

Universitatea Ecologica Bucuresti
Facultatea de Managementul Transportului Fereviar
Cursul de Locomotive Electrice

LOCOMOTIVE ELECTRICE

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Capitolul 1 Generalitati si notiuni introductive

1.1 Elemente principale ale ansamblului de tractiune electrica

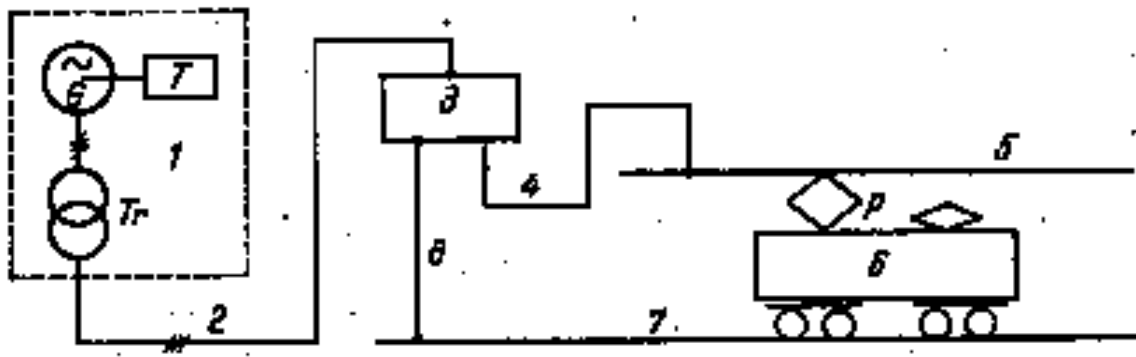
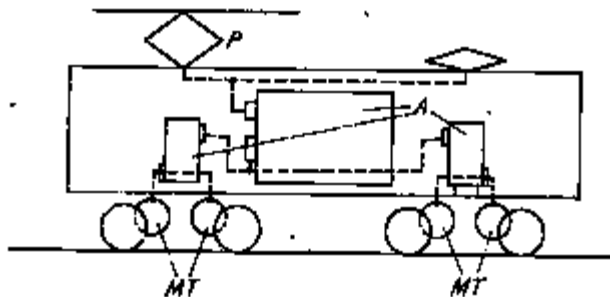
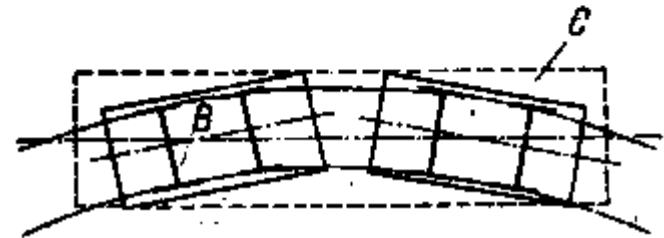
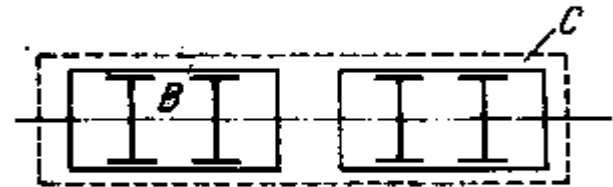
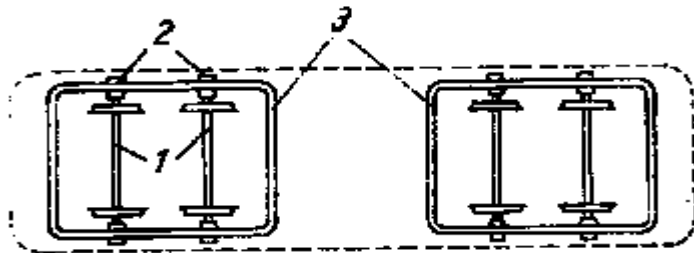
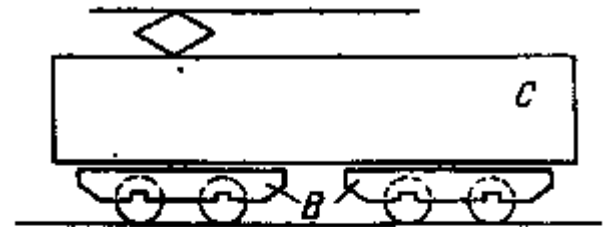
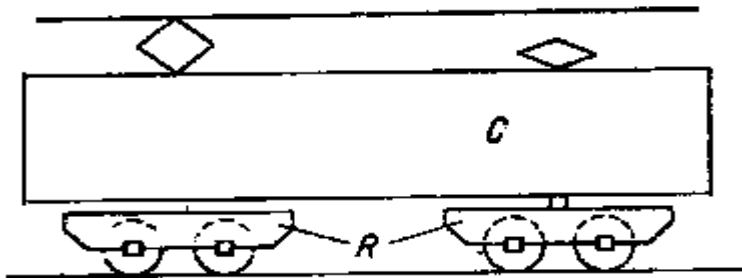


Fig. 1.1

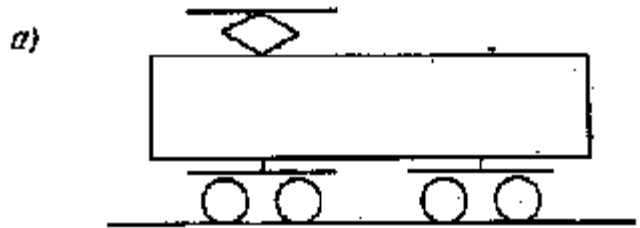
- 1 – Centrala Electrica : T – turbina; G – generator; Tr – transformator;
- 2 – Liniile de Transport
- 3 – Substatiile de Tractiune
- 4 – Alimentarea Liniei de Contact
- 5 – Linia de Contact
- 6 – Locomotiva Electrica
- 7 – Sina de Rulare
- 8 – Cablurile de Intoarcere

1.2 Partile principale ale locomotivei electrice

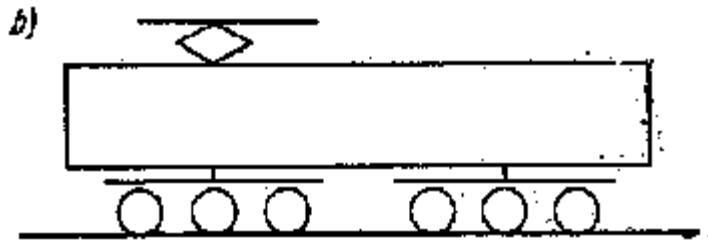


- A – agregate (trafo, m.e. servicii auxiliare, aparataj)
- B – boghiuri
- C – cutie
- Mt – motoare de tractiune

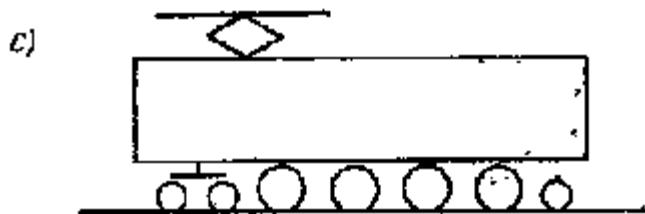
1.3 Formula locomotivei



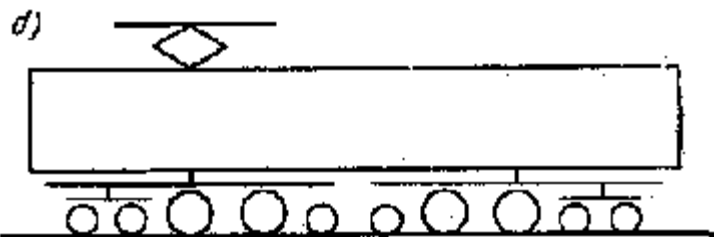
- $B_0 - B_0$ (bo-bo)



- $C_0 - C_0$ (co-co)

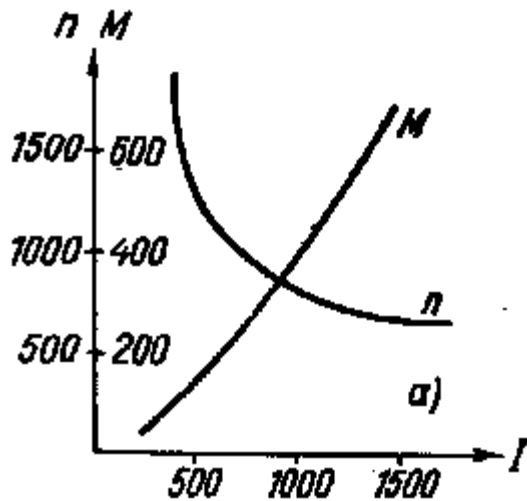


- $2D_01$ (doi-do-unu)



- $2B_01 1B_02$ (doi -bo -unu,unu-bo - doi)

1.4.a Caracteristicile electromecanice a M.E.T. cc cu excitatie serie



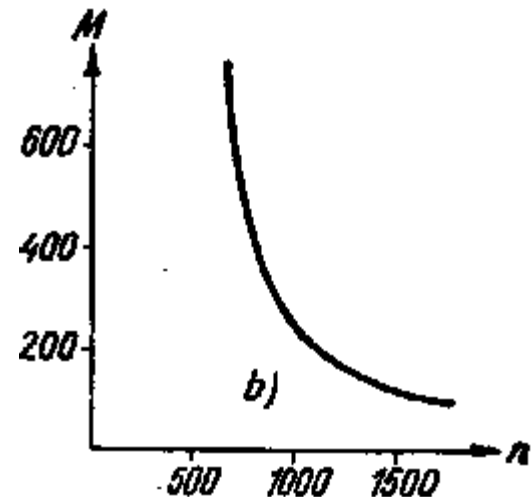
- $n = f(I)$

- I - (curentul indusului)

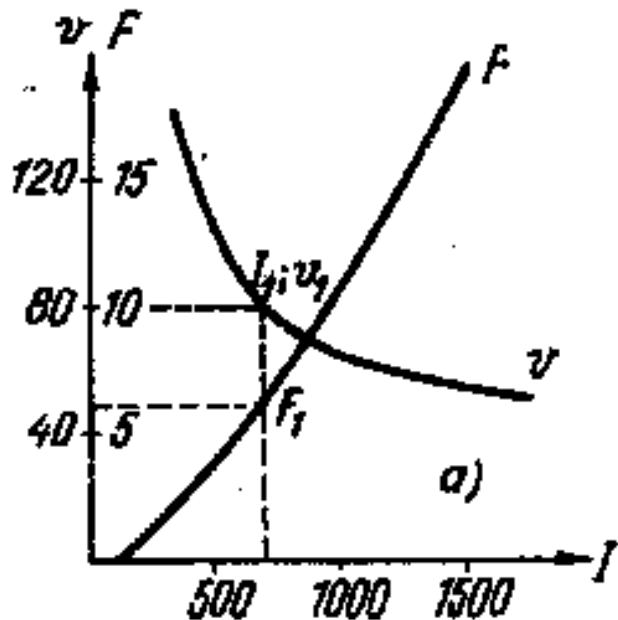
- $M = f(I)$

1.4.b Caracteristica mecanica

$$M = f(n)$$



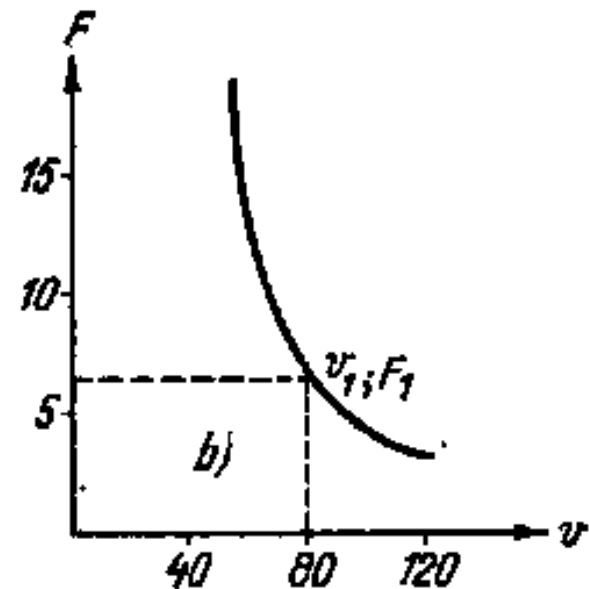
1.4.c Caracteristicile electromecanice a locomotivei



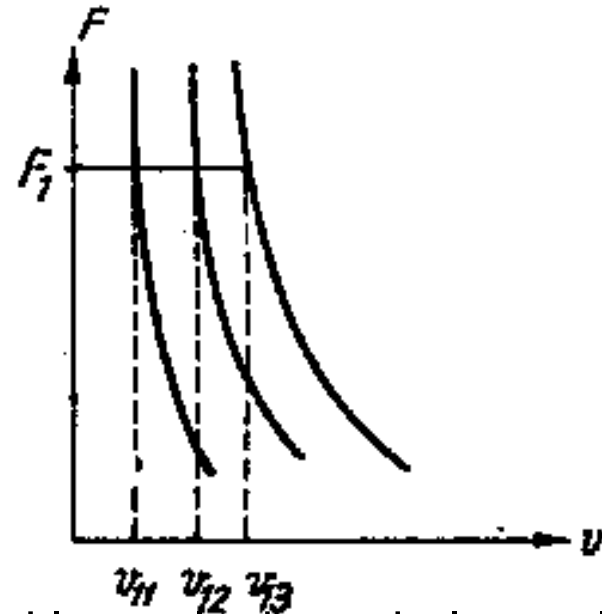
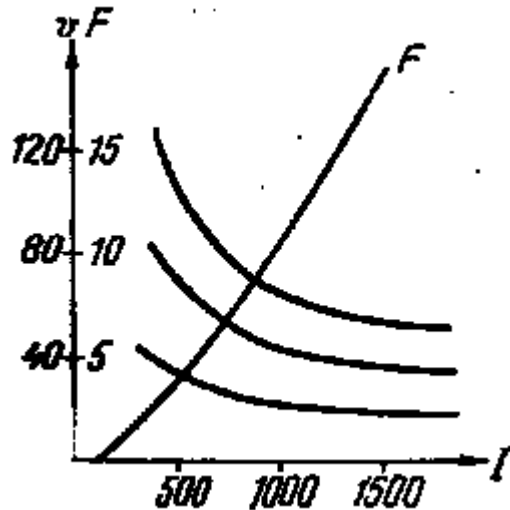
- $V = f(I)$
- $F = f(I)$

1.4.d Caracteristica mecanica

$$F = f(v)$$



1.4.e Familiile de caracteristici



Obs. 1. La aceeasi forta de tractiune F_1 (deci la acelasi tonaj al trenului si aceeasi declivitate a liniei) mecanicul poate alege una din cele trei viteze.

Obs.2. Realizarea unei familii de caracteristici depinde de posibilitatile de reglare a turatiei motoarelor electrice de tractiune.

CONDITIILE CE TREBUIE SA LE REALIZEZE O LOCOMOTIVA

- sa dispuna de un numar mare de caracteristici (trepte de reglare).
- reglarea turatiei M.E.T. sa se faca cu mijloace cit mai simple si economice.

Capitolul 2

SISTEME DE ALIMENTARE A LOCOMOTIVELOR SI CLASIFICAREA LOR

Sistem de alimentare: totalitatea parametrilor electrici care caracterizeaza felul curentului pe care substatia de tractiune il debiteaza in linia de contact

--parametri electrici sunt : --tensiunea U

--frecventa f

--numarul de faze

--sistemul de curent al M.E.T. si felul instalatiilor de adaptare definesc <sistemul de alimentare>

--alimentarea locomotivelor electrice se poate face :--in curent continuu

--in curent alternativ

--M.E.T. pot fi : -- de curent continuu

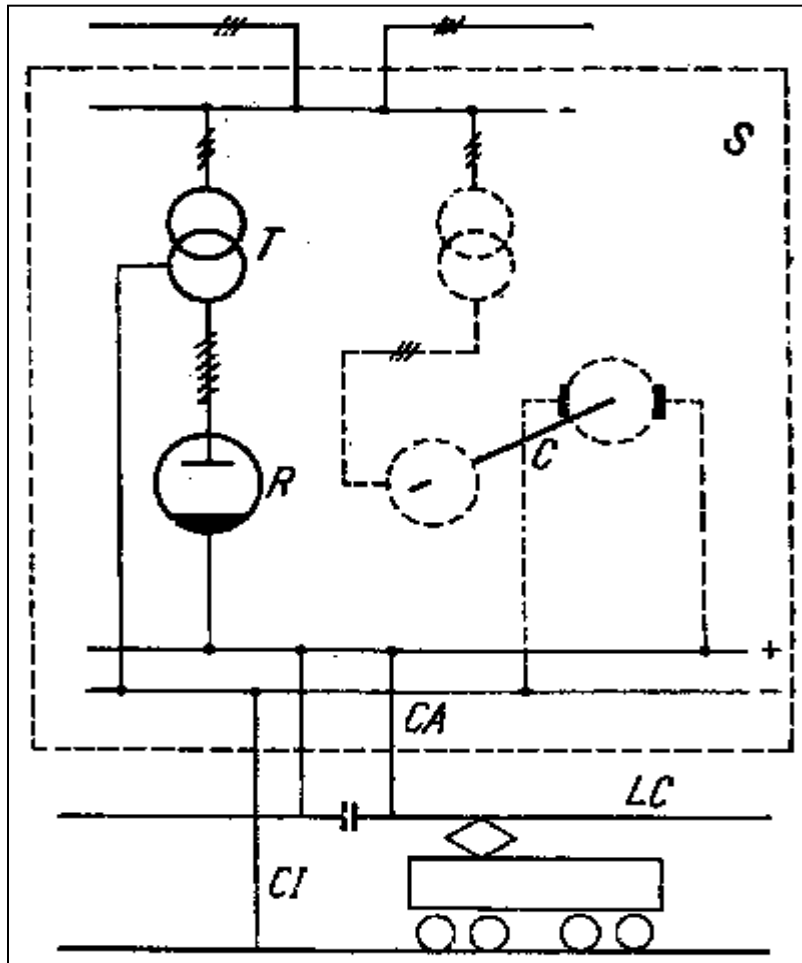
-- de curent alternativ

Observatie: se intilnesc frecvent cazuri cind sistemul curentului de alimentare difera de sistemul de curent al M.E.T.

SISTEME DE ALIMENTARE

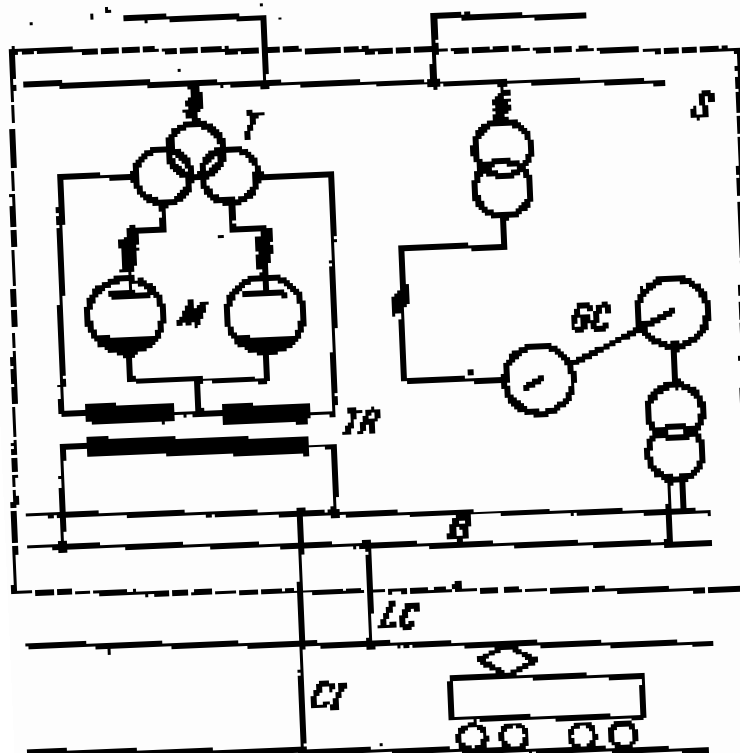
- a) curent continuu (pina la 3300 V);
- b) curent monofazat de joasa frecventa;
- c) curent monofazat de frecventa industrială;
- d) curent trifazat;
- e) curent continuu de inalta tensiune(6....12KV)

a.) Sisteme de alimentare in curent continuu

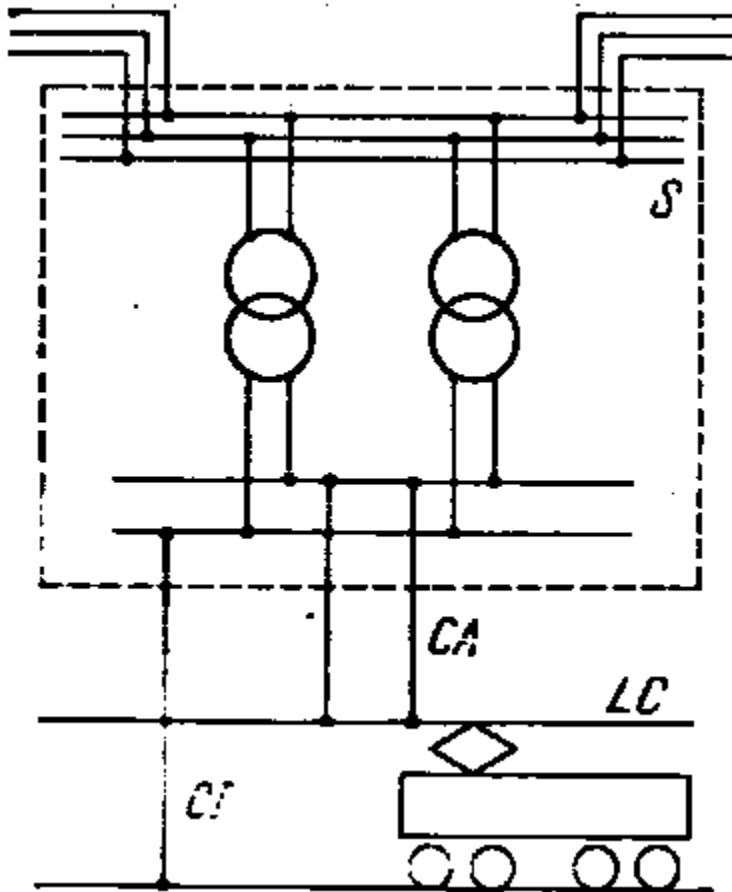


- S –substatie de tractiune
- T – transformator
- R – redresor
- C – convertizoare rotative

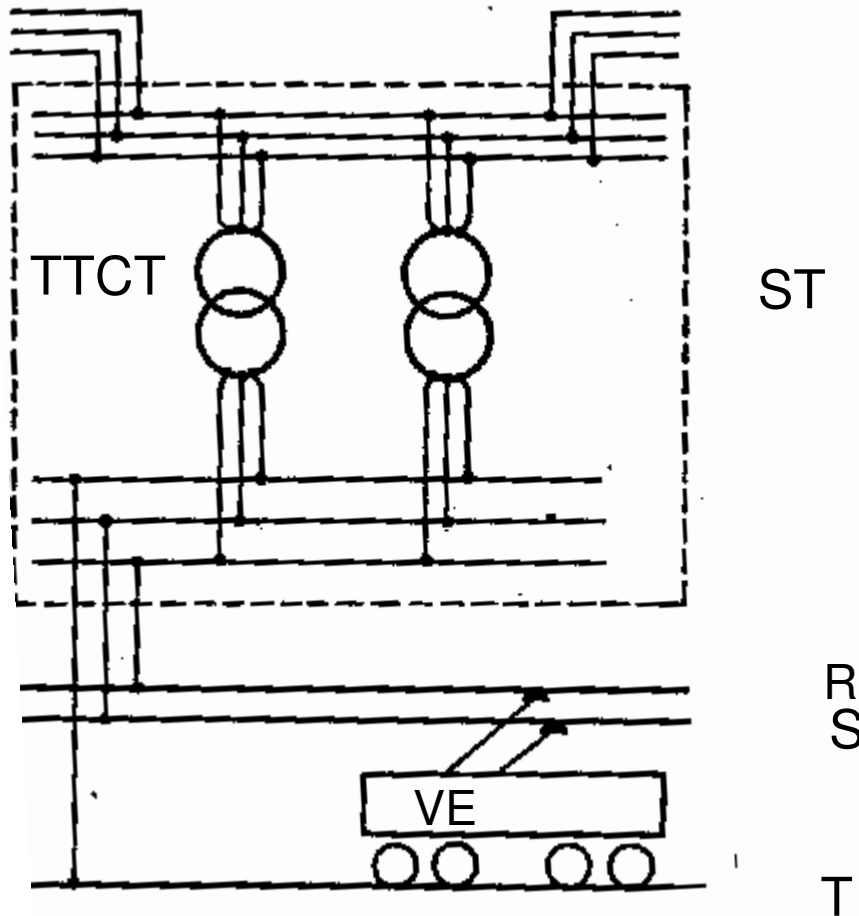
b.) Sisteme de alimentare in curent monofazat de joasa frecventa



c.) Sisteme de alimentare in curent monofazat de frecventa industrialala



d.) Sisteme de alimentare in curent trifazat



e.) Sisteme de alimantare in curent continuu de inalta tensiune(6...12kv)

- Schema de principiu este identica cu cea de curent continuu,
- Tensiuni utilizate :3300V,6000V,12000V
- Tensiunea de 12000V in curent continuu asigura pentru conditii Identice de circulatie(numar de trenuri, tonaj) si sectiune de conductori la linia de contact distante egale intre substatiile de tractiune cu cele obtinute in alimentarea in curent monofazat de 25KV si 50 Hz.

Capitolul 3

SISTEMELE DE LOCOMOTIVE ELECTRICE SI CLASIFICAREA LOR

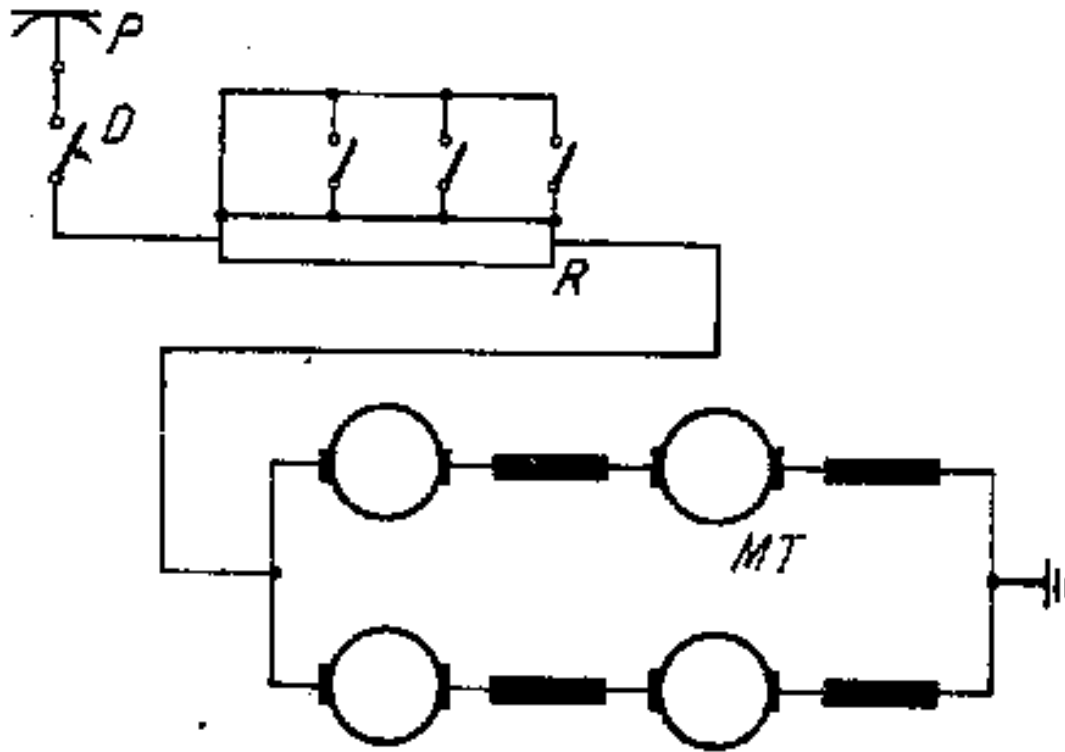
Locomotivele electrice se clasifica dupa urmatoarele criterii:

- sistemul curentului de alimentare;
- genul motoarelor de tractiune;
- sistemul instalatiilor de adaptare de pe locomotiva;

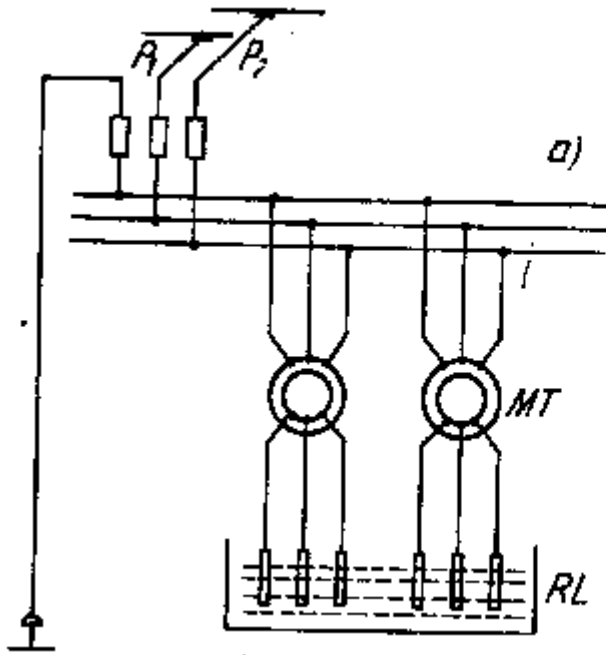
Locomotivele electrice se impart in:

- a) – locomotive electrice de curent continuu;
- b) – locomotive electrice de curent trifazat;
- c) – locomotive electrice de curent monofazat de joasa frecventa;
- d) – locomotive electrice de curent monofazat de frecventa industrială;
- e) - locomotive electrice de curent continuu de inalta tensiune;

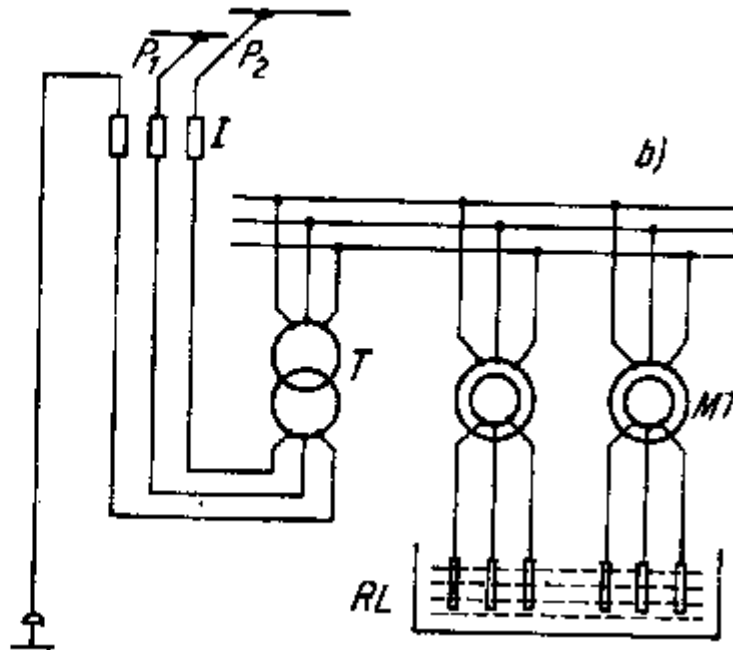
a.) Locomotive electrice de curent continuu



b.) Locomotive electrice de curent trifazat

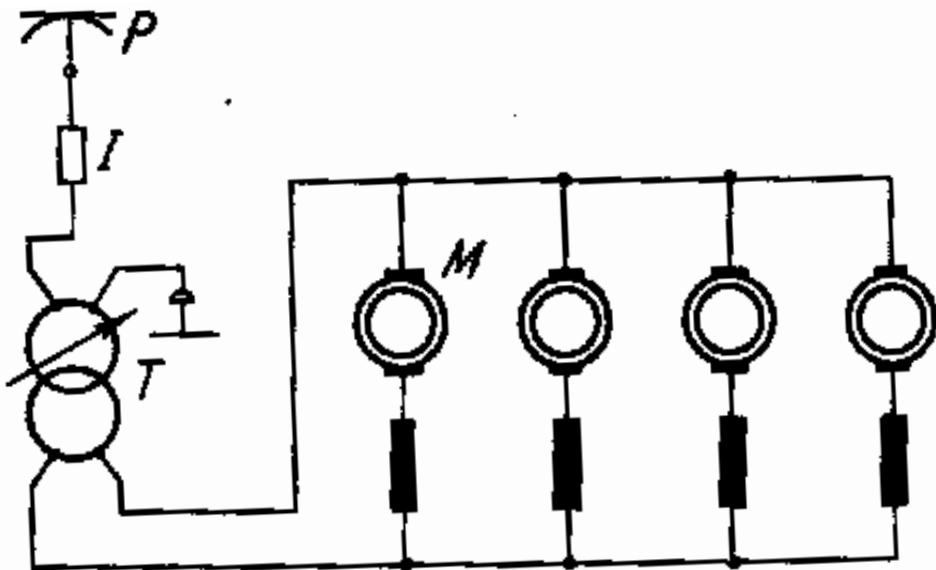


a.) fara transformator pe locomotiva



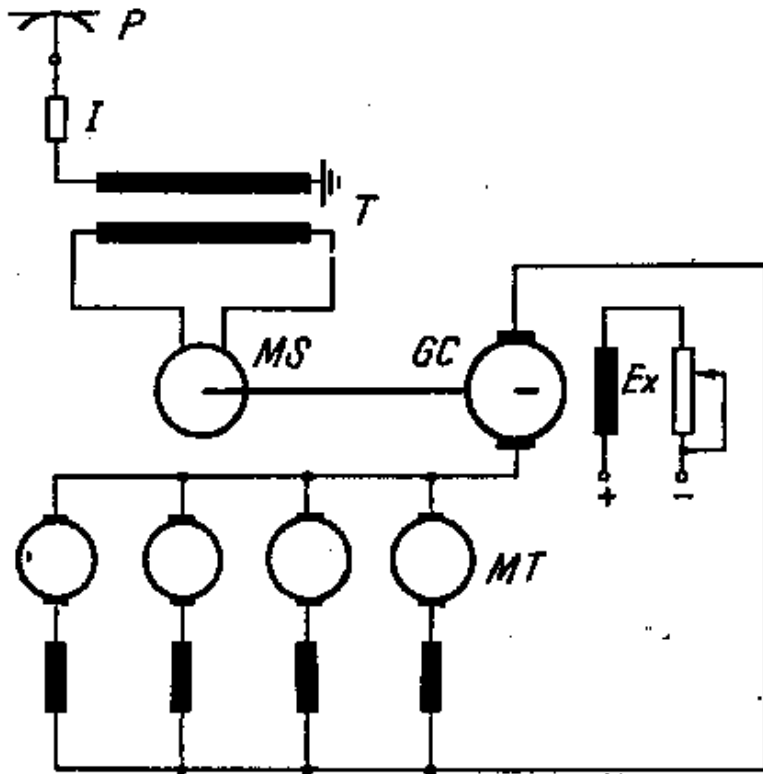
b.) cu transformator pe locomotiva

c.) Locomotive electrice de curent monofazat, de joasa frecventa

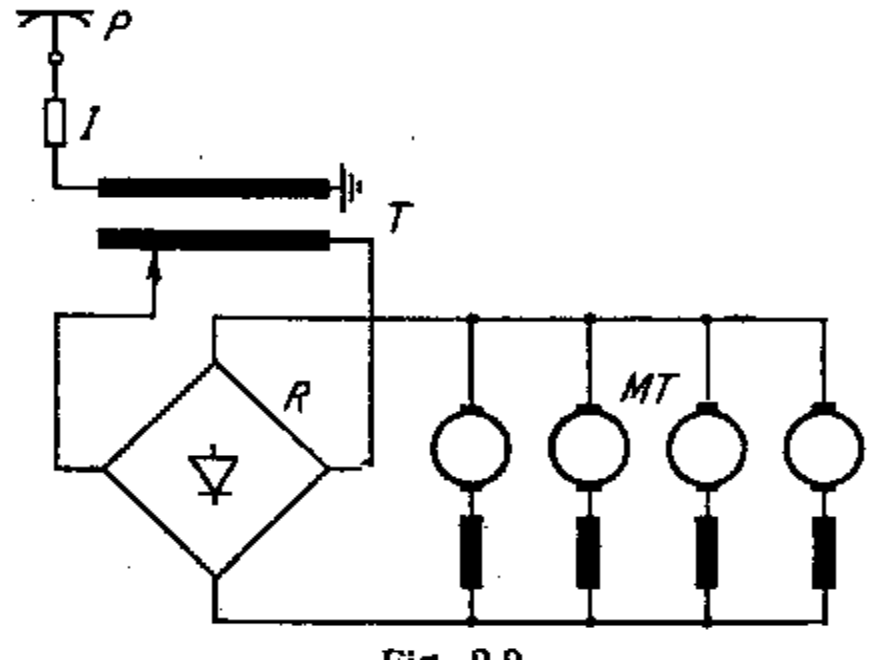


MET -- sunt monofazate
-- cu colector
-- excitatie serie

d.1) Locomotive electrice de curent monofazat, de frecventa industrială, cu motoare de curent continuu



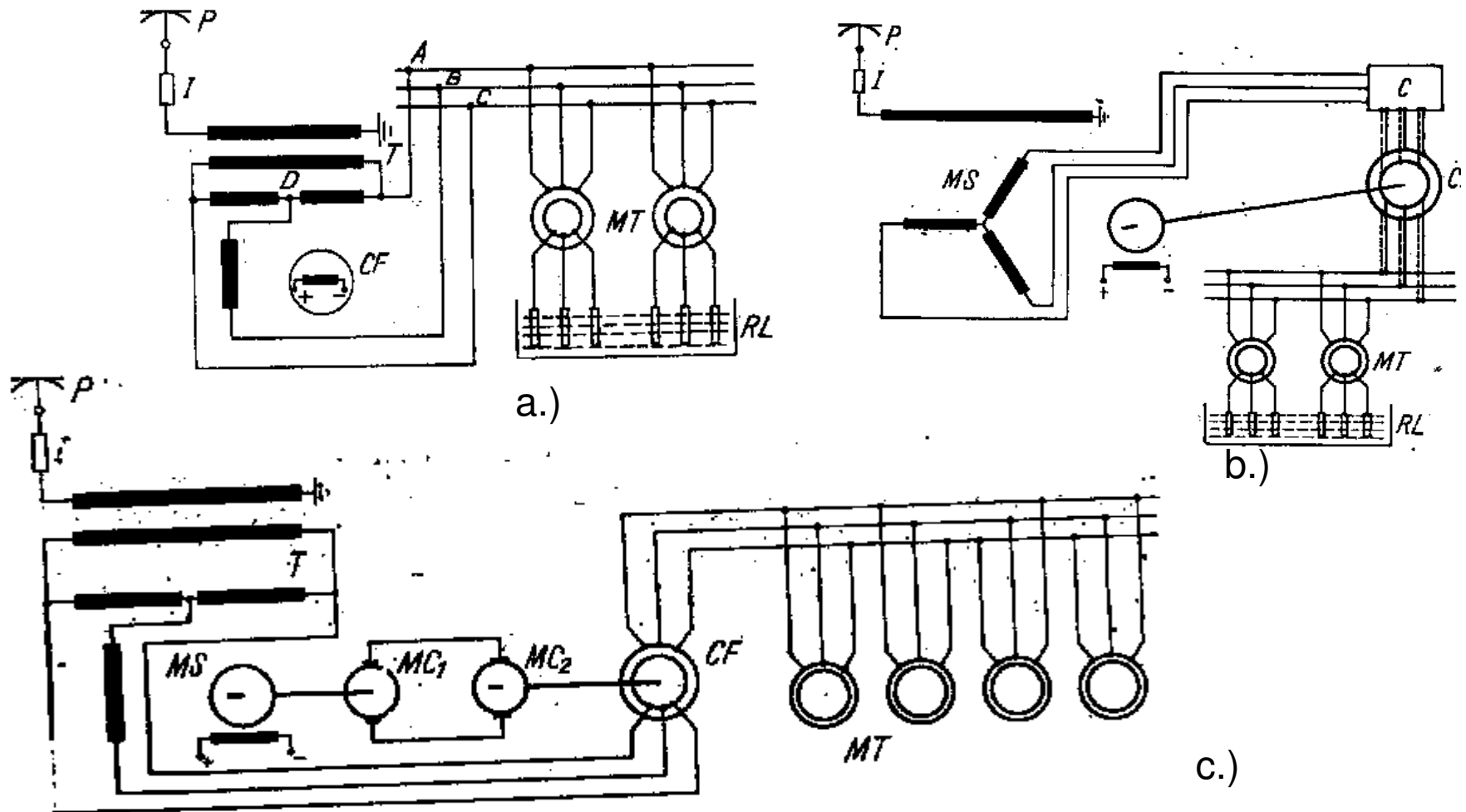
a.) cu grup motor-generator (convertizoare rotative)



b.) cu redresoare (convertizoare statice)

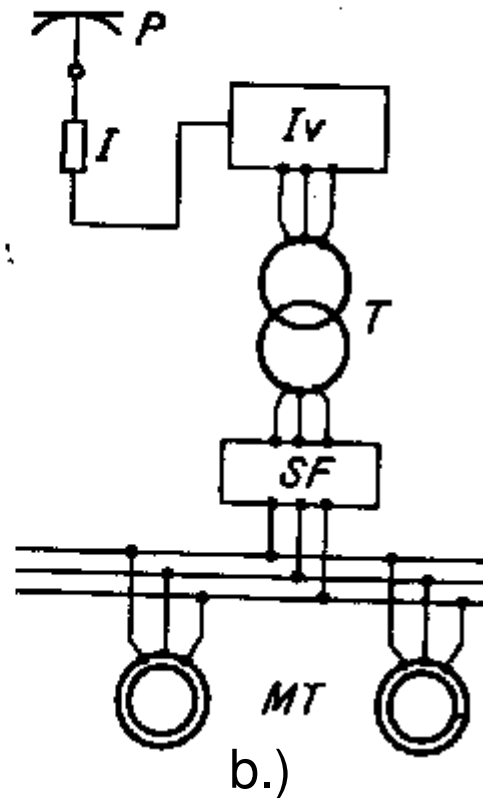
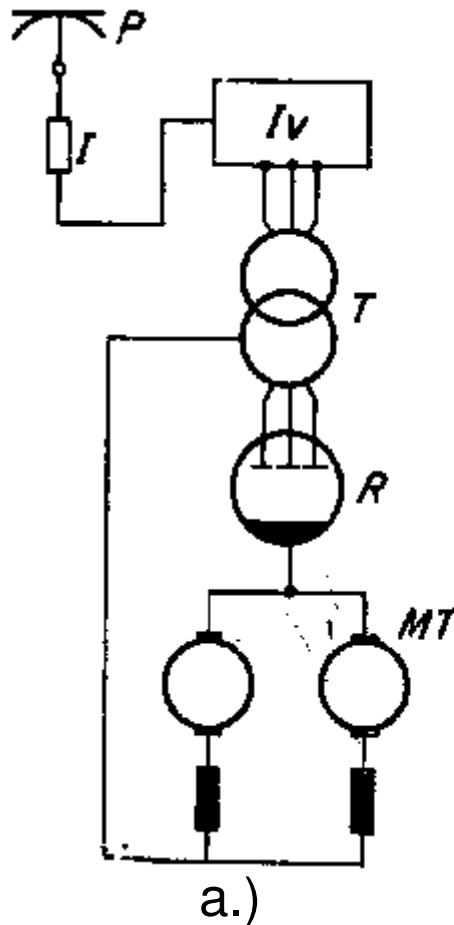
d 2.) Locomotive electrice de curent monofazat, de frecventa industrială

- a.) motoare asincrone cu frecventa constanta;
- b.) motoare asincrone cu frecventa reglata in trepte;
- c.) motoare asincrone cu frecventa continua variabila



e.) Locomotive electrice de curent continuu ,de inalta tensiune

- a.) cu MET de curent continuu;
- b.) cu MET de curent alternativ,fara culector;



CAPITOLUL 4

CARACTERISTICILE M.E.T. CU COLECTOR

4.1 GENERALITATI

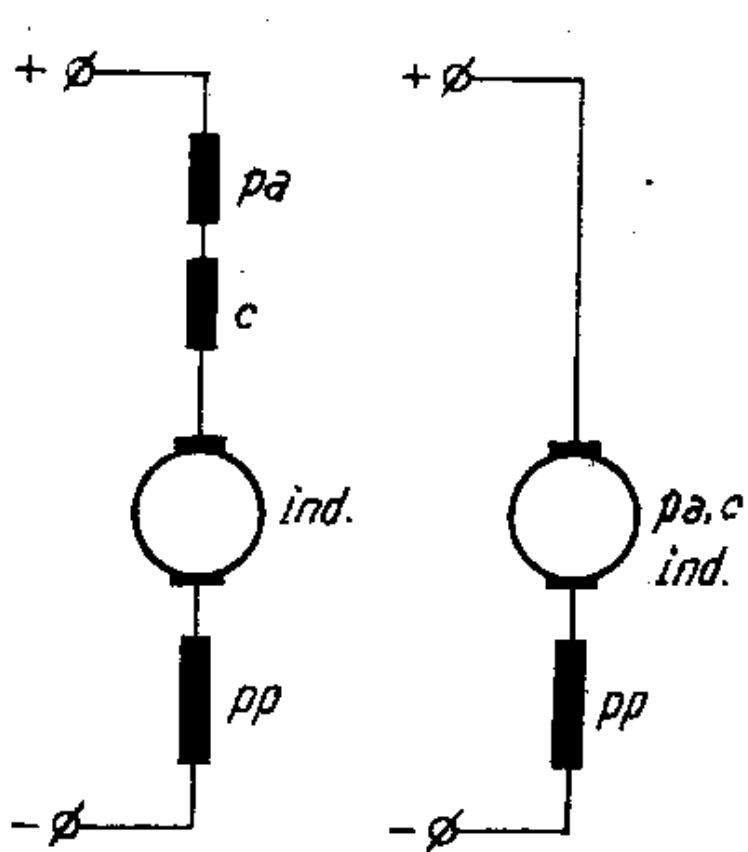
- M.E.T. transforma energie electrica in energie mecanica;
- regimul de functionare a M.E.T. de curent continuu este pe deplin determinat
daca se cunosc urmatoarele marimi;
 - tensiunea $\langle U \rangle$ aplicata la borne
 - curentul $\langle I \rangle$ ce trece prin indus
 - turatia $\langle \omega \rangle$ a rotorului
 - randamentul $\langle \eta \rangle$
- Functiile $n=f(I), M=f(I), \eta=f(I)$ la $U=\text{constant}$ sunt caracteristicile electomecanice
ale motorului. Ele se ridica la standul de proba.
- Functia $n=f(M)$ este caracteristica mecanica a motorului

4.1 GENERALITATI (cont.)

- Funcțiile $v=f(I)$, $F=f(I)$, $\eta=f(I)$, reprezintă caracteristicile electromagnetice la obada și se determină din caracteristicile electromagnetice și mecanice la arborele M.E.T. precum și diametrul $\langle D \rangle$ a roții de rulare și raportul $\langle i \rangle$ al angrenajului reductor.
- Funcția $F=f(v)$ reprezintă caracteristica mecanică la obada și se mai numește și \langle caracteristica de tracțiune \rangle

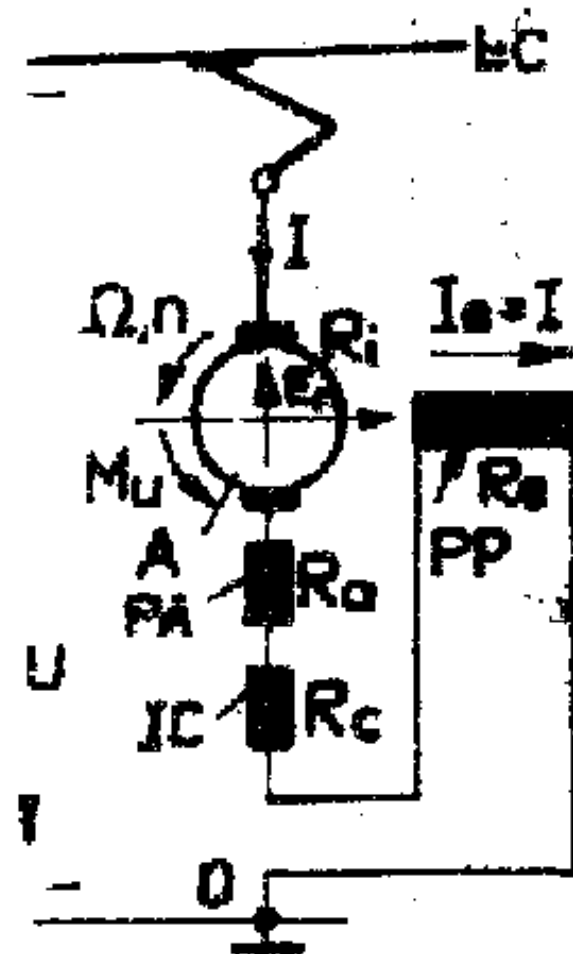
4.2 Caracteristicile M.E.T. cu excitatie serie

a) Schema de alimentare

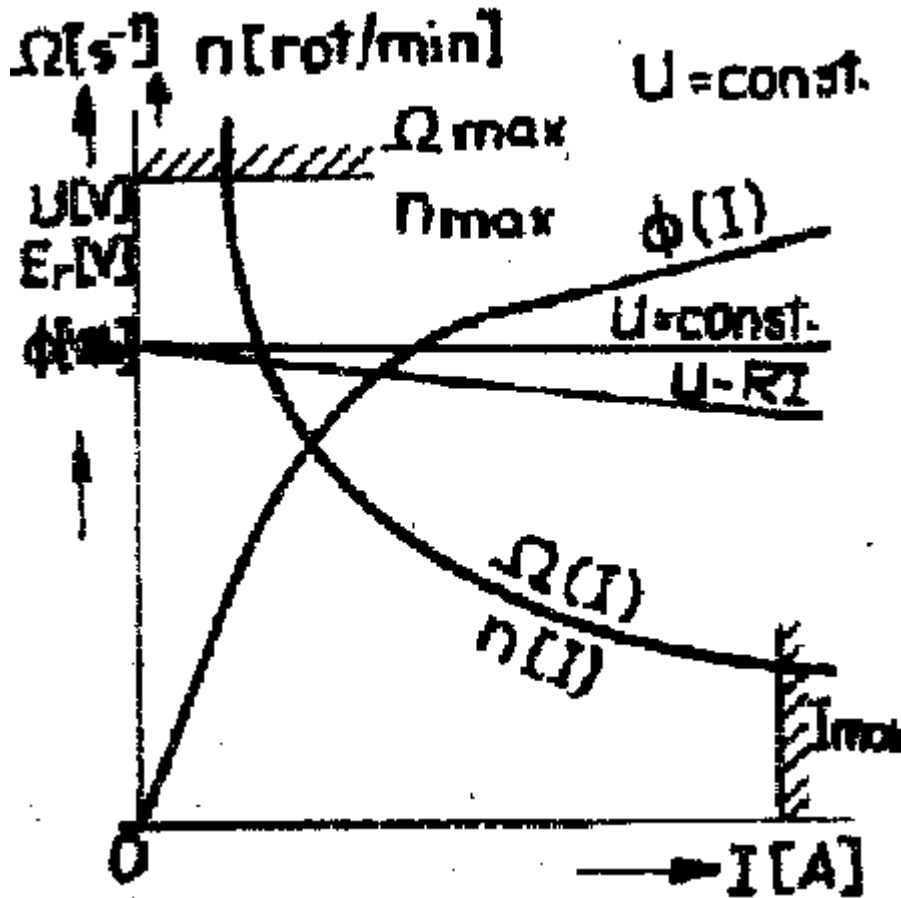


$$I_e = I$$

$$R = r(pp) + r(pa) + r(i) = r(c)$$



b) Caracteristica vitezei unghiulare (Ω)



$$e_r = -w \frac{d\Psi}{dt} [V]$$

$$f = \frac{\Omega}{2\pi} [s^{-1}]$$

$$E_r = k\Psi\Omega [V]$$

$$k = \frac{pN}{2\pi a} \text{ Constanta generala a MET}$$

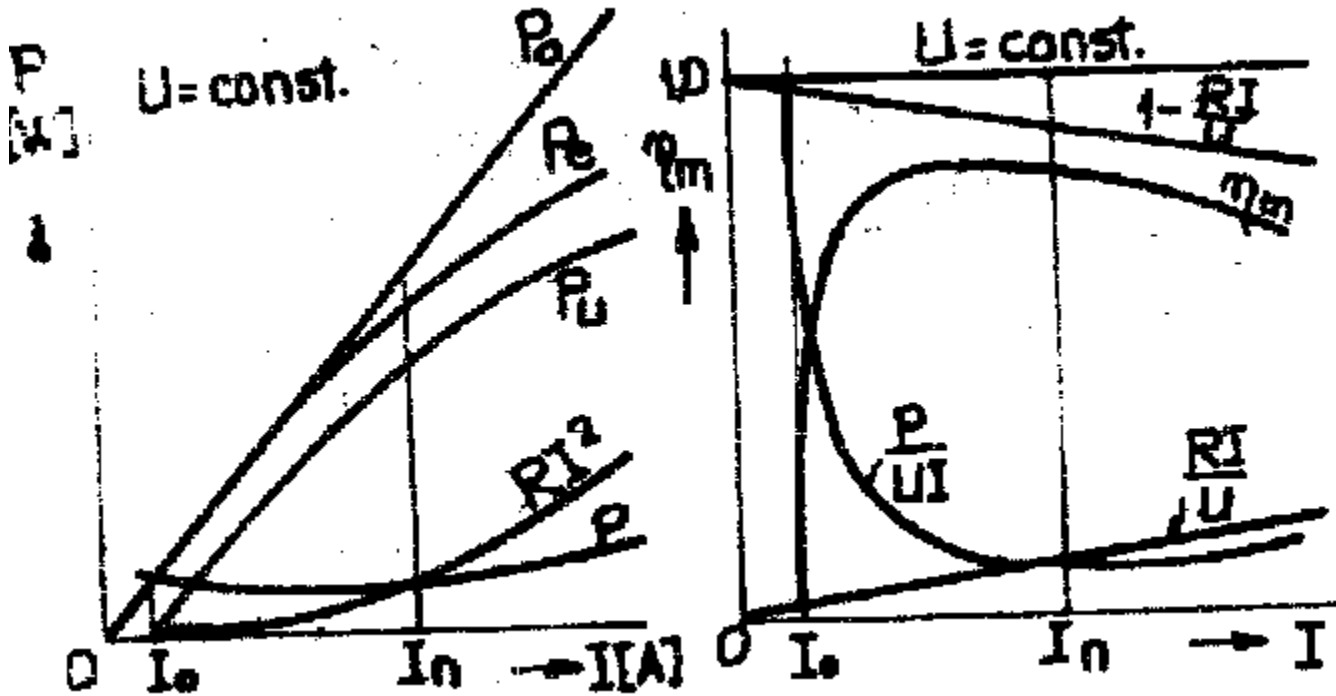
$$\Omega = 2\pi \frac{n}{60}$$

$$E_r = k_r \Psi n [V]$$

$$k_e = \frac{2\pi}{60} k \text{ Constanta de tensiune a MET}$$

$$\Omega = \frac{U - RI}{k\Psi} [s^{-1}]$$

4.3 Caracteristica randamentului



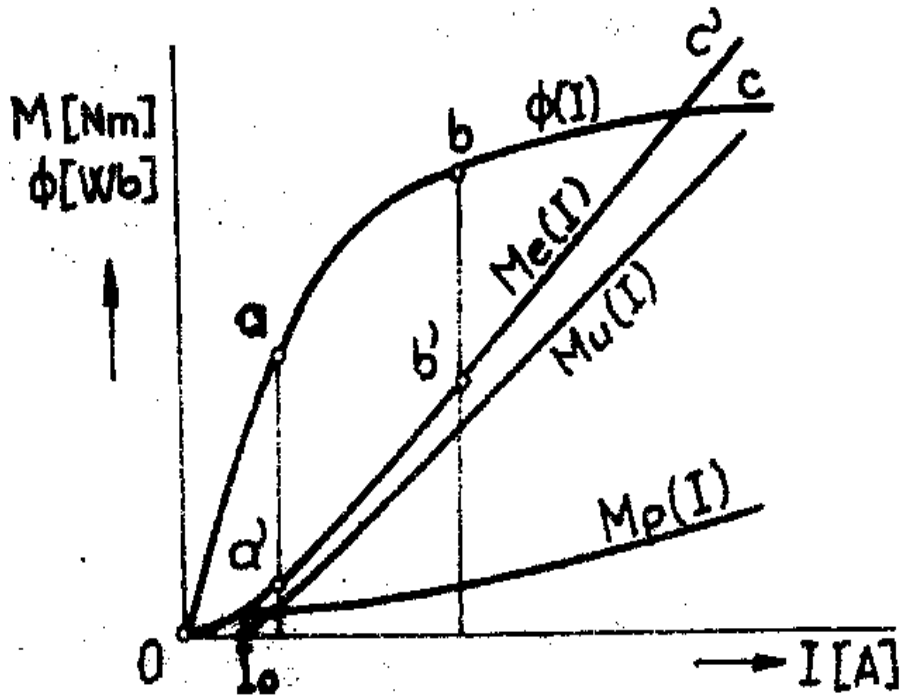
$$P_u = P_e - p [W]$$

$$p = P_m + P_{fe} + P_s$$

$$\eta_m = \frac{P_u}{P_a}$$

$$\eta_m = \frac{UI - RI^2 - p}{UI}$$

4.4 CARACTERISTICA MOMENTULUI



$$P_e = E_r I [W]$$

$$P_e = M_e \Omega [W]$$

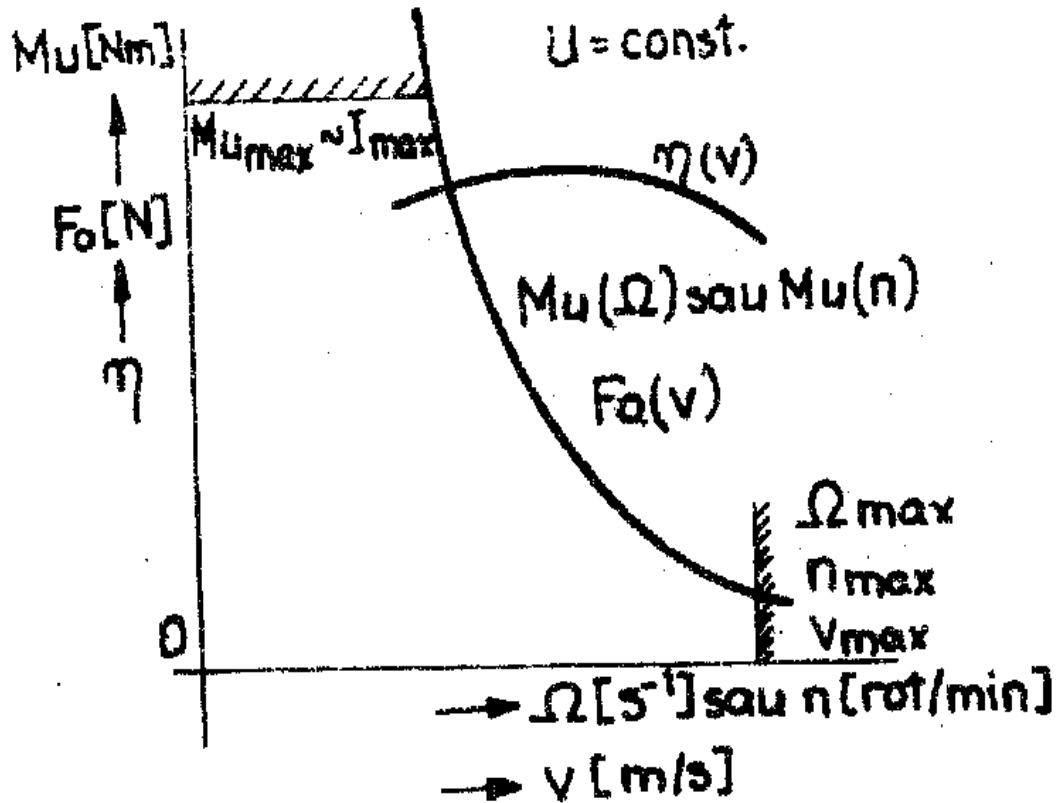
$$M_e = \frac{E_r I}{\Omega} = \frac{k \Psi \Omega}{\Omega} = k \Psi I [Nm]$$

$$M_u = \frac{P_u}{\Omega} [Nm]$$

$$M_u = \frac{k \psi I \Omega - p}{\Omega} = k \psi I - \frac{p}{\Omega} = M_e - M_p [Nm]$$

$$M_u = \frac{P_u}{\Omega} = \frac{UI}{\Omega(I)} \eta_m(I) [Nm]$$

4.5 Caracteristica mecanica si a fortei de tractiune la obada



$$M_u = \frac{30}{\pi} \left(\frac{U}{n} - \frac{E_{r0}}{n_0} \right) \eta_m$$

$$F_0 = \frac{UI}{v} \eta_m \eta_{tr}$$

η_m -randamentul MET

η_{tr} -randamentul transmisiei