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GUINEA PİG'LERDE YAPILAN ORTODONTİK ARAŞTIRMALARDA KULLANILMAK ÜZERE GELİŞTİRİLEN DARBELİ MANYETİK ALAN ÜRETECİ*

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ÖZET: Bu çalışmada, aşırı az frekanslı darbeli manyetik alanların kıkırdak dokuların hızlı kemikleşmesi üzerine etkilerini inceleme imkanı sağlayacak bir elektronik sistemin tasarımı ve uygulanması tarif edilmektedir. 8 cm aralıkla parallel olarak yerleştirilen 16 bobin tarafından oluşturulan silindirik hazne içerisinde 5.3 milli tesla (peak) şiddetinde 100 Hz darbeli manyetik alan üretmektedir.

ABSTRACT: A PULSED MAGNETIC FIELD GENERATOR DEVELOPED FOR USING IN ORTHODONTIC RESEARCHES CARRIED ON GUINEA PIGS In this study, design and implementation of an electronic system that will provide opportunity to investigate the effects of extremely low frequency pulsed magnetic fields on rapid ossification of cartilaginous tissues, is being described. The electronic system produces a 100 Hz pulsed magnetic field of intensity 5.3 milli Tesla (peak) within the cylindrical volume formed by 16 paralelly placed coils separated by 8 centimeters consecutively.

Key Words: Pulsed magnetic field, Orthodontics

INTRODUCTION

A great deal of researches about the effects of magnetic fields on living tissues have shown that applied magnetic field can alter the normal electrical states of cartilage and bone, induce increased rates of cellular division and metabolism and thus promote increased healing of bony and cartilaginous defects (1-5).

In the field of orthopedics, pulsed magnetic fields have been used successfully to induce healing in fractures of human extremities that have proved resistance to conventional treatment strategies (6,7). In dentistry, pulsed magnetic fields have been used to provide faster healing of periodontal defects, increase the rate of healing of facial fractures and stimulate the rate of mandibular condylar growth (6,8-11).

The purpose of this study was designing and implementation of an electronic system that will provide opportunity to investigate rapid ossification of cartilaginous tissues exposed to pulsed magnetic fields. Our main objective was to carry out a series of experimental studies to observe rapid ossification of mandibular condyles on guinea pigs aiming to evaluate the possibility of reducing functional orthodontic treatment time on humans.

MATERIAL AND METHOD

It has been aimed to perform a series of experimental studies by using the electronic system that should be regarded to be an improved and developed version of the system given by Stark and Sinclair (1,2).

Our system produces a pulsed magnetic field with a frequency of 100 Hz and a peak magnetic field strength of 5.3 milli Tesla within the cylindrical volume of space formed by 16 parallel placed identical coils of diameter 16 cm separated by 8 cm consecutively. In this way, a simultaneous exposure of 15 animals have been accomplished (Figure 1). On the other hand, in order to get an almost uniform field strength, we have chosen the distance between any two successive coils to be the same as the radius of the coils. We finally note that the pulsewidth can be set to any desired value from 10 sec to 1 m sec., for the calibration of the field strength.

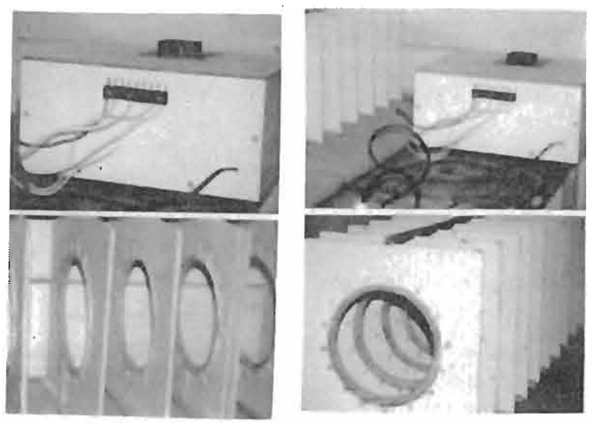

Figure 1. External view of the system consisting of the pulse generator, the coil-block and divisions for placement of guinea pigs

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Circuit Description

A close investigation of Figure 2 will show that the circuit consists mainly of an astable multivibrator (or a square-wave oscillator), a differantiator-clipper, a monostable multivibrator, a multiplexer-buffer, a power amplifier and finally a block of coils made up of 8 Helmholtz pairs.

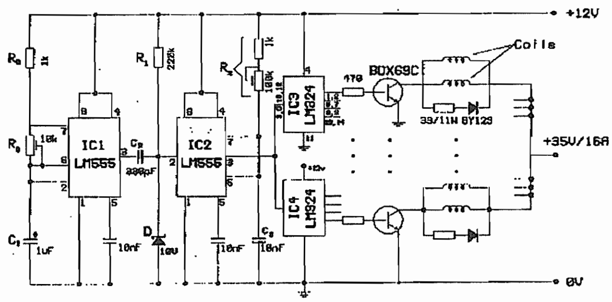

Figure 2. Schematic diagram of the circuit.

The astable multivibrator has been realized by the well-known IC timer LM 555 (IC1) operating in astable mode together with a few passive components around it (13). For the output frequency of this stage we have the formula;

$$f = \frac{1.443}{(R_A + 2R_B)C_1}$$

In transition from the astable multivibrator to the next stage a differantiator-clipper consisting of C2, R1 and D takes place. Despite its very simple structure, this intermediary circuit plays a fundamental role both in wave-shaping and prevention of the control terminal of IC2 from over-voltages.

The monostable multivibrator uses again LM 555 (IC2) connected in monostable mode of operation. For the pulse-width of the output signal of this stage we have;

$$t(\text{sec}) \cong 1.1\, R_2(\Omega) C_3(F)$$

It follows from this expression that, the circuit renders it possible to produce pulses with adjustable pulse-times that can be set to any desired value from 10 μ sec to 1 m sec., with the component values given in Figure 2.

The multiplexer-buffer has been realized by connecting the operational amplifiers involved in IC3 and IC4 in voltage-follower mode of operation.

The power amplification required by the Helmholtz pairs is obtained by means of the Darlington power transistors BDX 69C operating in common-emitter configuration.

As for the coil unit, it can be assumed that every consecutive pair of coils in the unit may be regarded as a Helmholtz system. For the magnetic field strength at a point z on the line segment joining the centers of the coils we have the expression (14);

$$(B\ z) = \frac{4\pi\, 10^{-7}\, I\, a^2\, N}{2} \left\{ \frac{1}{\left(a^2 + z^2\right)^{3/2}} + \frac{1}{\left[a^2 + (d - z)^2\right]^{3/2}} \right\}$$

where a denotes the radius of the coils in meter, N is the number of windings of the coils, I is the current flowing through each coil measured in ampere and finally d denotes the distance between the coils.

As we have already noted before, in order to get a uniform field strength we have to choose a=d. So, it follows from our preselections d=0.08 m and B_{peak} = 5.3 m T that a=0.08 and NI peak $\cong$ 470. Now, if it is foreseen 4.4A for the total collector current of BDX69C we have I_{peak} = 2.2 A and hence N $\cong$ 210.

As for the diameter of the wire to be used for the coils, it has been found experimentally that 0.60 mm will serve well even for 8 or 10 hour application periods.

It should also be pointed out to the fact that the prevention of the transistors from the back electromotive force that will be produced by the coils in cut-off states has been realized by means of conventional series diode-resistor combinations. In this way, a limitation of about -65 V has been reached with the values given in Figure 2.

Calibration

For the calibration of the system two adjustments are required. First, RB should be adjusted so as to obtain a 100 Hz square-wave output at pin 3 of IC1. Finally, R2 is to be adjusted as to get a total collector peak current of 2.2 A by the aid of an oscillator.

Discussion and Conclusion

First of all, we would like to mention that the electronic system that has been described briefly above should be considered to be an 'improved' and 'developed' version of the system given in reference (10), the design technique of which seems to be non-professional even at first glance. Indeed, the number of semi-conductor devices has been reduced appreciably and the values of certain passive components have been changed as to provide reasonable, reliable and economic operational conditions. In addition, the distance between the coils has been increased from 6.7 to 8 cm and simultaneous exposure facility has been provided up to 15 animals as subjects.

Another property of the system described here is that it constitutes an alternative to the instrument given in reference (12) that has already been developed for treatments such as delayed unions and pseudoarthroses, in orthopedics. In this way, it would be possible to compare effects of magnetic fields generated by different waveforms from a functional point of view.

On the other hand, the probability of long-term applications of the system has been taken into account meticulously in determination of design strategies, for the safety of operation. Also, a simple device sensing the back e.m.f and thus, monitoring whether the system operates properly or not has also been taken into the picture, as a useful accessory.

REFERENCES:

1. Darendeliler MA, Sinclair PM, Kusy RP. The effects of samarium-cobalt magnets and pulsed electromagnetic fields on tooth movement. Am J Orthod Dentofacial Orthop. 107: 578-588, 1995.

2. Darendeliler MA, Darendeliler A, Sinclair PM. Effects of static magnetic and pulsed electromagnetic fields on bone healing. Int J Adult Orthodon Orthognath Surg. 12: 43-53, 1997.

3. Norton JB, Young SO, Kenner GH. Epiphyseal cartilage changes produced by electrical and mechanical perturbation. Clin Orthop. 124: 59, 1977.

4. Friedenberg ZB, Brinhton CT. Bioelectric potentials in bone. J Bone Joint Surg. 48-A: 915, 1966.

5. McDonald F. Effect of static magnetic fields on osteoblasts and fibroblasts in vitro. Bioelectromagnetics. 14: 187-196, 1993.

6. Basset CAL. Pulsing electromagnetic fields; a new approach to surgical problems. Metabolic Surgery. New York, p : 255, 1982.

7. Brighton CT. Current concepts review - The treatment of non-unions with electricity. J Bone Joint Surg. 63-A: 847, 1982.

8. Jacobs JD, Norton LA. Electrical stimulation of osteogenesis in periodontal defects. Clin Orthop. 124: 41, 1977.

9. Measureik C, Eriksson C. Preliminary clinical evaluation of the effect of small electrical currents on the healing of jaw fractures . Clin Orthop. 124: 84, 1977.

10. Gerling JA, Sinclair PM, Roa RL. The affect of pulsating electromagnetic fields on condylar growth in guinea pigs. Am J Orthod. 87: 211, 1985.

11. Berki MA, Sönmez M. A pulsating electromagnetic field generator for use in delayed unions and pseudoarthroses. J Ins Sci Tech. Gazi University. 8: 84, 1995.

12. Stark JM, Sinclair PM. Effect of pulsed electromagnetic fields on orthodontic tooth movement. Am J Orthod. 91: 91-104, 1987.

13. Linear Databook. National Semiconduktor, p : 9-29, 3-113, 1980.

14. Edminister J. Electromagnetics. Schaum's Outline Series, Mc Graw Hill Book Camp. p : 121, 1979.

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