GROWTH EXPERIMENTS ON YOUNG CHICKENS
EXPOSED TO HIGH FREQUENCY ELECTRICAL TREATMENT

By

DRAYTON TUCKER KINARD

A THESIS

Submitted to the School of Graduate Studies of Michigan
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Final examination: June 18, 1954, 8 - 10 a.m.
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Dissertation: Growth Experiments on Young Chickens Exposed to High Frequency Electrical Treatment

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GROWTH EXPERIMENTS ON YOUNG CHICKENS EXPOSED TO HIGH FREQUENCY ELECTRICAL TREATMENT

By

DRAYTON TUCKER KINARD

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan
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Approved D. E. Wiant

GROWTH EXPERIMENTS ON YOUNG CHICKENS

EXPOSED TO HIGH FREQUENCY ELECTRICAL TREATMENT

An abstract of a Ph.D. thesis in the Department of Agricultural Engineering, by Drayton Tucker Kinard, June, 1954.

Electrical phenomena associated with living things have been a subject of study for over a hundred years. The presence of the electrical environment of the earth and concepts of the constituency of matter imply close relationships between electricity and life processes. The impression of external electrical potentials of different types and magnitudes on living systems are known to produce various biological effects. Although many questions related to those findings are yet in the hands of the biologists, at least one report has appeared to justify the attention of those agricultural engineers whose major interest is in the field of electricity in agriculture.

Baker (1913) applied high frequency electrical treatments to young chickens and reported that treated birds grew a third or more faster, had a more efficient feed conversion, and feathered earlier than those untreated. His experiments were interrupted by World War I. Aside from the present study, apparently no further work has been undertaken to investigate the ideas suggested by the early report.

Marsh and Beams (1952) have obtained interesting effects on growth by the application of continuous currents. Marked differences in growth resulting from high frequency treatment have not been reported. Most of the high frequency experiments have involved intense exposures, and the effects attributed primarily to heating (Osborne and Holmquest, 1945); whereas, continuous currents are employed effectively in small intensities. Baker's theory is that "minute currents, comparable with those in nature" cause a better metabolism, resulting in more efficient utilization of feed and faster growth. Chickens respond to the application of light, (Clegg and Sanford, 1951; Staffe, 1951). That they may respond to small amounts of radiation of much greater wavelength is suggested by theories that birds may sense electromagnetic waves (Mattingley, 1946). The evidence presented by Baker is not convincing. On the other hand, he is a man of integrity and of considerable technical background, (Poggendorff, 1936). Still active, he affirms his faith in the treatments (Baker, 1952). The literature does not provide the evidence to refute or confirm his findings.

The present work was intended to determine if marked response in growth of young chickens might be obtained by the application of treatments similar to those used by Baker. If results were positive the study was to be pursued toward practical ends. Chicks were grown to age six weeks under the influence of the electromagnetic field within coils energized at different frequencies and at different intensities from high frequency generators. Treatments considered similar to the original ones, and related treatments, were tried. Treated and untreated birds were compared primarily on the basis of gain and

An abstract of a Ph.D. thesis, by Drayton Tucker Kinard

feed conversion efficiency. Five experimental trials were involved, three at Michigan State College on White Rock chicks, and two at the University of Georgia on Newhampshire cockerels.

No marked differences were found between treated and untreated birds as measured in terms of gain and feed conversion efficiency. Nor did there appear to be any change in the treated chicks to suggest the need for other measurements of their growth or behavior. Temporary increase in heart and respiratory activity resulting from intense treatments, attributable to heating, was demonstrated, as was to be expected. It is considered likely that the observed differences in growth previously reported were caused by factors other than the high frequency treatments.

An abstract of a Ph.D. thesis, by Drayton Tucker Kinard

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INTRODUCTION

Electrical phenomena associated with living things have been a subject of study for over a hundred years. The presence of the electrical environment of the earth, and concepts of the constituency of matter imply close relationships between electricity and life processes. Differences in electrical potential may affect the end product of the combination of certain basic compounds involved in digestion and metabolism. Charges on cells perhaps influence their permeability to ions of the body fluids. Nerve stimuli and perhaps glandular secretion are somewhat electrical in nature. The medical profession has long used electricity in various ways for therapy and certain measurements of electrical potential as aids in diagnosis. Burr (1935) advanced an electrodynamic theory of life. The existence of patterns of potential fields about living organisms and their relationships to some of the life processes have been described. The impression of external electrical potentials of different types and magnitudes on living systems in less than lethal dosages might be expected to, and is known to, produce biological effects. Effects on animals and other living material have been reported from treatments employing continuous (direct) currents and from treatments involving the application of high frequency electrical fields.

Although many questions related to those findings properly are yet in the hands of the biologists, at least one report has appeared to justify the attention of agricultural engineers, particularly those whose major interest is in the field of electricity in agriculture.

High frequency electrical treatments were used on young chickens in experiments in England by a physicist, T. Thorne Baker, who reported that treated birds grew a third or more faster, had a more efficient feed conversion, and feathered earlier than untreated birds (Baker, 1913). The use of such treatments if successful might have enormous possibilities even if applicable to just poultry alone.

If chickens could be made to grow faster by the use of electrical stimulation, then attention should be devoted to determining the factors involved and to learning how to utilize that stimulation to economic advantage. Unfortunately, the original work was interrupted by World War I, and, aside from the present study, apparently no further work has been undertaken specifically for the purpose of investigating the ideas suggested by the early report.

OBJECTIVES

The present study was intended to determine if marked increase in gain or improved feed conversion efficiency could be obtained in young chickens by the use of high frequency electrical treatments similar to those used in the early experiments by Baker.

The study was exploratory. It was felt that observation of a growth response or improved feed conversion efficiency as a result of electrical treatments was pre-requisite to the development of further objectives such as estimating the relative importance of the factors of the treatment and identifying the mechanism involved in any stimulating effect. However, it was intended that any apparent effect of the treatment be described, particularly if it suggested a change in a process related to growth.

REVIEW OF LITERATURE

Baker (1913, and personal communication 1952, 1953) gave an account of experiments in which he used high frequency electrical treatment on young chickens (popularly referred to at the time as petits poussins), and reported getting an appreciable growth response and other effects from the treatment. Because of the nature of the report, it should be considered in some detail.

Large scale trials followed a number of experiments he had made personally. Treated chickens were ready for market in five weeks instead of three months. In another instance, the increase in weight of treated chickens was 35 per cent. Mortality was about 1.5 per cent. In still another test, electrified chickens given only two-thirds the feed given non-treated chickens in one month were equal in weight to the untreated birds. As many as 4000 chickens were treated at one time and marketed at seven weeks. He concluded that chickens grown under the influence of electricity would grow to normal weight on a third less feed, or on normal feed would grow about a third again as heavy to twice as heavy as untreated birds. It was noted also that treated birds developed feathers earlier than usual, and were said to be less nervous than those not treated. Information is lacking as to just how treated and untreated birds were compared and on points regarding the rations used and the method of feeding.

Equipment for administering periodic treatments consisted of a Ruhmkorff coil, with a motor-driven mercury interrupter, in a circuit like that of the wireless telegraph, common at the time. This induction coil was used to energize instead of an antenna, a helix of insulated wire wrapped in turns about four inches apart about a six-deck pen, holding 75 birds on each deck. A four-volt battery was used to supply power for the induction coil. Although specific measurements of the characteristics of the electrical treatment were not reported, a one-inch spark on the induction coil was said to be adequate for treating a thousand chickens. A neon tube placed within the field glowed, indicating the presence of high frequency radiation. Treatments were applied periodically, 10 minutes every hour or for 20 minutes three or four times a day. During treatment, a distinct shock was felt on touching the birds, and sparks were noticed as they pecked at a finger.

The original report was given publicity at the time with one account and some accompanying illustrations appearing in this country*. Other references to the work have been made by Trullinger (1924) and Mathews (1928).

Mr. Baker repeated some of his experiments in 1941, using a static transformer connected directly to a 230-volt alternating current supply and otherwise employing the same arrangement as used with the induction coil. A static transformer as distinguished from the induction coil is presumably a conventional alternating current transformer, possibly one of high voltage and of high reactance. No results were reported from those tests, but the implication was that

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* Scientific American Supplement, Vol. 77, No. 1986, pp 63 and cover, January 24, 1914.

similar results were obtained. That work was interrupted by World War II. The use of equipment slightly different from that in the early investigation suggests that some variation in the characteristics of the treatment was not critical.

The literature does not provide sufficient evidence to refute or confirm Baker's findings. His report apparently was lost sight of as important British and American sources have indicated that they were not familiar with the work. Many other studies have been made, however, involving the use of continuous currents and the use of high frequency fields for treating animals and other biologic material.

Burr (1936) concluded that living organisms possess steady state, or direct current, potential differences; and Burr and Hovland (1937) from studies of the bio-electric potential gradients in the chick embryo say that the potential gradient is an expression of one part of the energy intake of the organism, and is related to the pattern of organization. The existence and relationship of such electrical potentials suggest that the application of external electrical forces might modify growth processes, the characteristics of such electrical treatment being suggested by the characteristics of the natural field, in this case the application of direct current potentials. High frequency electrical treatments would influence those natural potentials, perhaps to the extent of stimulating the process from which the potential arises, and thus affect growth.

Electrical effects produced by continuous currents on living materials are described by Lund (1947), Ellis and Wiersma (1945), Marsh and Beams (1952), and others. Whether or not there is a specific electrical effect attributable to the use of high frequency treatments is as yet controversial. Heat is a product of the treatment along with any purely electrical effects. McKinley (1936) in a review of studies on the biological effects of high frequency, reported that although all workers admit that heat resulting from such treatments is a major factor in producing biological effects, many investigators believe there is an effect other than that of heat. Osborne and Holmquest (1944) in a comprehensive review of reports supporting both sides of the question are of the opinion that "the burden of proof (of a specific electric or athermic effect) still lies on those who claim any biologic action of these currents other than heat". However, selective effects are indicated as they point out that the relative amount of heat developed in tissues exposed to high frequency fields, which differ markedly in their electrical characteristics, as for example fat and vascular tissues, can be influenced by varying wavelength and technic of application. similarly, they feel that what has been reported as a specific bactericidal action of high frequency may be more rationally explained on the basis of point heating, the raising of the temperature of the micro-organism above the temperature of the medium. Christie and Loomis (1929), in a study of the biological effects of high frequency involving frequencies from 8.3 to 158 megacycles in experiments on mice, concluded that the effects on the animals can be fully explained on the basis of the heat generated by the induced high frequency currents.

Another point brought out by McKinley (1936) is that the possible utility of high frequency in studies of growth has been demonstrated by its power to bring about acceleration in the germination of seed. Jonas (1952) attributes a higher seed emergence to an effect of heating. Treatments used by Baker obviously involved comparatively small amounts of energy because of the nature of the apparatus (Bailey, 1910; Jones, 1932) and the circuit used. Any heating effect produced would be quite small. Marked effect on the chickens therefore possibly could be caused by selective heating or by some factor other than heating.

Effect on growth per se as a result of high frequency treatment has been considered by only a few investigators. Knudson and Schaible (1931) concluded that exposure of young rats for one-half hour to one hour daily and raising their temperature to 40.5° C does not seem to retard their growth appreciably or cause a loss in power to breed. Boak, et al (1932) reported that in a majority of cases, rabbits exposed to repeated short wave fevers gained a greater maximum than did the controls. Treated rabbits appeared more vigorous, healthier, and better nourished. Differences were never more than 6 per cent, the average being 2 to 3 per cent. In this case treatments were administered two, three, and five times a week, and temperature of the animals was raised to 41.5° C. Small numbers were used and the question of stimulated growth was not pursued further. Marked differences in growth as observed by Mr. Baker apparently have not been reported.

In a majority of high frequency experiments, the treatment was applied by a dielectric method in which animals or materials were placed between two plates energized from an oscillator as decribed by Ark and Parry (1941) and others. The induction method of application has some advantages as discussed by Osborne and Holmquest (1944). Inductothermy is common in medical practice, and induction heating is commonly used in industry. Mr. Baker's arrangement provided a treatment by induction.

Continuous currents used in experiments on growth are employed in very small intensities. Most of the high frequency experiments have involved the application of rather intense treatments. The temperature of the experimental animals or material has been raised, and interest has been directed toward the effect of elevated temperatures. Mr. Baker's theory is that small doses of high frequency treatment, "minute currents comparable with those in nature", cause a better metabolism resulting in more efficient utilization of feed and faster growth.

That chickens can be stimulated by minute quantities of radiated energy is evidenced by the response of layers to lighting in winter months and by short flashes of light as reported by Staffe (1951), and of growing chickens to controlled cycles of light and darkness reported by Clegg and Sanford (1951). There is a possibility that chickens may sense and be stimulated by low intensities of radiation of much greater wavelength. Mattingley (1946) reported various observations in support of the hypothesis that the capacity for orientation in birds is based on sensitivity to electromagnetic waves. For example, homing pigeons were said to have lost their directional ability in the vicinity of a radio station while it was transmitting, but recovered it when transmission ceased. Gordon (1948) in experiments with pigeons, by attaching magnets to their wings, did not show any effect on homing in an attempt to test a similar theory.

Thus there is a lack of specific evidence to refute or confirm Mr. Baker's findings. His conclusions may not be supported adequately by the evidence he offered. The work was forgotten, and, so far, such a decided effect on growth has escaped detection by others. Those points provide some basis for question. On the other hand, Mr. Baker is a man of integrity and of considerable technical background, as recorded by Poggendorff (1936), and remains a firm believer in the treatments. There apparently have been no experiments quite similar to his on chickens. It is also significant that relationships of electricity and vital processes are not yet fully understood. Electrical treatments are capable of producing various biological effects. Perhaps it may be a question of application as to whether such an effect may be to the extent of stimulating some growth mechanism.

EXPERIMENTAL PROCEDURE

The approach selected for this problem involved the use of experiments in which chicks were grown under controlled conditions while being exposed to various high frequency electrical treatments by induction. Gain and feed conversion of the chicks were the basic criteria.

A selected number of treatments was used to make the comparisons desired. Detection of some evidence of a growth response, or some other apparent effect of the treatment, was an objective in each trial The response to be expected, based on Baker's studies, was large, perhaps as much as thirty-five per cent or more. Some variations in equipment and treating schedule employed by Baker suggested that some degree of variation in the frequency and the treating program was not critical. It seemed reasonable to expect that use of a treatment patterned after the original ones, to the extent permitted by information available, would produce at least some evidence of stimulation. Accordingly, a treatment similar to his was used in each trial.

The variable factors of such a treatment were expected to include the frequency and intensity of the applied field and possible variations in the treating schedule, such as duration of exposure and intervals between exposures to treatment. As the induction coil is more difficult to control and less stable than modern vacuum tube transmitters, more modern equipment was selected to provide treatments having differences in frequency and intensity. Radio transmitters and a short wave generator, normally employed in human therapy, were used to broaden the scope of the exploratory treatments.

Practical difficulties provided some restriction on the number of treatments which could be compared in this study. Non-conducting pens were required, thus not permitting the use of commonly available battery pens. Treating pens had to be shielded to eliminate interference with radio communication. Equipment suitable for providing treatments of desired frequency and intensity was not readily available. Construction of special radio frequency generators, which might have been desirable, was considered not justified, but it was possible to obtain the transmitters or short wave generators needed to complete a suitable series of treatments. Administering the treatments and maintaining the experiment required considerable time and close attention. Consequently, initial experiments were of simplest design involving two treatments and a control. In subsequent experiments, the latitude of the treatments was extended to include variations in frequency and intensity of treatments and in the schedule or time of treatments.

In addition to the principal observations made on gain and feed conversion efficiency of the chicks, chicks were observed for signs of possible reaction to treatments. In the last experiment, objective measurements were attempted on heart rate and respiration, but this procedure was not incorporated as a principal feature of the experiment. Record of heart beats, however, were made on some chicks exposed to the most intense treatments. Also some birds were sacrificed at the conclusion of the last experiments for a preliminary histological examination of some of the endocrine glands for possible evidence of treatment effect.

Five experimental trials were involved in the study during the period January 1953 to March 1954, three being done at Michigan State College and two at the University of Georgia.

Trial 1

Two treatments were used on groups of chicks from age one day to age six weeks. One treatment was designed to be quite similar to that used in Baker's experiments. For a second treatment a modern radio frequency generator was used. A treating schedule was followed based on Baker's suggestion of a 20-minute exposure three or four times a day. The experiment was run from February 5 to March 19, 1953 and was located in the nutrition laboratory of the Poultry Department at Michigan State College, along with feeding experiments.

A random sample of 180 day-old, straight-run White Rock chicks was divided into three experimental groups, two for electrical treatment and one for a control. Chicks were wingbanded for individual weight records and were placed under test at age one day for a period of six weeks. They were weighed at one day and thereafter once a week.

Chicks were held in separate pens (Fig. 1 and Fig. 2) by groups, each a three-level battery constructed of non-conducting materials for the purpose. Floors were of pressed fiber board and the screen was of plastic. Each deck was 24 inches wide by 36 inches long, had a height of 12 inches, and was designed to hold 14 to 20 birds from day old to six weeks of age. Heat was provided at each level by two incandescent

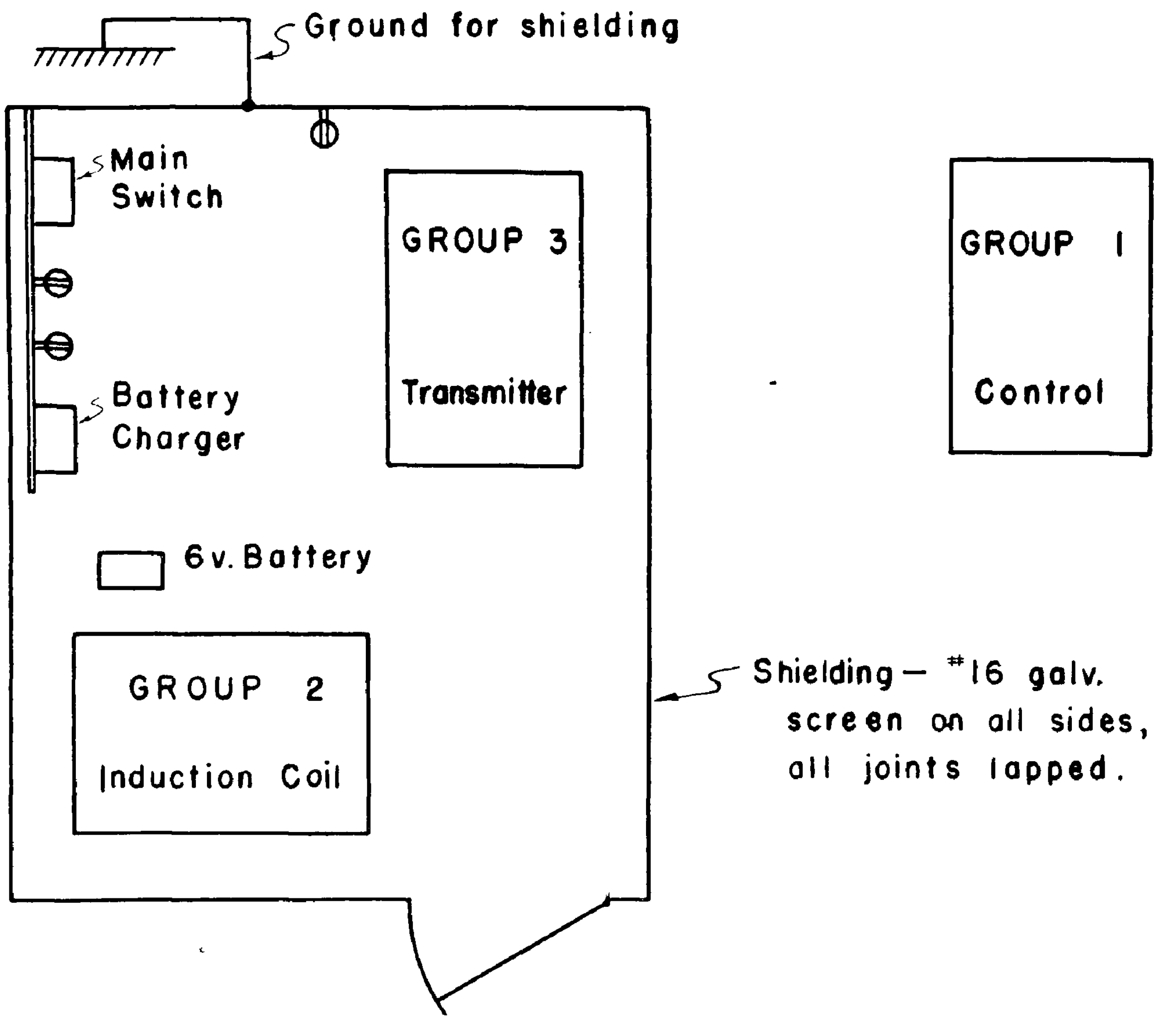


Fig. 1 Layout of the experiment for Trials 1, 2, and 3. Chicks were housed by groups in three-level pens as illustrated in Fig. 2.

Fig. 2 View of the arrangement illustrated in Fig. 1. Non-conducting, three-level pens were used to house chicks by groups. The control group is in the foreground; shielded enclosure for the two treated groups is in the background.

lamps above the chicks. Lamp wattage was selected to provide brooding temperatures beginning at about 90 to 95 deg. F. which was lowered periodically, as suggested by the temperature and apparent comfort of the birds, by using smaller lamps. These lamps were on continuously except during treatment when all were turned off including those in the control pen.

Each of the two treated pens was encircled by a helix of 10 turns of No. 12 insulated conductor (type TW). The turns were about three inches apart from front to rear of the pen and thus formed a large coil enclosing the birds.

Chicks were all fed alike, ad libitum, using a standard all-mash, chick starting ration containing vitamin supplements and antibiotic and identified as Chick Starter, Michigan State College 1953 formula 53 S-1, manufactured by King Milling Company, Lowell, Michigan. Metal chick feeders and one-quart glass waterers were placed in with the chicks. Feed was weighed in on gram scales as needed and weighed back weekly, as the birds were weighed, to provide data on feed conversion by lots. Water was changed twice daily, and pens cleaned twice a week.

Treatment consisted of energizing with high frequency the coil enclosing the pen, whereby the chicks were exposed to high frequency induction. Treatments were administered four times daily at intervals of three hours beginning at 8:00 AM.

For the treatment patterned after that used by Baker, an induction or Ruhmkorff coil supplied by a 6-volt automobile battery was used as a source of high Frequency power (Fig. 3 and Fig. 4). One terminal of the secondary was grounded and the other terminal was attached to one end of the helix about the pen of chickens. The other end of the helix was free. The helix replaces the antenna of the wireless system which was commonly used at the time for communication before widespread use of vacuum tube transmitters. The induction coil used is identified as a 3-inch Edison coil, as manufactured by the Detroit Coil Company, Ferndale, Michigan. It is equipped with vibrating, platinum contacts. A spark length of 1-1/4 inches to 1-1/2 inches was used in this experiment. Direct current to the coil was maintained at 3.5 to 4.5 amperes at 6 volts d.c., for an average input of approximately 24 watts. Radio frequency current at a point 18 inches from the spark gap and at the start of the first turn of the helix normally ranged from 300 milliamperes, r.f. to 370 milliamperes, r.f. Natural capacitance of the helix and adjacent grounds apparently provided a condition of near resonance. Additional high voltage capacitors across the secondary terminals influenced, but apparently did not improve, the performance of the induction coil and accordingly were not used. Power output was estimated (Bailey, 1910) at less than 12 watts. Frequency varied from less than one megacycle to over two megacycles as measured on a wide band receiver.

Mr. Baker noted that during treatment a spark could be seen upon contact as one touched a chicken with a finger, and also that a neon tube placed in the pen glowed, indicating the presence of high fre-

Fig. 3 Induction coil used as a source of high frequency current. This equipment was mounted on top of the pen of chicks to be treated.

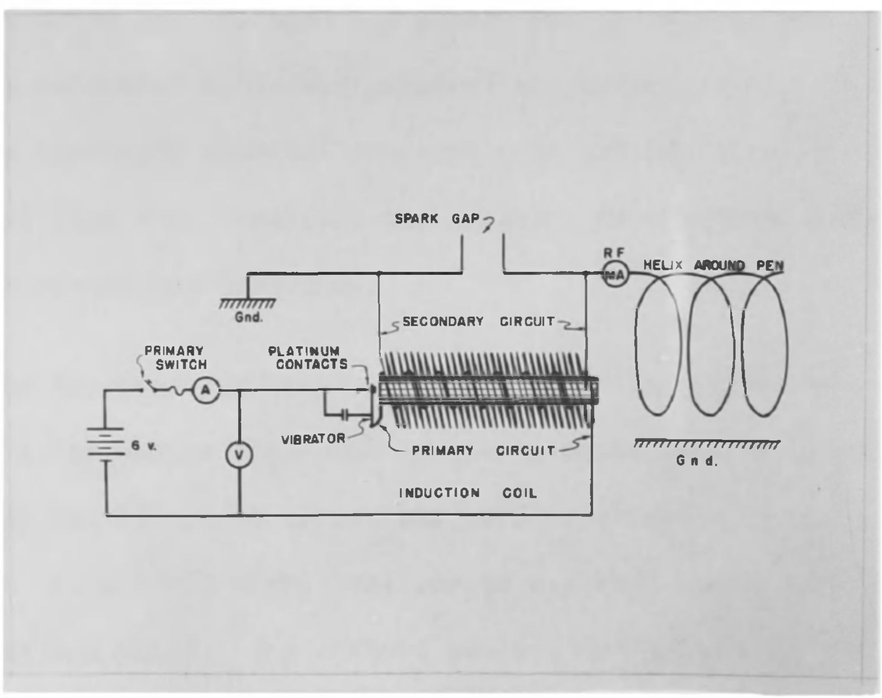


Fig. 4 Electric circuit for the induction coil pictured in Fig. 3. This arrangement is patterned after that used in the early experiments by T. Thorne Baker. See Fig. 22.

quency radiation. Those phenomena were observed during these experiments. The length of the spark developed by touching a chicken appeared to be approximately equal to that used on the induction coil secondary.

A radio transmitter was used for the second treatment (Fig. 5, Fig. 6). As the induction coil is less stable in frequency and is more difficult to control, the transmitter was selected to permit control of such factors as frequency and total power output. The equipment used was a surplus aircraft transmitter, identified as the ARC 5, operated at a frequency of 6 megacycles with a power input of approximately 35 watts (125-150 ma, 250 V.D.C.) and an estimated power output of approximately 17 watts. Radio frequency current 18 inches from the antenna terminal on the chassis and at the initial end of the first turn of the helix around the pen averaged approximately 0.6 amperes as regulated by a variable capacitor connected parallel to ground. This arrangement provided a treatment somewhat comparable to the one using the induction coil except that this treatment was slightly more intense and was of a higher and controlled frequency.

The two pens for treatment were placed in a screened enclosure to reduce interference with high frequency communications. Ordinary galvanized, No. 16 window screen was used to shield a room 6 ft. 6 inches x 8 ft. x 7 ft. high. The screen was well bonded throughout and grounded at one point. The control pen was not enclosed in the shielded area but was placed near the treated pens to have essentially the same environment of atmosphere and lighting. Arrangement of the experimental

Fig. 5 Radio transmitter used to provide an electromagnetic field as treatment for a third group of chicks.

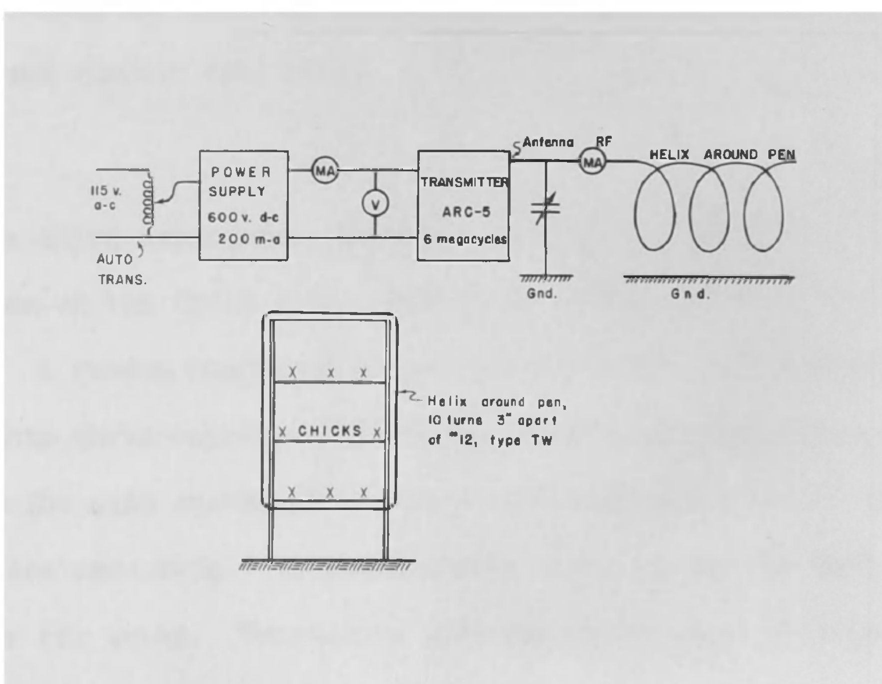


Fig. 6 Schematic wiring diagram of the equipment shown in Fig. 5.

layout is shown in Fig. 1. It was necessary to place the two treated pens at 90 degrees to each other to minimize mutual induction from one pen to the other. In any other position there was a pronounced effect of the circuit of either pen on the other.

Trial 2

The second experiment, March 27 to May 7, 1953, was a duplication of the first trial except that all male chicks were used, and a slightly different treating schedule was followed. A random sample of 115 day-old White Rock cockerels was divided into three experimental groups and assigned to the three pens, two for treatment and one for a control. Each group was divided into three lots for the decks in the pens. Treatments were begun at the end of the first week and administered daily at intervals of four hours beginning at 8:00 AM. Otherwise this trial was like the first one. The same equipment arrangement was used and similar data taken.

Trial 3

The third experiment, December 1, 1953 to January 12, 1954 was a duplication of the first trial except for number of chicks and treating schedule. A random sample of 108 straight-run White Rock chicks was divided into three experimental groups, two for treatment and one for control. The same equipment was used as for trials 1 and 2, and similar observations were made. Treatments were begun at age one week and continued for six weeks. Treatments were administered as in trial 2. Some equipment failures interrupted the treatment schedule for short intervals but not for extended periods.

Trial 4

The fourth experiment, September 26 to November 7, was located at the University of Georgia in an experimental building of the Poultry Department.

Experience with the second experiment suggested the desirability of replicating the treated and control groups. Accordingly, an experiment similar to that in trials 1 and 2 was set up so that six groups of birds were involved, two treatments and a control, each with a replication.

Groups were housed separately, but all were placed in the shielded enclosure as shown in Fig. 7. The positioning of the various groups was random even though two groups having the same treatment did fall at the same end of the enclosure. The pens were like those used in trials 1 and 2, of non-conducting materials, but were made six inches wider, were equipped with side feeders; and the lower deck was two feet instead of one foot above the floor. Also, heat for the chicks in each pen was provided by three infra red lamps, one at each level mounted about 15 inches to the rear of the pen, directed in at chick level. Intensity of these lamps was manually controlled by use of series resistors in the supply. Panels of galvanized screening, five feet square, were suspended vertically between pens and grounded to the overall shielding to prevent radiation from one pen to the next.

Uniformity of experimental birds was considered to be of particular importance in this trial as in nutrition experiments. A random lot of 500 New Hampshire cockerels was selected and raised for two

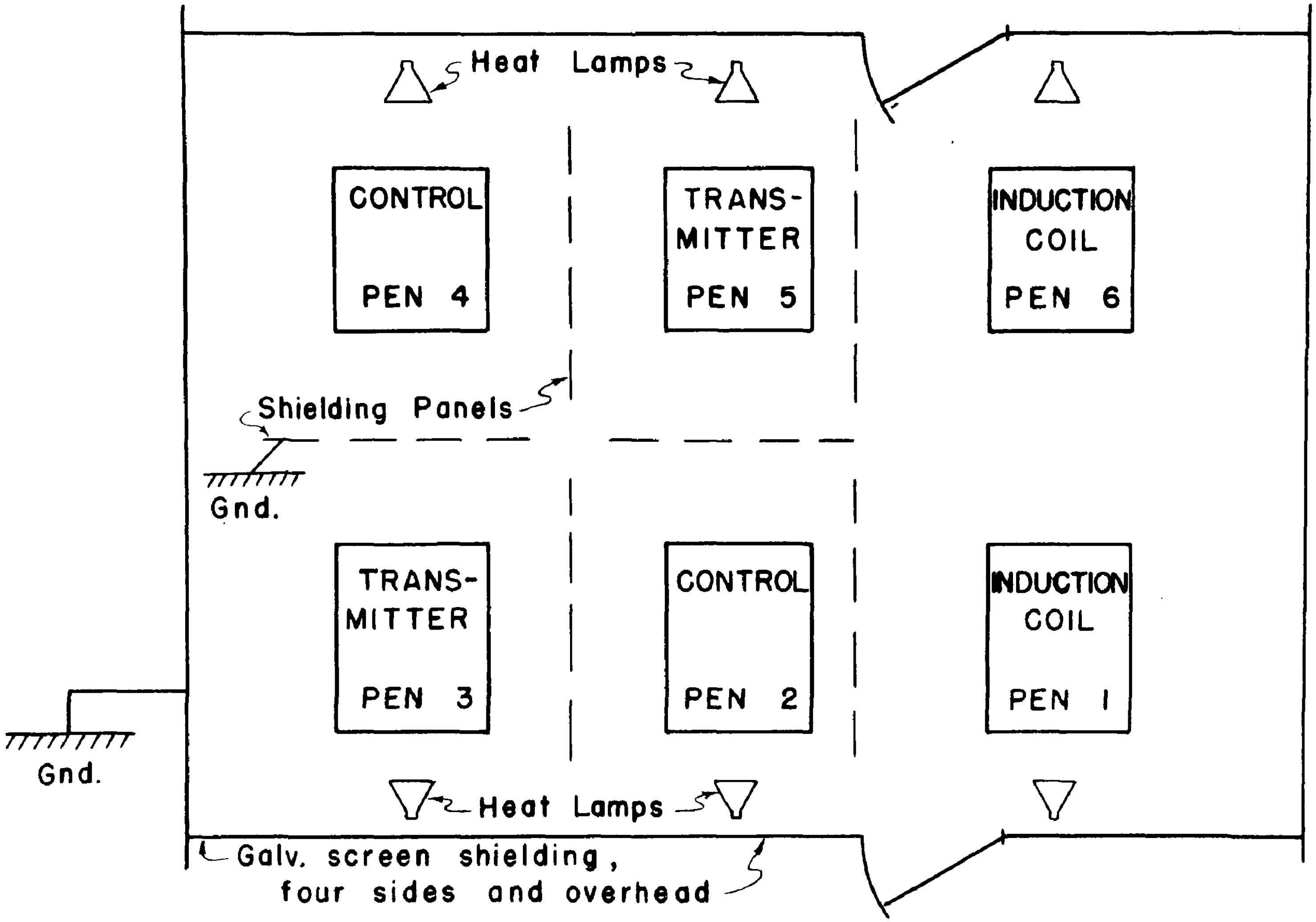


Fig. 7 Layout of the experiment for Trial 4. There were three experimental groups, two pens for each group. Pens were of non-conducting materials and held 54 birds each, 18 birds on each of three levels. Four pens were exposed to high frequency treatment. Two pens were untreated.

weeks in a brooder house. At two weeks all chicks were weighed in grams in order to get an estimate of their capacity to grow and were wingbanded for individual identification. To avoid wide variability, a sample of 18 lots of 18 birds each was then selected by pairing individuals, working from the median weight, thus eliminating the heaviest and smallest birds and providing a slightly restricted but random selection of birds for the six experimental groups of three lots each.

The procedure used for this pairing involved preparing individual index cards showing the wingband number and weight of the chicks. Cards were then arrayed by weight from small to large and the median weight determined. Beginning with the median weight, cards were dealt from the lower weight group to the right to start 18 lots. Cards were then dealt to the left on the same 18 lots, then to the right again, and so on until each of the eighteen lots had 9 birds each below the median. Then, beginning at the median and working toward the heavy chicks, an additional 9 cards each were added in the same manner to each of the 18 lots. This selection provided 18 lots of 18 chicks, each having almost identical weights by lot and range of weights of individuals. The eighteen lots were then assigned at random to the six experimental groups.

Chicks were all fed alike, ad libitum, on a standard broiler ration containing vitamin supplements and antibiotic, and sulfaquinoxiline, as manufactured by the Marbut Milling Company, Augusta, Georgia. Feed was weighed out into cans by lots for a week supply and weighed back as the chicks were weighed weekly to get feed conversion records.

Glass waterers placed in with the chicks were changed twice daily and pens cleaned twice a week.

The electric circuits used are shown in Fig. 8. Treatments were administered four times daily for 20 minutes at a time at intervals of four hours as in trials 2 and 3, and were begun when the chicks were two weeks old.

One treatment involved the use of the induction coil and was similar to treatments used in trials 1, 2, and 3 except that two pens were connected to the ungrounded secondary terminal. This arrangement provided a less intense treatment, approximately half that for the other experiments. A spark length of 1-1/4 inches was used on the induction coil, and input current was held to 4 amperes at 6 volts d.c. Radio frequency current at the initial end of the first turn in each pen was about 200 millamperes. Frequency ranged from approximately one megacycle to two megacycles as measured on a wide band receiver. Other frequencies were present but not predominant.

A 32.5-megacycle transmitter, crystal controlled, was used as a source of radio frequency for a second treatment. Total power output was estimated at 20 watts as indicated by use of a dummy antenna replacing the connection to the two pens. Radio frequency current at the first turn of the helix on each pen ranged from 50 to 150 milliamperes.

A fluorescent tube was used to indicate presence of high frequency in each treating pen, but no additional electrical measurements were made. The electrical characteristics of the helix on each treated

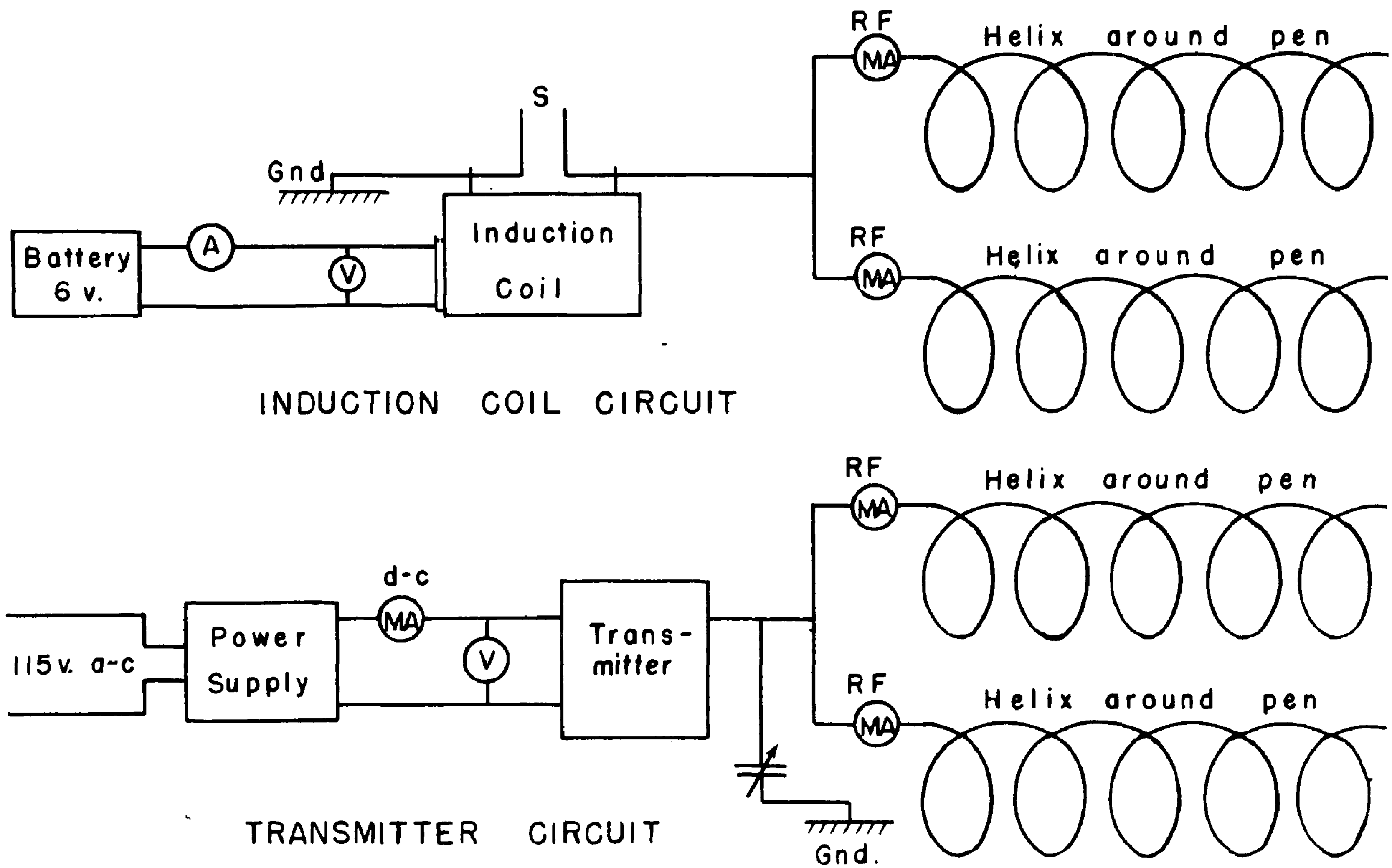


Fig. 8 Circuits used for treatments in Trial 4. Two pens were energized from each source of high frequency. Otherwise this arrangement was similar to that used in Trials 1, 2, and 3.

pen changed as the size of the chicks increased, but accurate measurements of this change were not made. Movement of the chicks within a pen also changed the resonant frequency of the helix slightly as did accumulation of droppings, which are conductive.

At the end of the experiment, five birds were selected at random from each of the six pens and were sacrificed for removal of some of the endocrine glands. The pituitary, thyroids, adrenals, and testes were removed for a preliminary histological examination by the laboratory of the University of Georgia Poultry Department, to gain additional information as to possible treatment effect. These tissues were weighed as removed and placed in fixing solution pending preparation of slides for microscopic examination.

Trial 5

The final experiment, December 29, 1953 to March 9, 1954, was carried out in the same location as trial 4 but was much more elaborate. Up to this point the number of treatments employed was quite limited. It was decided to increase the number of treatments and to attempt measurements of heart rate and respiration, and to make a preliminary examination of samples of tissues from the endocrine glands as in trial 4 as additional possible measures of treatment effect.

The trial involved eight different electrical treatments and three controls. The experimental layout for this trial is shown in Fig. 9.

Four of the three-deck pens from the previous experiment were

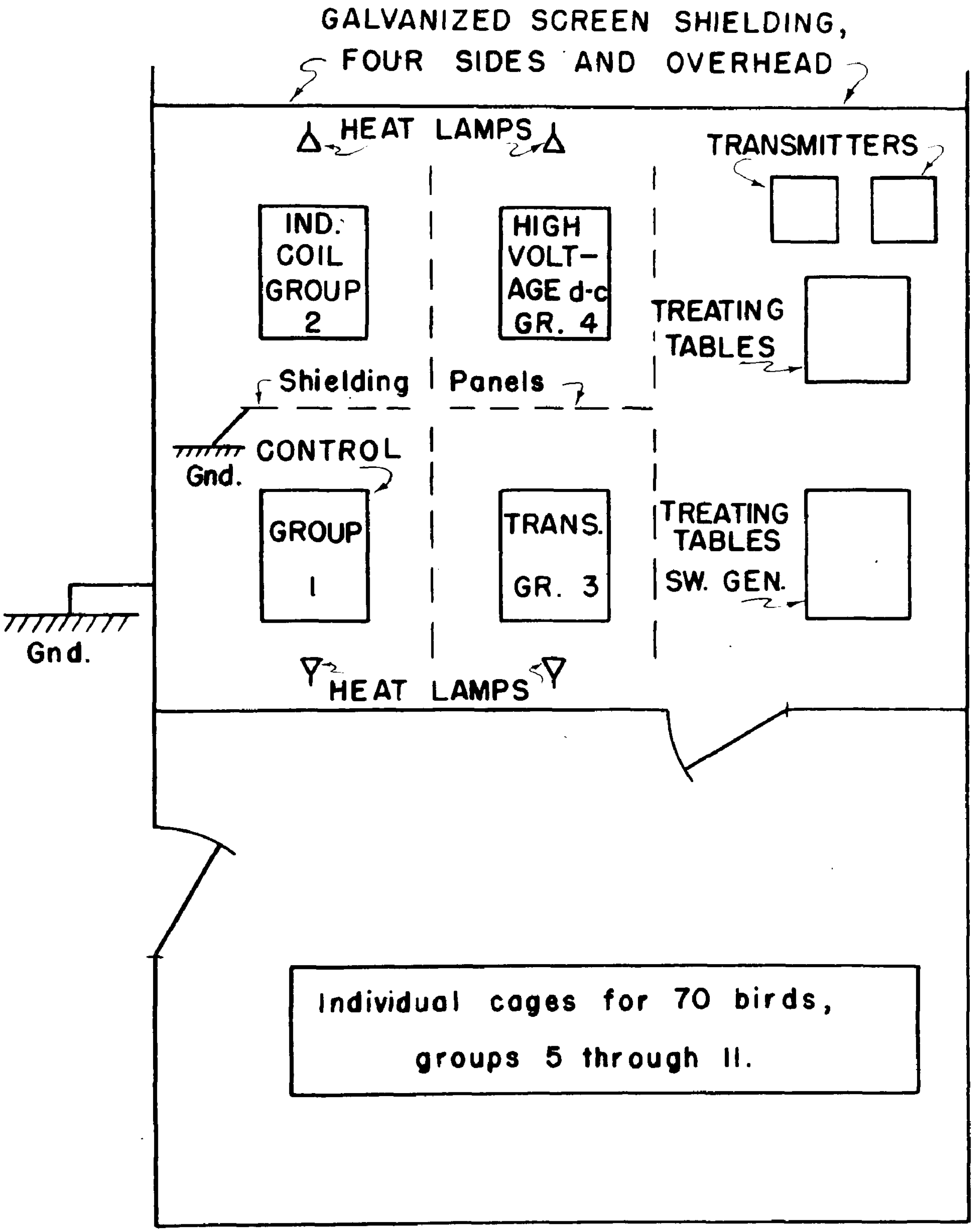


Fig. 9 Layout of the experiment, Trial 5.

used in this experiment: one for an untreated control, one for a continuous treatment using the spark coil, one for a continuous treatment using a 6-megacycle transmitter, and one for a continuous exposure between plates held at a high potential difference of unchanging polarity.

The purpose of the continuous treatments was to get a comparison of treated vs. untreated birds using a maximum time of exposure as a possible means for producing evidence of a growth response, thus possibly eliminating questions about time intervals and duration of treatment. The treatment involving unchanging polarity of the applied voltage was intended as a possible check on frequency treatments.

In addition to that group experiment, seventy birds, comprising seven experimental groups of ten were housed in individual cages. Positions of individuals were randomized. Three of these groups were used for three respective treatments of different intensity, all of the same frequency, 16 megacycles. Two of those groups were used for two respective treatments of different frequencies, 6 megacycles and 32.5 megacycles, of approximately the same intensity. The two remaining groups were used as controls. The ten birds comprising a group were removed from their cages daily for treatment as a group and then returned to their cages.

Birds for this trial were selected from 500 New Hampshire cockerels, vaccinated against bronchitis and Newcastle disease, and paired at age two weeks as in the preceding trial. Each of the four large pens held 54 birds, 18 to the deck making a total of 216 birds in that portion of the experiment. Seventy birds were selected for the individual cages. As there were 12 lots of 18 birds each in the larger pens and 7 groups of 10 in the individual cages, pairs 1 to 10 were selected for 19 different lots. Pairs 11 to 18 were selected for only the four large pens. This arrangement was intended to provide a common basis of selection for all lots.

Treatments were begun on the large pens, Groups 1 through 4, when the birds were two weeks old and continued for four weeks to age six weeks. Treatments were begun on the birds housed individually, Groups 5 through 11, when they were three weeks old and continued for four weeks. It had been intended to start all treatments at the same time, but there was an unaccountable delay in the arrival of individual cages.

For the continuous treatment from the induction coil, a spark length of 1/4 inch was used, and current input to the primary was held to 2 amperes at 6 volts. The total power input was approximately 12 watts, about half that used in trials 1, 2, and 3 and, on a pen basis, the output was estimated to be approximately equal to that used in trial 4 although at lower voltage. The radio frequency current 18 inches from the secondary terminal of the coil and at the initial end of the first turn of the helix averaged about 150 milliamperes. A variable high voltage capacitor shunted across the secondary terminals of the induction coil improved the performance of the coil operating under these conditions. The capacitor consisted of two flat plates of 24-gage aluminum, 4 in. x 6 in., separated by three plates of single thickness window glass, having an estimated capacitance of 100 uufd. Predominant frequency was about 1.6 megacycles as measured on a wide-band receiver.

For the second continuous treatment, an ARC-5 transmitter operating at 6 megacycles was used, having an estimated power output of 10 watts. Radio frequency current between the transmitter and the helix, connected as an antenna averaged about 150 milliamperes, ranging from 50 to 200 milliamperes.

For the third treatment, one pen was equipped with 24-gage aluminum plates, 26 in. x 32 in., above and below each of the three lots of chickens as shown in Fig. 10 and Fig. 11. These plates were energized from a 15,000-volt, 30 m.a., luminous tube, alternating current transformer connected as a half-wave rectifier. A d.c. voltmeter made up of a 0 - 1 milliammeter, d.c., and a series resistor of 20 megohms (1000 ohms per volt) read 8000 volts across the plates. Top and bottom decks were exposed to voltage of the same polarity, negative overhead, and the middle deck was exposed to the opposite voltage. Movement of dust particles within the pens evidenced the presence of a charging field. Chicks were exposed to this treatment continuously from age two weeks to age five weeks, except when waterers were changed or the birds removed for weighing. At that time the height of the individuals was enough to cause a short circuit between plates, and it was necessary to turn off the treatment. Lots were held in the pen however until age six weeks.

Fig. 10 Pen used for exposing chicks between plates at high potential difference, unchanging polarity.

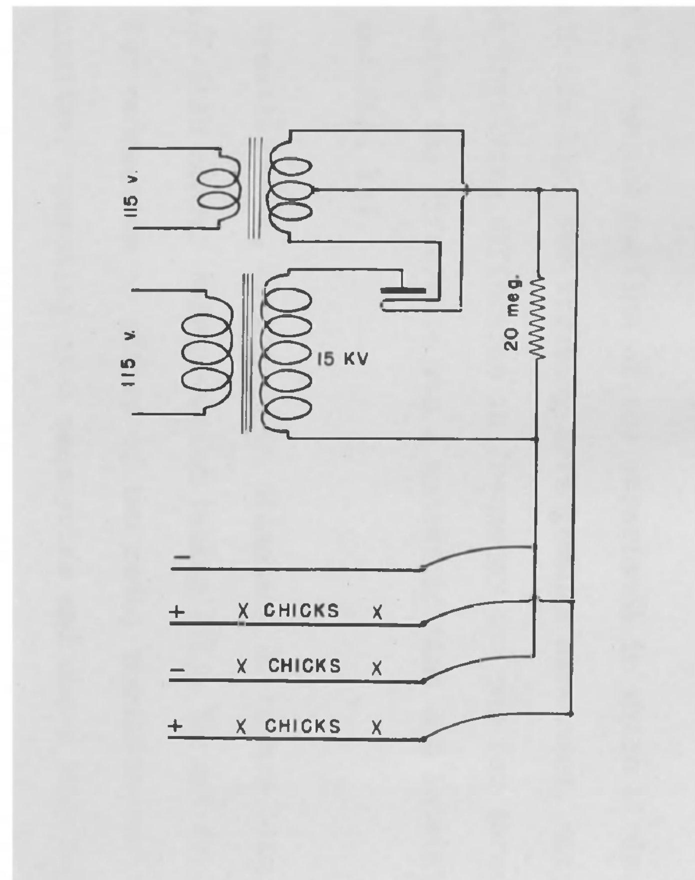


Fig. 11 Circuit of half-wave rectifier used to provide a high d-c potential for the pen shown in Fig. 12. Tube is an 8020 rectifier with a 5-volt filament supply.

In the second portion of the experiment in which birds were housed individually, two treating arrangements were used, one for two treatments involving difference in frequency and one for three treatments in which the difference was a matter of time and intensity, (Fig. 12 and Fig. 13).

A treating coil, 24 inches in diameter, 24 inches long, of 42 feet of 1/2-inch copper refrigeration tubing (Fig. 14 and Fig. 15) was arranged for connection to either of two radio transmitters, one an ARC-5 transmitter operating at 6 megacycles and one a 32.5-megacycle Motorola model FST-508R transmitter. Treatment was accomplished by placing the 10 birds in a non-conducting, plastic screened box, 22 in. x 24 in. x 10 in., within the treating coil for 1-1/2 hours daily. The exposure of 1-1/2 hours was comparable in total time to the four 20-minute treatments daily as used in the preceding four trials. The treatment was more intense than the earlier treatments in that the size of the coil was smaller for the power output, estimated at 15 watts (based on 50 per cent of measured input to the power supply) for both transmitters, but extremely mild as compared to the remaining three treatments.

For three additional treatments, a short wave generator, as commonly used for human therapy, provided treatments at 16 megacycles by induction. A Liebel-Flarsheim, Model SW-221, machine was used with a standard induction cable looped three turns, six inches apart, around a non-conducting, plastic screened box, 10 in. x 24 in. x 10 in., holding the 10 birds, (Fig. 16 and Fig. 17). The treating circuit was

Fig. 12 Individual cages used to house seven experimental groups of ten birds. Chicks were removed from these cages once daily for treatment as a group.

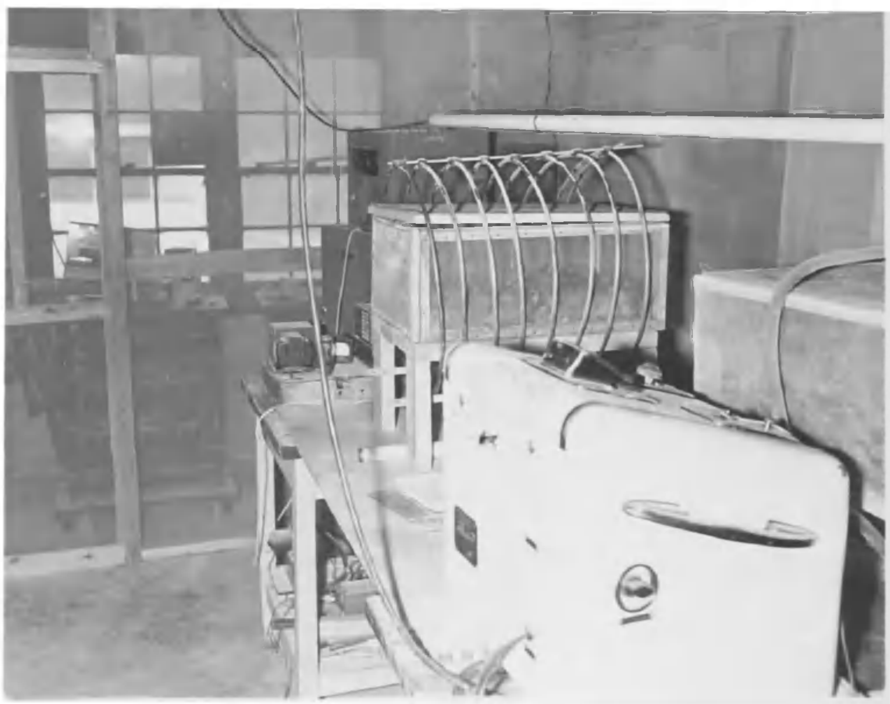


Fig. 13 View of the equipment used for treating birds in groups of ten.

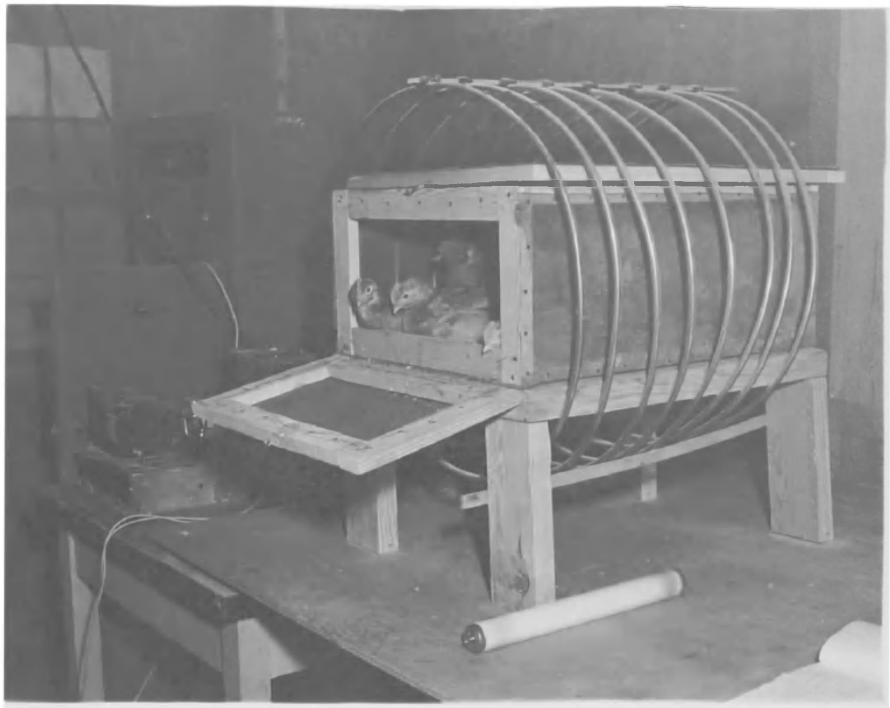


Fig. 14 Arrangement for exposing groups of ten chicks to the high frequency field produced by a radio transmitter. Pen is non-conducting.

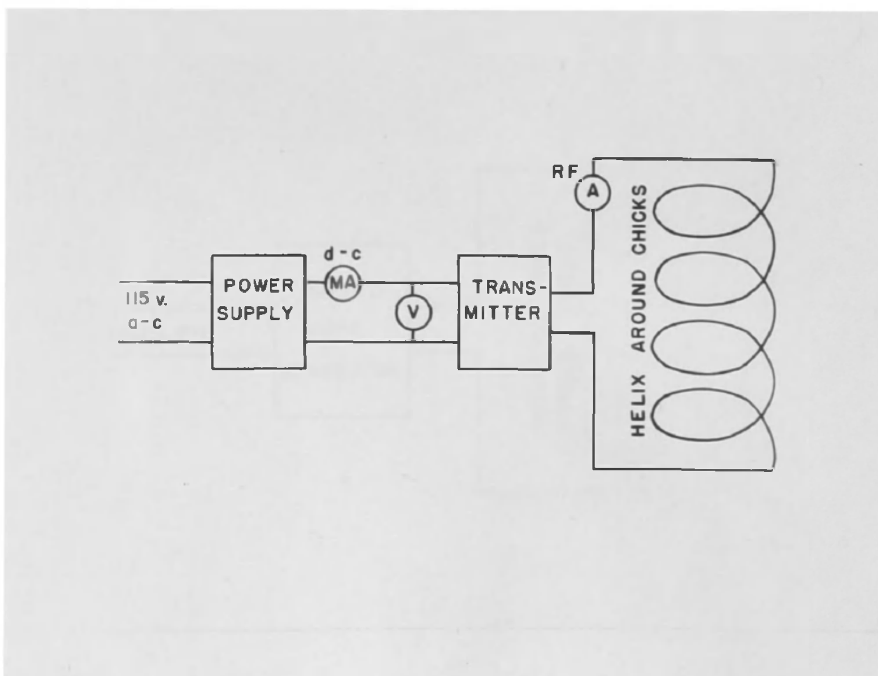


Fig. 15 Circuit used for the treatment shown in Fig. 14. Transmitters were interchanged to get different treatments.

Fig. 16 Short wave generator used for intense treatments on groups 6, 7, and 8. Machine is one commonly used for human therapy.

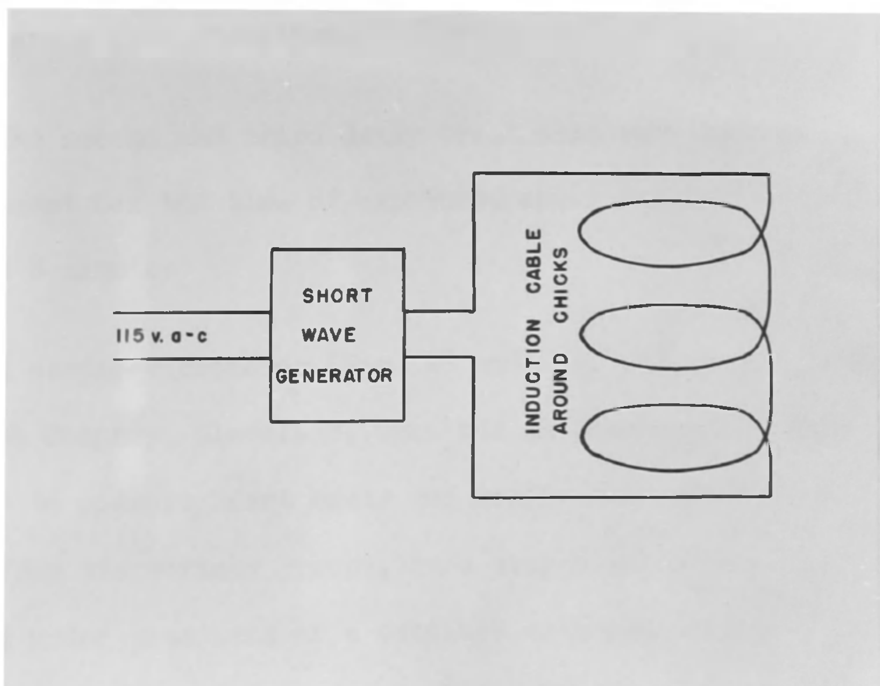


Fig. 17 Circuit arrangement of Liebel-Flarsheim model SW-221 generator shown in Fig. 16.

tuned to maximum intensity, reading 12 to 25 on the power indicator, a relative indication on a machine capable of approximately 250 watts output, this being about 20 to 40 per cent of the output capacity.

The first treatment with this arrangement was intended to be one of maximum intensity. The ten birds in the cage were exposed for a period of 30 minutes, once daily, for four weeks. With a typical room condition of 72 deg. F. at a relative humidity of 60 per cent, this exposure appeared to be as much as they could safely endure. The birds experienced a rapid increase in rate of respiration as the treatment was applied, which became normal about twenty minutes after treatment was discontinued. Temperature of the birds was elevated from approximately 106.2 deg. F. to a maximum of 110.2 deg. F. Temperature was measured intermittently with clinical thermometers, rectally at three-fourths inch insertion.

The second and third daily treatments were identical with the first except for the time of exposure, which was respectively 15 minutes and 8 minutes.

A cardio-vibrometer (Fig. 18 and Fig. 19) as manufactured by The Brush Company, Cleveland, Ohio and as described by Odum (1940) was used to measure heart beats and respiration of birds selected at random from the various groups, in a search for a possible reaction of birds under treatment or a possible treatment effect. This measure was abandoned, however, except for some birds exposed to the most intense treatments. The individual was placed in a small box and allowed

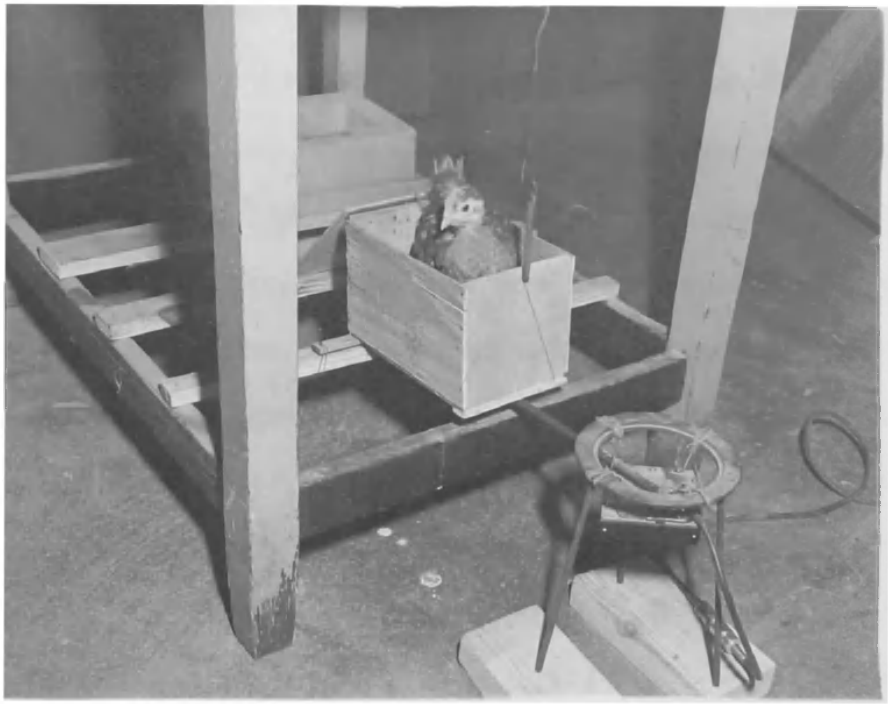


Fig. 18 Pick-up crystal of cardio-vibrometer and arrangement used in measuring heart and respiratory activity.

Fig. 19 Amplifier for signal received from pick-up crystal and the recorder for heart and respiratory activity.

to come to rest before a record was made. One end of the box rested on a pivoted support, and the other end rested on the arm attached to the crystal detector. The signal from the crystal resulting from the heart beat or respiration of the bird was transmitted to an amplifier, then to a recorder. From the recorded wave, counts were made of the peaks caused by heart beats and the peaks caused by the breathing. To determine the reaction of birds to the application of the electromagnetic field, the box holding the bird was placed within the treating coil, and a wooden dowel rod was used for a linkage arrangement to transmit the vibrations to the pickup crystal well below the coil.

A sample of five birds from each lot was sacrificed at the end of the experiment as in trial 4 for a preliminary examination of some of the endocrine glands.

Remaining birds were placed in broiler houses and were weighed at eight weeks and at ten weeks as a further check on possible gain effects.

RESULTS

No marked differences caused by the high frequency electrical treatments were found between treated and untreated birds as measured in terms of gain and feed conversion efficiency. Nor did there appear to be any change in the treated chicks to suggest the need for other objective measurements of their growth or behavior.

Birds exposed to the most intense treatments experienced a rise in body temperature and an increased heart rate and rate of respiration during treatment. Measurements of temperature and heart rate showed that these two body activities became normal within a few minutes following the treatment. Rate of respiration, not measured, appeared to become normal in the same time. Similar measurements among birds from other groups under mild treatment were attempted, purely for the purpose of obtaining supplementary information. These measurements were abandoned when it became obvious that differences, if any, between treated and untreated birds were so small that they could be measured only by a very large number of observations, so many as to be prohibitive in this study.

A preliminary histological examination of tissues from some of the endocrine glands removed from a sampling of treated and untreated birds in trials 4 and 5 revealed no additional evidence of treatment effect. A more complete examination therefore appeared to be of doubtful value and was not made.

The results of the five trials are summarized by trials in the pages following.

The presentation of results of the gain and feed measurements is similar for each experiment, and includes four principal tables:

1. A summary of the mean gains of the experimental chicks by treatment and the standard deviation of those means.

2. An analysis of variance of the net gains of chicks for the treatment period. It is assumed that the net gain is representative of any cumulative effects on growth caused by treatment, the principal interest in the experiment, and caused by other conditions of the experiment.

3. A summary of the feed consumed, total gains, and feed conversion ratios of the groups of chicks by treatment. The figures include the gain and feed consumed for all birds participating in the experiment and not just those completing the experiment. The feed conversion ratio is judged to be quite representative of any cumulative effects of the experiment as far as feed efficiency is concerned. As the gain data is analyzed rather completely and as no new differences are suggested in the comparison of feed conversion ratios, no further mathematical treatment of that data is provided.

4. A summary of the initial weights and gains by weeks in a form which depicts the experimental design. The purpose of this table is to provide a record of the progress of the various lots of birds during the experiment so that, if necessary, a more critical examination

might be made of the data summarized otherwise.

Trial 1

The first experiment involving a comparison of two electrical treatments and a control showed no differences in gain or feed conversion between the control and treated groups of chicks. Table 1 summarizes the gains by treatment. Table 4 records the progressive gains of birds by weeks. There was no mortality in this experiment, although the two largest birds and the two smallest birds were removed at the end of the fourth week from each of the three lots comprising a group in order to leave more space for the remaining 48 birds per group. Mean weights for groups were only slightly affected by that change.

TABLE 1. MEAN GAINS OF WHITE ROCK CHICKS FROM AGE ONE DAY TO AGE SIX WEEKS, BY TREATMENT AND SEX, TRIAL 1

Treatment	Sex	No. of Chicks	Mean Gain Grams	Standard Deviation
None	Male	26	565.7	42.3
	Female	22	487.6	45.3
Induction Coil	Male	29	557.7	41.6
	Female	19	482.4	38.2
Transmitter (6 meg.)	Male	32	544.3	49.2
	Female	16	488.4	51.3

The gains by treatment are compared as shown by the analysis of variance in Table 2. Although the experimental design justifies removal of any differences because of pen level, or height above floor, those differences obviously are unimportant and are not removed from the error term. In a preliminary analysis of variance, it was found that interaction between sexes and treatment, two degrees of freedom, was not significant. That interaction is pooled with error in Table 2.

TABLE 2. ANALYSIS OF VARIANCE OF GAINS IN GRAMS OF WHITE ROCK CHICKS FROM AGE ONE DAY TO AGE SIX WEEKS, TRIAL 1

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	143	451,446	-	-
Sexes	1	164,275	164,275	77.3
Treatments	2	425	212.5	0.1
Error	140	286,746	2,048.2	-

F Value required for significance between treatments at five per cent level: 3.07

Feed efficiencies of the experimental groups of chicks are shown by feed conversion ratios, total feed consumed divided by total gain, in Table 3. There is close agreement between these figures indicating no marked differences between treatments.

TABLE 3. FEED CONSUMED AND FEED CONVERSION RATIOS OF WHITE ROCK CHICKS FROM AGE ONE DAY TO AGE SIX WEEKS, TRIAL 1

Treatment	Feed Consumed Grams	Total Gain Grams	Conversion Ratio Feed/Gain
None	73,677	28,765	2.56
Induction Coil	73,010	28,359	2.57
Transmitter, 6 meg.	73,512	28,129	2.61

Trial 2

The second experiment was complicated by a failure of the control group to grow normally during the first week prior to treatment. The 114 White Rock cockerels either were not adequately randomized, or else the control group had some experience, unaccounted for, possibly disease,

TABLE 4. INITIAL MEAN WEIGHTS AND GAINS OF WHITE ROCK CHICKS FROM AGE ONE DAY TO AGE SIX WEEKS, BY WEEKS AND TREATMENT, TRIAL 1

Treatment	No. of Chicks	Initial Wt.Grams	Gain by Weeks, Grams 1	2	3	4	5	6	Pen Level
None	16	41.0	28.8	55.8	61.1	131.7	115.1	136.0	Top
	16	39.8	30.0	52.1	59.2	126.4	112.3	136.1	Middle
	16	41.5	26.1	50.8	59.9	133.1	123.3	156.1	Bottom
Mean		40.8	28.3	52.9	60.1	130.4	116.9	142.7	
Induction Coil	16	40.5	28.1	51.1	72.3	103.2	136.9	154.5	Top
	16	40.0	26.7	45.6	63.8	123.2	124.3	134.1	Middle
	16	39.7	27.4	48.0	63.9	115.4	138.2	143.7	Bottom
Mean		40.1	27.4	48.2	67.0	113.9	133.1	144.1	
Transmitter (6 meg.)	16	40.3	31.0	53.8	59.8	122.4	121.0	140.5	Top
	16	40.8	26.0	51.5	57.0	116.4	132.4	130.5	Middle
	16	39.6	27.8	53.8	59.6	100.8	139.3	137.7	Bottom
Mean		40.2	28.3	53.0	58.8	113.2	130.7	136.2	

which caused their growth to be less uniform and on the whole less than expected. Initial weights of all three experimental groups were fairly uniform, but gains for the first week prior to treatment suggested a difference in capacity to grow in favor of the groups assigned for electrical treatment. An analysis of the gains for the first week is given in Table 5. This difference was thought at first not critical but became consistently more pronounced as the birds developed, Table 6. Mortality for the experiment was 2 birds from the initial 114.

TABLE 5. ANALYSIS OF VARIANCE OF GAINS OF CHICKS IN GRAMS DURING FIRST WEEK PRIOR TO TREATMENT, TRIAL 2

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	113	7900	-	-
Groups assigned	2	639	319.5	4.88**
Error	111	7261	65.4	

** F Value required for significance at one per cent level: 4.78

Differences in gain which appear to favor the treated groups cannot be attributed to the treatments because the sample of chicks at the beginning of treatments was not valid. It was observed that the largest chicks in the control group at the end of the test were fully as large as the largest chicks in the treated groups. The control group had several chicks which could be designated as runts, suggesting that the growth of the control was not normal. This variation is shown by differences in the standard deviations of the mean gains of the various groups shown in Table 7. An analysis of variance of the gains in this experiment is given in Table 8, but the differences indicated are not

TABLE 6. INITIAL MEAN WEIGHTS AND GAINS OF WHITE ROCK COCKERELS FROM AGE ONE DAY TO AGE SIX WEEKS, BY WEEKS AND TREATMENT, TRIAL 2

Treatment	No. of Chicks	Initial Wt. Grams	Gain by Weeks, Grams 1	2	3	4	5	6	Pen Level
None	12	39.1	24.6	32.5	56.0	85.2	110.5	127.2	Top
	13	39.2	24.6	40.8	59.1	92.6	113.2	139.8	Middle
	12	38.9	27.9	35.4	42.6	73.5	102.2	137.8	Bottom
Mean		39.7	25.8	36.2	52.6	83.8	108.7	134.9	
Induction Coil	13	39.9	29.5	42.2	52.2	93.8	131.0	140.7	Top
	13	40.1	32.8	52.6	69.8	103.3	142.0	135.0	Middle
	12	39.6	31.0	37.3	66.7	92.6	117.3	140.5	Bottom
Mean		39.9	31.1	44.2	62.8	96.6	130.1	138.7	
Transmitter (6 meg.)	13	39.3	29.5	51.7	84.5	110.1	123.5	131.0	Top
	13	38.6	30.1	40.1	72.4	95.5	123.5	143.0	Middle
	11	39.4	30.9	46.8	85.2	108.8	140.1	143.3	Bottom
Mean		39.1	30.2	46.2	80.7	104.8	129.0	139.1	

Least significant difference between means of first week gains at five per cent level, 3.67 grams, and at one per cent level 4.85 grams, based on analysis shown in Table 5.

useful as a basis for comparison of treatment effect.

TABLE 7. MEAN GAINS OF WHITE ROCK COCKERELS FROM AGE ONE WEEK TO AGE SIX WEEKS, TRIAL 2

Treatment	Number of Chicks	Mean Gain Grams	Standard Deviation, Grams
None	36	420.9	101.7
Induction Coil	38	470.0	57.7
Transmitter, 6 meg.	37	483.8	77.9

TABLE 8. ANALYSIS OF VARIANCE OF GAINS IN GRAMS OF WHITE ROCK COCKERELS FROM AGE ONE WEEK TO AGE SIX WEEKS, TRIAL 2

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Total	110	498,437		
Treatments	2	79,677	39,838	10.27
Error	108	418,760	3,877	

F Value required for significance at one per cent level: 4.82

Records of feed conversion, summarized in Table 9, follow the same trend as the mean gains, but the differences are not so pronounced. It is to be expected that chicks which grow poorly are not efficient users of feed. Differences in these ratios cannot be taken as evidence of treatment effect, but do reflect a difference between the groups which has been described.

TABLE 9. FEED CONSUMED AND FEED CONVERSION RATIOS OF WHITE ROCK COCKERELS, AGE DAY OLD TO SIX WEEKS, TRIAL 2

Treatment	Feed Consumed Grams	Total Gain Grams	Conversion Ratio Feed/Gain
None	42,905	16,505	2.60
Induction Coil	46,134	19,141	2.41
Transmitter, 6 meg.	46,132	19,388	2.37

Trial 3

The third experiment, similar in design to the first two, also showed no significant differences between groups either in gain or feed conversion efficiency, thus confirming the results of trial 1. Results of trial 3 are summarized in Tables 10, 11, 12, and 13 in the same manner as for the preceding tests. Mortality in this trial amounted to three birds from the original 108, all occurring in one treatment group. However, this mortality was ascribed to factors other than the treatment.

TABLE 10. MEAN GAINS OF WHITE ROCK CHICKS BY TREATMENT, AGE ONE DAY TO AGE SEVEN WEEKS, TRIAL 3

Treatment	No. of Chicks	Mean Gain Grams	Standard Dev.,Grams
None	36	644.39	108.35
Induction Coil	33	617.30	112.74
Transmitter	36	633.81	81.00

TABLE 11. ANALYSIS OF VARIANCE OF GAINS IN GRAMS OF WHITE ROCK CHICKS FROM AGE DAY OLD TO AGE SEVEN WEEKS, TRIAL 3

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Total	104	1,060,050	-	-
Treatments	2	12,758	6,379	0.6
Error	102	1,047,292	10,267	-

F Value required for significance at five per cent level: 3.04

TABLE 12. FEED CONSUMED AND FEED CONVERSION RATIOS OF WHITE ROCK CHICKS FROM AGE FOUR WEEKS 1/ TO AGE SEVEN WEEKS, TRIAL 3

Treatment	Feed Consumed Grams	Total Gain Grams	Conversion Ratio Feed/Gain
None	40,141	14,439	2.78
Induction Coil	37,469	12,564	2.98
Transmitter, 6 meg.	41,070	13,849	2.96

1/ Feed records were begun at the end of the fourth week.

TABLE 13. INITIAL MEAN WEIGHTS AND GAINS OF WHITE ROCK CHICKS FROM AGE DAY OLD TO AGE SEVEN WEEKS BY WEEKS AND TREATMENT, TRIAL 3

Treatment	No. of Chicks 1/	Day Old Wt.Grams	Gain by Weeks, Grams 2/ 1 & 2	3	4	5	6	7	Pen Level
None	12	34.5	91.5	84.5	69.6	124.2	149.5	139.5	Top
	12	35.6	90.5	71.6	83.7	109.5	110.0	148.5	Middle
	12	37.4	93.8	77.4	69.5	107.9	133.0	179.3	Bottom
Mean		35.8	91.9	77.8	74.3	113.9	120.8	155.8	
Induction Coil	11	34.3	95.7	70.0	75.5	80.5	125.2	113.0	Top
	10	34.2	84.6	68.8	84.2	100.2	143.3	149.6	Middle
	12	33.2	91.6	72.5	86.4	103.2	141.5	180.0	Bottom
Mean		33.9	90.6	70.3	82.0	94.7	136.7	147.5	
Transmitter	12	34.3	93.0	59.8	82.2	94.1	129.8	122.0	Top
	12	33.2	93.8	67.4	92.6	96.3	124.0	152.0	Middle
	12	35.1	107.5	78.0	89.2	114.6	148.2	165.2	Bottom
Mean		34.2	98.1	68.4	88.0	101.7	134.0	146.4	

1/ Number of chicks represents number completing test.

2/ Gain by weeks is the mean gain by lots and includes gains of all birds, some of which were lost before end of test.

Trial 4

The fourth trial was complicated to some extent by two factors. One was a mild respiratory infection among the birds during part of their fourth and fifth week, halfway during the treatment period. The second, less disturbing factor, was the presence of 16 pullets among the total sample of 324 chicks, presumably a sexed group, all cockerels. The females were removed from the final data because the number was too few to consider as a representative sample based on sex. Four additional birds were lost during the experiment, making a total of 20 individuals removed from the entire sample, or a loss of 6.18 per cent of the total observations. The effect of the respiratory difficulty is noticeable in the gains for the fifth week as compared to the fourth week, shown in Table 14. Differences in gain for those two weeks would be expected to be larger in favor of the fifth week. The birds apparently had recovered from the condition during the sixth week, and this is evidenced by the normal gain for that week.

The intended precision of the comparisons made in the experiment was impaired by those circumstances, but the test is considered valid. A summary of the gains is shown in Table 15, and an analysis of variance of the gain data is presented in Table 16. Significance at the five per cent level is indicated between treatments. This difference is apparent in the summary in Table 15 but cannot be assigned to the treatments. The level of the difference is not high because it could occur, of course, once in twenty due to chance. The difference could be locational since, because of the design used, the two pens having maximum gain are located at one end of the space used, (Fig. 7, page 22). Also

TABLE 14. INITIAL MEAN WEIGHTS AND GAINS OF NEW HAMPSHIRE COCKERELS BY WEEKS AND TREATMENT, TRIAL 4

Treatment		No. of Chicks	Initial Wt.Grams 1/	Gain by Weeks, Grams				Mean Net Gain 2/	Pen Level
				3	4	5	6		
None		32	169.5	112	134	126	175	548.41	Top
		33	169.5	111	136	125	172	545.00	Middle
		36	169.5	117	137	135	165	552.50	Bottom
	Mean		169.5	113	136	129	171	548.75	
Ind. Coil		34	169.5	112	151	140	177	584.41	Top
		36	169.5	110	140	144	157	552.36	Middle
		33	169.5	113	133	137	190	573.27	Bottom
	Mean		169.5	112	141	141	175	569.64	
Transmitter (30 meg.)		35	169.5	119	124	138	192	574.46	Top
		34	169.5	114	134	135	171	553.26	Middle
		31	169.5	113	137	148	171	569.03	Bottom
	Mean		169.5	116	132	140	178	565.57	

1/ Weight at age two weeks, beginning of treatment.

2/ Mean net gain is based on gains of birds at end of test for treatment period of four weeks.

TABLE 15. MEAN GAINS OF NEW HAMPSHIRE COCKERELS FROM AGE TWO WEEKS TO AGE SIX WEEKS, BY TREATMENT, TRIAL 4

Treatment	No. of Chicks	Mean Gain Grams	Standard Dev., Grams
None	101	548.75	60.21
Induction Coil	103	569.64	64.42
Transmitter (30 meg.)	100	565.57	59.41

TABLE 16. ANALYSIS OF VARIANCE OF GAINS IN GRAMS OF NEW HAMPSHIRE COCKERELS FROM AGE TWO WEEKS TO AGE SIX WEEKS, TRIAL 4

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Total	303	1,161,190	-	-
Treatments	2	24,888	12,444	3.30
Error	301	1,136,302	3,775	-

F Value required for significance at five per cent level: 3.03; and at one per cent level: 4.68.

TABLE 17. FEED CONSUMED AND FEED CONVERSION RATIOS OF NEW HAMPSHIRE COCKERELS FROM AGE TWO WEEKS TO AGE SIX WEEKS, TRIAL 4

Treatment	Feed Consumed Grams	Total Gain Grams	Conversion Ratio Feed/Gain
None	161,694	57,724	2.801
Induction Coil	168,325	59,980	2.806
Transmitter, 30 meg.	165,763	59,332	2.794

the difference might be attributed to effects of the respiratory difficulty if the control group had been affected more severely than the treated groups. That this might have been the case is suggested by the drop in rate of gain principally during the fifth week for that group, Table 14, accounting for a difference sufficiently large to cause the difference indicated by the analysis of variance. It is noted that there is not a significant difference between gains for the other weekly periods, including those for the sixth week.

When the loss of observations and the conditions of the experiment just described are considered, it appears that there is little reason to think that there was any treatment effect. There is no doubt that there was not a marked effect on gains attributable to the treatments. This conclusion is supported by the close agreement of the respective feed conversion ratios shown in Table 17.

Weights of the endocrine glands removed from ten birds sacrificed from each treatment group at the end of the test are shown in Table 18. These observations possess too much individual variation to form a sample suitable for conclusive statistical treatment, and no trend is apparent among the weights.

A preliminary histological examination 1/ of these tissues by the Poultry Department, University of Georgia, revealed no evidence of

1/ The author is indebted to Dr. Robert S. Wheeler, then Head of the Division of Poultry Husbandry, for this examination and for the one reported for trial 5.

marked differences in morphology between the respective tissues of the treated and untreated birds. That conclusion was based on objective measurements taken on slides selected at random from the treated and control groups.

TABLE 18. MEAN WEIGHTS OF ENDOCRINE GLANDS FROM SAMPLES OF BIRDS FROM EACH GROUP, TRIAL 4

Treatment	Body Wt. Grams	Pituitary Mg.	Thyroids Mg.	Adrenals Mg.	Testes Mg.
Untreated	807.2	6.5	71.6	92.2	222.1
Induction Coil	834.2	6.2	78.3	62.4	251.3
Transmitter	809.0	5.8	79.64	81.33	288.1

Weights for thyroids, adrenals, testes are total for two glands.

Trial 5

No evidence of a growth response from treatments was developed in trial 5.

This experiment consisted of two parts. The first part involved four groups of chicks, identified as groups 1 through 4, one of which was used as an untreated control and three of which were exposed to continuous treatment. The second portion involved seven experimental groups of ten birds which were raised in individual cages, five groups being exposed by groups to respective treatments once daily, and two groups being used as untreated controls.

Observations are summarized under headings: feed and gain measurements, histological examination, and other observations.

Feed and Gain Measurements

Gains for the treatment groups of the first part of this experiment, groups 1 through 4, are summarized in Table 19. There were no significant differences between the gains of the various treatment groups. There was a highly significant difference between the gains for the decks or pen levels in this test, the bottom level showing the highest gain. The analysis of variance, Table 20, accounts for those differences. This trial was run during the winter months, and there was a temperature gradient, not recorded, between the top of the pens and the concrete floor. It therefore seems reasonable to think that the environment for the bottom level was more favorable for growth. All groups did not respond identically to this condition as is indicated by the significance of the treatment by level interaction and as may be determined from the summary of gains by levels and treatment in Table 22. This still might have been a reflection of differences in environment. Since each treatment group was housed separately, treatment effect could be confounded with a pen effect, and the interaction perhaps might be referred to as a pen by level interaction. Of principal importance, however, is the fact that differences between treatment groups were not significant.

Records of feed conversion efficiency are shown by Table 21, and do not suggest marked differences between treated and untreated chicks.

Gains for the seven groups, 5 through 11, in the second part of trial 5 are summarized in Table 25. No significant differences are in-

TABLE 19. MEAN GAINS OF NEW HAMPSHIRE COCKERELS FROM AGE TWO WEEKS TO AGE SIX WEEKS, GROUPS 1 THROUGH 4, TRIAL 5

Treatment	Number of Chicks	Mean Gain, Grams	Standard Dev., Grams
None	53	595.28	61.90
Induction Coil	54	601.78	60.40
Transmitter, 6 meg.	54	609.44	46.63
High Voltage, D.C.	54	589.56	37.63

TABLE 20. ANALYSIS OF VARIANCE OF GAINS IN GRAMS OF NEW HAMPSHIRE COCKERELS FROM AGE TWO WEEKS TO AGE SIX WEEKS, GROUPS 1 THROUGH 4, TRIAL 5

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	214	596,597	-	-
Treatments	3	12,080	4,027	1.77
Pen levels	2	78,540	39,270	17.25**
Treatments x Levels	6	43,890	7,315	3.24**
Error	203	462,087	2,276	-

F values required for significance:

d.f.	5% level	1% level
3, 200	2.65	3.88
2, 200	3.04	4.71
6, 200	2.14	2.90

TABLE 21. FEED CONSUMED AND FEED CONVERSION RATIOS OF NEW HAMPSHIRE COCKERELS FROM AGE TWO WEEKS TO AGE SIX WEEKS, GROUPS 1 THROUGH 4, TRIAL 5

Treatment	Feed Consumed Grams	Total Gain Grams	Conversion Ratio -Feed/Gain
None	72,487	31,505	2.30
Induction Coil	75,881	32,390	2.34
Transmitter, 6 meg.	72,843	32,891	2.21
High Voltage, D.C.	73,584	31,834	2.34

TABLE 22. INITIAL MEAN WEIGHTS AND GAINS OF NEW HAMPSHIRE COCKERELS BY WEEKS AND TREATMENT, GROUPS 1 THROUGH 4, TRIAL 5

Treatment	No. of Chicks	Initial Wt. Grams 1/	Gain by Weeks, Grams 3	4	5	6	Mean Net Gain, Grams	Pen Level
None	17	159.9	115.7	120.1	172.6	187.4	598.41	Top
	18	159.9	108.1	122.8	168.5	179.3	580.00	Middle
	18	159.8	110.1	130.4	181.9	186.2	608.33	Bottom
Mean		159.9	111.3	124.4	174.3	184.3	595.28	
Induction Coil	18	160.1	115.8	116.3	166.7	170.8	566.33	Top
	18	159.9	114.4	119.9	169.6	204.5	608.50	Middle
	18	159.8	107.8	132.2	183.7	204.5	630.50	Bottom
Mean		159.9	112.7	122.8	173.3	193.3	601.78	
Transmitter (6 meg.)	18	159.8	118.4	118.7	162.1	184.8	584.04	Top
	18	160.2	96.4	126.0	178.3	191.1	591.77	Middle
	18	159.9	120.3	132.1	195.0	205.5	652.50	Bottom
Mean		160.0	111.7	125.6	178.5	193.8	609.44	
High Voltage D.C.	18	160.3	106.2	111.7	156.0	179.6	558.78	Top
	18	159.8	114.3	132.1	173.8	186.0	609.44	Middle
	18	159.8	103.1	131.9	184.9	181.9	600.44	Bottom
Mean		159.9	107.9	125.2	171.6	182.5	589.56	

1/ Initial weight at age two weeks, beginning of treatment.

dicated among the groups as shown by the analysis of variance of the gains, Table 23, by the feed conversion ratios in Table 26, or by the analysis of variance of the individual amounts of feed consumed, Table 24. Although the gain and feed intake data could be analyzed jointly, the two sets of observations are analyzed separately for purposes of simplicity. There is considerably more error in the measure of the feed intake than in the measure of the gains, ten per cent or more against one per cent. Also errors in measures of feed intake are not consistent among individuals, not only because of differences in their capacity to utilize feed consumed but also because of wide variation in individual feeding habits. It was observed that some of the birds were meticulous eaters and others particularly wasteful. Efforts were made to minimize waste of feed, but that difference remained.

TABLE 23. ANALYSIS OF VARIANCE OF GAINS IN GRAMS OF NEW HAMPSHIRE COCKERELS IN INDIVIDUAL CAGES FROM AGE THREE WEEKS TO AGE SEVEN WEEKS, GROUPS 5 THROUGH 11, TRIAL 5

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Total	69	438,523	-	-
Treatments	6	27,931	4,655	0.7
Error	63	410,592	6,517	-

F Value required for significance at five per cent level: 2.16

TABLE 24. ANALYSIS OF VARIANCE OF FEED CONSUMED, GRAMS, BY NEW HAMPSHIRE COCKERELS IN INDIVIDUAL CAGES FROM AGE THREE WEEKS TO AGE SEVEN WEEKS, GROUPS 5 THROUGH 11, TRIAL 5

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	69	4,090,048	-	-
Treatments	6	134,170	22,361	0.35
Error	63	3,955,878	62,792	-

F Value required for significance at five per cent level: 2.16

TABLE 25. GAINS IN GRAMS OF NEW HAMPSHIRE COCKERELS IN INDIVIDUAL CAGES FROM AGE THREE WEEKS TO AGE SEVEN WEEKS, BY TREATMENT, GROUPS 5 THROUGH 11, TRIAL 5

	Untreated Control	16 Megacycle 30 min.	16 Megacycle 15 min.	16 Megacycle 8 min.	6 Meg. 90 min.	32.5 Meg. 90 min.	Untreated Control
	777	581	773	695	517	805	775
	700	791	718	595	874	730	788
	763	814	842	823	760	711	721
	752	720	688	728	806	733	758
	870	675	763	741	748	776	477
	727	741	798	724	839	730	580
	674	840	732	799	670	662	655
	756	810	711	896	646	741	712
	784	657	795	770	817	732	702
	555	738	777	630	706	716	717
Treatment Means	735.8	736.7	759.7	740.1	738.3	733.6	688.5
Std. Dev.	82.48	81.43	47.04	88.92	107.03	37.36	95.69

TABLE 26. FEED CONSUMED, IN GRAMS, AND FEED CONVERSION RATIOS FOR NEW HAMPSHIRE COCKERELS IN INDIVIDUAL CAGES FROM AGE THREE WEEKS TO AGE SEVEN WEEKS BY TREATMENT, GROUPS 5 THROUGH 11, TRIAL 5

	Untreated Control	16 Megacycle 30 min.	16 Megacycle 15 min.	16 Megacycle 8 min.	6 Meg. 90 min.	32.5 Meg. 90 min.	Untreated Control
	2278	1979	1904	1962	1595	2159	2725
	1926	1931	1755	1736	2228	1975	2057
	2093	1916	1915	1994	1878	2181	1895
	2003	1869	1852	1819	2190	2432	1834
	1630	1944	1777	1797	2139	2205	1376
	1912	1929	2354	1853	1908	1947	1635
	1990	1997	2010	2121	1849	2413	1766
	2220	2007	1963	2205	2162	2057	2106
	2062	1510	2041	1862	1978	1647	2136
	2236	2606	1992	2458	2348	1876	2355
Mean	2035.0	1968.8	1956.3	1980.7	2027.5	2089.2	1988.5
Std. Dev.	192	266	169	223	225	241	379
Mean Gain	735.8	736.7	759.7	740.1	738.3	733.6	688.5
Feed/Gain Ratio	2.77	2.67	2.57	2.68	2.75	2.85	2.89

Histological examination

Weights of endocrine glands removed from five birds sacrificed from each group at the end of the test are shown in Table 27. As in the preceding trial, individual variation obscures any trend in weights, if present, and the number of observations is too few to permit conclusive statistical analysis.

A preliminary histological examination 1/ of these tissues revealed no evidence of treatment effect.

Other Observations, Trial 5

Measurements of heart rate and rate of respiration on birds selected at random from the various groups revealed that differences, if any, between treated and untreated birds were slight and, because of individual variation and other factors, could be determined only by a great number of measurements. The other factors affecting heart rate include the time the bird has been away from feed, his state of rest, activity, or excitement, and the temperature of his environment. That there might not have been differences is indicated by the fact that individuals exposed to 90-minute treatments using the 6 and 32.5 megacycle treatments exhibited no change in heart rate or respiration. For those reasons, an extensive number of measurements of heart rate were not made.

The mean heart rate of one typical set of 47 observations on 5-week old New Hampshire cockerels at rest was 320.5 beats per minute with a standard deviation of 42.7 beats per minute. The rate of res-

1/ Loc. cit., page 52.

TABLE 27. MEAN WEIGHTS OF ENDOCRINE GLANDS FROM SAMPLES OF FIVE BIRDS FROM EACH GROUP, TRIAL 5

Treatment (and Group) 1/	Body Wt., Grams	Pituitary Mg.	Thyroids2/ Mg.	Adrenals Mg.	Testes Mg.
Untreated (1)	842.4	6.44	96.8	99.9	269.3
Induction Coil (2)	820.6	9.1	76.36	102.2	291.8
Transmitter (3)	845.2	6.74	63.9	80.3	304.7
High Voltage, D.C. (4)	755.8	7.16	53.5	86.3	287.4
Untreated (5)	1017.6	10.6	77.6	108.2	412.2
16 Meg., 30 Min. (6)	1049.6	11.8	126.2	128.4	805.8
16 Meg., 15 Min. (7)	1082.2	10.1	111.2	137.4	921.3
16 Meg., 8 Min. (8)	1079.4	9.60	106.6	133.2	551.2
6 Meg., 90 Min. (9)	1053.0	11.16	105.2	135.5	673.7
32.5 Meg., 90 Min. (10)	1025.8	9.64	106.4	110.4	861.4
Untreated (11)	975.6	11.3	78.6	114.2	556.6

1/ Groups 1 through 4, age six weeks;
Groups 7 through 11, age seven weeks.

2/ Weights for thyroids, adrenals, testes are for two glands.

piration for the same group of birds at the same time had a mean of 37.3 per minute with a standard deviation of 4.5 breaths per minute.

Under all treatments in trial 5 except for the three intense exposures (those treatments for groups 6, 7, and 8), there apparently was no effect on heart rate caused by application of the treatment. Under the three intense treatments, however, as was to be expected, the temperature of the birds was raised during treatment, and there was a corresponding increase in heart activity and in rate of respiration. Rapid rates of respiration could not be measured accurately at the time and are not recorded. These effects were temporary, being initiated by the application of treatment, and lasting for a few minutes after treatment. Tables 28 and 29, and Fig. 20 and Fig. 21 illustrate those effects. Environmental temperature, and probably relative humidity, had an effect on the capacity of the birds to endure these treatments. Lower temperatures noticeably relieved the stress of the treatment.

Energy transfer to the birds under these conditions was estimated to be at the rate of approximately 6 to 10 Btu per hour per bird. This estimate is based on the temperature rise of containers of a saline solution, used to replace the birds in the cage enclosed by three turns of the induction cable of the short wave generator. The saline solution was a 0.2 per cent concentration of NaCl and distilled water. It was held in ten glass containers, each having a weight equal to that of one chick. That solution has an electrical conductivity under those conditions comparable to that of human tissue

(Osborne and Holmquest, 1944).

TABLE 28. BODY TEMPERATURE OF NEW HAMPSHIRE COCKERELS, AGE FIVE WEEKS, BEFORE AND FOLLOWING TREATMENT OF HIGH FREQUENCY INDUCTION 1/

8-Min. Elapsed Time, Min.	Treatment Body Temp. Deg. F.	15-Min. Elapsed Time, Min.	Treatment Body Temp. Deg. F.	30-Min. Elapsed Time, Min.	Treatment Body Temp. Deg. F.
0	106.4	0	106.4	0	106.2
8	108.3	15	109.1	30	110.0
12	107.9	19	109.3	40	108.2
18	107.1	25	107.7	55	106.2
23	106.7	30	107.0		
28	106.4	35	106.7		

TABLE 29. HEART RATE OF NEW HAMPSHIRE COCKERELS, AGE FIVE WEEKS, BEFORE AND FOLLOWING TREATMENT OF HIGH FREQUENCY INDUCTION 1/

8-Min. Elapsed Time, Min.	Treatment Heart Rate Beats/min.	15-Min. Elapsed Time, Min.	Treatment Heart Rate Beats/min.	30-Min. Elapsed Time, Min.	Treatment Heart Rate Beats/min.
0	281	0	304	0	297
8	324	15	347	30	348
11	317	17	332	32	347
14	299	19	312	34	321
17	299	21	310	36	312
20	296	23	303	38	312
23	293	25	303	40	314
26	291	27	302	42	317
29	285	29	300	44	308
		31	297	46	293
				48	290
				50	290
				52	287

1/ Frequency of the applied electromagnetic field was 16 megacycles. Energy transfer to the birds was estimated to be at the rate of 6 to 10 Btu per hour per bird.

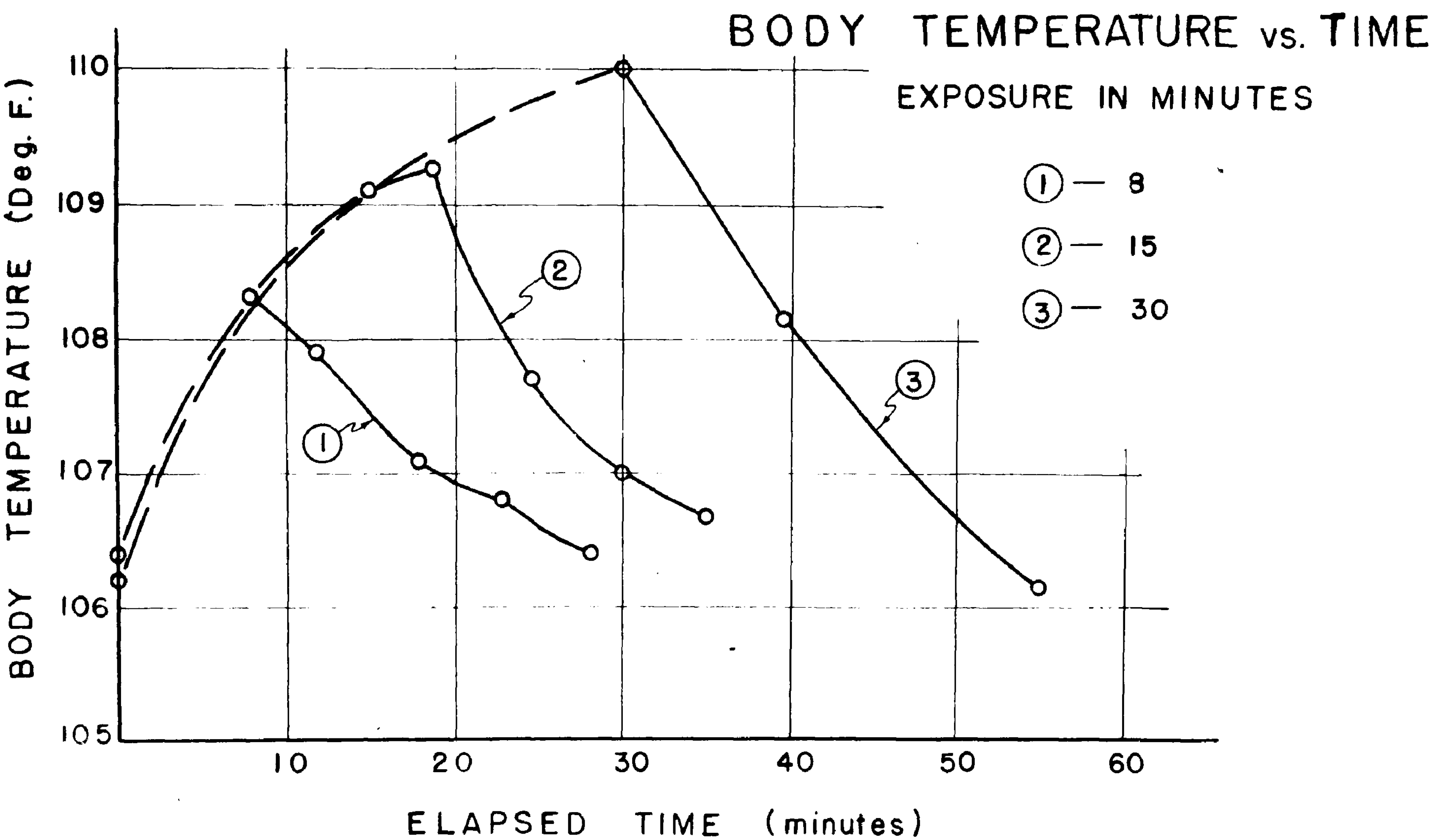


Fig. 20 Changes in body temperature of chicks exposed to intense treatment of high frequency induction for 8, 15, and 30 minutes at a frequency of 16 megacycles. Each point is the mean of readings on five birds. Energy transfer to the chicks was estimated to be at the rate of 6 to 10 Btu per hour per bird. Room temperature 72 deg. F., relative humidity 60 per cent.

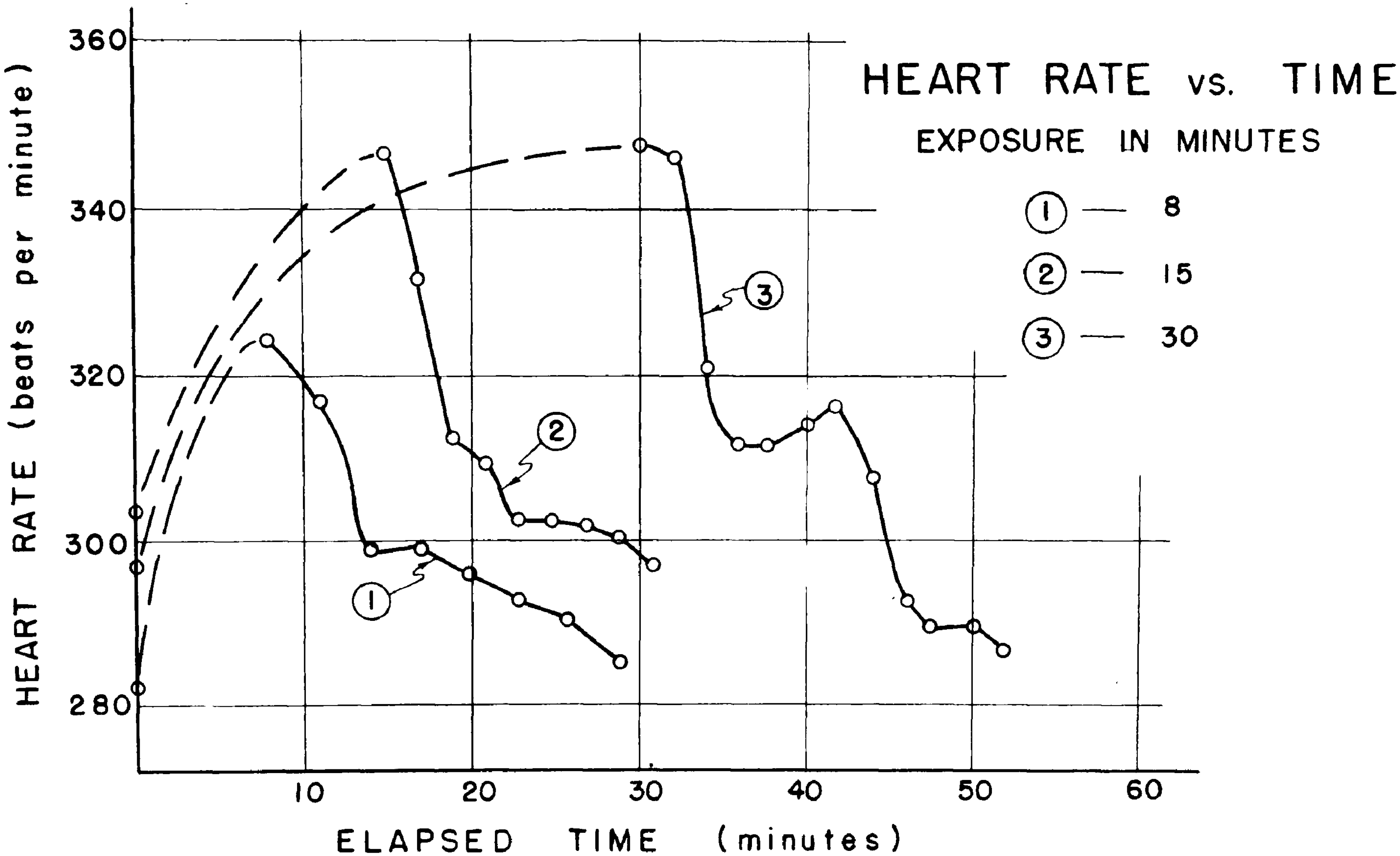


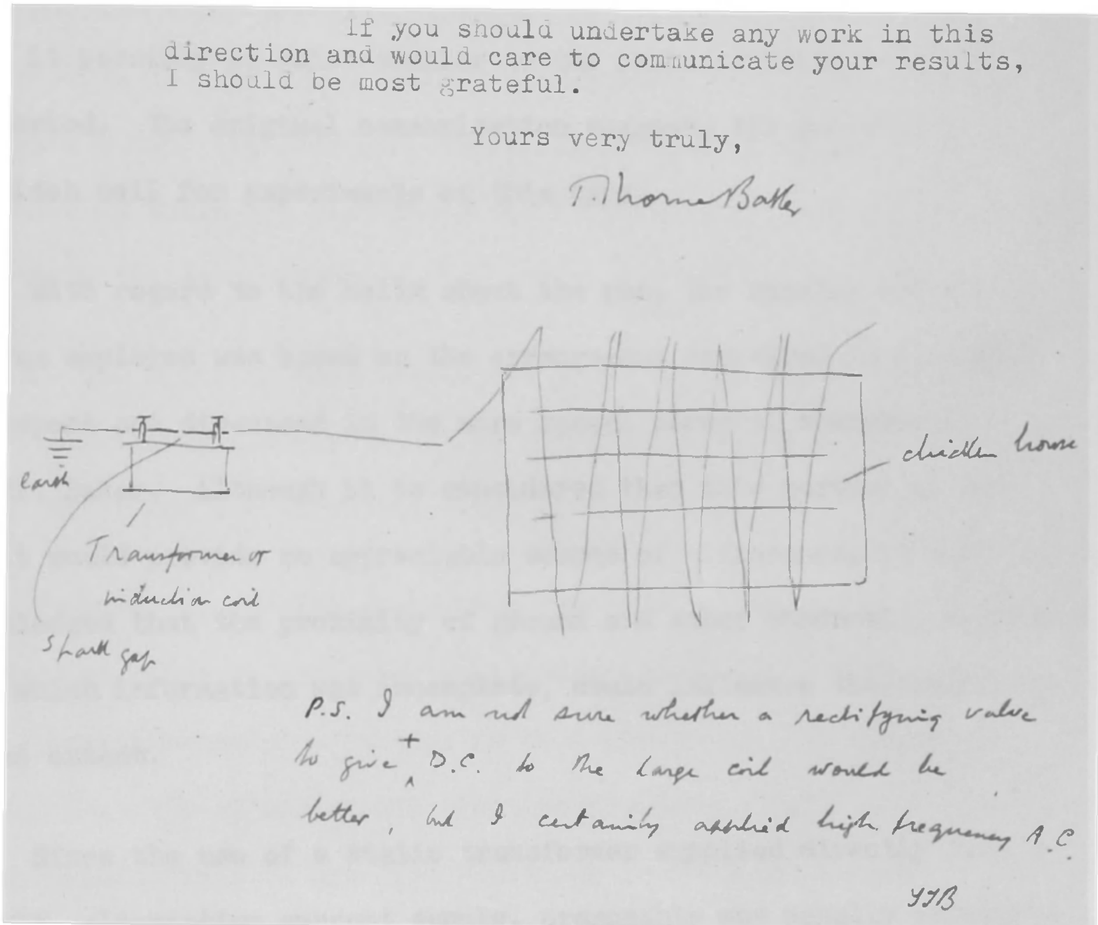
Fig. 21 Changes in heart rate of individual New Hampshire cockerels at age 5 weeks exposed to intense treatment of high frequency induction at a frequency of 16 megacycles. Treatment is the same as that referred to in Fig. 20 which was administered as shown in Fig. 16 and Fig. 17. Heart activity measured as illustrated in Fig. 18 and Fig. 19.

DISCUSSION OF RESULTS

Since apparently no marked differences were developed in the experimental birds between those exposed to high frequency and those untreated but handled alike, two principal deductions might be made. Either the original treatment was not closely approximated, or the differences observed by Baker were caused by factors other than the treatment.

Some doubt may exist as to whether or not the treatments employed in this study were nearly identical with those used by Baker. The original communication does not record a description of the electrical treatment in terms to permit exact duplication. The frequency used cannot be determined closely. The power used can be estimated with less possible error. That the circuits and quantities employed in both the original work and this are quite similar, however, is evidenced by close agreement of the circuits used in the two instances. The importance of this question is minimized further by the scope of the observations reported from the present investigation.

The electrical arrangement depicted by Fig. 4, used in each trial and with some variation, is essentially the same as that provided by Mr. Baker, illustrated in Fig. 22. There could be differences in the electrical characteristics of the two circuits, in which there are two important parts, the induction coil and the helix about the pen of chickens. (The performance of an induction coil of this type is analyzed in detail in the two references listed, Jones (1932) and Bailey (1910)). It is of interest that the induction coil provided by the



If you should undertake any work in this direction and would care to communicate your results, I should be most grateful.

Yours very truly,

T. Thorne Baker

P.S. I am not sure whether a rectifying valve to give + D.C. to the large coil would be better, but I certainly applied high frequency A.C.

TTB

Fig. 22 Electrical arrangement for treating chicks suggested by the original investigator who reported getting growth responses from the treatment. The circuit depicted here and that shown by Fig. 4 are essentially the same.

Detroit Coil Company for these experiments is a type as used for wireless communication prior to World War I and still retains an identification W-3, meaning a three-inch (spark) coil for wireless communication. Although of American manufacture (it is also identified as an Edison coil), it possibly is quite similar to the coils of British make of the same period. The original communication suggests the suitability of a three-inch coil for experiments of this type.

With regard to the helix about the pen, the spacing and number of turns employed was based on the arrangement described in the original report and discussed in the more recent personal communication from Mr. Baker. Although it is considered that this portion of the circuit would provide no appreciable source of difference, it must be acknowledged that the proximity of ground and other conducting material, about which information was incomplete, could influence the treatment to some extent.

Since the use of a static transformer supplied directly from a 230-volt, alternating current supply, presumably was equally effective as a source of high frequency treatment when connected as illustrated in Fig. 22, some differences in frequency and power output from the high frequency generator must not have been critical. In general, some variation in frequency and minor variations in power output are not critical in obtaining effects with high frequency, such as heating.

It was recorded earlier that the phenomena noted by Mr. Baker, the spark from the chick and the glow of a neon tube, were also observed in these experiments. Though not descriptive of the treatment in specific terms, the presence of these phenomena was a manifestation of some degree of the similarity sought between his arrangement and this one.

The treatment schedule suggested by Mr. Baker, an exposure of 20 minutes three or four times a day, was followed by using that exposure four times a day. In addition, one trial provided a comparison of treatments in which the treated chicks were exposed continuously during a four-week treatment period.

On the basis of those facts, it might be assumed with slight reservation that there were no great differences between the treatments used by Baker and the treatments used in this study.

Further, treatments at various frequencies and treatments with a considerable range of variation in intensity were tried without producing any growth response or change in feed conversion efficiency in the chicks. The only effect of the treatments observed was one of heating and increased metabolic activity resulting from the application of rather intense treatments, a total effect attributable to heating. These findings are in accord with those of many other investigators, including Knudson and Schaible (1931) who found that raising the body temperature of young rats to 40.5 deg. C. did not retard their growth appreciably, and with those of Christie and Loomis (1929), who, in a study of the biological effects of high frequency involving frequencies from 8.3 to 158 megacycles in experiments on mice, concluded that the effects on the animals can be fully explained on the basis of the heat generated by the induced high frequency currents. Although some investigators have suggested the possibility of effects other than heating, as discussed by McKinley (1936) and by Osborne and Holmquest (1944), there was nothing in this work to suggest that there was any effect other than that of heating.

More complete information on the source, magnitude, and characteristics of the natural electrical potentials of the experimental birds might have provided more insight into the possible influence to be expected by super-imposing upon them another electrical field. In the absence of that information, and without additional evidence of a specific electrical effect, or the equivalent, from treatments of this nature, then the claim by Mr. Baker provides the principal basis for thinking that there might be a growth response or similar effect on chickens to be obtained in such a manner. Since treatments of a type considered similar have been tried without getting the same results, but instead, agreement with the findings of others insofar as the studies are comparable, it may be considered that the responses observed by Mr. Baker were caused by factors other than the electrical treatment.

Chickens are quite variable creatures. As commonly observed in growth experiments, significant differences in rates of growth of similar chickens may be caused by such things as slight differences in environment, differences in care and handling, difference in manner of feeding and watering, and other factors. In order to obtain valid comparisons of growth between groups of chickens, it is necessary to select carefully an arrangement of the groups so as to account for the influence of those many variable factors which become involved in any measure of a treatment effect. This is now commonly done with the aid of well known experimental designs which permit conclusive statistical analysis, Cochran and Cox (1950). Even so, researchers are plagued with the variability mentioned. Although sound statistical methods have been employed in some instances as long ago as a hundred years, the use of statistical methods has become popular and widespread only in recent years, since the time of the early experiments by Mr. Baker. He did not describe the manner in which he made his comparisons, nor how his untreated birds were grown. It is unlikely that the comparisons were made in a manner which would bear critical analysis by the standards used today. The differences he observed possibly were brought about by one or more of several factors other than the electrical treatment.

Further study along the lines of this investigation appears to have little justification. A more fruitful approach might involve a study of the natural potentials of the bird, the source, magnitude, and characteristics of those potentials in a manner somewhat similar to that used by Burr and Hovland (1937) except to include fully developed chicks at various stages of maturity. That information, perhaps it need not be complete, might provide a basis for suspecting a possible effect from the application of external potentials.

Also, the procedure used in trial 5 in which the temperature and heart rate of birds were charted immediately before and following an intense treatment by high frequency electromagnetic induction suggests a method of determining additional facts about the capacity of chickens to withstand the application of heat and rid themselves of the excess heat. The use of different conditions of heating combined with different cooling environments would afford the observations which might be of value in predicting the performance of the bird under different environmental conditions.

SUMMARY

Young chickens were exposed to the electromagnetic field within coils energized at different frequencies and at different intensities from high frequency generators to determine the possible effects on their gain and feed conversion. Marked increases in growth and improvement in feed conversion efficiency of young chickens exposed to such treatment were reported by Baker (1913) and indicated that the treatments might have possibilities for practical application. Although similar effects had not been reported by others, and it seems such a marked response could not have been overlooked, the literature did not provide the evidence to refute the claim. The original investigator, still active, was firm in his belief. His claim apparently had heretofore not been investigated. The purpose of this study was to determine if the effects reported might be obtained in young chickens by the use of high frequency electrical treatments similar to those used by Baker with a view toward determining the factors involved and learning how to utilize the stimulation to practical advantage.

Five experimental trials were involved, three done at Michigan State College on White Rock chicks and two at the University of Georgia on New Hampshire cockerels during the period January 1953 to March 1954.

Principal treatments involved the use of a Ruhmkorff coil as used in the early experiments. Although it was not possible to prove that the treatments used in this study and the early one were identical, it appeared that the extent of the difference was not critical based on

variations of the treatment as described by Baker which apparently were equally effective. Furthermore, additional variations in the treatments used in the present experiments increased the scope of possibilities of this investigation.

No marked differences caused by the high frequency electrical treatments were found between treated and untreated birds as measured in terms of gain and feed conversion efficiency. Nor did there appear to be any change in the treated chicks to suggest the need for other objective measurements of their growth or behavior.

Birds exposed to the most intense treatments did experience, as was to be expected, a rise in body temperature and increased heart and respiratory activity during treatment, which became normal a few minutes after the treatment.

A preliminary histological examination of endocrine tissues from samples of birds from some of the experimental groups did not reveal any evidence of treatment effect.

It is considered likely, in view of the present findings, that the differences observed by Baker might have been caused by factors other than the high frequency electrical treatments.

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