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PULSED CORELESS BETATRONS.(U)
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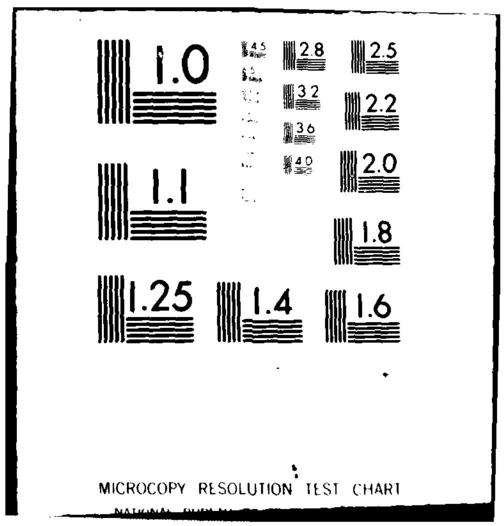
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PULSED CORELESS BETATRONS

by

A. I. Pavlovskiy, G. D. Kuleshov

FOREIGN TECHNOLOGY DIVISION

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By (10) A. I./Pavlovskiy, G. D./Kuleshov

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

2033,gw

PULSED CORELESS BETATRONS

A. I. Pavlovskiy, G. D. Kuleshov.

Work on creating induction cyclic accelerators with coreless electromagnets was begun in 1955. A year and a half later the first working designs of coreless betatrons were completed. Further development of this direction led to the creation of heavy-current betatrons in which high acceleration energy is combined with large circulating currents [1].

One of the developed versions of accelerators of this type is described below.

Electromagnet.

During development of coreless electromagnets the basic attention was given to obtaining the necessary characteristics determining the intensity of the electron beam: the maximum possible aperture of the range of stability and distribution of the magnetic field ensuring sufficiently effective axial and radial focusing of the beam. Along with this it was necessary to provide high mechanical and electrical strength of the structure of the electromagnet for achieving high values of the acceleration energy.

An electromagnet which meets these requirements to a sufficient degree is shown in Fig. 1. It consists of turns forming two plane spiral coils and a solenoid connecting them with a gap in its middle part. The principle of construction of the plane coils is clear from the figure: concentric left half-turns are joined along axis AA' by turns of the right half-plane.

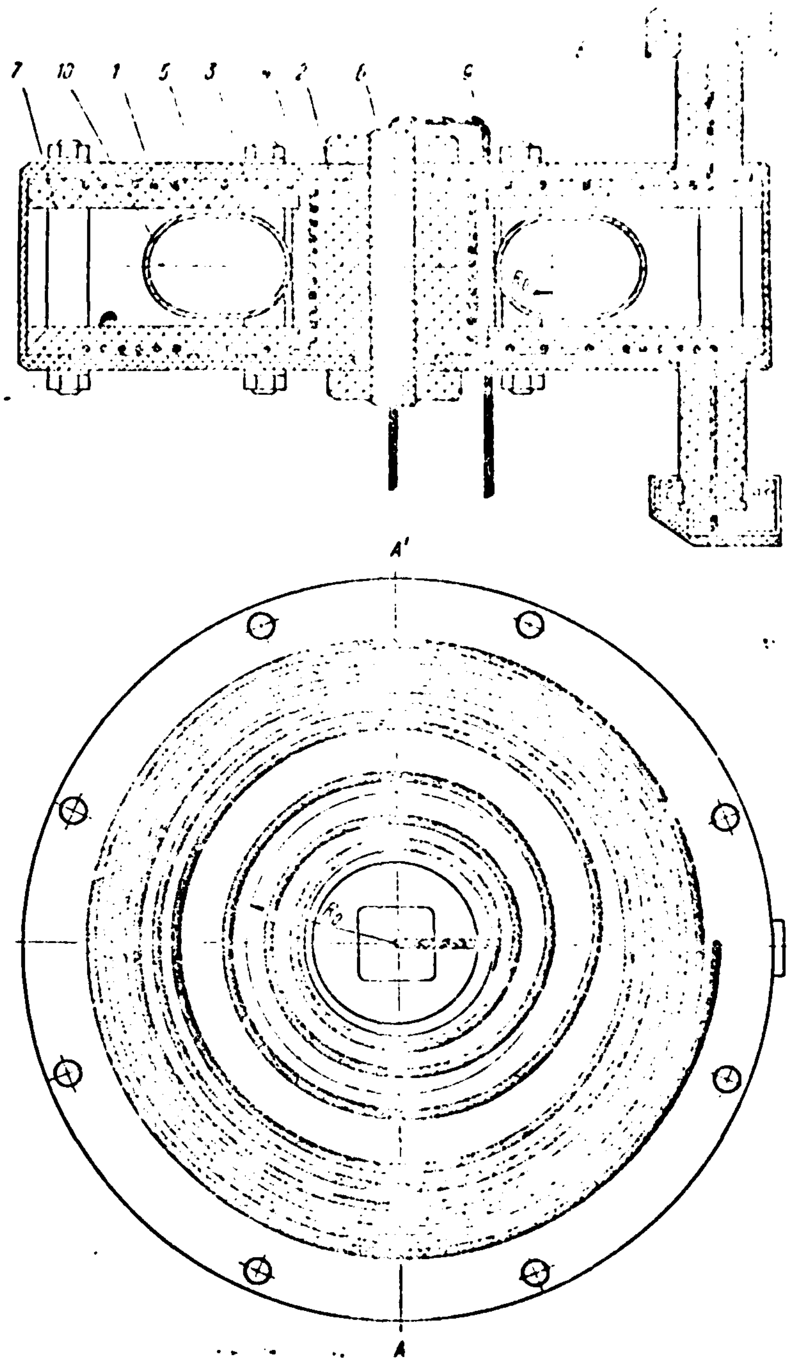

Fig. 1. Construction of a coreless betatron:

1 - turns of electromagnet; 2 - housing of central solenoid; 3 - housing of plane coils; 4 - jacket of central solenoid; 5 - clamping covers; 6 - central bolt; 7 - supports; 8 - end contacts of the electromagnet; 9 - contacts of the central solenoid; 10 - vacuum chamber.

The betatron field is characterized by the following parameters: connection between current I (A) in the winding of the electromagnet and the leading field N (V) in the equilibrium orbit of radius R_0 (cm) is determined by the ratio:

$$N=3.9\ I/R_0.$$

Azimuthal heterogeneities do not exceed 0.5 %. Distribution of the index of drop of the field n(r, z) is shown in Fig. 2.

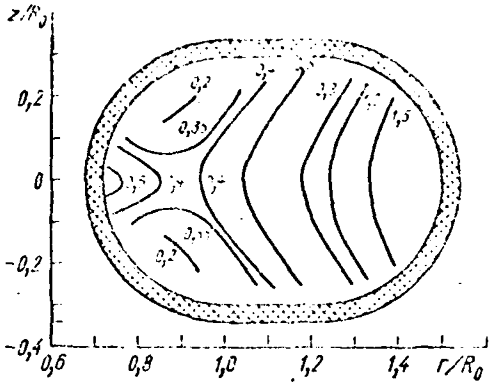

Fig. 2. Distribution of the index of drop of the field.

On the basis of this design using the method of geometric modeling several working accelerators were created with R_0 from 3.9 cm to 23.4 cm.

In the pulsed mode of operation capacitor stores were used for feed of the electromagnet. The energy capacity of the store is determined by the type of the betatron and the final acceleration energy:

$W \cong 3.5 R_0 E^2$ for $E \gg m_0 c^2$, where W is the energy capacity of the capacitor store, J; E is the final acceleration energy, MeV.

The characteristic acceleration time is from several microseconds to milliseconds. The maximum attainable acceleration energy in coreless betatrons using capacitor stores is 100 MeV.

Experiments were also performed on feeding coreless betatrons from explosive-magnetic generators MK [2].

Injection.

External, high-voltage injection is used for attaining large circulating currents in coreless betatrons. The basic type of injector is a sectioned accelerating system for a voltage up to 500 kV and currents of about 10 A with a pulse length of 10^{-7}-10^{-8} s with magnetic focusing of the beam at the output of the injector.

For introduction of the beam into the area of stability a deflector-free system has been developed for screening the electron channel at the moment of injection using a channel of highly conductive metal which causes a low rate of diffusion of the field through the wall of the channel. For localizing the distortions of the magnetic field outside the range of acceleration the input system is equipped with a special screen, the shape of which is determined by the curvature of the magnetic power lines of the betatron field at the point of its installation.

A characteristic peculiarity of injection is the operation in the range of collective interaction of the beam: the orbit of injection lies outside the range of stability (n 1.5) and capture is realized only with injection currents above a certain threshold value. For convenience of operation the vacuum chambers of the accelerators with R_0<11.7 cm are made sealed off.

Discharging the beam to the target and removal from the betatron chamber.

Depending on the requirements on the output parameters of the accelerator, in betatrons of the examined type various methods are used for displacement of the electron beam: removal of the dynamic stability at the end of the acceleration cycle, deformation of the orbit, excitation of forced betatron oscillations.

The basic employed methods of beam displacement: unbalancing of currents in the solenoid and of plane "spirals" of the electromagnet during the supply of current pulses to the places of joining of these elements and the stimulation of local disturbances of the leading field using sector turns. The indicated systems of discharge make it possible to displace beams to the target of the accelerator during 10^{-8} to 10^{-5} s and to obtain pulses of bremsstrahlung of a corresponding duration.

In some cases the accelerated electron beam was removed from the betatron chamber. The basic diagram of removal: throwing of the electron beam, locally excited in the equilibrium orbit, into the ferromagnetic cone channel with its subsequent transport by a longitudinal magnetic field and with compression by a short-focus coreless magnetic lens. Feed of the systems of transport and focusing are combined with feed of the electromagnet. The efficiency of removal in the range of 5-30 MeV was 65 $^{0}/_{0}$. The beam was focused on an area of about 0.5 cm².

Heavy-current coreless betatrons may be used as generators of powerful pulses of bremsstrahlung in industrial flaw detection, in particular in the flaw detection of moving objects, in the investigation of rapidly proceeding processes, etc.

LITERATURE.

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