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TRANSLATION

A DEVICE FOR THE DETERMINATION OF CORE FREQUENCY PROPERTIES IN THE RE-MAGNETISATION PROCESS ALONG HYSTERESIS SYMMETRIC CYCLES CLOSE TO A LIMITING HYSTERESIS LOOP

By

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FOREIGN TECHNOLOGY DIVISION

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AIR FORCE SYSTEMS COMMAND

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A DEVICE FOR THE DETERMINATION OF CORE FREQUENCY PROPERTIES IN THE RE-MAGNETISATION PROCESS ALONG HYSTERESIS SYMMETRIC CYCLES CLOSE TO A LIMITING HYSTERESIS LOOP

E. F. Berezhnoy

In the evaluation properties of magnetic cores used in switching circuits of automatic devices and computing techniques, an important role is played by the functions which show the nature of the change in the output signal of the core, in connection with a change of the frequency of its re-magnetisation process in the pulse rates along the cycles close to a limiting loop. The necessity of determining the characteristics of this kind is dictated by the following considerations. The dissipation of thermal energy in the body of the core in a real system brings about an increase in its temperature and a corresponding change of magnetic properties. Property changes are expressed in the change in amplitude and pulse form e.m.f. on the outgoing coil of the core with a change of the remagnetisation frequency and of other invariable conditions. Thus the upper limit of the working frequency band is determined along with the limitation in speed of the pulse remagnetisation of the core, as well as the limitation of frequency of remagnetisation by the temperature resultant affecting the magnetic properties. Especially essential is the knowledge of the frequency-temperature relations for materials with a low value Curie point or with high specific losses on remagnetisation. A comparison of the frequency-temperature relationship with a direct measurement of the temperature of the core gives a criteria for the evaluation of the construction of the core (material and geometry of the casing, the thickness of the inter-coil insulation, the affect of possible overflow, etc.).

Frequency-temperature relations cannot be replaced by those temperature characteristics of the cores, which are determined

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by means of heating up the core from an outside-thermal source and its remagnetisation by single impulses. Such characteristics show the change of magnetic and impulse properties in relation with the temperature. However, they do not contain the data about the magnitude of the excess of the core temperature over the surrounding agents, conditioned by the losses in the core with the concrete conditions of the remagnetisation.

The device described below, allows for the determining of the frequency and frequency-temperature relations of ferrite and band magnetic cores at remagnetisation frequency intervals from 10 to 1000 kilocycles. With regards to the core under investigation, the apparatus is a two channel source of rectangular current pulses of regulated length and amplitude, having a porosity in each channel equal to two.

A diagram sketch of the device is presented in Fig. 1, a principle sketch is given in Fig. 2[a]. The symmetrical multivibrator Mv, accomplished by pentodes 6P15P, gives an output fixing the remagnetisation frequency of the core. The interval of the remagnetisation frequencies is secured by a device split into two bands: from 10 to 100 kilo, and from 100 to 1000 kilo. The switching over from one band frequency to the other is brought about by a switching of the changeover capacitors in the circuits of the first tube grids of the multi-vibrator (tumbler switch Tb. 8); a continuous change of frequency within the limits of the band is achieved by a change of resistances in the circuits of the changing over discharge capacities and by a change in the setting of the discharge voltage variable resistances R_{19} and R_{21}). Oscillation from the anode of the multivibrator tube

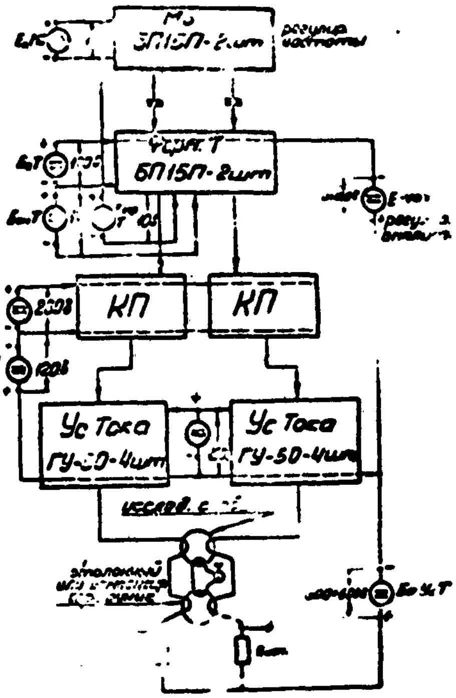


Fig. 1. A diagram sketch of a stand of frequency characteristics

is coupled through the differentiating R-C circuits into a third network of tubes (trigger T), which generates signals with front steepness, for practical purposes independent of the frequency, and without an inclination of the flat top. The trigger is thrown over from one state to another by the negative pulse, entering from the differentiating circuit to the suppressor grid of the conducting tube and effecting the beginning of the process of its cutting off. At the same time a positve pulse enters the suppressor grid of the cutoff tube through the R-C circuit from a different anode of the multivibrator. This speeds up the switching of the trigger into a new stable condition. Other elements are introduced into the trigger circuit, promoting an increase of the front steepness of the signal at the circuit outlet.

Key - Fig. 2

D - Д
L - Л
N - Н
Z - З
I - И
U - У
G - Г
Zh - Ж
R - Р
P - П
B - Б
S - С

Studied core - исслед. серд.
Compens. core- компенс. серд.

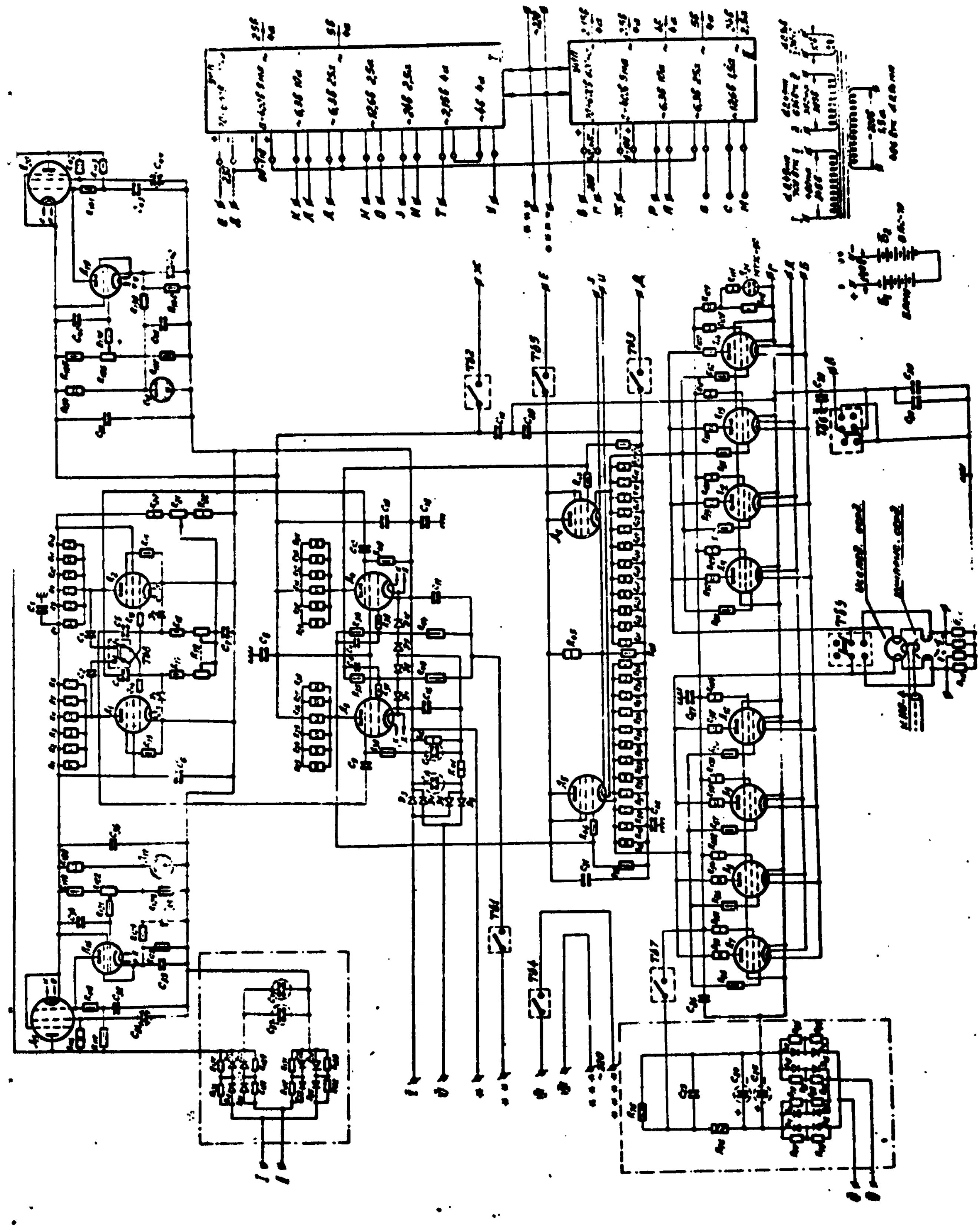


Fig. 2

4a

The anodes of the tubes are connected with the first grids of the cathode followers (KP), provided by the tubes GU-50 in the triode connected configuration. The outputs of the cathode followers are each connected separately to the in-puts of the tubes of the output stages. The amplifiers form a two-cycle circuit in relation to the core under investigation, each leg of which consists of four GU-50 type, working in a pentode system.

Two magnetising coils with the same number of turns, and a measuring coil were applied to the core under investigation. Each of the magnetising coils is hooked into the leg of the output current amplifiers. The measuring coil is connected to the "Y" input of a series oscillograph, type IO-4 or UO-1M, used as a measuring component of the described device. The amplifier vertical deflection of the oscillograph is calibrated according to sensitivity, after which the amplitude of the output signal of the core is determined by the magnitude of the (ray) deflection on the screen of the oscillograph. The amplitude of the magnetising current is measured by the drop in voltage on the measured resistances $R_{meas.}$ = 5 ohms, connected in series with the magnetising coils.

In investigating cores with small magnetic fluxes, when the signal of the direct link by air between the magnetisation coils and the computing coil is of the same order as the signal from the core magnetisation, additional compensating coils are hooked into the circuit wound onto a covering, similar to the covering of the core being investigated. The compensating measuring coil is connected to the measuring coil of the core under investigation, and the current compensatory coil is hooked in series with the remagnetisation coils. In this case, the signals of the direct link between the current and measuring windings are reduced to a significant degree.

In connection with the fact that it is extremely undesirable to apply a constant voltage in any amount significantly differing from the frame potential of the device, the anode bar of the output stages (and one end of the measuring resistances) is grounded, and the cathodes of the output tubes are connected to a negative voltage. The connections from the stages to the magnetizing coil are direct, which makes significantly easier the task of obtaining an even waveshape characteristic over a wide frequency band. Two stabilized power sources UIP-1, and also two electronic stabilizers arranged on the chassis of the device, two unstabilized rectifiers and an anode battery are used in the system of feeding the stages of the device. The feed is divided into two separate parts: power supply Mv and T and feed KP (CP) of the output stages. Both groups of feed sources are independent and are connected with one another through a regulated voltage source "amplitude regulator." With a decrease in the absolute voltage magnitude of this source, the anode potential of the trigger approximates the cathode potential of the output tubes, the total amplitude of the signal grows on the first grid and the amplitude of the current pulses increases in both channels. A separate current amplitude control for each channel is not provided.

The counter e.m.f. induced in the current widnings with remagnetisation of the core is subtracted from the voltage of the anode feed of the output stages, lowering the voltage of the anode-cathode of tubes GU-50 and, at the same time, decreasing the magnitude of the remagnetising current. Thanks to the pentode characteristic of the output tubes, the magnitude and form of the remagnetising current for all practical purposes are not related to the parameters of the core in question (for the measurement of the cores used in the switching currents), i.e., the device comes close in characteristics to the ideal current source. The output resistance forms about 5000 ohms along each of the channels. However, for working the tubes on the horizontal section of the anode characteristic, the source of the anode feed should place the voltage of the band of the pentode characteristic of tube GU-50. At that time the force, separated on the anodes of the output tubes increases with the increase of voltage of the anode feed. Therefore, the magnitude of the voltage of the source of the anode feed of the output stages is regulated, during the testing of the cores, in relation to their overall gage and the observed speed of the remagnetisation within 250-600 (v) with a visual control of the form of the remagnetising current of the oscillograph.

The relation of the amplitude of the currents in the channel with the remagnetisation frequencies at three different settings of voltage source is cited in fig. 3. The irregularity of the frequency characteristic of the current does not exceed ± 5%. The oscillograms of the waveform of one of the channels' current are illustrated in fig. 4. The rise-time of the waveform is almost 0.15 ucsec.

The method of determining the frequency characteristics of the cores, with the aid of the described device, and the diagrammatic operation of these characteristics are described in job (1). In fig. 5 are cited the relations of the output signal amplitude of the core (in volts per turn) from remagnetisation frequencies for two cores of a super thin metal ribbon of alloys with a rectangular hysteresis loop of the type 34 NKMP and 79 NMA. The amplitude value of the remagnetisation field in relation to the coercive force of the material of the core (the so-called "forcing") is indicated near each curve. Here are recorded the rises of the surface temperature of the band over the temperature of the surrounded elements, received by directly measuring the temperature with a nichro-constantan thermo-couple. The basic constructive parameters of the cores (the average diameter of the core dcp; width of the band h; number of turns of band n; the type of protective enclosure) are indicated in the figures. The cited characteristics give a notion of the nature of the tangible, observed relations and of the role of thermal effects during the working of the cores in a wide frequency band.

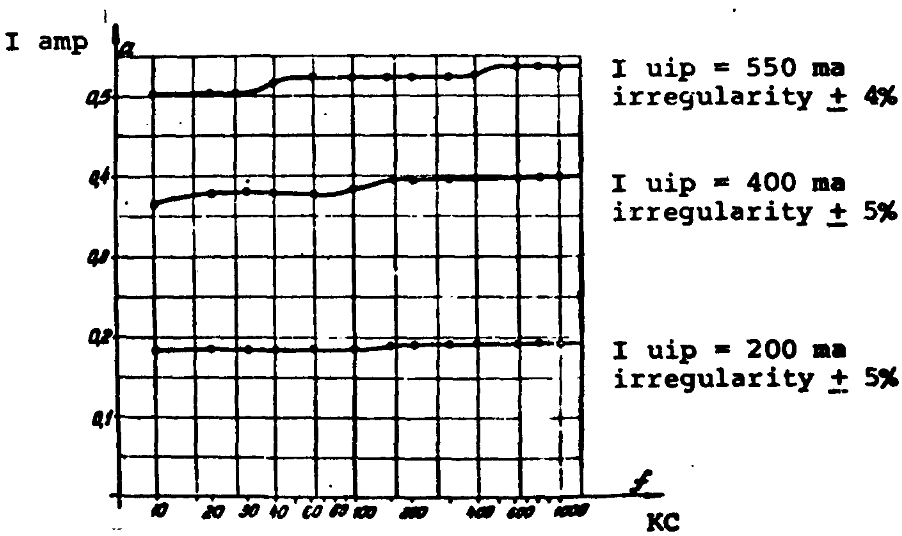


Fig. 3

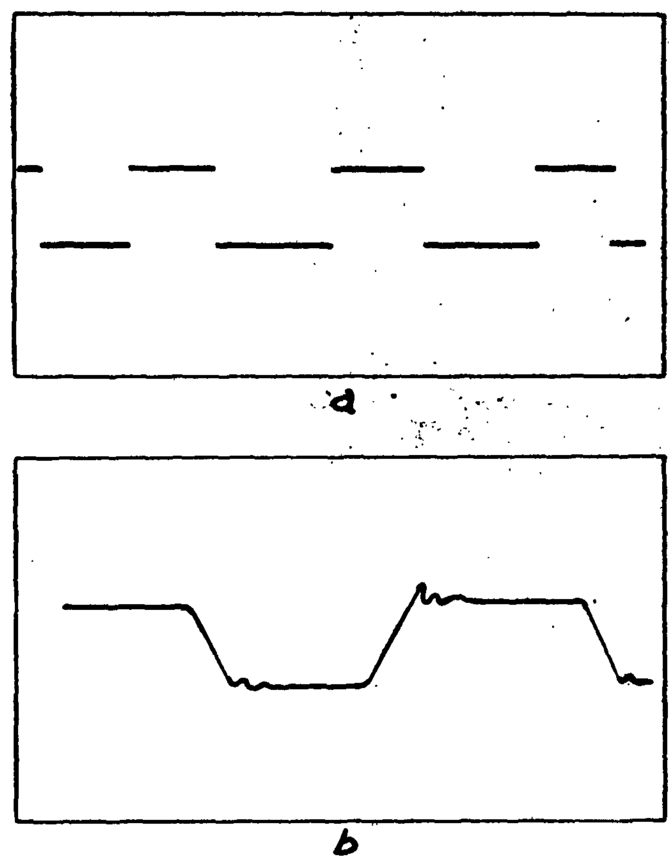
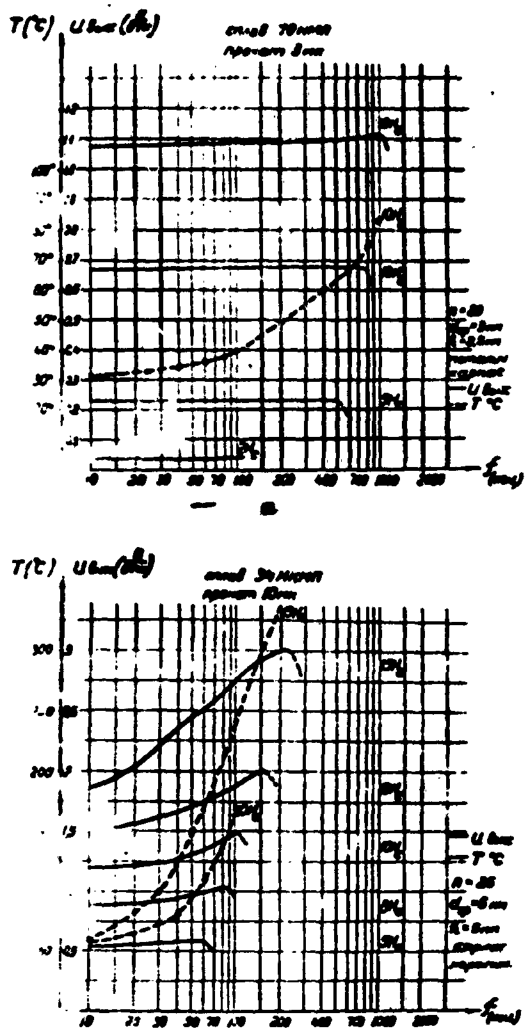


Fig. 4. Oscillograms of the signal on one of the channels the measured resistance $R_{meas.} = 5$ ohm.

(a) - frequency of pulses 50 kilocycles/sec.
(b) - frequency of pulses 300 kilocycles/sec.



Key

сплав = alloy

прокат = roll, sheet.

п = p

металич. каркас = metallic frame

КГЦ = Kilocycles/sec.

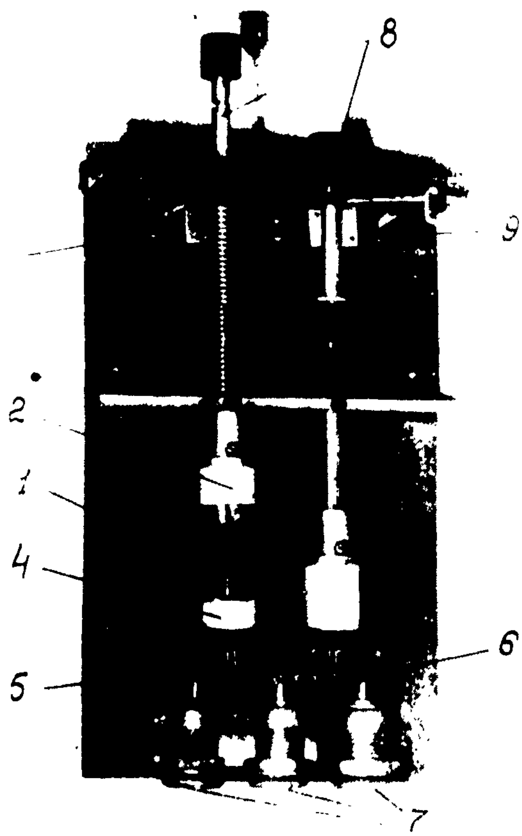
каркас керамич? = ceramic frame

Fig. 5. Frequency characteristics of toroidal magnetic cores of the bands of a super-thin roll with a rectangular hysteresis loop:

(a) the core of an alloy band, type 79 NMA, with a thickness of 3 mc;

(b) the core of an alloy band, type 34 NCMP, with a thickness of 10 mc.

A useful addition to the device is a series of contact jigs doing away with the necessity of manual winding during the testing of single layer cores. The external appearance of one of this type of nodes, intended for testing the cores of metal bands on a ceramic form or one of the ferrite cores, is shown in figure 6. The contact node has two contact knobs, one of which is shown in a closed condition, and the other in an opened condition. The core is placed into a vertical bar (1) in the center of the knob, consisting of four silver wires connected into a single unit by epoxy resin. The resin isolates the wires from each other. After splicing the outer cylindrical surfaces of the wires, they are milled until they are flat, so that each of the four wires acquires the form of a half-circle in the cross-section. The moving (upper) Part 2 - cont.



of the contact knob carries four jump bridge contacts of beryllium bronze, each of which joins, on closing the knob, one of the four segments of the central bar with the immobile contact, situated inside the frame (4) of the knob. By joining the outlets of the contacts and the central bar, it is possible to create the desired circuit on the coils in question. In the given case, it is convenient to have two single-turn magnetising coils and a double-turn measuring coil. (In fig. 6, the electronic connections are absent.) The coils of the contact node are connected to the device through terminals of a 14-contact telephone connector (6), and with the measuring oscillograph, through a coaxial connector (7). The contact node is set directly on the device in a vertical position. The contact posts (8) are held in the lower switching-on position by catch devices mechanically interlocked with microcut-off (9) switches, which break the anode feed circuit of the output tubes of the device before opening the contact knob, warding off electrocorrosion of the knob contacts and taking the voltage away from the coils.

The basic technical characteristics of the device

1.	Frequency of pulses of the remagnetising current	10 ÷ 1000 kc/sec
2.	Amplitude of current pulses along one channel	150 ÷ 550 ma
3.	Number of current channels - two	
4.	Length of front of remagnetising current	0.12 ÷ 0.15 mc sec.
5.	Maximun possible value of the counter-e.m.f. on the remagnetising coil	400 volts
6.	Output resistance of the device along each of the channels	~ 5000 ohms

The basic data of the contact nodes series

Type of	No. of conductors in central rod. post.	Overall sizes of core, mm		
		minimum diameter of aperture	maximum external diameter	maximum height
1 (fig.6)	4	2	7	8
2	8	3.5	10	9
3	12	6	13	10

SPECIFICATION OF COMPONENTS OF THE MAIN DIAGRAM OF THE DEVICE

1		2		3	
$Л_1-Л_4$	6П15П	$R_{85}-R_{92}$	510 ом	C_7	1 мкф
$Л_5-Л_{15}$	ГУ-50	$R_{93}-R_{100}$	100 ом	C_8	1000 пф
$Л_{16}, Л_{19}$	6Ж1П	$R_{101}-R_{108}$	430 ом	C_9-C_{12}	20 пф
$Л_{17}, Л_{18}$	СГ2П	R_{109}	10 ком	C_{13}	0,05 мкф
$Л_{20}$	ГУ-50	R_{110}	18 ком	C_{14}, C_{15}	10 мкф
$Л_{21}$	МТХ-90	R_{111}	68 ком	C_{16}	6800 пф
R_1-R_{12}	5,6 ком	$R_{112}-R_{115}$	10 ом	C_{17}	1 мкф
R_{13}, R_{15}	1,2 ком	R_{116}	2,4 ком	C_{18}	2000 пф
R_{14}, R_{16}	360 ом	R_{117}	100 ком	C_{19}, C_{20}	1 мкф
R_{17}, R_{18}	16 ком	R_{118}	510 ком	C_{21}	10 мкф
R_{19}	100 ком	R_{119}	120 ком	C_{22}	0,02 мкф
R_{20}	11 ком	R_{120}	6,2 ком	C_{23}	10 мкф
R_{21}	68 ком	R_{121}	300 ком	C_{24}, C_{25}	20 мкф
R_{22}	6,8 ком	R_{122}	68 ком	C_{26}	0,05 мкф
$R_{23}-R_{34}$	5,6 ком	$R_{123}-R_{125}$	68 ком	C_{27}, C_{28}	0,02 мкф
R_{35}, R_{36}	39 ком	$R_{126}-R_{133}$	51 ком	C_{29}, C_{30}	4 мкф
R_{37}, R_{38}	120 ом	R_{134}	6,2 ком	C_{31}	20 мкф
R_{39}, R_{40}	1,1 ком	R_{135}	120 ком	C_{32}, C_{33}	0,05 мкф
R_{41}	6,8 ком	R_{136}	68 ком	C_{34}, C_{35}	0,1 мкф
R_{42}	3,9 ком	R_{137}	68 ком	C_{36}, C_{39}	10 мкф
R_{42}, R_{44}	51 ком	R_{138}	300 ком	C_{37}, C_{38}	20 мкф
R_{45}	68 ком	R_{139}, R_{140}	68 ком	C_{40}, C_{41}	0,1 мкф
R_{46}, R_{47}	120 ом	R_{141}	510 ком	C_{42}, C_{43}	0,05 мкф
$R_{48}-R_{59}$	4,7 ком	R_{142}	2,4 ком	C_{44}	20 мкф
R_{60}	150 ком	R_{143}	100 ком	$Д_1, Д_2$	ДГЦ-8
$R_{61}-R_{72}$	4,7 ком	C_1	7500 пф	$Д_3-Д_6$	ДГЦ-23
R_{73}, R_{74}	1 мегом	C_2, C_3	300 пф	$Д_7-Д_{10}$	ДГЦ-8
R_{75}, R_{76}	2 ком	C_4, C_5	30 пф	$Д_{11}-Д_{26}$	Д7Б
$R_{77}-R_{84}$	51 ком	C_6	0,05 мкф		

Л = L (Tube, V)
П = P
Ж = zh
С = S
Г = G
Х = Kh
Д = D (Diode)

ом = ohms
ком = c om Kilohm
мегом = megohm
пф = micromicrofarad
мкф = microfarad

FOOTNOTE

a) The specification for the main diagram is given in the appendix.

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