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CATHODE-RAY INSTRUMENT FOR MEASURING VIBRATIONS OF MOTOR VANES IN THE "ELURA" TURBODYNAMO

E. E. Zablotskii, et al

Foreign Technology Division
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I. Ye. Zablotskiy, Yu. A. Korostelev, et.al.

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By: I. Ye. Zablotskiy, Yu. A. Korostelev, et.al.

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

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

FOLLOWING ARE THE CORRESPONDING RUSSIAN AND ENGLISH DESIGNATIONS OF THE TRIGONOMETRIC FUNCTIONS

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

CATHODE-RAY INSTRUMENT FOR MEASURING VIBRATIONS
OF ROTOR VANES IN THE "ELURA" TURBODYNAMC

A cathode-ray instrument for measuring the vibrations of rotor vanes in the "Elura" turbodynamo has been patented under authorship certificate No. 160886. The instrument allows the simultaneous measurement, on the screen of its cathode ray tube, of the amplitude of transverse oscillations in all of the rotor's vanes perceptible to contactless inductance transducers mounted on the non-rotatory parts of the machine.

However, the instrument does not permit the determination of the amplitude value of the velocities and frequency of vane oscillations, the type of vane oscillations, static deformation of the vane by centrifugal and stationary aerodynamic forces, the amplitude of torsional oscillations, or the rotary speed of the rotor. Special calibration is required before the instrument can be used to measure vibrational stresses in the vanes.

The proposed instrument contains several transducers which respond with a short electric pulse to the by-pass of the transducer by the end of the vane or some marker, such as a steel pin. One of the transducers, situated near the shaft of the turbodynamo and connected to a continuous vertical scanning generator, reacts to the marker mounted on the dynamo shaft. A second transducer is located near the vane marker, the latter taking the form of pins or notches evenly placed along the length of the rotor disc according to the number of vanes, or along a special disc sitting firmly on the dynamo shaft; a third transducer, situated opposite the peripheral section of the vane, is connected to the cathode-ray tube's modulating grid, while the fourth transducer, though located opposite the periphery, has been moved some distance from the third transducer in the direction counter to that of the rotor's rotation. The fourth transducer, as the second transducer, is connected to a manual switch joining one of the transducers to a driven sweep generator turned on with each pulse. The sawtooth voltage of the generator, dropped to zero with each following impulse, controls the horizontal movement of the beam. The fifth and sixth transducers are placed opposite the lead and trailing edge of the vane's periphery, respectively, while the fifth transducer, as the second and fourth, is connected via the manual switch to the driven sweep generator controlling the horizontal deflection of the first beam; the sixth transducer, as the third, is connected to the modulating grid.

This ensures contactless measurement of the oscillations' amplitude, the amplitude value of the velocities and frequency of bending oscillations, the angle of rotation and the amplitude of torsional oscillations simultaneously for all vanes.

A double-beam cathode-ray tube was used to make possible the simultaneous measurement of the turbodynamo's rotation speed, and thus, the acquisition of an image scale on the screen. The second beam receives the horizontal movement of sawtooth voltage of rigidly-fixed duration from the driven sweep generator started by signals from the first transducer, and vertical movement from the driven sweep generator excited by the second and fourth transducers through the switch.

So that the results of the experiment may be unambiguously attributed to the appropriate scanning speed, a time-base indicator consisting, for example, of a set of bulbs connected to a time-base switch, was placed in front of the screen of the cathode-ray tube. A generator regulated by pulse delay was connected between the pulse shapers of the second and fourth transducers and the driven sweep generator, to improve the instrument's accuracy of measurement.

To reduce the scattering of moments of pulse-feed while the markers and vane tips are passing by the transducers, the amplifier-pulse shapers consist of one or several amplifier stages, an amplifier stage with symmetrical limiting of the upper and lower amplitude boundaries, a rectifying amplifier stage, a differentiating circuit and a delayed blocking oscillator.

The layout of the instrument is shown in the diagram.

A single marker is placed on the dynamo shaft, and the first transducer (1) is situated opposite, emitting one pulse during each rotation of the dynamo. This pulse acts through the transducer's pulse shaper (2) on the continuous vertical scanning generator (3) deflecting the first beam and on the driven sweep generator (4) horizontally deflecting the second beam of the dual-beam cathode-ray tube (5). The pulse, acting on the generator continuously scanning the vertical beam (3), causes the oscillation to be disrupted, and the beam is quickly transferred to a higher position; the pulse then begins to descend from this higher position until the next pulse appears.

The pulse acting on the driven sweep generator (4) controlling the horizontal deflection of the second beam starts the generator, producing a time-base of rigidly-fixed duration. This duration is set beforehand with the manual switch (6), and is signaled by the time-base indicator (12). A single marker is mounted on the dynamo's disc or on a special disc fastened to the shaft opposite each vane. The second transducer (7), placed opposite these markers, controls the driven sweep generator (10) through the manual switch (8) connected to the transducer's own pulse shaper (9). The sawtooth voltage causes the horizontal deflection of the first beam and the vertical deflection of the second beam. The rotation speed of the dynamo can be judged from the reference mark for the second beam designated II. A delay line (12) is placed between the pulse shaper and the horizontal deflection plates deflecting the first beam to improve the accuracy of the reading.

The third transducer (13), located opposite the peripheral section of the vane, is connected via its pulse shaper (14) to the modulating grid (15) for the first beam of the cathode-ray tube, so that an image in the form of an intense dot will appear on the screen the moment a pulse appears.

The fourth transducer (16) is connected through the manual switch in a manner similar to the second transducer, but is located together with the third transducer in the dynamo's housing, and some distance apart from the third in the direction opposite the direction of the rotor's rotation.

The fifth and sixth transducers (17) and (18) are installed in the housing of the dynamo opposite the lead and trailing edges of the vane, respectively. The fifth transducer is connected through the manual switch (8) in a manner similar to the second and fourth transducers, while the sixth transducer is connected through the switch's second plate in a manner similar to the third transducer.

The measurements are taken in the following manner:

a) measurement of the amplitude and movement of the tips of the vanes.

The driven sweep generator, turned on by the second transducer during the by-pass of each vane marker (19), forces the beam to move along the screen of the cathode-ray tube, drawing the lines (20); the number of the lines corresponds to the number of vanes. As the end of the vane passes by the third transducer, a luminous point appears on each of the lines, with the point remaining stationary in the absence of vane oscillations. In the presence of such oscillations, the point is washed out into the strip (21), the length of which is proportional to the amplitude of the vane tip's movement, since the vane passes by this transducer in different stages of oscillation.

b) measurement of the amplitude of the velocity of oscillations of the vane tip.

The driven horizontal sweep generator is started in this instance by the fourth transducer, as the end of the vane passes by the latter, and the luminous point appears, as usual, upon the passage of the tip of the same vane by the third transducer. The distance between the point and the beginning of the line will depend on the speed at which the end of the vane moves from one transducer to the other. Since when the frequency of the vane's oscillations is not a multiple of the rotation speed, the vane will arrive at the fourth transducer in different stages of oscillation--and hence with a different speed--the distance from the luminous point to the beginning of the line will be altered: the point will be washed away into a line whose length is proportional to the difference between the maximum and minimum speeds of the vane tip, e.g. the amplitude of the velocity of vane tip oscillations. The distance between the third and fourth transducers is chosen in such a manner that the oscillation rate during the passage of the vane tip between them will remain essentially the same.

The frequency of the vane oscillations is determined from the values measured for the range of the movement and rate of oscillation.

c) determination of the angle of overspeeding and torsional oscillations of the vane.

For this measurement the fifth and sixth transducers are placed so that if the profile of the vane is not deformed, the vane passes both transducers simultaneously and the luminous point on the screen falls on the beginning of the line. During overspeeding of the vane, its corresponding point passes under the sixth transducer later than the other point on the vane under the fifth transducer, so that the luminous point is moved along the horizontal line corresponding to the given vane to a value proportional to the angle of overspeeding and inversely proportional to the peripheral speed.

In the presence of torsional oscillations the luminous point will be washed away in the line whose length is proportional to the range of the oscillation angle.

d) measurement of the rotor's rate of rotation.

The rate of rotation of the rotor is measured by markings corresponding to the passage of the vane through a time-base of rigidly-fixed duration.

The transducer, starting the driven horizontal sweep generator, is placed somewhat in advance of the transducer which establishes the luminous point on the screen. This advancement proves unnecessary when the peripheral speeds are low. A delay line allowing the use of greater scanning rates is placed between the transducer and the driven sweep generator, to improve the precision of work in this range.

In contrast to the instrument with patent no. 160886, in which the pulse transducer operates once a certain amplitude has been attained, in the instrument proposed the transducer is actuated the moment the value of the pulse passes through zero (at the moment of change of markers), thus keeping the moment of actuation from being scattered.

Purpose of the Invention

1. The cathode-ray instrument for the measurement of oscillations of the rotor vanes of a turbodynamo, consisting of transducers mounted on the non-rotational parts of the dynamo reacting with short electric pulses to the passage of vane tips or markers in the form, for example, of steel pins, a cathode-ray tube and electronic device for pulse-shaping and controlling the cathode-ray tube beams, is distinguished by the fact that with the aim of contactless measurement of the oscillations' amplitude, the amplitude value of the speed and frequency of bending oscillations, the angle of rotation and the range of torsional oscillations simultaneously for all vanes, it contains several above-mentioned transducers, one of which, placed near the shaft of the turbodynamo, is connected to a continuous vertical scanning generator and reacts to the marker situated on the dynamo shaft; a second transducer is located near the vane markers, the latter being made in the form of pins or notches evenly placed along the length of the rotor disc according to the number of vanes, or along a special disc sitting firmly on the dynamo shaft; a third transducer, situated opposite the peripheral section of the vane, is connected to the cathode-ray tube's modulating grid, while

the fourth transducer, though located opposite the periphery, has been moved some distance from the third transducer in the direction counter to that of the rotor's rotation; the fourth transducer, as the second transducer, is connected to a manual switch joining one of the transducers to a driven sweep generator which is started up by each pulse; the sawtooth voltage from the generator controls the horizontal movement of the beam; the fifth and sixth transducers are placed opposite the lead and trailing edge of the vane's periphery, respectively, while the fifth transducer, as the second and fourth ones, is connected via the manual switch to the driven sweep generator controlling the horizontal deflection of the first beam; the sixth transducer, as the third, is connected to the modulating grid.

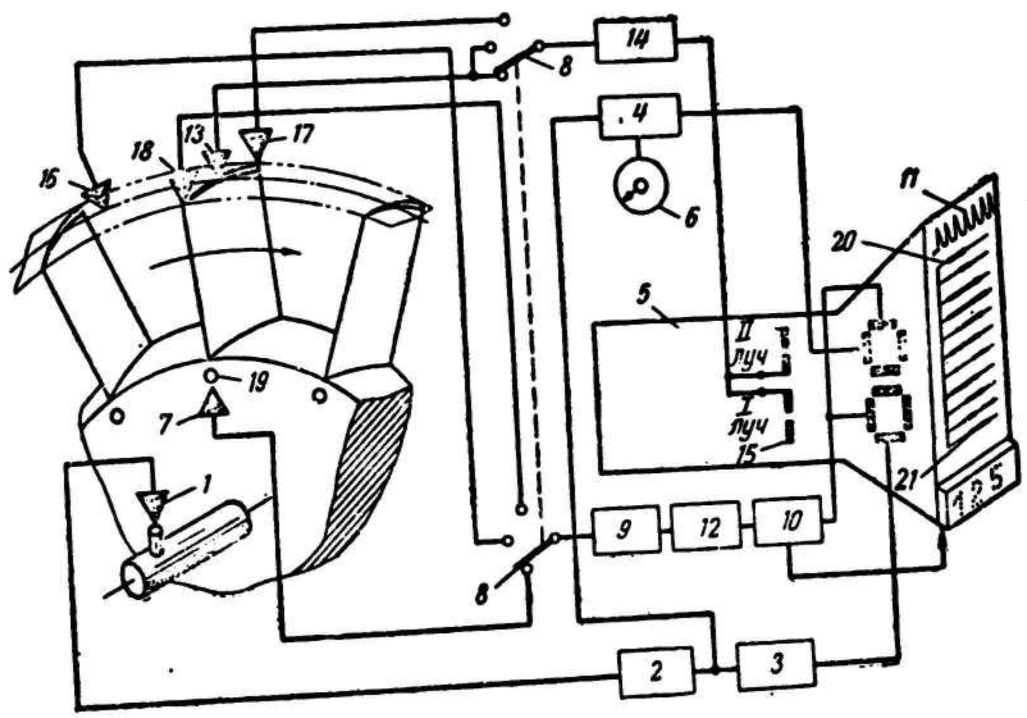
2. The instrument in paragraph one is distinguished by the fact that with the aim of simultaneously measuring the turbodynamo's speed of rotation so that an image scale may be obtained on the screen, a double-beam cathode-ray tube is used; the tube's second beam receives the horizontal movement from the driven sweep generator of the sawtooth voltage of rigidly fixed duration established earlier by signals from the first transducer placed near the shaft of the dynamo, and vertical movement from the driven sweep generator excited through the switch by the second and fourth transducers.

3. The instrument in paragraph one is distinguished by the fact that with the aim of unambiguously attributing the results of the experiment to the appropriate scanning speed, a time-base indicator consisting, for example, of a set of bulbs connected to a time-base

switch, is placed in front of the cathode-ray tube's screen; by connecting the bulbs to the time-base switch, each base established corresponds to a certain combination of switched-on bulbs.

4. The instrument in paragraph one is distinguished by the fact that with the aim of using greater scanning speeds to improve the accuracy of measurement, a generator controlled by pulse delays connects the driven sweep generator with the pulse shaper of the second or fourth transducer.

5. The instrument in paragraph one is distinguished by the fact that with the aim of reducing the scattering of pulse-feed moments during the passage of the markers and vane tips past the transducers, the amplifiers-pulse shapers consist of one or several amplifier stages, an amplifier stage with symmetrical limiting of the upper and lower bounds of the amplitude, a rectifying amplifier stage, a differentiating circuit and a delayed blocking oscillator, which emits a short-lived square pulse at the moment the sign of the pulse emitted by the transducer changes.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