Electrical activity of the human uterus in vivo in the phases of the menstrual cycle

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Summary: The Authors established a method for detecting the electrical activity in the human uterus in vivo in order to observe possible variations in the two phases of the menstrual cycle. The results of surveys on six women, both in the follicular and in the luteal phase, as well as the spectral analysis, indicated an increase of frequency and intensity in the follicular phase.

Key words: Electrical activity, uterus.

INTRODUCTION

The uterine muscles have an electrical activity similar to that of the smooth muscles of the falloppian tubes (1).

Surveyes carried out on different animal species showed that the electrical activity of the uterine muscles changes in terms of frequency, direction and propagation speed according to the different phases of the estrous cycle and during pregnancy (2, 3, 4). Considerable experience has been acquired regarding the pregnant human uterus from an electrical (5, 6, 7) and from a mechanical (8, 9) point of view.

Experiments in the non-pregnant human uterus have been numerous from a mechanical point of view (10, 11, 12, 13), whereas rather limited from an electrical point of view (14(.

The well-known studies of Serr and coll. (15, 16) pointed out three different types of electrical potentials which vary according to the different phases of the menstrual cycle.

All the works on electrical activity of the human uterus in vivo showed the fast activity, neglecting the slow one.

We therefore established a method for studying electrical activity in non pregnant in vivo human uteri, in order to look for connections between slow (BSER) and fast electrical activity in the different phasese of the menstrual cycle, since variations of the electrical activity of the human uterus might be at the root of anatomic, or functional disorders such as dysmenorrheas, anomalies of the implant of fertile eggs etc.

MATERIAL AND METHODS

The study was performed on six women between 25 and 39 years of age with regular menstrual cycles as to rhythm, quantity and duration (28+4 days), among whom 2 were nulliparae and 4 pluriparae (Fig. 1), with no disorders of the uterus or the ovaries.

The two phases of the menstrual cycle were determined according to the history of the last

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No.	Name	Age	Obstetric story A/B/C/D
1	M. G.	25	0/0/0/0
2	E. M.	35	4/0/2/4
3	R. A.	39	2/0/1/2
4	C. L.	28	0/0/0/0
5	C. M.	35	3/0/2/3
6	I. E.	29	2/0/2/2

P.S.: A = Number of pregnancies
B = Number of premature deliveries
C = Number of abortions
D = Number of live births

Fig. 1. — Age and Obstetric story of women.

N°	Name	1st dosage	2nd dosage
1	M. G.	6°	24°
2	E. M.	7°	21°
3	R. A.	10°	24°
4	C. L.	8°	28°
5	C. M.	11°	23°
6	I. E.	12°	26°

Fig. 2. — Days of the menstrual cycle on which samplings for hormonal dosage were taken.

menstrual period (Fig. 2), and to hormonal dosage carried out with the RIA method (Fig. 3).

Recordings were made of one hour in each phase of the menstrual cycle. We used a special coil which was specifically devised in our istitute: it was made af a 15 cm polyethelene tube, having a 1.5 mm diameter with three pairs of two electrodes each at a distance of 1 cm the one from the other (Picture 1).

The electrodes were made of copper wires. The coil was sterilized with ethylene oxide and properly ventilated. It was then placed in the uterine cavity after disinfection of the genitalia and hysterometry. Subsequently, a pelvic echotomography was performed to check the proper positioning of the coil (Picture 2).

Electrical signals obtained from the intrauterine electrodes were sent simultaneously to an 8 channel REEGA MINUIT ALWAR TR paper recorder, with a 2 mm/sec running speed for immediate visual analysis.

After an adequate filtering of higher frequences at 0.5 Hzc, recordings were made with a HP3968A magnetic tape recorder for subsequent computerized processing One of the channels was to control respiratory frequency.

1 and 5 time constants were employed for the detection of fast and slow electrical activity.

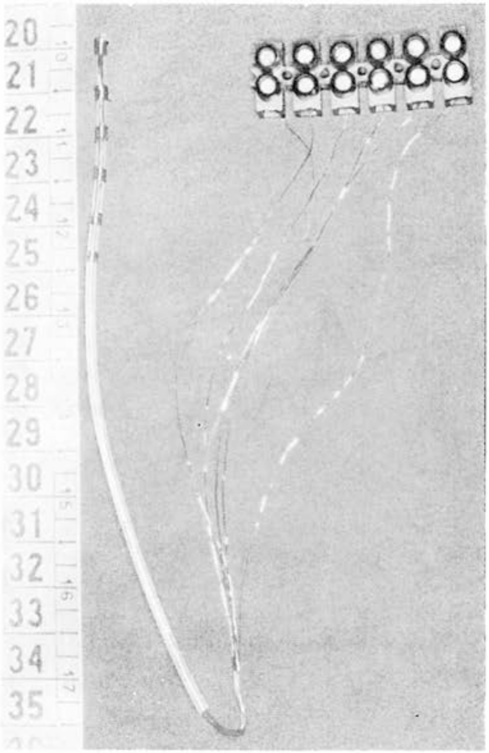
Computer data (Data General Eclipse S130) were preceded by antiliasing filterimg with low-pass filters having 12.8 Hzc shear frequency, and by a sampling procedure carried out with a 16 byte-digital analogic converter. Computer signals were reprocessed in order to provide the first data for subsequent visual and mathematical statistical analyses.

Specifically, the following algorythms were carried out: the " prewhitening " which gives a spectral analysis of signals subtracting noise phenomena that might interfere (Fig. 4); the FFT (Fast Fourier Transform) which adopts the Welch method on 256 samples with a frequency discrimination of 0.039 Hzc and a 50% overlapping. The FFT was applied both throughout the whole (60-minute period (Fig. 5) and on 4-minute periods (Fig. 6).

Signal frequency and amplitude were measured for each of the 6 channels in every subject.

N°	Name	FSH mU/ml		LH mU/ml		Estradiol pg/ML		Progesterone ng/ml		Testosterone ng/ml		PRL ng/ml
		1°	2°	1°	2°	1°	2°	1°	2°	1°	2°	
1	M. G.	17	2.8	12	10.5	65	160	0.5	20	0.8	0.8	11
2	E. M.	40	1.5	190	3.2	15	48	1.6	11	1.1	0.8	8
3	R. A.	14	4.4	15	12	80	100	0,1	7	0.3	0.5	8,5
4	C. L.	11	7.5	10	23	44	130	0.5	3,4	0.8	1.5	7,5
5	C. M.	13	6	15	8.5	70	75	0.1	12	0.3	0.4	8.5
6	I. E.	11	5	12	9.5	50	95	0.1	3.8	0.6	0.5	8.5

Fig. 3. — Hormone dosage with RIA method in the follicular phase (1st) and in theluteal phase (2nd).



Picture 1. — Polyethylene coil with terminal electrodes for intrauterine electrical survey.

RESULTS

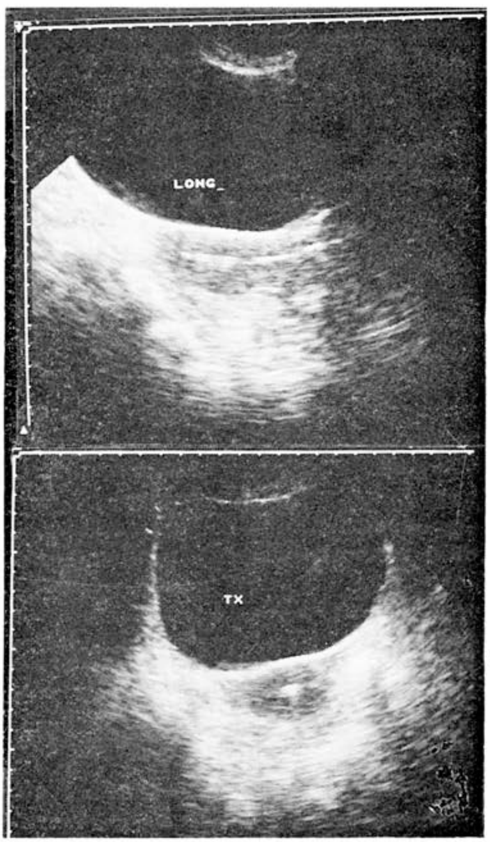
The study of paper plots points out that both in the follicular and in the luteal phase there is slow and fast electrical activity.

The follicular phase: in this phase, the slow activity (BER) which was homogeneous throughout the organ, had a frequency that ranged from 2 to 6 cycles/minute and a maximum speed amplitude that reached 3500 microvolts (Fig. 7).

The fast activity was detected in all portions of the uterus and appeared with isolated spikes (Fig. 8) or wave trains (Fig. 9, 10) which had a maximum duration of 25 seconds, frequency between 2 and 4 cycles/minute and a 250 microvolts amplitude.

The luteal phase: in this phase as well, slow activity was always present with a 2-4 cycles/minute frequency which was rhythmically regular in 3 cases only (Fig. 11) and an amplitude which reached, in some cases, 900 microvolts (fig. 12).

The fast activity was detected throughout the whole organ and was more evident in only three cases as isolated spikes (fig. 13) and wave trains (fig. 14); the latter had a frequency ranging from 2 to 3 cycles/minute and an amplitude which reached 100 microvolts.



a

b

Picture 2. — Echotomographies showing the positioning of the coil for uterine electrical survey: *a)* longitudinal section; *b)* transverse section.

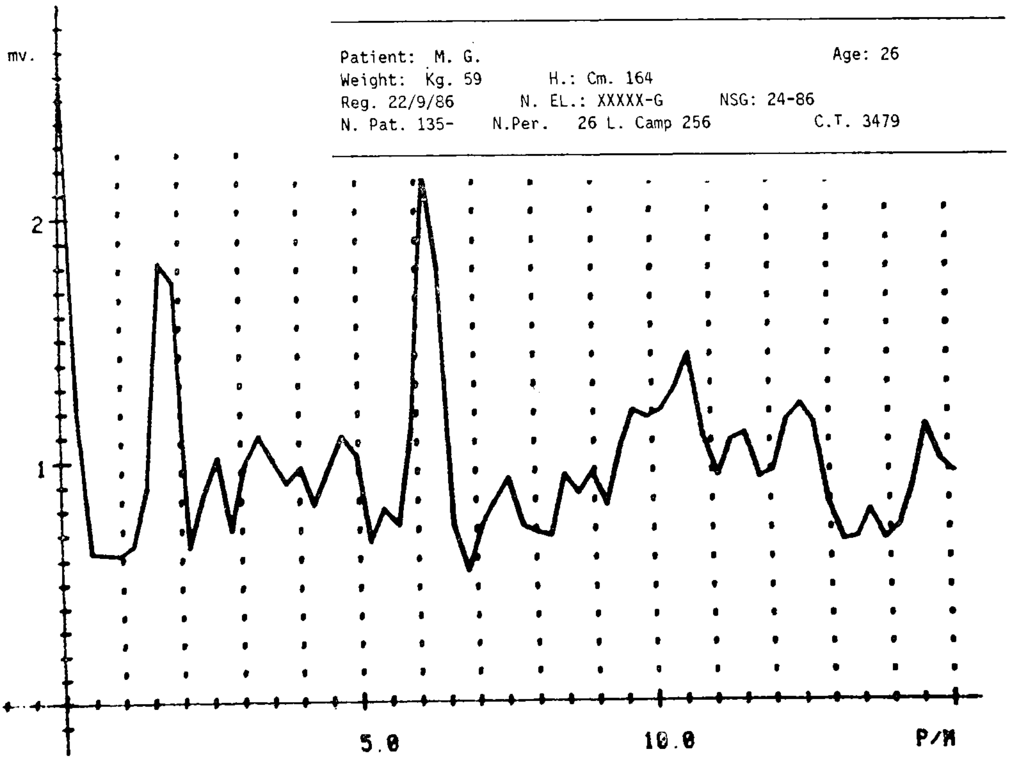

mv.
Patient: M. G.
Age: 26
Weight: Kg. 59
H.: Cm. 164
Reg. 22/9/86
N. EL.: XXXXX-G
NSG: 24-86
N. Pat. 135-
N.Per. 26 L. Camp 256
C.T. 3479
2
1
5.0
10.0
P/M

Fig. 4.

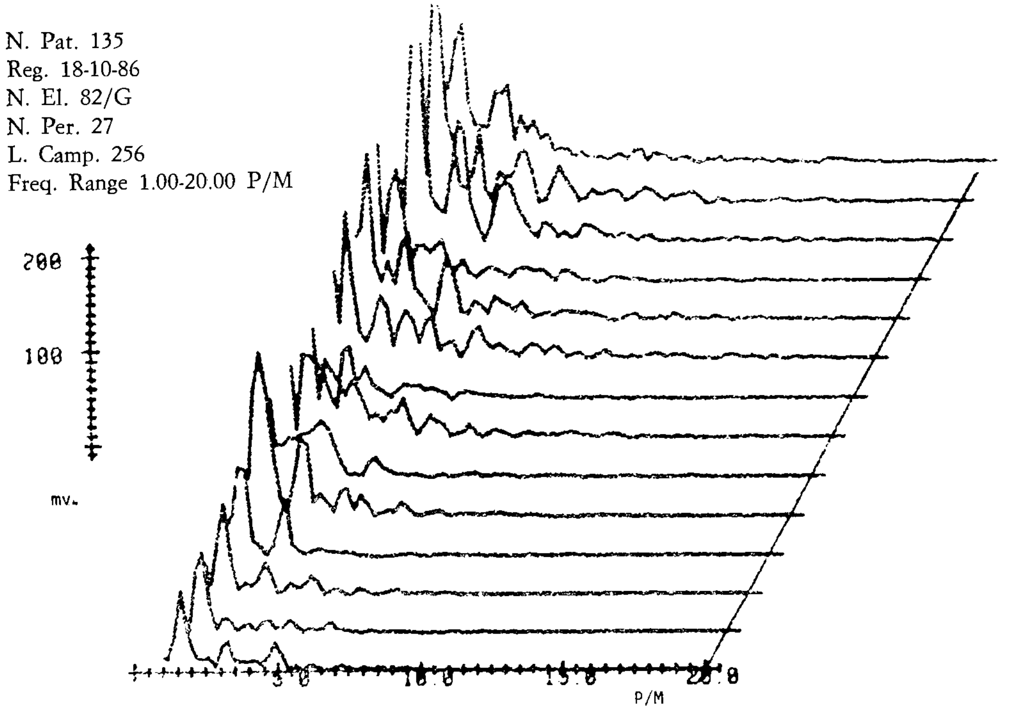
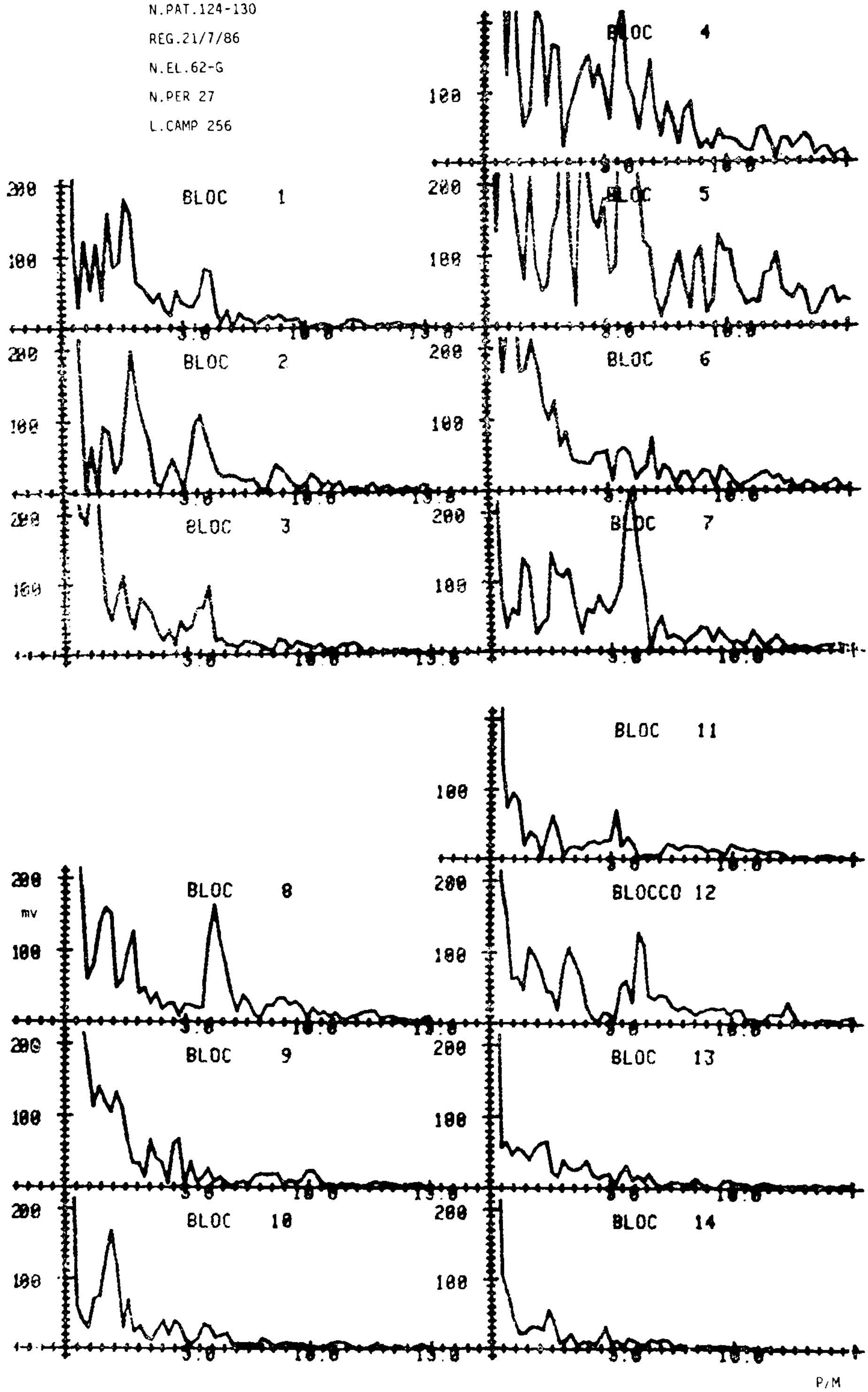

N. Pat. 135
Reg. 18-10-86
N. El. 82/G
N. Per. 27
L. Camp. 256
Freq. Range 1.00-20.00 P/M
200
100
mv.
P/M

Fig. 5.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REG.21/7/86
N.EL.62-G
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BLOC 2
BLOC 3
BLOC 4
BLOC 5
BLOC 6
BLOC 7
BLOC 8
BLOC 9
BLOC 10
BLOC 11
BLOCCO 12
BLOC 13
BLOC 14
200
100
mv
P/M

Fig. 6.

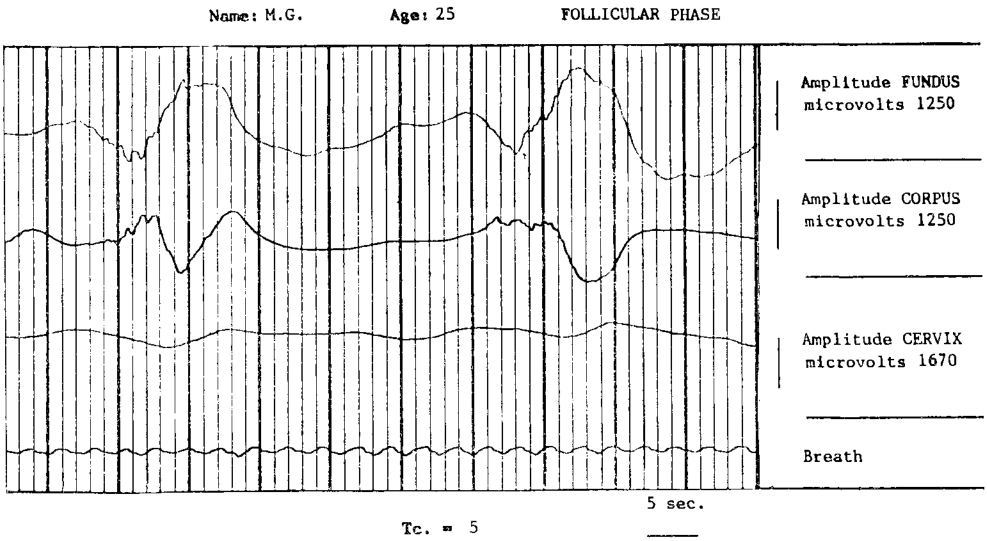
Name: M.G.
Age: 25
FOLLICULAR PHASE
Amplitude FUNDUS microvolts 1250
Amplitude CORPUS microvolts 1250
Amplitude CERVIX microvolts 1670
Breath
5 sec.
Tc. = 5

Fig. 7.

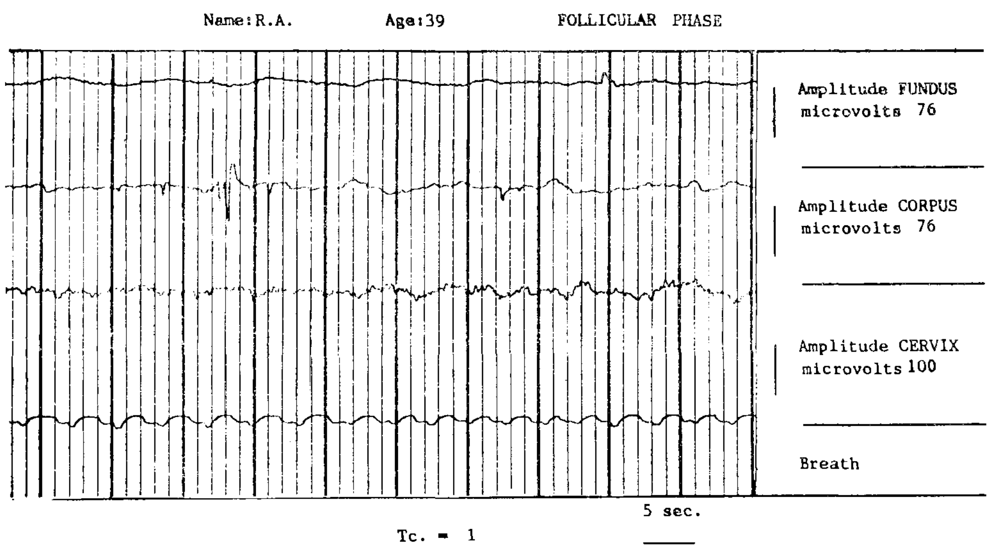
Name: R.A.
Age: 39
FOLLICULAR PHASE
Amplitude FUNDUS microvolts 76
Amplitude CORPUS microvolts 76
Amplitude CERVIX microvolts 100
Breath
5 sec.
Tc. = 1

Fig. 8.

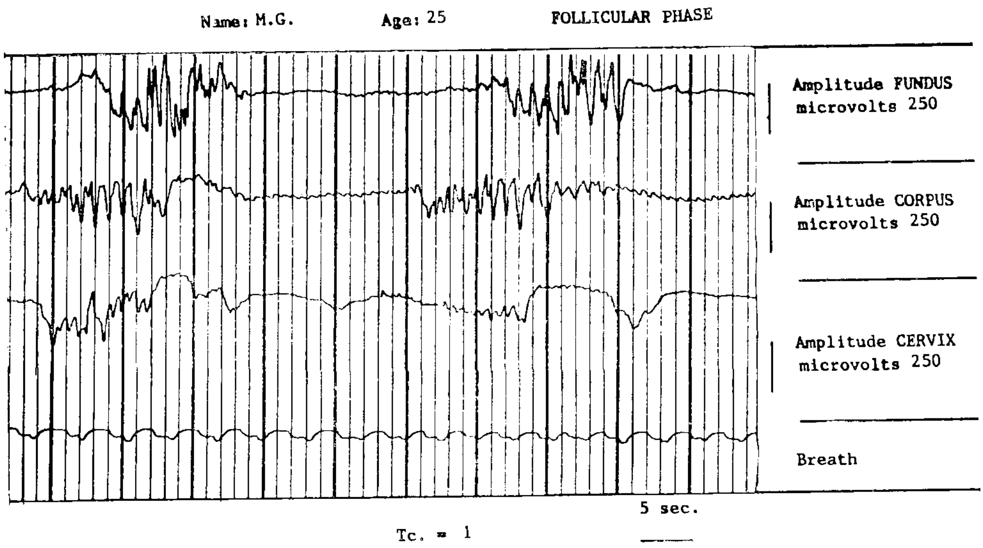
Name: M.G.
Age: 25
FOLLICULAR PHASE
Amplitude FUNDUS microvolts 250
Amplitude CORPUS microvolts 250
Amplitude CERVIX microvolts 250
Breath
5 sec.
Tc. = 1

Fig. 9.

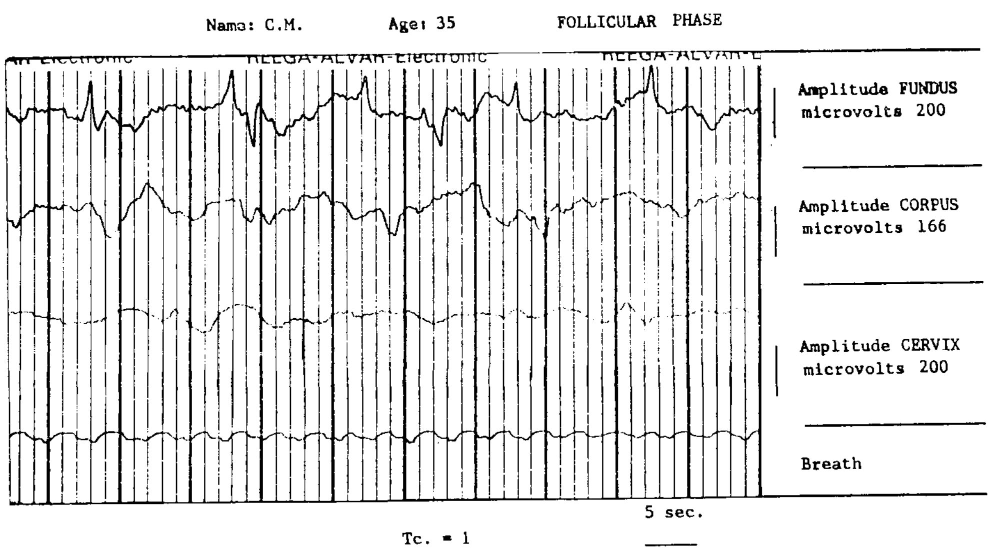
Name: C.M.
Age: 35
FOLLICULAR PHASE
Amplitude FUNDUS microvolts 200
Amplitude CORPUS microvolts 166
Amplitude CERVIX microvolts 200
Breath
5 sec.
Tc. = 1

Fig. 10.

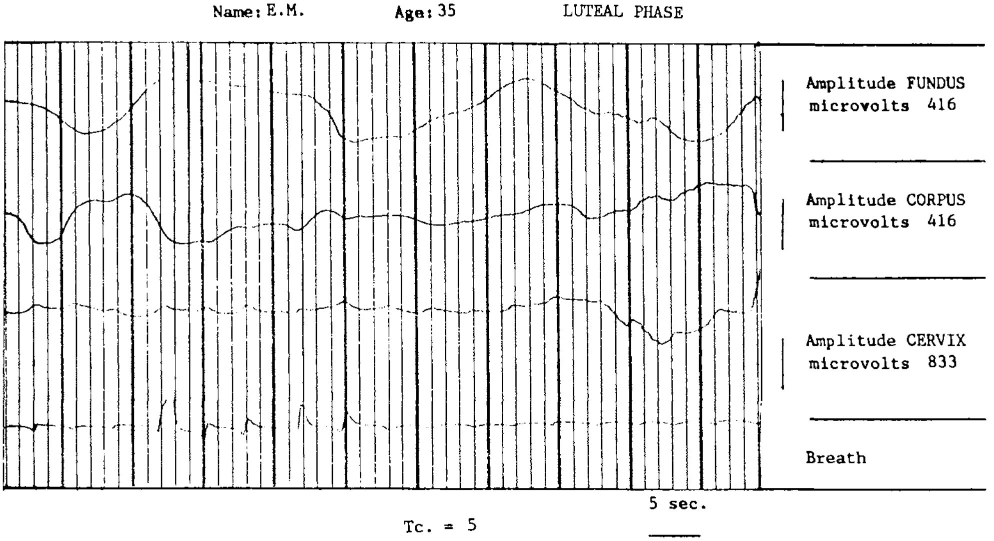
Name: E.M.
Age: 35
LUTEAL PHASE
Amplitude FUNDUS microvolts 416
Amplitude CORPUS microvolts 416
Amplitude CERVIX microvolts 833
Breath
5 sec.
Tc. = 5

Fig. 11.

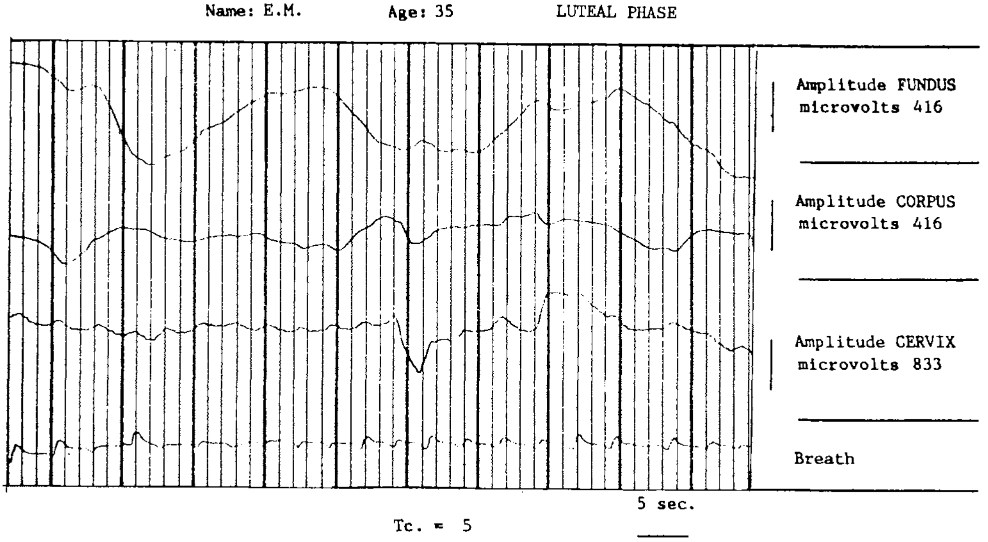
Name: E.M.
Age: 35
LUTEAL PHASE
Amplitude FUNDUS microvolts 416
Amplitude CORPUS microvolts 416
Amplitude CERVIX microvolts 833
Breath
5 sec.
Tc. = 5

Fig. 12.

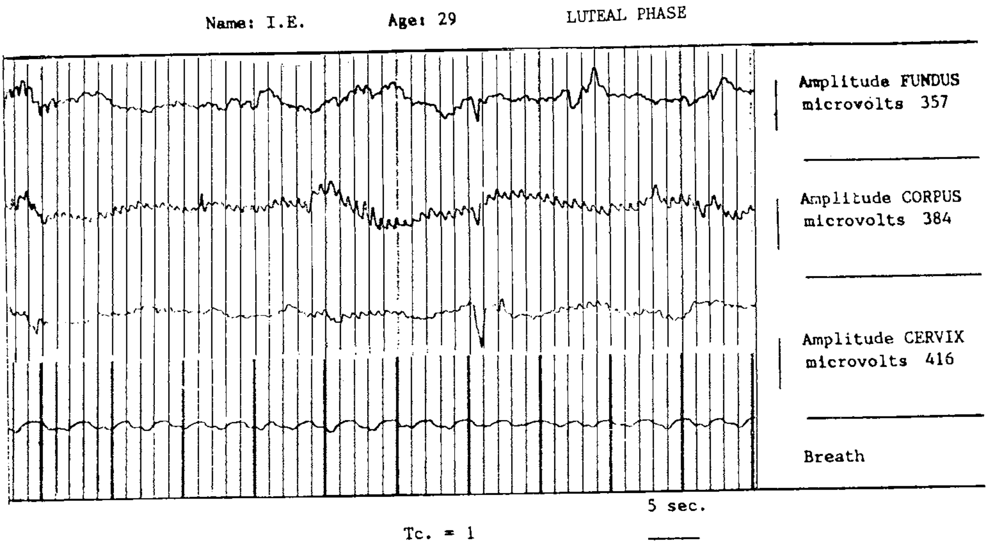
Name: I.E.
Age: 29
LUTEAL PHASE
Amplitude FUNDUS
microvolts 357
Amplitude CORPUS
microvolts 384
Amplitude CERVIX
microvolts 416
Breath
5 sec.
Tc. = 1

Fig. 13.

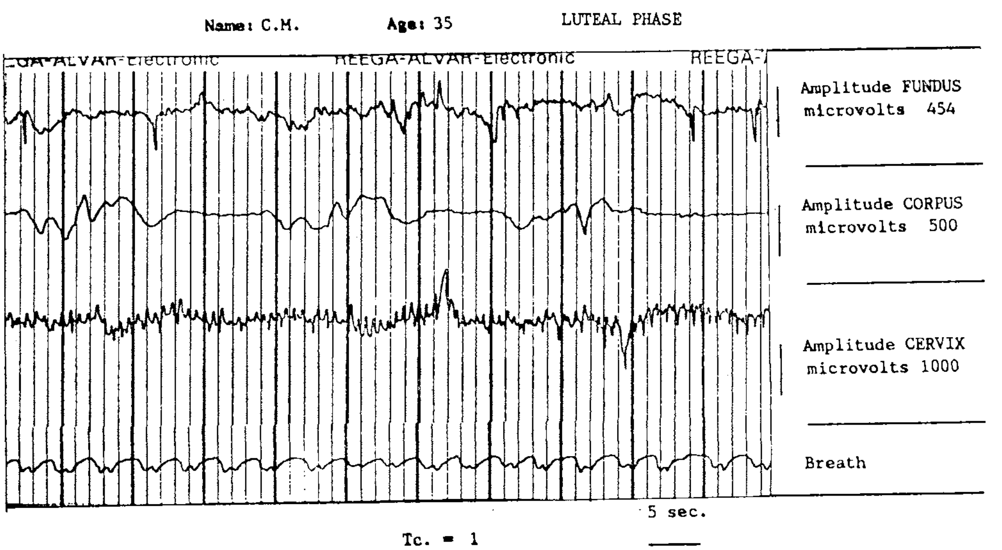
Name: C.M.
Age: 35
LUTEAL PHASE
REEGA-ALVAR-Electronic
Amplitude FUNDUS
microvolts 454
Amplitude CORPUS
microvolts 500
Amplitude CERVIX
microvolts 1000
Breath
5 sec.
Tc. = 1

Fig. 14.

Spectral analysis: the spectral analysis performed on signals leads to the conclusion that in the follicular phase there are clearly detectable frequency peaks between 1.4/min and 6.7/min.

Amplitude figures ranged from 12 to 721 microvolts with a 70 microvolt average.

In the luteal phase, instead, frequency ranged from 1.6 to 5.6/min and amplitude from 9 to 287 microvolts with a 45 microvolt average.

DISCUSSION AND CONCLUSIONS

Paper recondings and spectral analyses of signals show that electrical activity in the human uterus in vivo have specific characteristics: it is uniform throughout the whole organ, it has amplitude and frequency values higher in the follicular phase than in the luteal phase. Although a sort of hyper-reactivity might be hypothesized as a consequence of the presence of the uterine coil, electrical activity undoubtedly differs in the two phases on account of the hormone situation of the individual. Such data, already confirmed by several Authors, underline the fact that progesterone apparently increases the excitation threshold of the smooth muscle cells of the uterus, whereas estrogens give the opposite effect.

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