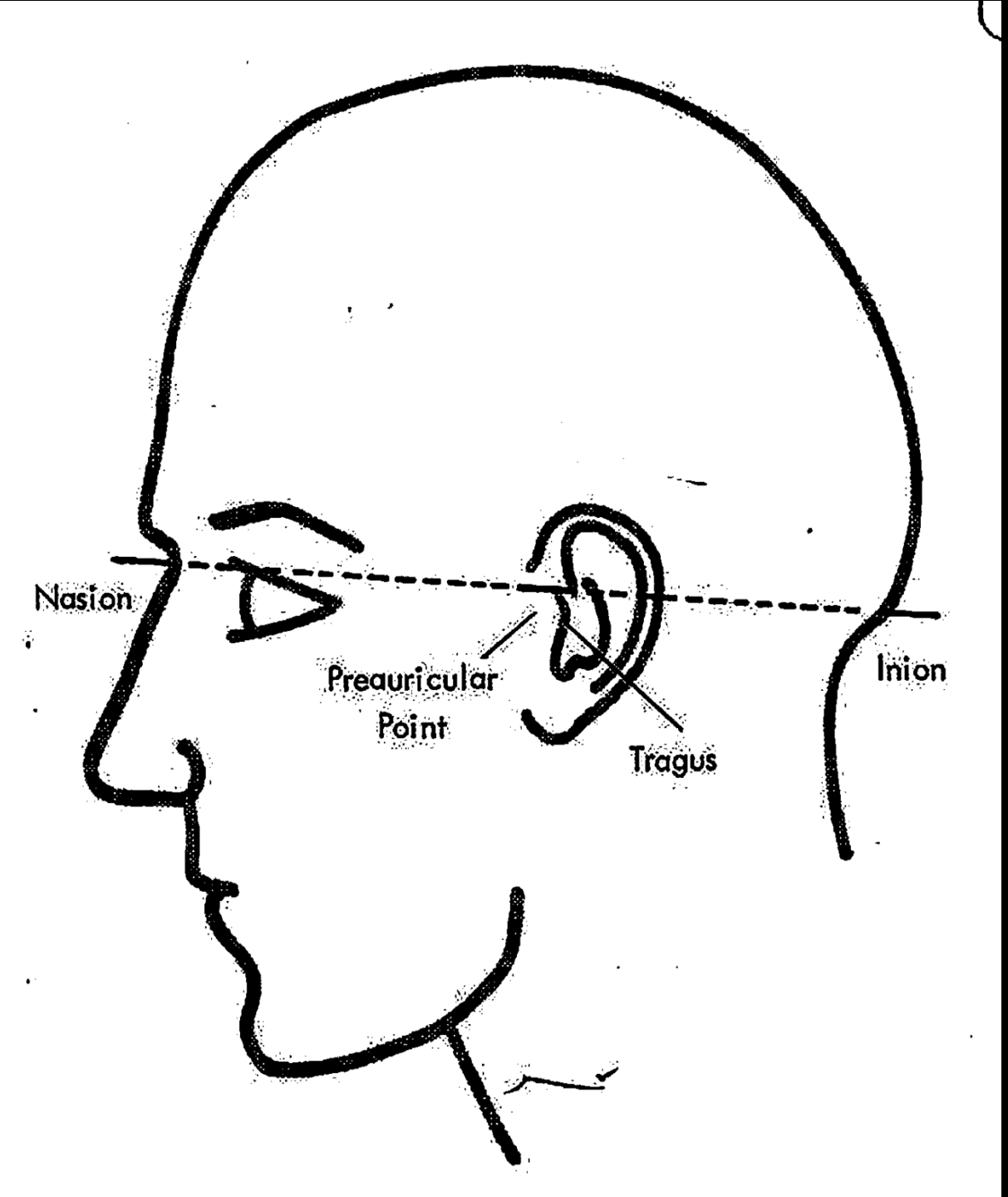


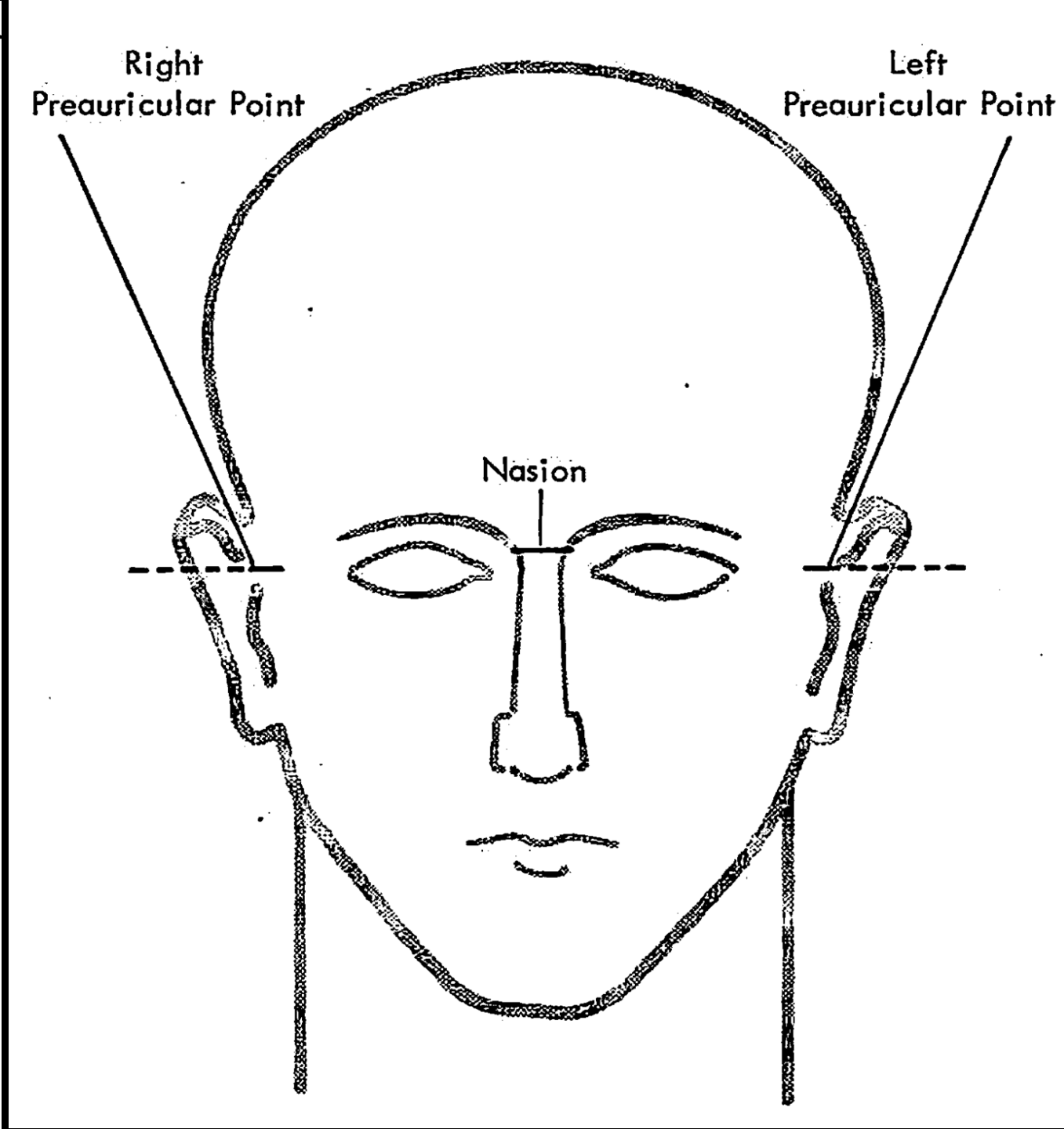
Fig. 12

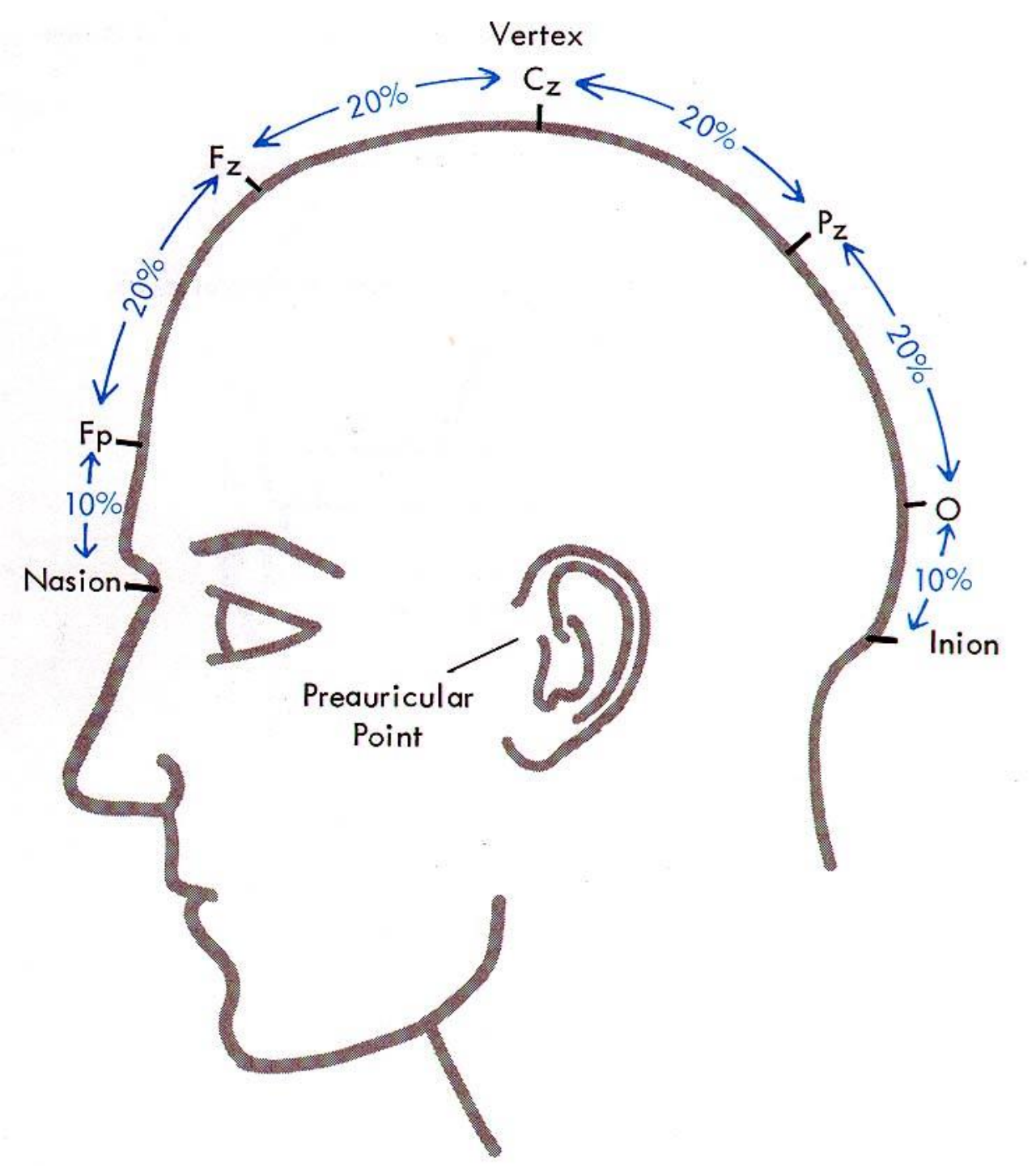


The10-20 Measuring Procedure

- Locate the skull landmarks: inion, nasion and pre-auricular points. See FIG 3A and FIG 3B.
- Measure the distance along the midline between the nasion and the inion with the centimeter tape. Refer to FIG 10, Remember the arbitrary value for this example is 30 cm.
  - Determine what half (50%) of this distance is, i.e. 15 cm. One half the distance between the nasion and the inion, place the a-p mark for Cz. See FIG 11.


Nasion
Preauricular
Point
Tragus
Inion


Right
Preauricular Point
Left
Preauricular Point
Nasion


Vertex
Cz
20%
20%
Fz
Pz
20%
20%
Fp
10%
Nasion
O
10%
Inion
Preauricular
Point

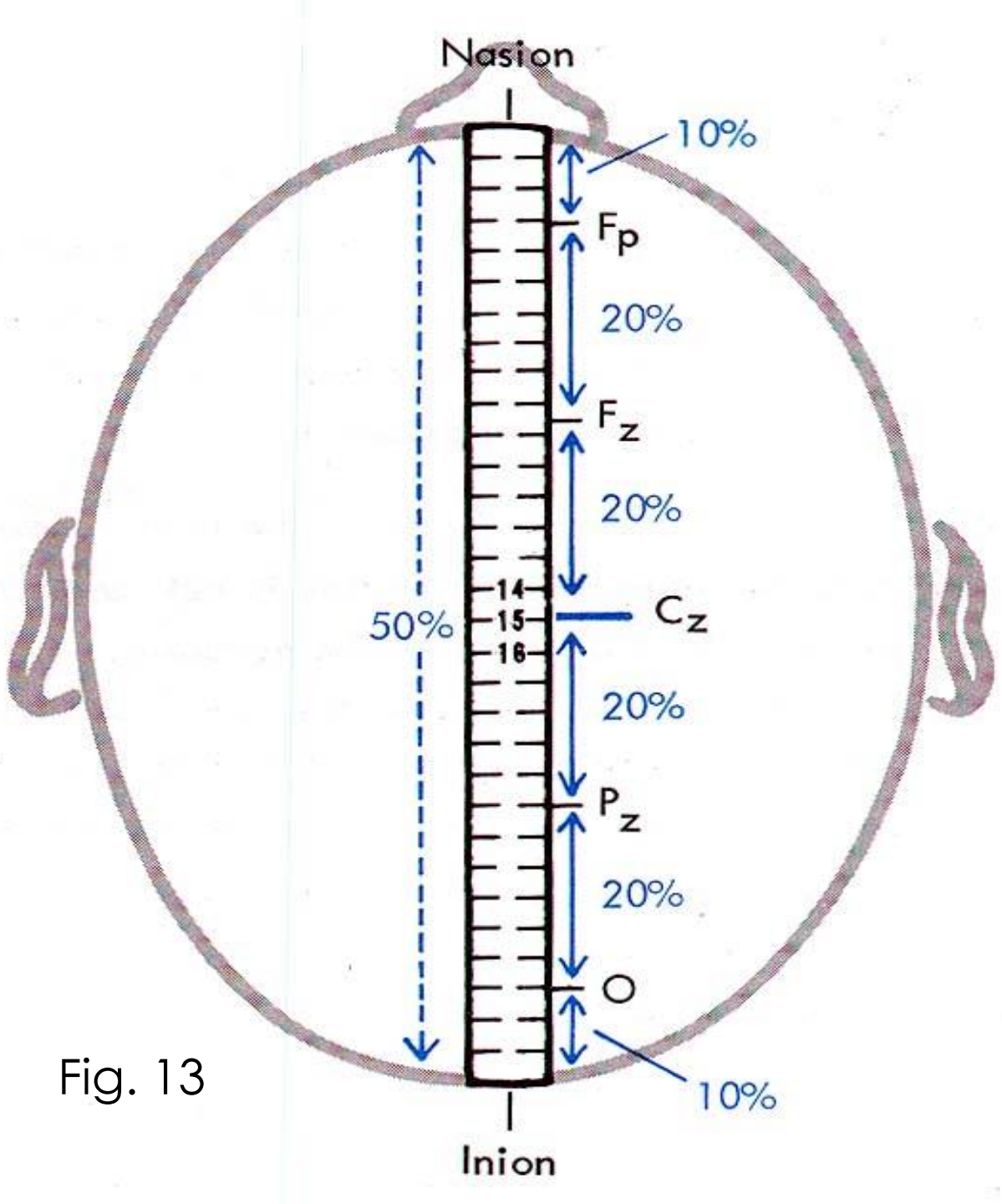

Nasion
10%
Fp
20%
Fz
20%
14
15
16
50%
Cz
20%
Pz
20%
O
10%
Inion

Fig. 13

FT_9 and FT_{10} Measurements

- Measure from auditory canal to the outer canthus of the eye.
- Make a vertical mark at one third the distance.
- Make a mark along the top edge of the tape.
- Measure up one centimeter from the last mark and intersect with the vertical mark.

FT_9 and FT_{10} Measurements

10-20 System of Electrode Placement and Add on FT_9, FT_{10}

FT_9 and FT_{10} electrodes are placed, them ideal for recording seizures with long-term monitoring.

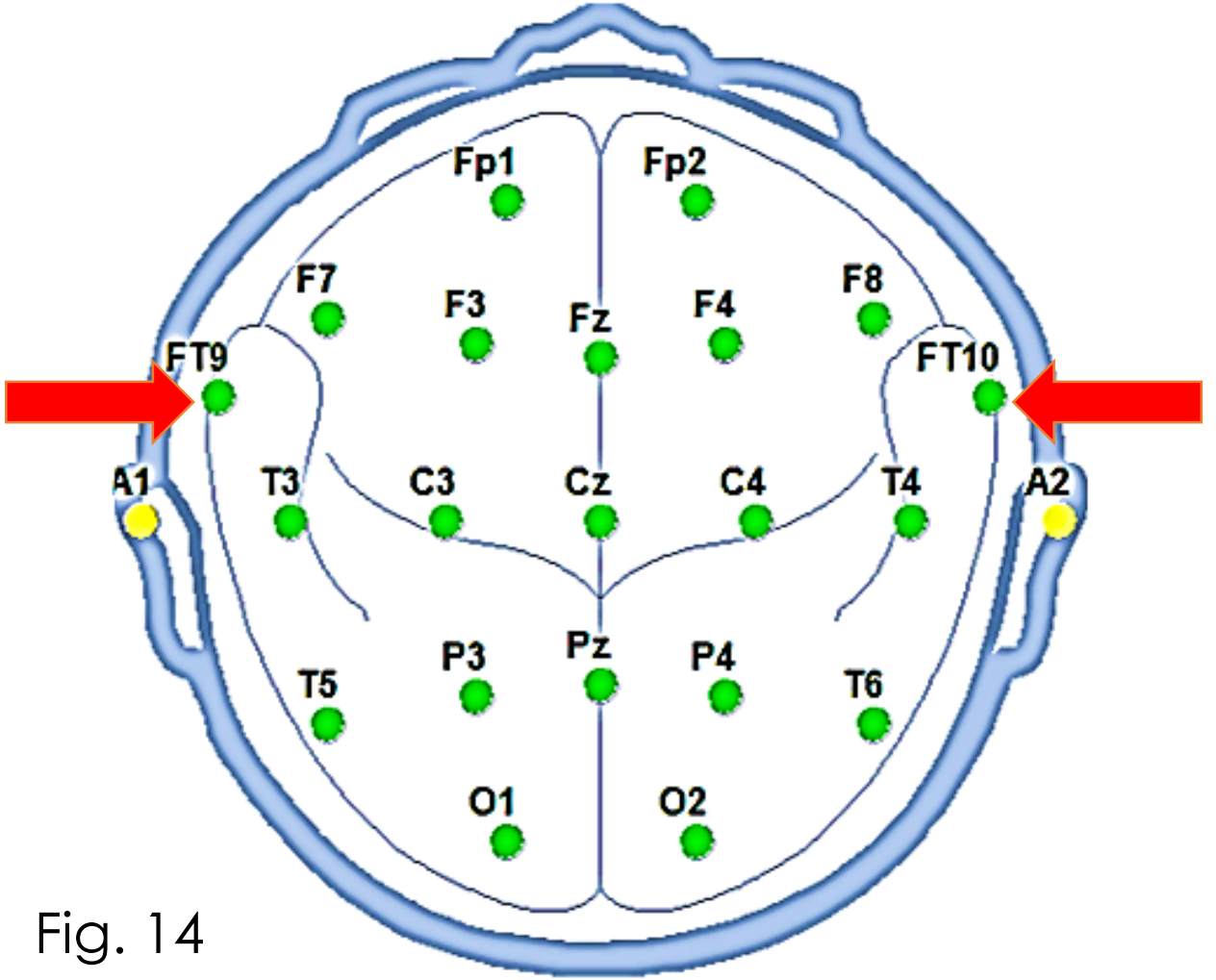


Fig. 14

ANTERIO TEMPORAL ELECTRODES

Schematic diagram locating electrodes T_1 & T_2.

A = External auditory meatus,
B = outer cantus;
C = 1/3 distance, A to B,
T2 = right anterior temporal electrode

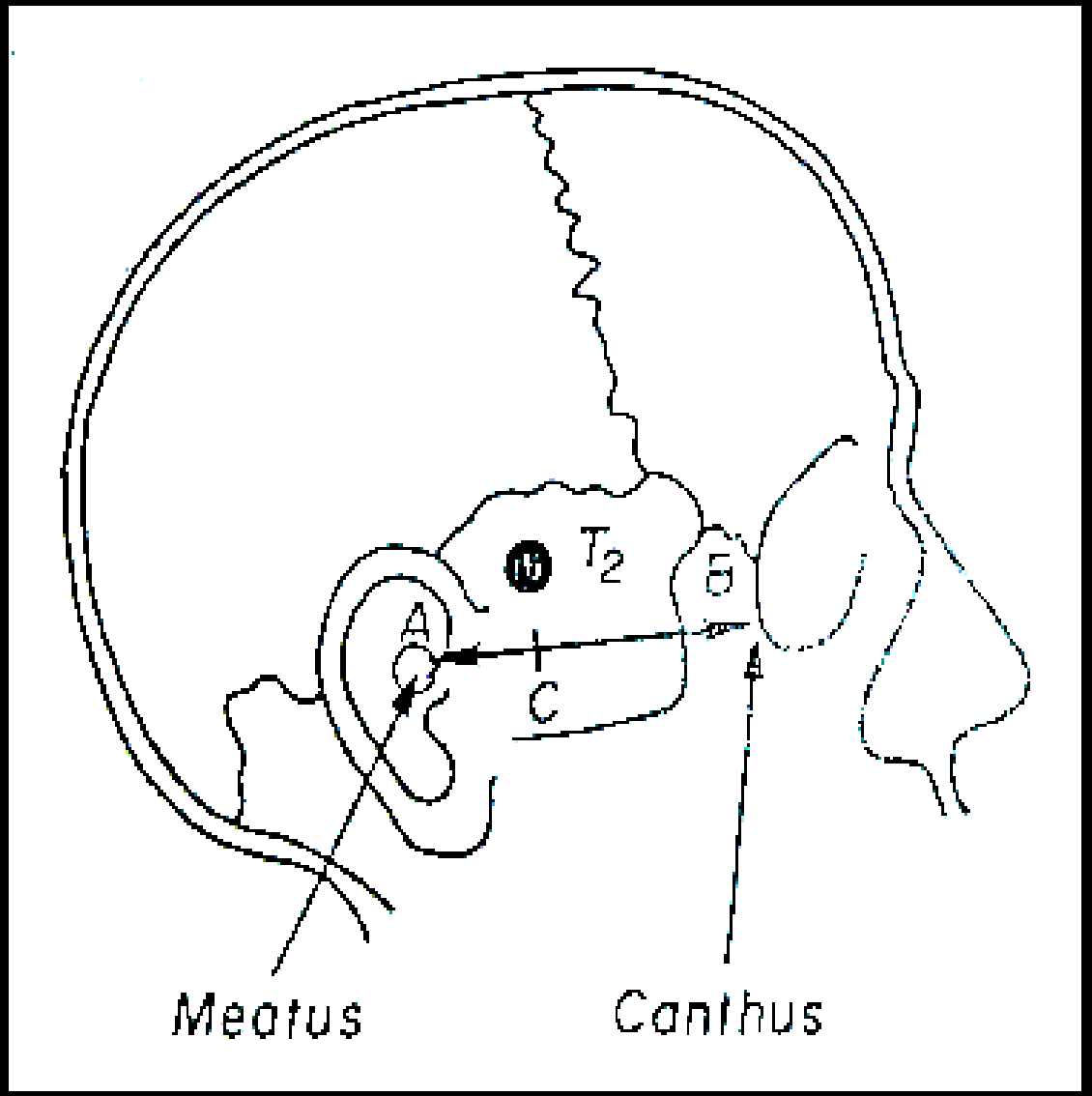


Fig. 15

Have you noticed that

FRONTAL, CENTRAL AND PARIETAL ELECTRODES ARE HALFWAY BETWEEN ADJACENT ELECTRODES

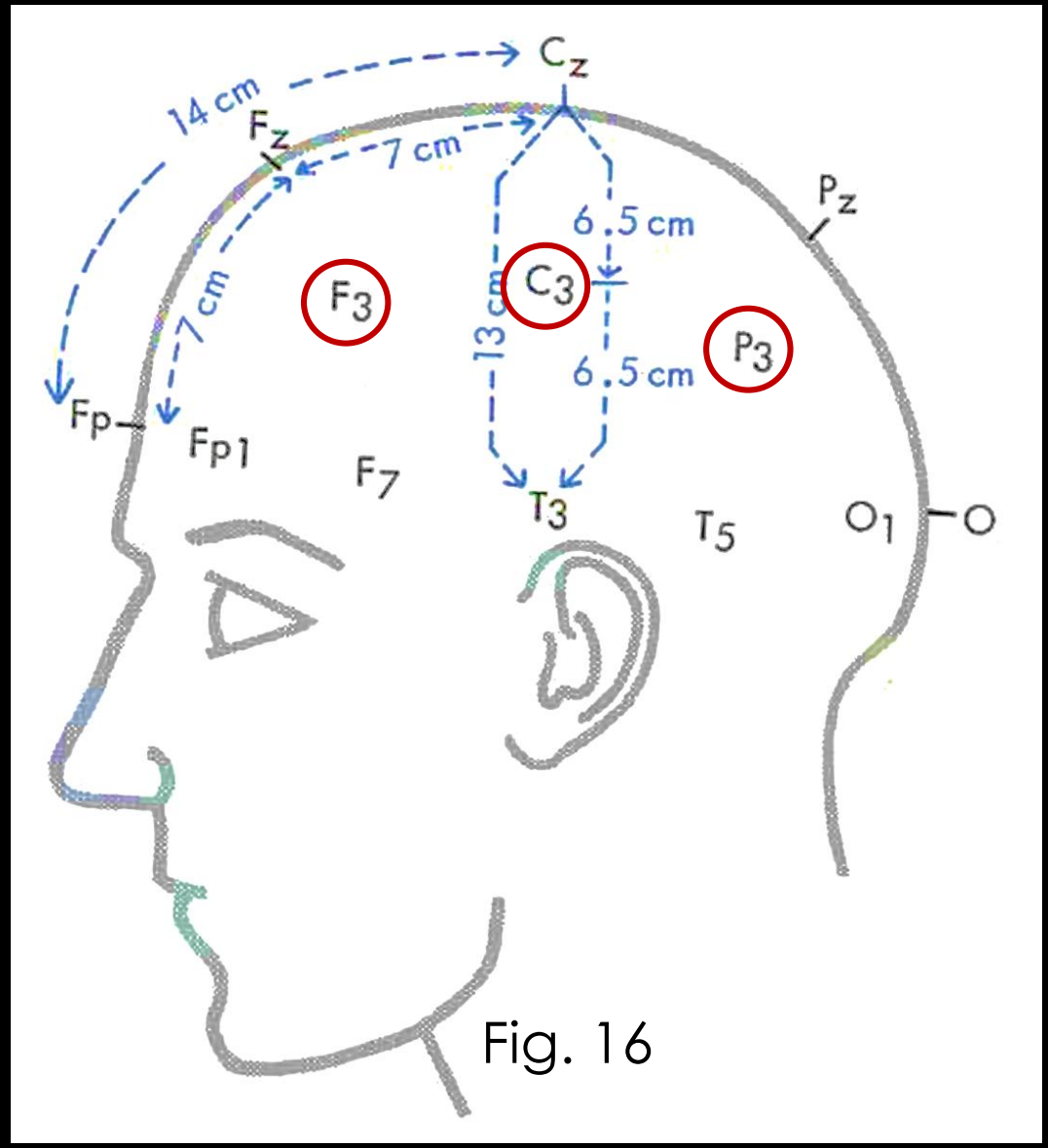


Fig. 16

QUICK VERIFICATION OF THE 10-20 SYSTEM MEASUREMENT

Common source of error in the 10-20 system of electrode placement

A quick verification of The 10-20 System measurement

- CORRECT ELECTRODE POSITIONS AND LANDMARKS ARE INDICATED IN BLACK.
- INACCURATE POSITION OF INION AS EVIDENCED BY UPWARD SLANT OF TAPE DURING CIRCUMFERENCE MEASUREMENT IS INDICATED IN BLUE.
- THE RESULTING INACCURATE ELECTRODE LOCATIONS ARE ALSO MARKED IN BLUE.

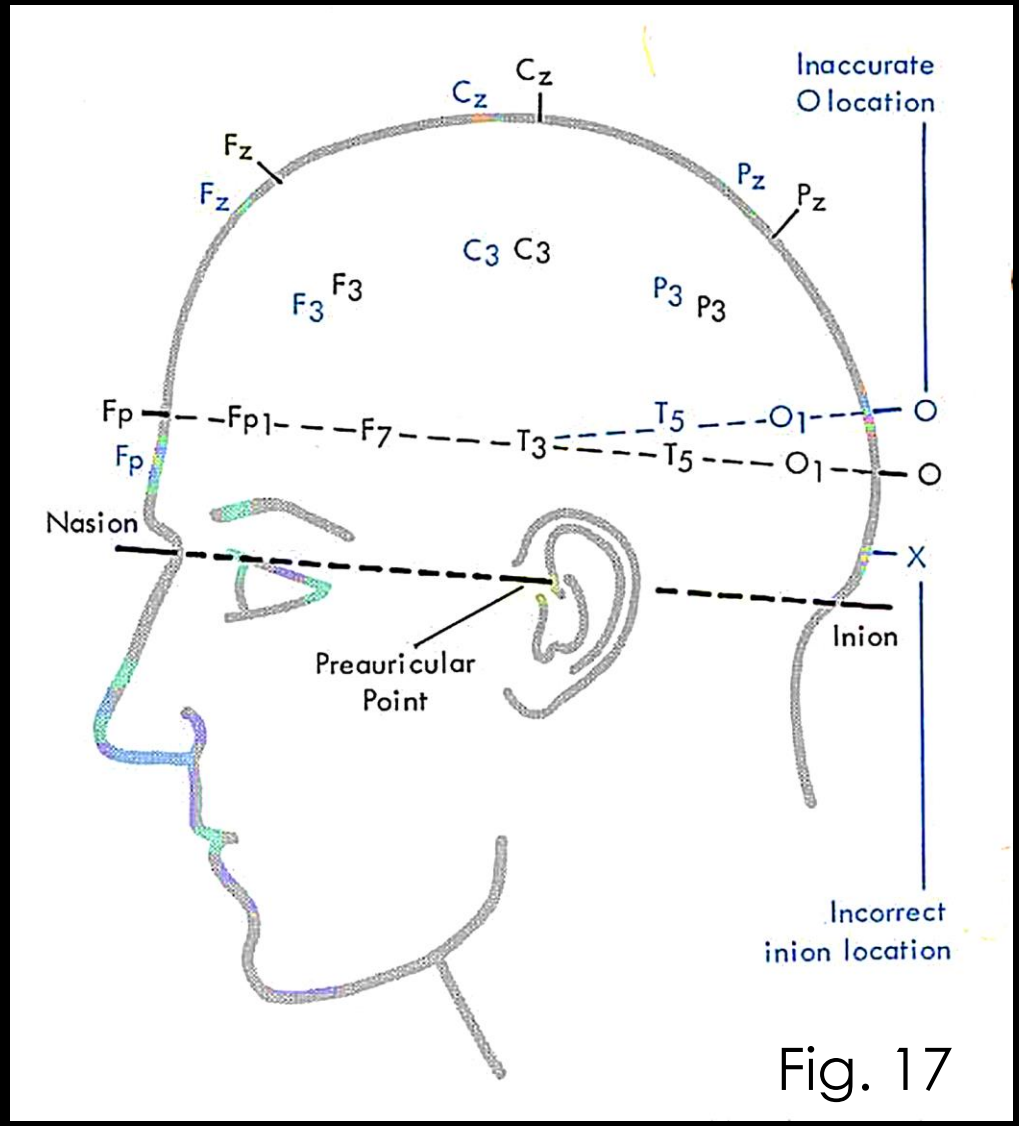


Fig. 17

- CORRECT [BLACK] AND INCORRECT [BLUE] LEVEL FOR CIRCUMFERENCE MEASUREMENT

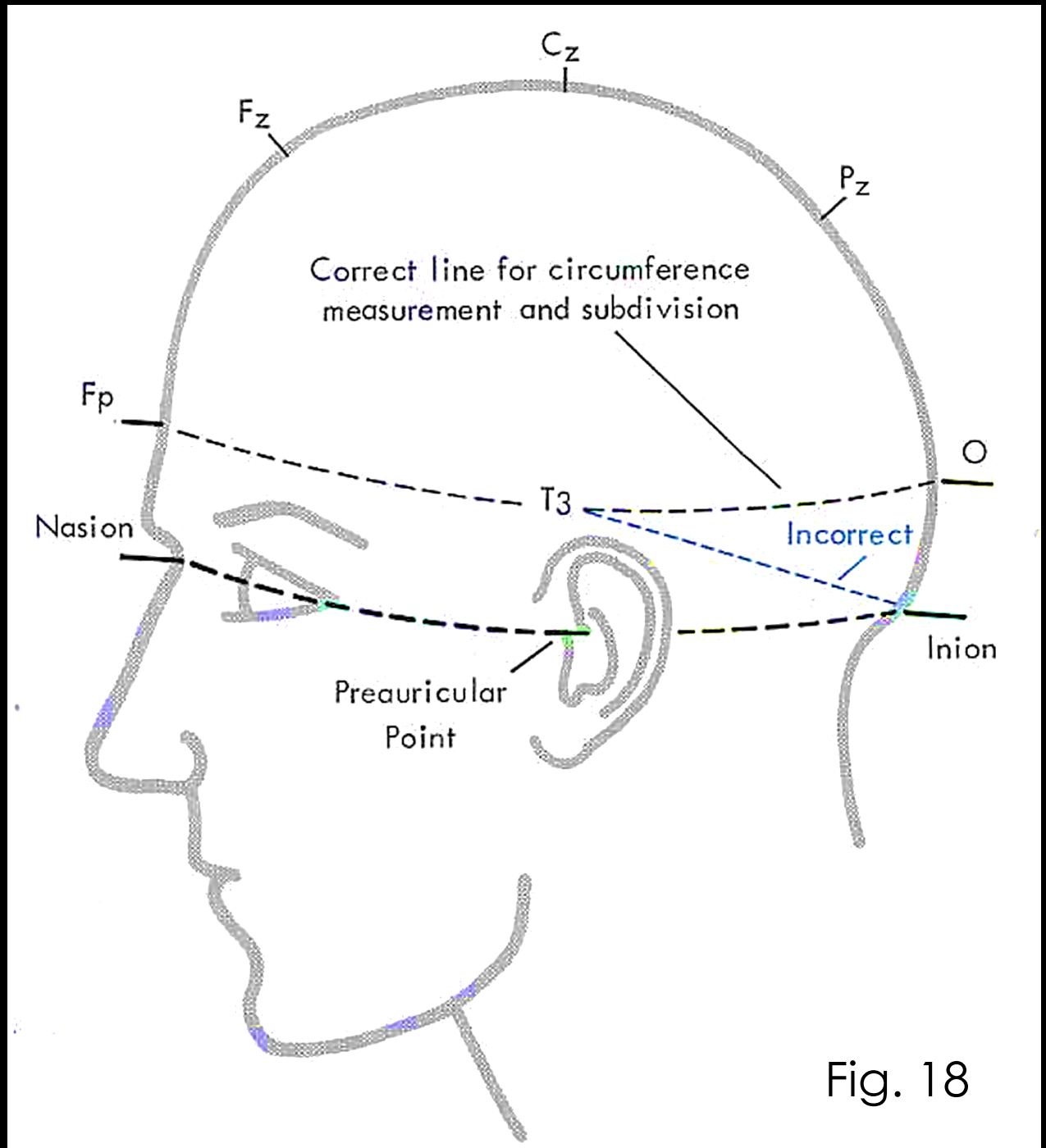


Fig. 18

- ACCULATELY LOCATED AND EQUALLY SPACED TEMPORAL CHAIN ELECTRIDES ARE INDICATED IN BLACK.
- INACCULATELY LOCATED, BUT EQUALLY SPACED, ELECTRODES ARE INDICATED IN BLUE.

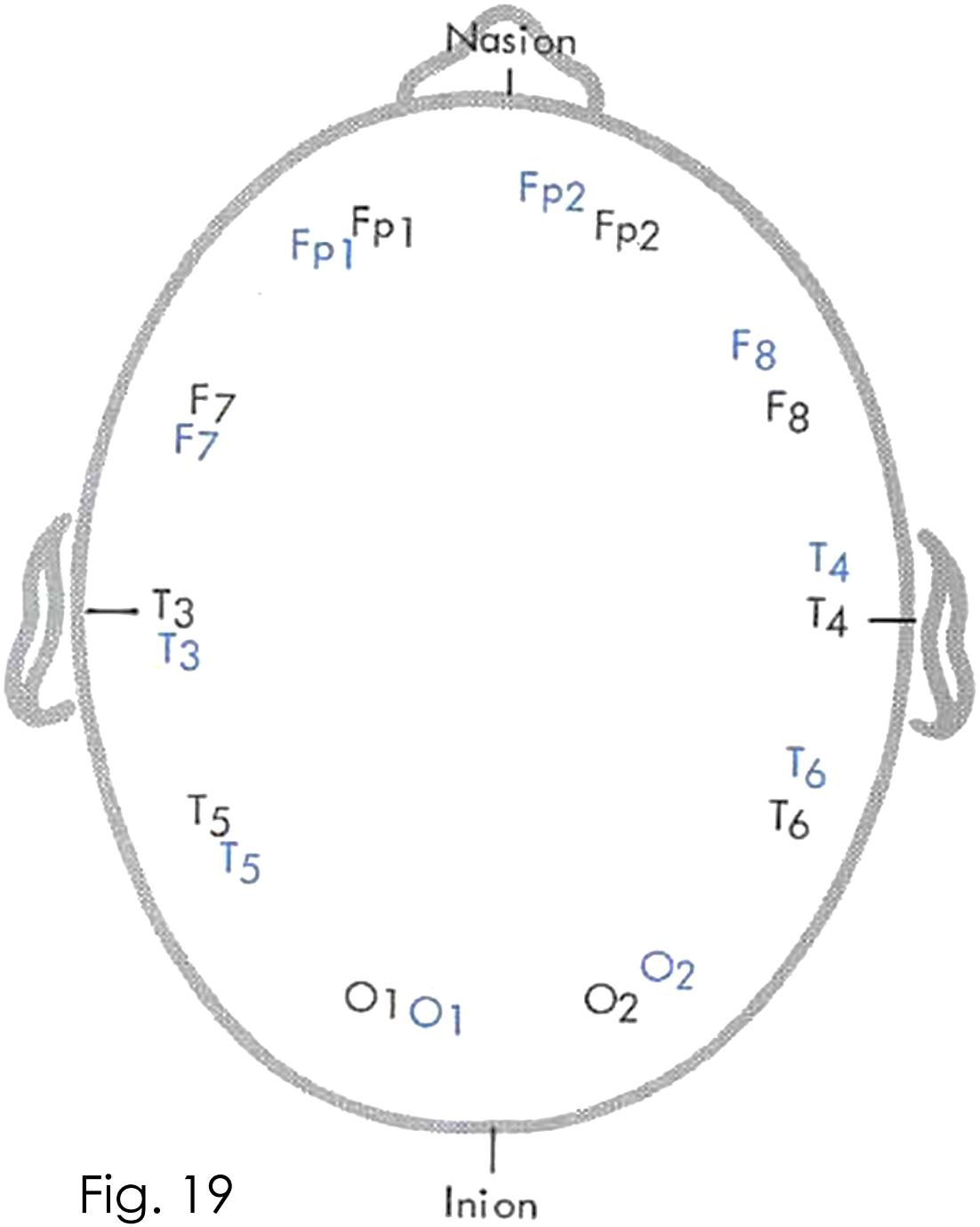


Fig. 19

Deformity

- SITING ELECTRODES IN CASES OF POSTERIOR SWELLING

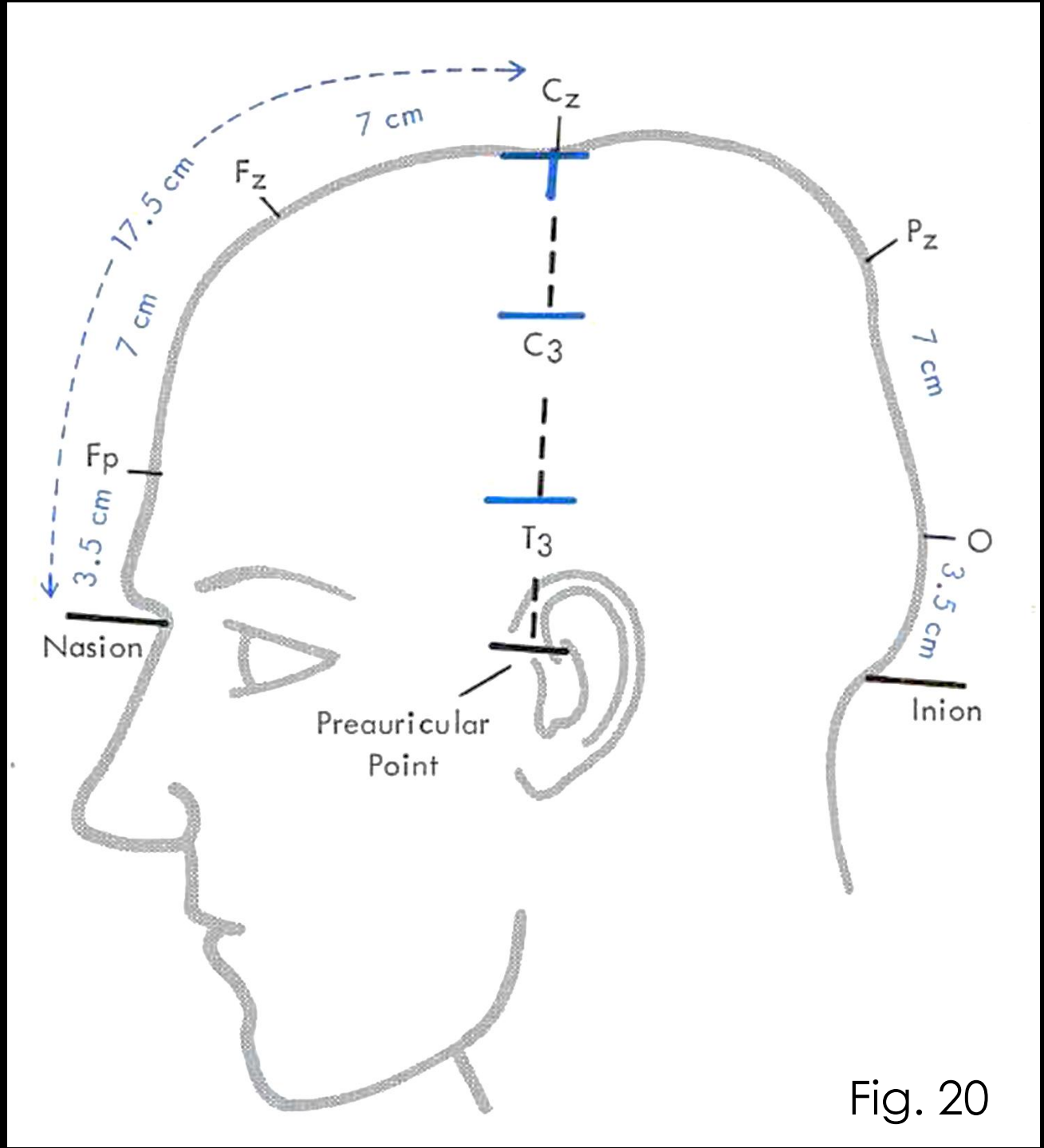


Fig. 20

- SITING ELECTRODES OVER HEAD WITH EXTENSIVE POSTERIOR SWELLING

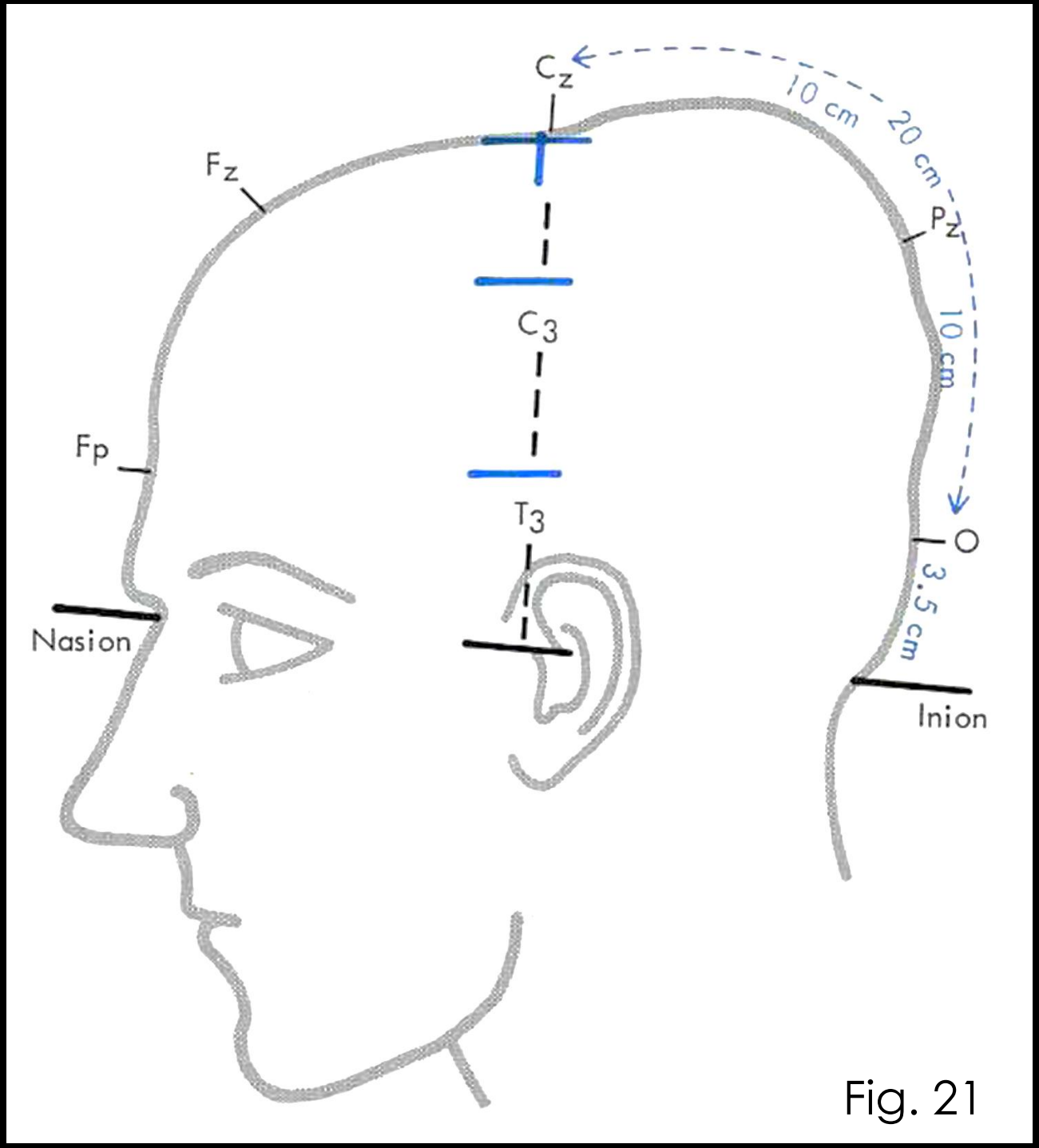


Fig. 21

- SITING ELECTRODES ON HEAD WITH SINGLE HEMISPHERE DEFORMITY

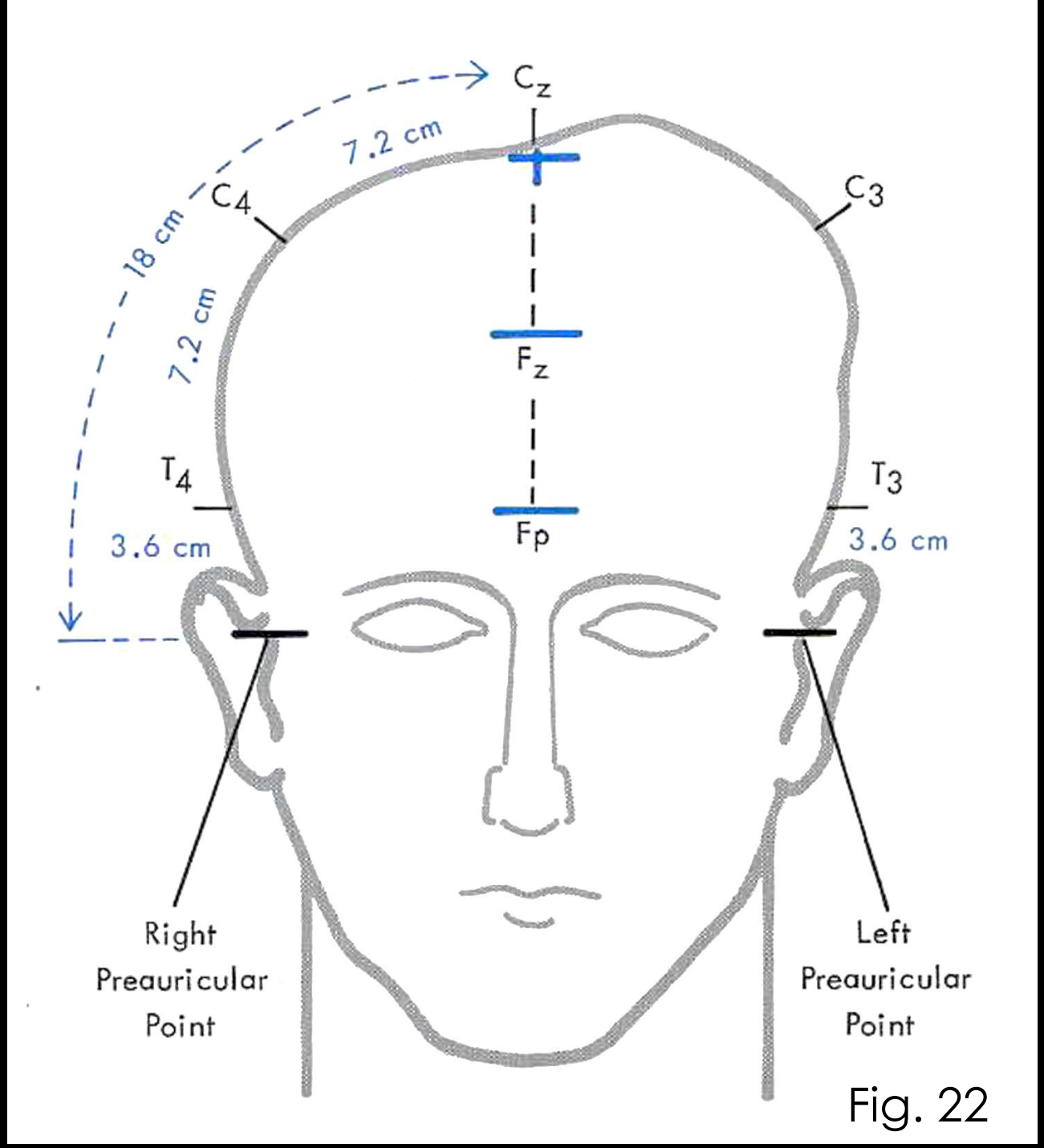


Fig. 22

SINGLE PLANE VIEW OF TOP OF HEAD SHOWING PLACEMENT OF ADDITIONAL ELECTRODES IN BLUE

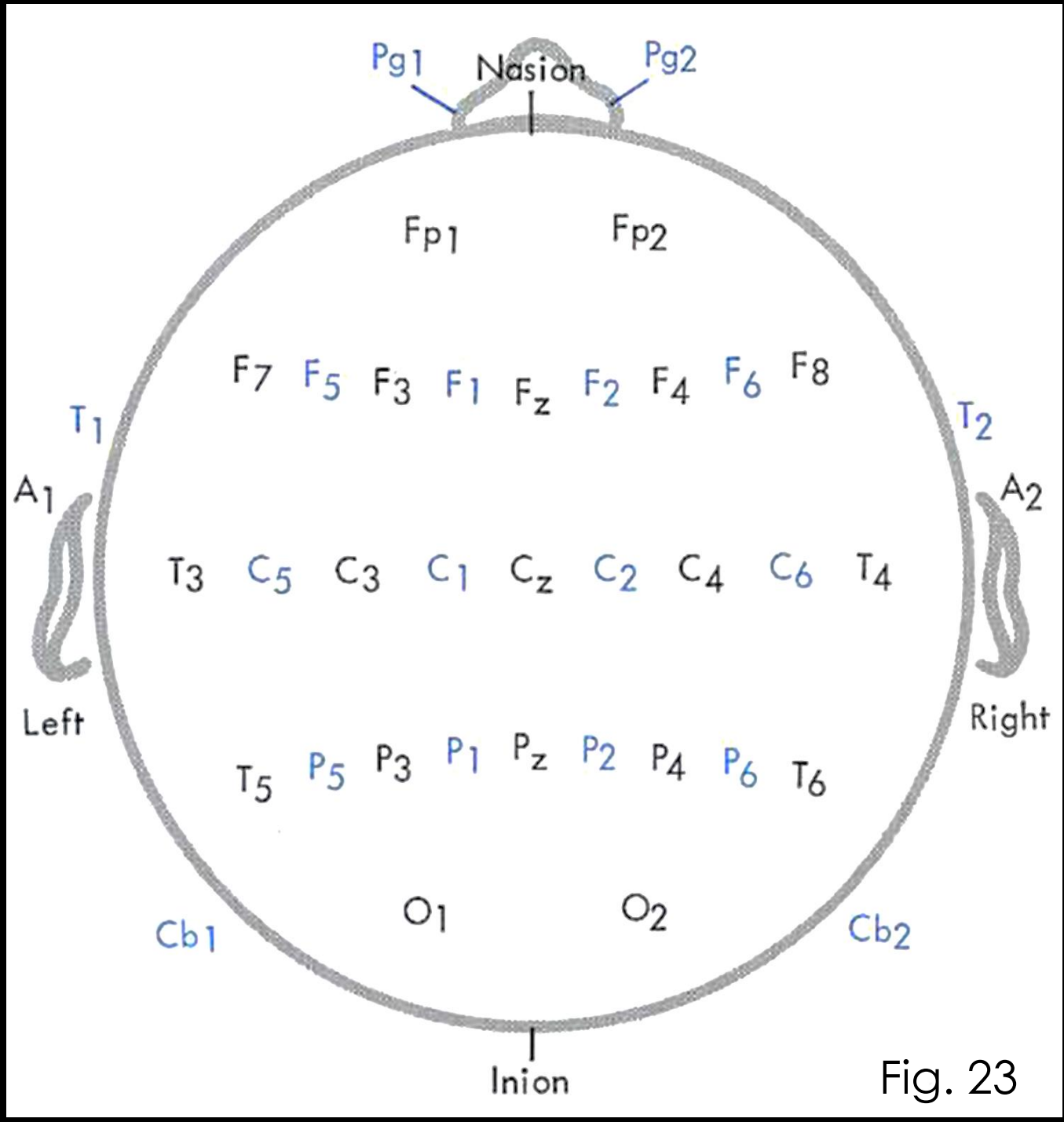


Fig. 23

10-20 PLACEMENT FOR NEWBORN

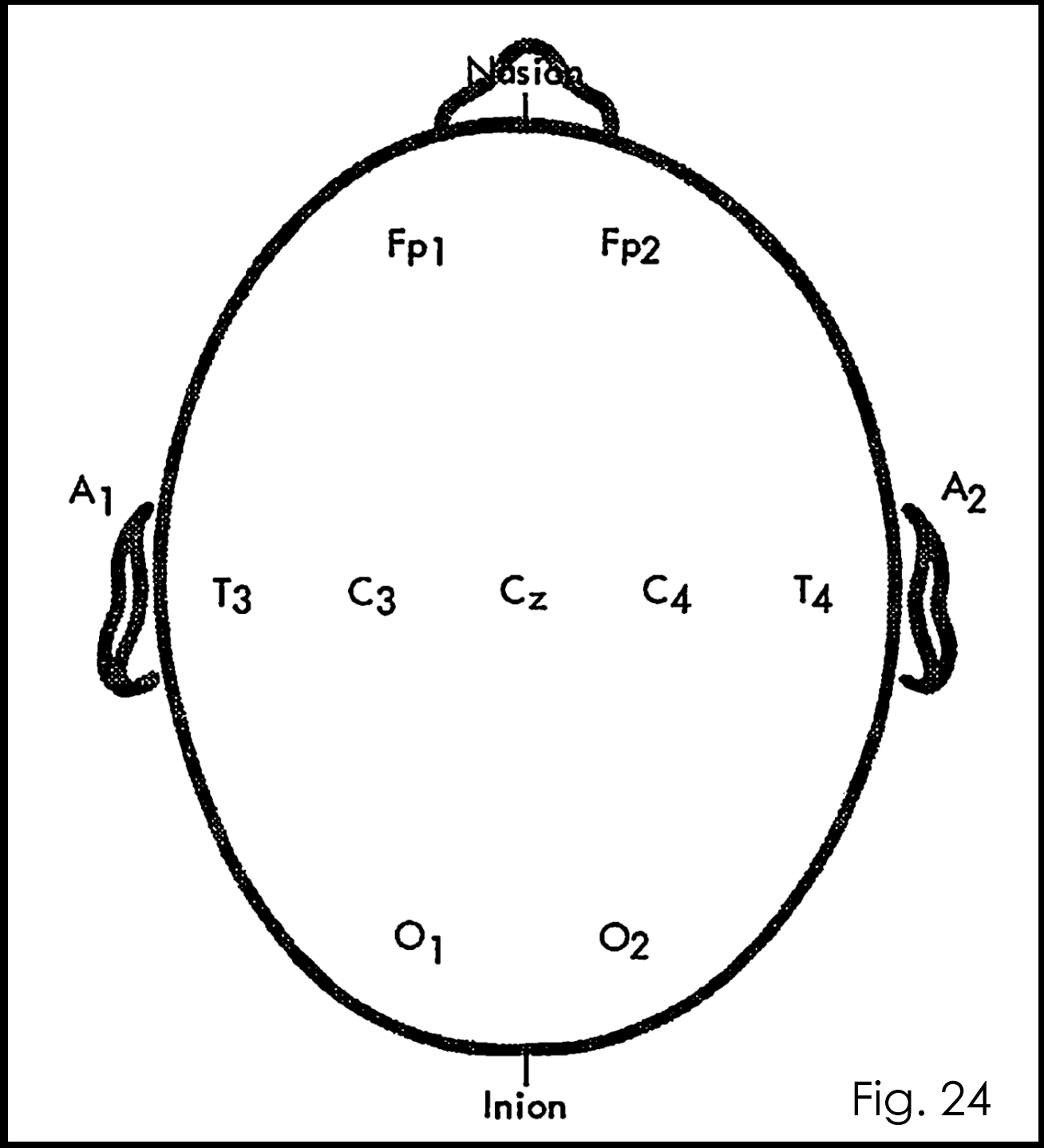


Fig. 24

Standard International (10-20) Electrode Placement

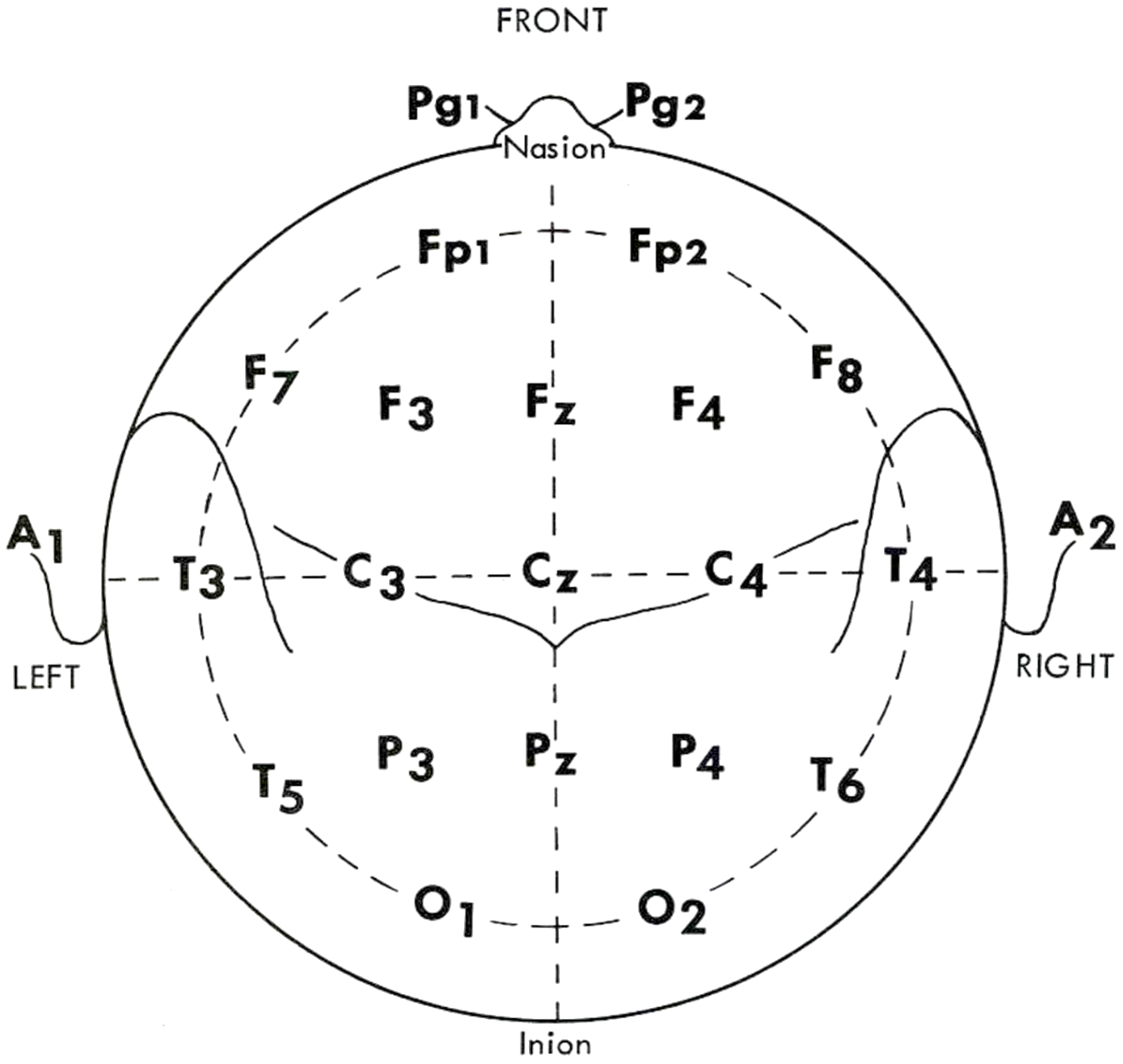


Fig. 25

ELECTRODES

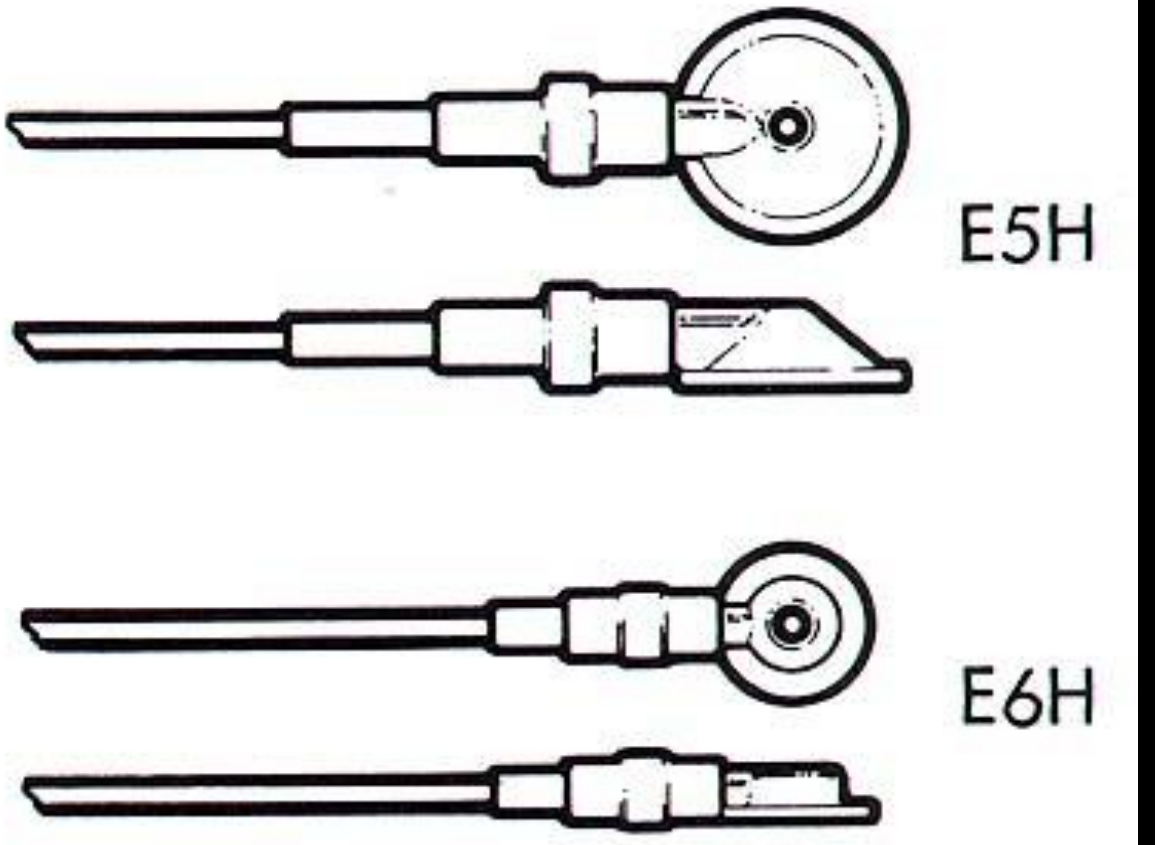
- Electrode basics
- Electrode placement
- Electrode application

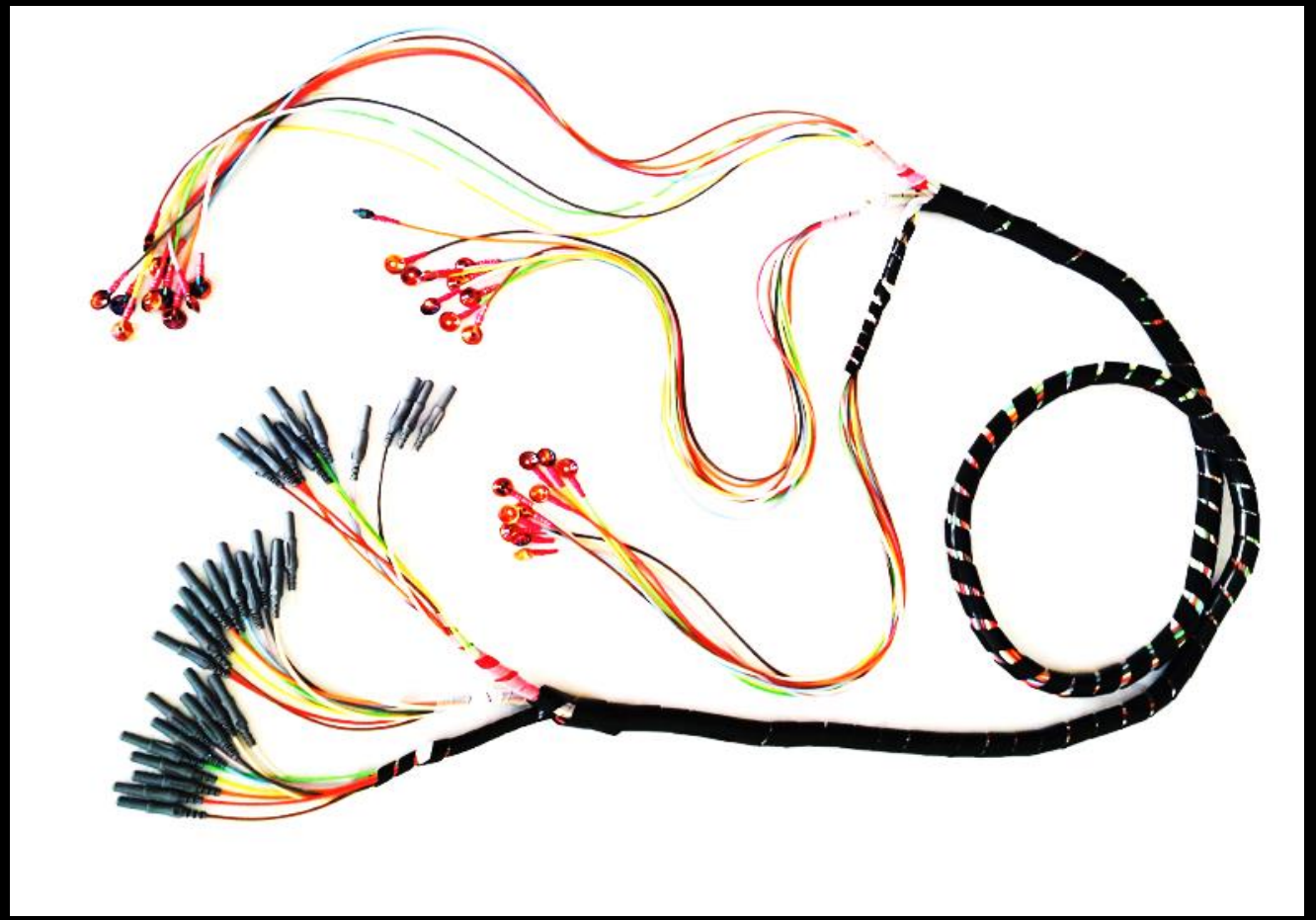
Electrode basics

- Electrodes of the same type and manufacturer
- Equal lead length
- Equal electrode impedances
- Leads are not in proximity to other devices
- Leads are not coiled

❖Electrodes should all be of good condition and be of the same type and manufacturer.

Standard Disc with Hole





Disc Electrode for E.E.G Recording

- The electrodes are manufactured in Tin, Silver, Silver Gold Plated, Silver/Silver Chloride and difference connector types as for example T.P. DIN 42802. For E.E.G recording we suggest to position the electrodes according to the 10-20 System approved by the E.E.G International Society.

Instruction for use

- Degrease the skin of the patient in the area on which should be applied the electrode using a wad of cotton soaked with abrasive cream. Rinse with a solution of warm water and mild soap and dry the area.
- Apply the electrodes to the scalp using adhesive and conductive cream

Instruction for use [con]

- **Fill with gel the syringe equipped with a bunted needle, insert the needle in the electrode hole and inject the gel in the electrode cap, then rub slightly the skin with a round movement.
- Make sure that the electrode skin impedance is not too much high.
- In case of high impedance on some electrodes *replete what is described from* **

Cleaning:

- To keep the efficiency of the electrodes please take care to clean them after every test in the following way:
- Remove the residual gel from the electrode washing with lukewarm water and a neutral detergent (take care not to dip the connector in water).
- Next, dry the electrodes at the room temperature, without using other means that could damage them.

Disinfection the electrodes

- Disinfection the electrodes with the products commonly used in hospital 2% diluted. The electrodes can be sterilized with Ethylene Oxide.

Do not sterilize the electrode in autoclave.

Electrode placement

- Electrodes are usually placed according the 10-20 System.
- This is a widely accepted method of electrode lead placement, which takes advantage of measurement of the skull with defined landmarks.
- Details of how the electrodes application are presented as follows:

Electrode application

- There are two basic ways to attach electrodes to the scalp, gel and collodion.
- Gel is used mainly for office and hospital short-term studies.
- Collodion is used when stability of the electrodes is especially important, such as for long-term monitoring and ambulatory patients.

Electrode application using gel

- Locate the positions for electrodes using the 10-20 Electrode Placement System
- Separate strands of hair over the electrode positions using the wooden end of a cotton-tipped applicator
- Clean dead skin and dirt from the region with a mildly abrasive cleaning agent such as Nu Prep using the cotton-tipped applicator

Electrode application using gel [con]

- Scoop the electrode paste into the electrode
- Place the electrode in position over the skin
- Put a 2.5 cm x 3 cm fixomull stretch pad over the electrode and push it firmly onto the head, providing a seal that prevents the electrode from falling off the scalp.

Electrode application using collodion

- Prepare the head at the electrode positions as mentions above.
- Place the electrode on the scalp
- Place a piece of gauze soaked with collodion over the electrode

Electrode application using collodion [con]

- Use compressed air to dry the collodion
- Insert a blunt-tipped needle into the cup and scrape the skin to lower electrode impedance
- Inject electrolyte (electrode gel) into the cup of the electrode using the blunt-tipped of the needle.

Remove of paste-fixed electrodes

- Pull off the fixomull stretch pads, then the electrode gently pull off, tilting them to release the vacuum effect that holds them on.
- The paste left on the scalp can be largely removed by rubbing with a warm, wet wash cloth.
- After the patient washes the hair that evening, all traces of the recording are gone.

Removal of collodion-fixed electrodes

- First, the collodion is softened by use of acetone, then the area cleaned as above.
- The degree of washing required is greater both immediately by the technician and later by the patient.
- Some patients object to the acetone smell more than any other part of the procedure.

Removal of collodion-fixed electrodes [con]

- Collodion provides a more secure attachment and is more suitable for long-term recordings
- Electrode paste is easier to apply and remove and suitable for most routine office and hospital recordings.

- Modified combinatorial nomenclature
- The following are the new and old names for the revised 10-20 system
  - T7 = T3
  - T8 = T4
  - P7 = T5
  - P8 = T6

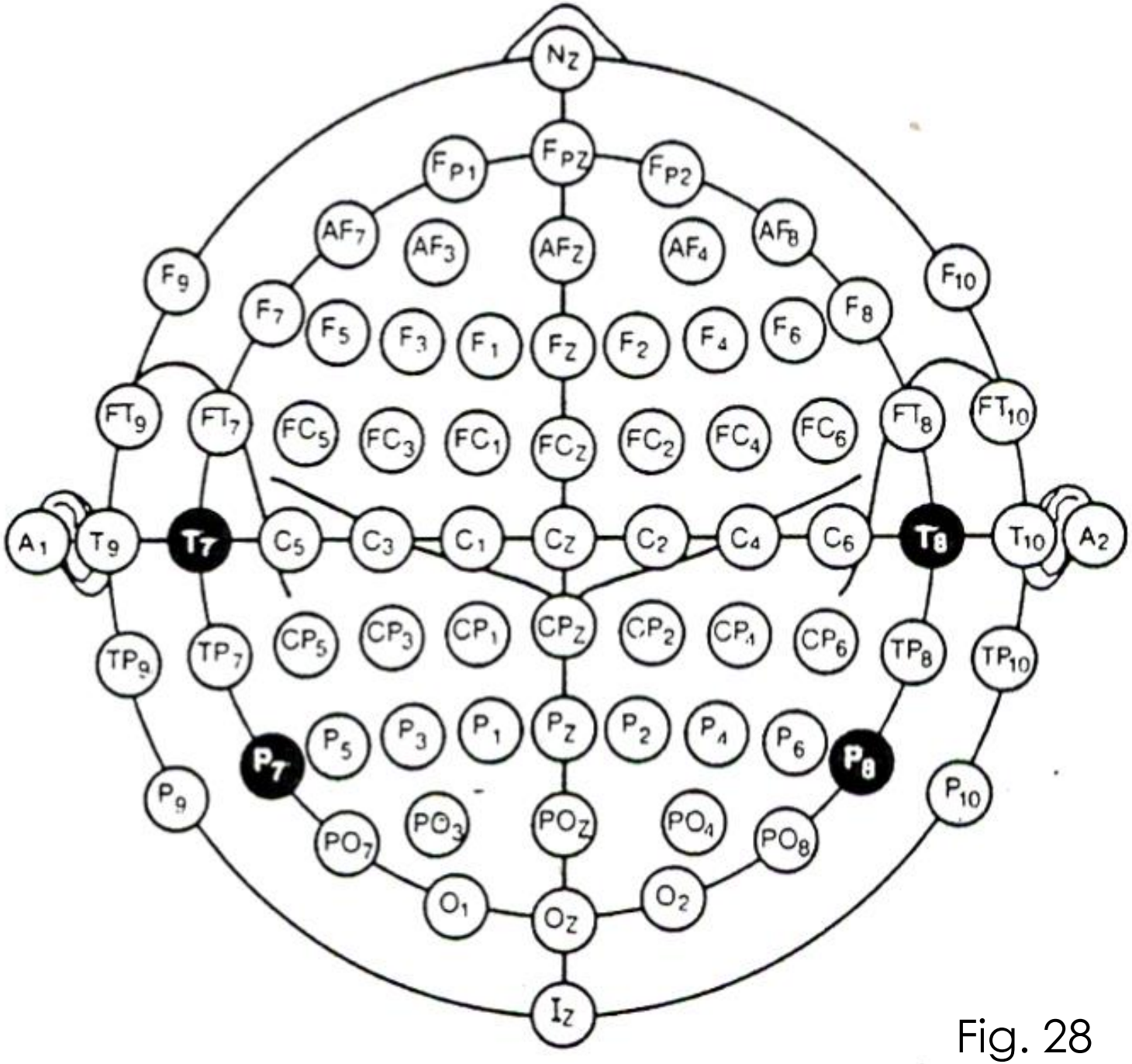


Fig. 28

Clinical EEG using 10 -10 system

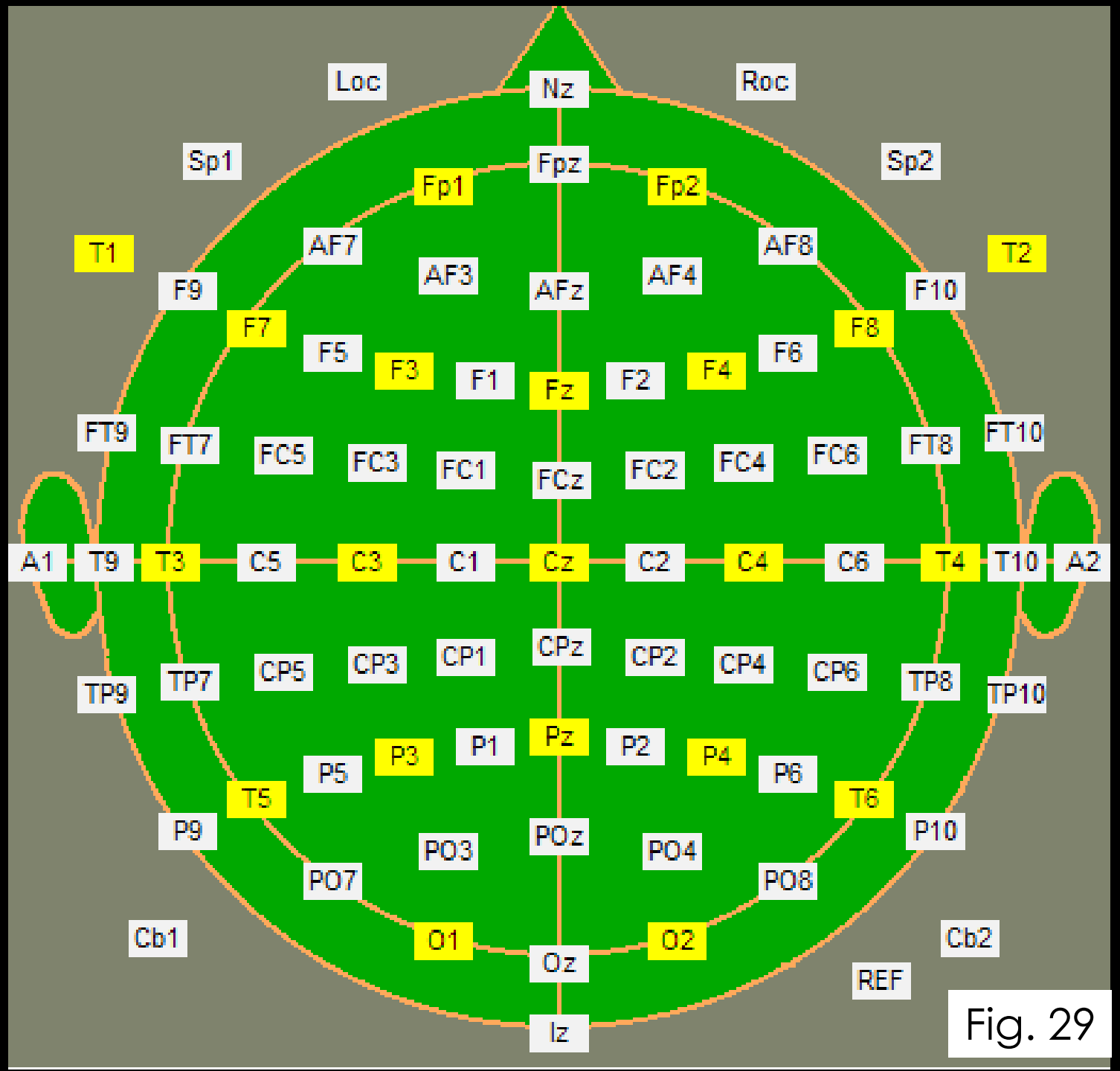
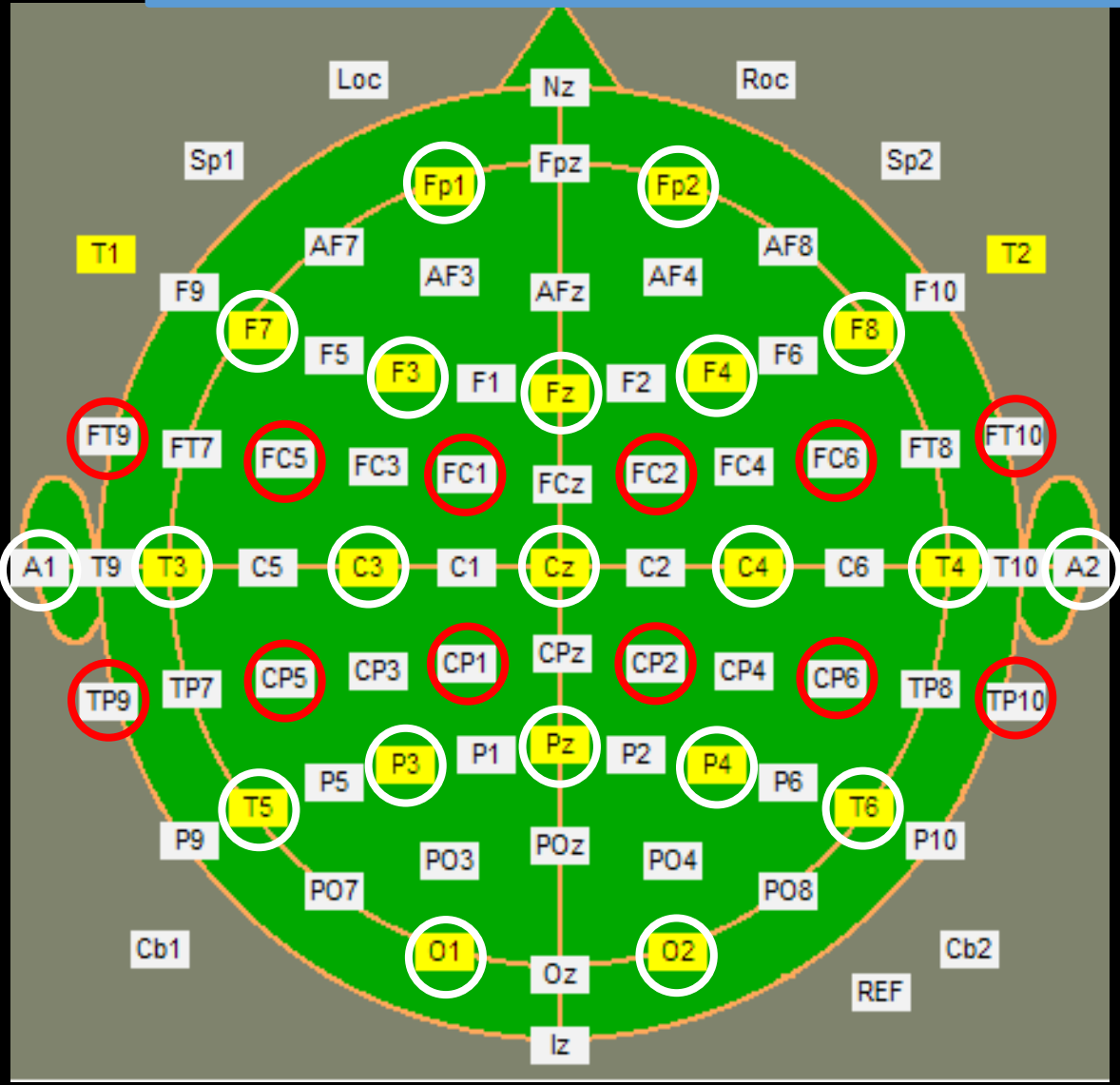


Fig. 29

GOLDMAN MONTAGE DESIGN



CHN	ELEC	CHN	ELEC	CHN	ELEC	CHN	ELEC
C1	Fp	**C11**	Fp2	**C21**	Fz	**C31**	FC6
C2	F3	**C12**	F4	**C22**	Cz	**C32**	TP9
C3	C3	**C13**	C4	**C23**	Pz	**C33**	CP5
C4	P3	**C14**	P4	**C24**	EKGL	**C34**	CP1
C5	O1	**C15**	O2	**C25**	EKGR	**C35**	CP2
C6	F7	**C16**	F8	**C26**	EMGL	**C36**	CP6
C7	T7	**C17**	T8	**C27**	EMGR	**C37**	TP10
C8	P7	**C18**	P8	**C28**	FC5	**T7 = T3**	
C9	A1	**C19**	A1	**C28**	FC1	**T8 = T4**	
C10	FT9	**C20**	FT10	**C30**	FC2	**P7 = T5**	
						P8 = T6	

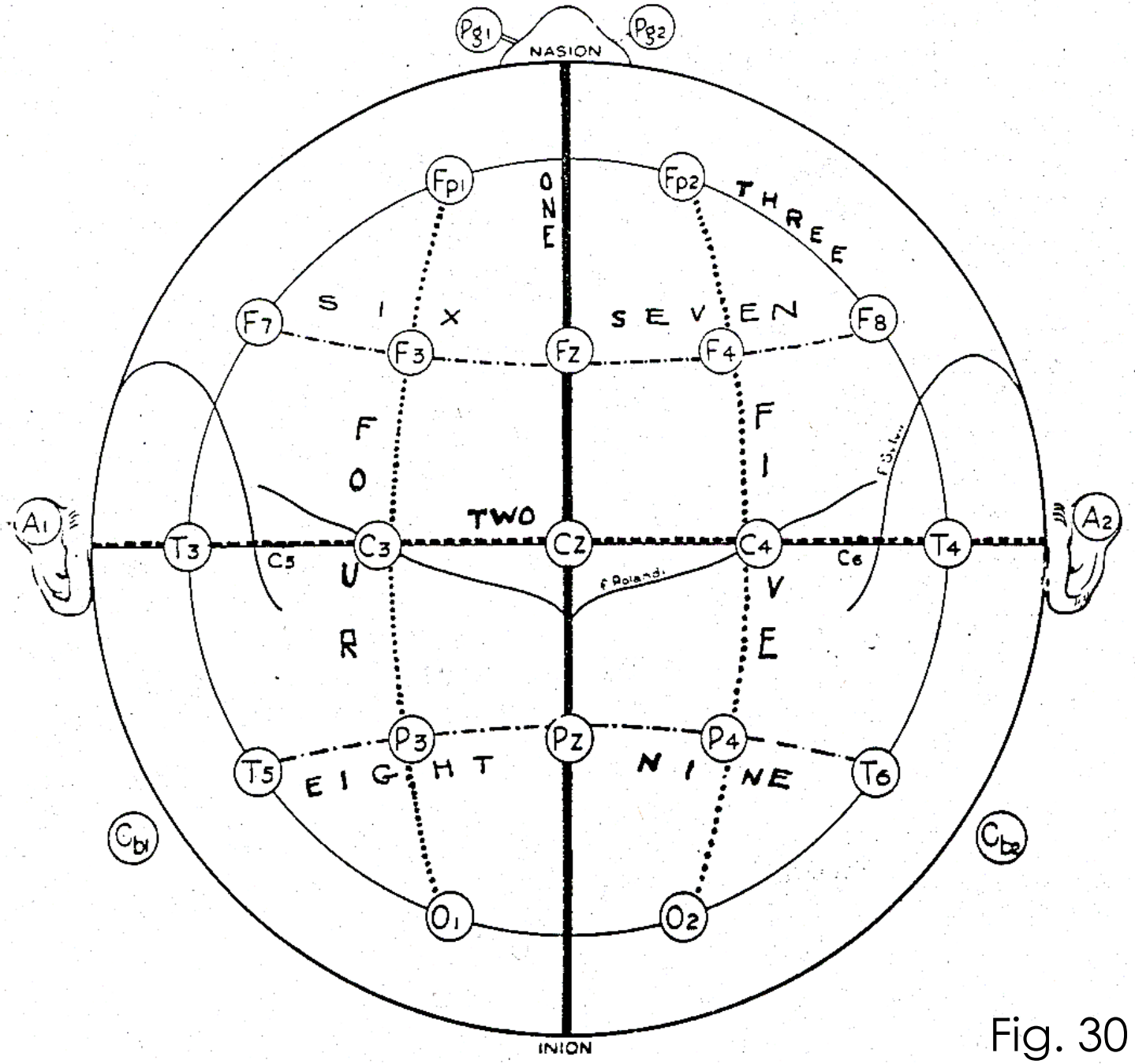
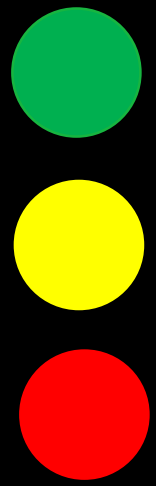

Pg1
Pg2
NASION
Fp1
Fp2
ONE
THREE
F7
SIX
SEVEN
F8
F3
Fz
F4
FOUR
FIVE
A1
T3
C5
C3
TWO
Cz
C4
C6
T4
A2
V
E
P3
Pz
P4
T5
EIGHT
NINE
T6
O1
O2
INION

Fig. 30

Color Code		Left Hemisphere	Midline	Right Hemisphere
BROWN	BROWN	Fp1		Fp2
RED	RED	F3	Fz	F4
BLUE	BLUE	F7		F8
WHITE	WHITE	FT9		FT10
VIOLET	VIOLET	T3		T4
GRAY	GRAY	T5		T6
ORANGE	ORANGE	C3	Cz	C4
YELLOW	YELLOW	P3	Pz	P4
GREEN	GREEN	O1		O2
GREY	GREY	A1		A2
BLUE	BLUE	ECG LA	WHITE	ECG RA
GREEN	GREEN		GROUND	
GRAY	GRAY	REFERENCE	BROWN	REFERENCE
VIOLET	VIOLET	EMG L	GREY	EMG R

IMPEDANCES:

LOW and BALANCED



0.5 Kohms

5 Kohms

10 KOhms

BIBLIOGRAPHY

- American EEG Society, minimu 36: 303-307, 197m technical standards for EEG recording in suspected cerebral death. Ad Hoc Committee on Standards of Practice, 1970. (Available from Am. EEG Soc.)
- Blume, W.T., R.C. Buza and H. Okazaki, Anatomic correlates of the Ten-Twenty electrode placement system in infants. EEG Clin. Neurophysiol. 36: 303-307, 1974.
- Caveness, W. Personnal communication.

BIBLIOGRAPHY [con]

- Hellstrom, B., B. Karlsson and H. Mussbichler. Electrode placement in EEG of infants and its anatomical relationship studied radiographically. Am. J. of EEG Technol., 4: (4), 71-76, 1964.
- Jasper, H. H., Techniques, nomenclature and Electroencephalographers. Dis. Nerv. Syst., 8: 357, 1947.
- Jasper, H. H. The ten-twenty electrode system of the International Federation. EEG Clin. Neurophysiol. 10: 371-375, 1958.

BIBLIOGRAPHY [con]

- Kagowa, N., Electroencephalography in infants with special reference to the newborn: technique. Am. J. of EEG Technol., 2: (3), 99-105. 1962.
- Kagowa, N., EEG recordings in neonate. Am. J. of EEG Technol. 13: (2), 163-176. 1973.
- Sannit, T., The 10-20 system: footnotes to measuring technique. Am. J. of EEG Technol., 3: (1), 23-30, 1963.

BIBLIOGRAPHY [con]

- Silverman, D., The anterior temporal electrode and the 10-20 system. Am. J. of EEG Technol., 5: (10), 11-14. 1965.
- Silverman, D., The rationale and history of the 10-20 system of the International Federation. Am. J. of EEG Technol., 3: (1), 17-22. 1973.

BIBLIOGRAPHY [con]

- Ten-Twenty Electrode System , International Federation of Societies for Electroencephalography and Clinical Neurophysiology. EEG Clin. Neuorphysiol., 10: 371-375, 1958. Reprinted in Am. J. of EEG Technol., 1: (1), 13-19. 1961.
- Torres, F. and M. E. Blow, Longitudinal EEG – Clinical correlations in children from birth to 4 years. Pediatric, 41: 945-954, 1968.

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