BLOOD-PRESSURE
IN
SURGERY

AN EXPERIMENTAL AND CLINICAL RESEARCH

THE CARTWRIGHT PRIZE ESSAY
FOR 1903

BY
GEORGE W. CRILE, A.M., M.D.
PROFESSOR OF CLINICAL SURGERY, WESTERN RESERVE MEDICAL COLLEGE; VISITING SURGEON TO ST. ALEXIS HOSPITAL; ASSOCIATE SURGEON TO LAKESIDE HOSPITAL, CLEVELAND

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June 27, 1903.

Dr. George W. Crile,

275 Prospect Street,

Cleveland, Ohio.

My dear Doctor,—I have the honor to inform you that the Cartwright Prize of the Alumni Association of the College of Physicians and Surgeons, New York City, has been awarded to your essay entitled "Blood-Pressure in Surgery," and designated "G. B."

Yours truly,

HENRY E. HALE,

Secretary Alumni Association.

PREFACE

In all the experiments the animals were completely anesthetized. But one recovery experiment was made. This animal was kept under the influence of morphin until it was killed. This research opened so many leads that a large number of experiments became necessary to bring it to even so imperfect a close. I have pleasure in making most grateful acknowledgment of invaluable aid in the form of suggestions and criticisms from Professor George N. Stewart and Professor Torald Sollman, both of whom at all times generously gave me the benefit of their wide experience and scientific knowledge. To my pupil, Mr. Homer H. Heath, who displayed commendable originality during the research, the responsible task of collecting the major portion of the experimental data was intrusted. In the collection of this data other pupils, Mr. Lenhart and Mr. Worth Brown, rendered valuable assistance. To my associate, Dr. William E. Lower, I am indebted for many valuable suggestions, criticisms, and aid in both the experimental and the clinical research. To my clinical assistant, Dr. Clyde E. Ford, was intrusted the collection of the larger portion of the clinical data on the human blood-pressure, and a portion of the experimental work. Dr. A. Cudell undertook the preparation of the historical notes. To the Board of Trustees of Lakeside Hospital I am under obligation for arranging and placing at my disposal a special pneumatic room.

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INTRODUCTION

INVESTIGATION of the views as to the various causes of low blood-pressures in surgical cases, and of the methods employed in controlling the same in the various clinics of the surgical world, reveals a diversity of opinion as to the former and a diversity of method as to the latter. One may say, in fact, that each surgeon holds distinctive opinions. On a closer inquiry as to the foundations of belief, it is often found to have taken its origin as a tradition handed down by predecessors in a hospital service, or from master to pupil, and accepted in the same way as religion or politics. This is not advanced as an argument for or against the correctness of the beliefs, but indicates that the matter has been placed upon an empiric rather than a scientific basis.

The most striking fact with regard to this is the contradictory methods of treatment: one surgeon gives alcohol as a routine after severe operations; another, both before and after; while another never gives it. One gives digitalis, another strychnin; some give strychnin and its antagonist, nitroglycerin, at the same time. Some give hypodermic injections of ether, even if ether anesthesia has been employed; atropin, because the circulation in the skin may be increased, thereby removing the symptom of coldness of the skin. Another gives caffein, because it stimulates the heart. In France ergotin is the favorite; in Germany, strychnin. Almost every known drug is given; synergists and antagonists simultaneously, while some surgeons give no drugs.

A closer comparison between results in wards in which stimulation, particularly "heavy" stimulation, is the rule, and in wards in which it is the exception, is not unfavorable to the latter.

Nitroglycerin, atropin, saline infusion, digitalis, alcohol, caffein, camphor, ergotin, ether, strophanthus, etc., have so many individual, even contradictory, actions that it would seem that these drugs could not all be indicated in the same condition. In selecting one of these drugs in a case of shock or collapse, would it not first be necessary to know definitely to what the fall in the blood-pressure is due? Is it due to the exhaustion of the anatomical periphery (blood-vessels); of the heart; of the vasomotor; of the cardiac centre; or of the respiratory centre; is it an exhaustion or a suspension of function, or has the blood plasma passed through the vessel walls? If it is due to exhaustion of one or more of these centres or organs, would stimulation relieve the exhaustion, or would an increased exhaustion follow the stimulation? Would it be better to lash the tired horse or give it rest?

If not all the centres and organs are exhausted, would it be advantageous to stimulate those not affected while the exhausted ones rested? Would it be advantageous to restore the blood-pressure, as far as possible, by use of harmless mechanical means?

Are not the centres governing the circulation automatic, and are they not all automatically stimulated? And are they not all stimulated to the point of exhaustion before the final circulatory break-down occurs? As applied to the centres that are depressed, is it better to depend upon a drug stimulation, or upon automatic stimulation?

These questions have prompted this research, the results of which were continually subjected to a clinical comparison in an active surgical practice. Much of the experimental data might have been omitted, publishing instead only illustrative experiments and the summaries, but the task of making so large a number of experiments is so costly in time and labor that it was thought best to publish all the data for the benefit of some future investigator, who may be spared many weary details by making use of the data our research has yielded.

METHODS OF INVESTIGATION AND ANNOTATION

THE animals were all reduced to full surgical anesthesia before the experiments were begun, and were killed before recovery from the same. In the greater number of experiments ether was used, and anesthesia was produced by the following method. A cloth hood, conical in shape, was constructed so as to accommodate the animal's entire head, and into the apex was thrust a piece of cotton wool. Saturating the cotton with the anesthetic and holding the hood closely over the head of the animal, reduction to surgical anesthesia was made with but little difficulty. After the completion of the anesthesia, the trachea was exposed and a breathing cannula inserted. To the free end of this cannula a strong rubber tubing was attached, and to the end of this tubing was fastened a funnel which was placed over a piece of cotton wool saturated with the anesthetic. By this method anesthesia was easily maintained and no impediment offered to free respiration. The blood-pressure was recorded in the usual way, by means of mercury manometers upon a revolving drum, carrying a smoked paper, according to the methods in vogue in experimental physiology. The drums were revolved by mechanisms so made as to be capable of a variety of movements, ranging from one revolution in thirty minutes to eighteen revolutions per minute, so that any phase of a given tracing might be duly recorded. In every experiment tracings were taken, and these have been carefully preserved. Accordingly there is no statement made in the following pages that may not be verified by tracings in my possession. A sufficient number of typical ones have been published to illustrate groups of their kind. The number of animals subjected to experiment was two hundred and forty-three, and complete notes of all the experiments have been preserved. The notes were made always at the time of the experiment, and every detail was carefully recorded. It is from these notes and the tracings that the material for the following pages was obtained. No matter how faithfully the notes and the illustrations may have been made, it is impossible to impart the full impression made by the experiments upon the experimenter, who received the impressions at first hand. In the experiments made in one year the metric system was employed, while in the later ones it was not. The confusion was unfortunately overlooked until the manuscript had been set up.

BLOOD-PRESSURE IN SURGERY

Experiment 1.

Alcohol.

Mongrel puppy; weight, three kilos. Morphin and ether anesthesia.

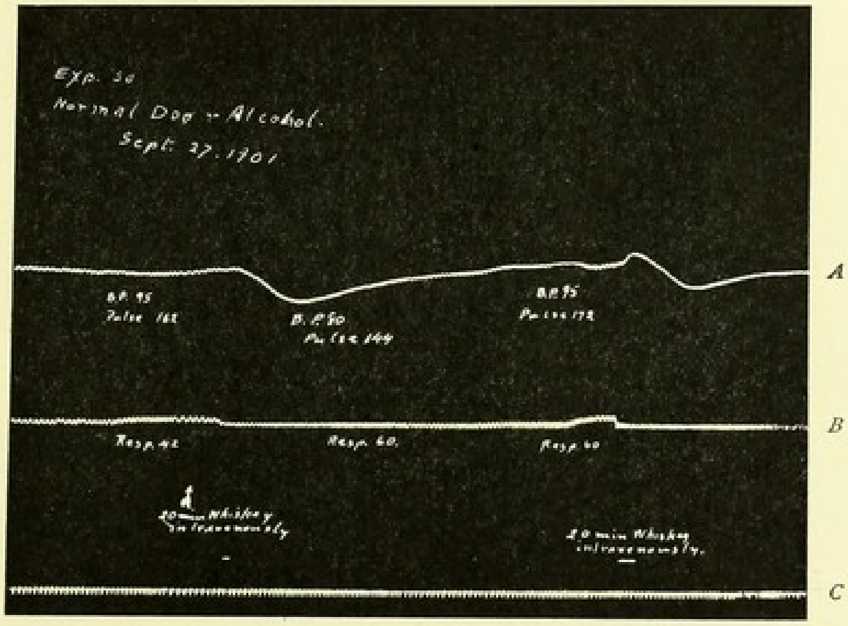

Fig. 1.—Exp. 1.—Alcohol administered to a normal animal. *A*, carotid pressure; *B*, respiration; *C*, seconds. Note the immediate fall in blood-pressure, and the compensatory rise on the intravenous administration of alcohol.

At 12.20, blood-pressure, 95 mm.; pulse, 186; respiration, 52. Ten minims of whiskey were injected intravenously. No effect was produced. A repetition of the injection caused no change. An injection of 20 minims of whiskey was followed by a slight irregularity in the blood-pressure.

At 12.25, blood-pressure, 95 mm.; pulse, 162; respiration, 42. An injection of 20 minims of whiskey was followed by a marked irregularity and fall in the blood-pressure.

At 12.28, blood-pressure, 80 mm.; pulse, 144; respiration, 60.

At 12.30, 20 minims of whiskey were injected. An irregularity in the blood-pressure followed.

At 12.31, blood-pressure, 80 mm.; pulse, 144; respiration, 60.

At 12.35, blood-pressure, 95 mm.; pulse, 172; respiration, 60.

At 12.37, an injection of 20 minims of whiskey was given. An irregularity in the blood-pressure followed.

At 12.38, blood-pressure, 85 mm.

At 12.42, blood-pressure, 95 mm.; pulse, 172; respiration, 60.

Experiment 2.

Alcohol.

Dog; good condition; weight, five kilos. Ether anesthesia.

At 10.12, initial blood-pressure, 120 mm.; pulse, 160; stroke, 15 mm. An injection of 22 minims of whiskey was given into the femoral vein. It was observed that raising the animal's legs caused the blood-pressure to fall with a return to the former level.

At 10.14, blood-pressure, 100 mm.; pulse, 148; stroke, 13 mm.

At 10.15.30, 22 minims of whiskey were injected into the femoral vein.

At 10.16.30, blood-pressure, 90 mm.; pulse, 124; stroke, 18 mm.

At 10.18, 22 minims of whiskey were injected. A gradual fall in the blood-pressure, with slowed respiration, followed until death. Death was due to respiratory failure.

Experiments 3, 4, 5.

Alcohol.

Dog 1, male mongrel; excellent condition; weight, sixteen kilos.

Dog 2, female mongrel; excellent condition; weight, fourteen kilos.

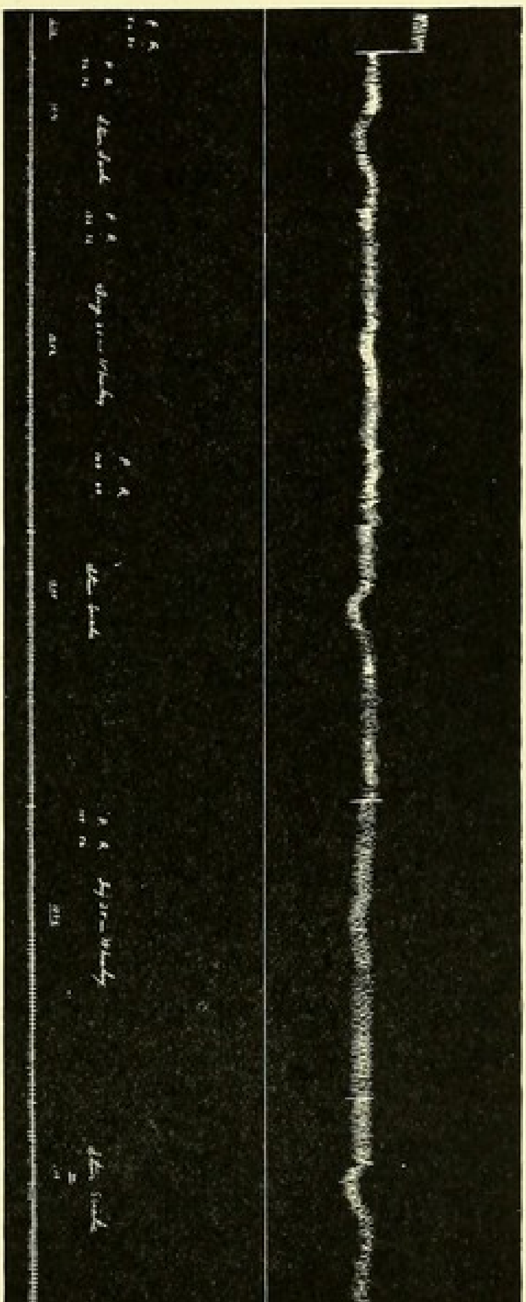

FIG. 2.—EXPS. 3, 4, 5.—Note the slight net alteration in the blood-pressure on administering whiskey intravenously.

Dog 3, male mongrel; excellent condition; weight, nine kilos. The tracheal and carotid cannula were applied. Ether anesthesia.

At 12.05, dog 1, blood-pressure, 140 mm.; stroke, 12 mm.; pulse, 140; respiration, 80.

Dog 2, blood-pressure, 112 mm.; stroke, 13 mm.; pulse, 156; respiration, 80.

Dog 3, blood-pressure, 98 mm.; stroke, 18 mm.; pulse, 152; respiration, 10.

At 12.45, the animal was reduced to shock by skinning and irritating the denuded surfaces.

Dog 1, blood-pressure, 115 mm.; stroke, 10 mm.; pulse, 144; respiration, 92.

Dog 2, blood-pressure, 95 mm.; stroke, 18 mm.; pulse, 132; respiration, 76.

Dog 3, blood-pressure, 50 mm.; stroke, 20 mm.; pulse, 128; respiration, 52.

In dogs 1 and 2 the sciatics were electrically stimulated. A sharp fall was recorded, followed by a gradual rise.

In dog 3 a sharp rise and fall, with a gradual return to the former level, was noted.

At 12.50, dog 1, blood-pressure, 125 mm.; stroke, 10 mm.; pulse, 132; respiration, 88.

Dog 2, blood-pressure, 80 mm.; stroke, 18 mm.; pulse, 132; respiration, 72.

Dog 3, blood-pressure, 70 mm.; stroke, 16 mm.; pulse, 132; respiration, 56.

From 12.51 to 12.53 an injection of 22 minims of whiskey was administered. An increased pulse-rate, slower respiration, and a rise in the blood-pressure in each animal followed.

At 12.54, dog 1, blood-pressure, 130 mm.; stroke, 16 mm.; pulse, 148; respiration, 68.

Dog 2, blood-pressure, 75 mm.; stroke, 18 mm.; pulse, 160; respiration, 60.

Dog 3, blood-pressure, 70 mm.; stroke, 18 mm.; pulse, 148; respiration, 48.

At 12.55, the sciatics were stimulated, with results similar to the previous stimulation.

At 1.02, dog 1, blood-pressure, 110 mm.; stroke, 12 mm.; pulse, 148; respiration, 76.

Dog 2, blood-pressure, 75 mm.; stroke, 19 mm.; pulse, 144; respiration, 56.

Dog 3, blood-pressure, 80 mm.; stroke, 16 mm.; pulse, 144; respiration, 48.

At 1.02.30, dog 1, an injection of 22 minims of whiskey was administered.

At 1.03.30, dog 2, an injection of 22 minims of whiskey was administered.

At 1.03.45, dog 3, an injection of 22 minims of whiskey was administered.

At 1.05, dog 1, blood-pressure, 115 mm.; stroke, 12 mm.; pulse, 148; respiration, 64.

Dog 2, blood-pressure, 70 mm.; stroke, 20 mm.; pulse, 168; respiration, 52.

Dog 3, blood-pressure, 80 mm.; stroke, 16 mm.; pulse, 152; respiration, 44.

At 1.08, the sciatics were electrically stimulated; the results were as before.

At 1.13, dog 1, blood-pressure, 112 mm.; stroke, 10 mm.; pulse, 144; respiration, 80.

Dog 2, blood-pressure, 70 mm.; stroke 12 mm.; pulse, 152; respiration, 52.

Dog 3, blood-pressure, 75 mm.; stroke, 13 mm.; pulse, 132; respiration, 48.

An injection of 22 minims of whiskey was administered in dogs 1, 2, and 3. The results were as follows:

Dog 1, blood-pressure, 115 mm.; stroke, 10 mm.; pulse, 144; respiration, 68.

Dog 2, blood-pressure, 68 mm.; stroke, 10 mm.; pulse, 152; respiration, 52.

Dog 3, blood-pressure, 80 mm.; stroke, 13 mm.; pulse, 132; respiration, 44.

At 1.38, dog 1, blood-pressure, 118 mm.; stroke, 10 mm.; pulse, 150; respiration, 60.

Dog 2, blood-pressure, 60 mm.; stroke, 11 mm.; pulse, 156; respiration, 64.

Dog 3, blood-pressure, 74 mm.; stroke, 17 mm.; pulse, 152; respiration, 48.

At 1.38.15, dog 1, an injection of 22 minims of whiskey was administered.

At 1.38.30, dog 2, an injection of 22 minims of whiskey was administered.

At 1.39, dog 3, an injection of 22 minims of whiskey was administered.

At 1.41, dog 1, blood-pressure, 115 mm.; stroke, 11 mm.; pulse, 144; respiration, 68.

Dog 2, blood-pressure, 60 mm.; stroke, 8 mm.; pulse, 156; respiration, 52.

Dog 3, blood-pressure, 70 mm.; stroke, 16 mm.; pulse, 112; respiration, 144.

At 1.43, electrical stimulation of the sciatics was made, with former results.

At 1.52.30, dog 1, blood-pressure, 115 mm.; stroke, 10 mm.; pulse, 156; respiration, 64.

Dog 2, blood-pressure, 70 mm.; stroke, 8 mm.; pulse, 156; respiration, 52.

Dog 3, blood-pressure, 55 mm.; stroke, 16 mm.; pulse, 96; respiration, 40.

At 1.53.15, dog 1, an injection of 22 minims of whiskey was administered.

At 1.54, dog 2, an injection of 22 minims of whiskey was administered.

At 1.55, dog 3, an injection of 22 minims of whiskey was administered.

At 1.56, dog 1, blood-pressure, 115 mm.; stroke, 10 mm.; pulse, 160; respiration, 68.

Dog 2, blood-pressure, 70 mm.; stroke, 8 mm.; pulse, 156; respiration, 56.

Dog 3, blood-pressure, 60 mm.; stroke, 10 mm.; pulse, 96; respiration, 40.

At 1.58, the sciatics were electrically stimulated. The results were not so marked as formerly.

At 2.05, dog 1, blood-pressure, 115 mm.; stroke, 10 mm.; pulse, 152; respiration, 68.

Dog 2, blood-pressure, 75 mm.; stroke, 10 mm.; pulse, 142; respiration, 52.

Dog 3, blood-pressure, 35 mm.; stroke, 18 mm.; pulse, 108; respiration, 36.

Dog 1, an injection of 22 minims of whiskey was given.

At 2.05.30, dog 2, an injection of 22 minims of whiskey was given.

At 2.06.30, dog 3, an injection, of 22 minims of whiskey was given.

At 2.08, dog 1, blood-pressure, 118 mm.; pulse, 156; respiration, 56.

Dog 2, blood-pressure, 78 mm.; stroke, 10 mm.; pulse, 152; respiration, 52.

Dog 3, blood-pressure, 55 mm.; stroke, 16 mm.; pulse, 96; respiration, 36.

At 2.19, dog 1, blood-pressure, 111 mm.; stroke, 8 mm.; pulse, 160; respiration, 56.

Dog 2, blood-pressure, 88 mm.; stroke, 19 mm.; pulse, 156; respiration, 44.

Dog 3, blood-pressure, 55 mm.; stroke, 14 mm.; pulse, 100; respiration, 36.

At 2.19.30, dog 1, an injection of 22 minims of whiskey was given.

At 2.20, dog 2, an injection of 22 minims of whiskey was given.

At 2.21, dog 3, an injection of 22 minims of whiskey was given.

At 2.22, dog 1, blood-pressure, 118 mm.; stroke, 10 mm.; pulse, 160; respiration, 72.

Dog 2, blood-pressure, 84 mm.; stroke, 9 mm.; pulse, 148; respiration, 56.

Dog 3, blood-pressure, 60 mm.; stroke, 16 mm.; pulse, 60; respiration, 36.

At 3.02, dog 1, blood-pressure, 100 mm.; stroke, 8 mm.; pulse, 60; respiration, 70.

Dog 2, blood-pressure, 70 mm.; stroke, 8 mm.; pulse, 156; respiration, 52.

Dog 3, blood-pressure, 55 mm.; stroke, 16 mm.; pulse, 56; respiration, 40.

At 3.55.15, an injection of 22 minims of whiskey was admintered to dogs 1, 2, and 3.

At 3.56, dog 1, blood-pressure, 115 mm.; stroke, 10 mm.; pulse, 160; respiration, 68.

Dog 2, blood-pressure, 70 mm.; stroke, 8 mm.; pulse, 156; respiration, 56.

Dog 3, blood-pressure, 60 mm.; stroke, 10 mm.; pulse, 56; respiration, 40.

At 3.58, electrical stimulation was applied to the sciatic nerve. Not so active a vasomotor mechanism was observed as in previous stimulations.

At 4.05, dog 1, blood-pressure, 115 mm.; stroke, 10 mm.; pulse, 152; respiration, 68.

Dog 2, blood-pressure, 75 mm.; stroke, 10 mm.; pulse, 142; respiration, 52.

Dog 3, blood-presssure, 55 mm.; stroke, 18 mm.; pulse, 100; respiration, 36.

At 4.06, an injection of 22 minims of whiskey was administered to dogs 1, 2, and 3.

At 4.08, dog 1, blood-pressure, 118 mm.; stroke, 11 mm.; pulse, 156; respiration, 56.

Dog 2, blood-pressure, 78 mm.; stroke, 10 mm.; pulse, 152; respiration, 52.

Dog 3, blood-pressure, 58 mm.; stroke, 9 mm.; pulse, 100; respiration, 36.

At 4.19, dog 1, blood-pressure, 111 mm.; stroke, 8 mm.; pulse, 160; respiration, 56.

Dog 2, blood-pressure, 88 mm.; stroke, 9 mm.; pulse, 156; respiration, 44.

Dog 3, blood-pressure, 55 mm.; stroke, 14 mm.; pulse, 100; respiration, 36.

At 4.20, an injection of 22 minims of whiskey was administered to dogs 1, 2, and 3.

At 4.22, dog 1, blood-pressure, 118 mm.; stroke, 10 mm.; pulse, 160; respiration, 72.
Dog 2, blood-pressure, 84 mm.; stroke, 9 mm.; pulse, 148; respiration, 56.
Dog 3, blood-pressure, 55 mm.; stroke, 12 mm.; pulse, 132; respiration, 40.

At 4.48.15, dog 1, blood-pressure, 114 mm.; stroke, 8 mm.; pulse, 156; respiration, 64.
Dog 3, blood-pressure, 60 mm.; stroke, 12 mm.; pulse, 128; respiration, 40.

At 4.49.45, an injection of 22 minims of whiskey was administered to dogs 1, 2, and 3.

At 4.50.45, dog 1, blood-pressure, 121 mm.; stroke, 8 mm.; pulse, 172; respiration, 68.
Dog 2, blood-pressure, 75 mm.; stroke, 7 mm.; pulse, 144; respiration, 52.
Dog 3, blood-pressure, 60 mm.; stroke, 11 mm.; pulse, 120; respiration, 44.

At 4.52, the sciatics were stimulated. The results were as in the last observation.

At 5.03, dog 1, blood-pressure, 120 mm.; stroke, 9 mm.; pulse, 144; respiration, 68.
Dog 2, blood-pressure, 75 mm.; stroke, 9 mm.; pulse, 144; respiration, 52.
Dog 3, blood-pressure, 62 mm.; stroke, 11 mm.; pulse, 120; respiration, 44.

At 5.04, an injection of 22 minims of whiskey was administered to dogs 1, 2, and 3.

At 5.07, dog 1, blood-pressure, 130 mm.; stroke, 11 mm.; pulse, 168; respiration, 60.
Dog 2, blood-pressure, 74 mm.; stroke, 8 mm.; pulse, 148; respiration, 48.
Dog 3, blood-pressure, 65 mm.; stroke, 10 mm.; pulse, 96; respiration, 36.

At 5.26.30, dog 1, blood-pressure, 120 mm.; stroke, 8 mm.; pulse, 160; respiration, 66.
Dog 2, blood-pressure, 80 mm.; stroke, 10 mm.; pulse, 152; respiration, 56.

Dog 3, blood-pressure, 65 mm.; stroke, 8 mm.; pulse, 100; respiration, 40.

At 5.27.30, an injection of 22 minims of whiskey was administered to dogs 1, 2, and 3.

At 5.30, dog 1, blood-pressure, 123 mm.; stroke, 10 mm.; pulse, 153, respiration, 72.

Dog 2, blood-pressure, 74 mm.; stroke, 10 mm.; pulse, 132; respiration, 56.

Dog 3, blood-pressure, 70 mm.; stroke, 8 mm.; pulse, 88; respiration, 40.

At 5.31, electrical stimulation was applied to the sciatics. The usual effect was noted.

At 5.35, the animals were killed with intravenous injections of $MgSO_4$.

Experiments 6, 7, 8.

Alcohol.

Dog 1, female mongrel; good condition; weight, eight kilos.

Dog 2, female mongrel; good condition; weight, ten kilos.

Dog 3, female mongrel; good condition; weight, eleven kilos. Ether anesthesia. The tracheal and carotid cannulæ were adjusted.

At 10.45, dog 1, blood-pressure, 125 mm.; stroke, 19 mm.; pulse, 156; respiration, 40.

Dog 2, blood-pressure, 110 mm.; stroke, 10 mm.; pulse, 136; respiration, 68.

Dog 3, blood-pressure, 138 mm.; stroke, 6 mm.; pulse, 144; respiration, 84.

The animals were reduced to shock by skinning, then sponging the denuded surfaces.

Dog 1, blood-pressure, 96 mm.; stroke, 18 mm.; pulse, 132; respiration, 40.

Dog 2, blood-pressure, 70 mm.; stroke, 9 mm.; pulse, 124; respiration, 64.

Dog 3, blood-pressure, 90 mm.; stroke, 10 mm.; pulse, 124; respiration, 72.

At 11.10, electrical stimulation was applied to the sciatics. The results were as follows:

Dog 1, a gradual rise was obtained in the blood-pressure.

Dog 2, a sharp rise in the blood-pressure, with a corresponding fall, was recorded.

Dog 3, a slight fall occurred in the blood-pressure, followed by a gradual rise.

At 11.23.45, dog 1, respirations failed. Artificial respirations were begun.

At 11.24, 22 minims of whiskey were injected in dogs 2 and 3. Prior to the injections, the following observations were made:

Dog 2, blood-pressure, 85 mm.; stroke, 8 mm.; pulse, 124; respiration, 56.

Dog 3, blood-pressure, 102 mm.; stroke, 6 mm.; pulse, 120; respiration, 64.

At 11.26, the observations after the injection were as follows:

Dog 2, blood-pressure, 96 mm.; stroke, 10 mm.; pulse, 120; respiration, 56.

Dog 3, blood-pressure, 120 mm.; stroke, 8 mm.; pulse, 108; respiration, 65.

At 11.28.45, the sciatics of dogs 1, 2, and 3 were stimulated.

Dog 1 had now recovered. The stimulation was followed by a rise then a fall in the blood-pressure.

Dog 2, there was an irregular rise and fall in the blood-pressure.

Dog 3, a slight fall occurred in the blood-pressure, followed by a gradual rise.

At 11.36.15, dog 1, blood-pressure, 110 mm.; stroke, 20 mm.; pulse, 160; respiration, 48.

Dog 2, blood-pressure, 90 mm.; stroke, 10 mm.; pulse, 128; respiration, 52.

Dog 3, blood-pressure, 95 mm.; stroke, 10 mm.; pulse, 116; respiration, 72.

At 11.37, dogs 1, 2, and 3 were injected with 22 minims of whiskey.

At 11.40, dog 1, blood-pressure, 130 mm.; stroke, 28 mm.; pulse, 136; respiration, 36.

Dog 2, blood-pressure, 94 mm.; stroke, 10 mm.; pulse, 128; respiration, 48.

Dog 3, blood-pressure, 110 mm.; stroke, 10 mm.; pulse, 112; respiration, 68.

At 12.05, dog 1, blood-pressure, 110 mm.; stroke, 12 mm.; pulse, 128; respiration, 48.

Dog 2, blood-pressure, 90 mm.; stroke, 10 mm.; pulse, 140; respiration, 48.

Dog 3, blood-pressure, 110 mm.; stroke, 9 mm.; pulse, 132; respiration, 76.

At 12.05.30, dogs 1, 2, and 3 were injected with 22 minims of whiskey.

Dog 1, blood-pressure, 111 mm.; stroke, 19 mm.; pulse, 153; respiration, 40.

Dog 2, blood-pressure, 92 mm.; stroke, 10 mm.; pulse, 140; respiration, 52.

Dog 3, blood-pressure, 112 mm.; stroke, 10 mm; pulse, 132; respiration, 72.

At 12.08, the sciatics were stimulated.

Dogs 1 and 2 showed a slight response in the blood-pressure.

In dog 3 there was a slight fall in the blood-pressure, with a gradual recovery.

At 12.16, dog 1, blood-pressure, 110 mm.; stroke, 19 mm.; pulse, 132; respiration, 36.

Dog 2, blood-pressure, 88 mm.; stroke, 8 mm.; pulse, 124; respiration, 56.

Dog 3, blood-pressure, 102 mm.; stroke, 11 mm.; pulse, 116; respiration, 64.

At 12.17.45, dogs 1, 2, and 3 were injected with 22 minims of whiskey.

At 12.20.30, dog 1, blood-pressure, 105 mm.; stroke, 18 mm.; pulse, 124; respiration, 36.

Dog 2, blood-pressure, 95 mm.; stroke, 11 mm.; pulse, 116; respiration, 56.

Dog 3, blood-pressure, 100 mm.; stroke, 10 mm.; pulse, 112; respiration, 64.

At 12.21.30, the sciatics were stimulated; very slight reaction was obtained.

At 12.31, dog 1, blood-pressure, 110 mm.; stroke, 18 mm.; pulse, 128; respiration, 44.

Dog 2, blood-pressure, 81 mm.; stroke, 8 mm.; pulse, 108; respiration, 52.

Dog 3, blood-pressure, 101 mm.; stroke, 10 mm.; pulse, 116; respiration, 64.

At 12.32, an injection of 22 minims of whiskey was administered to dogs 1, 2, and 3.

At 12.33.30, dog 1, blood-pressure, 110 mm.; stroke, 113 mm.; pulse, 124; respiration, 48.

Dog 2, blood-pressure, 90 mm.; stroke, 4 mm.; pulse, 122; respiration, 48.

Dog 3, blood-pressure, 98 mm.; stroke, 12 mm.; pulse, 128; respiration, 48.

At 12.45, dog 1, blood-pressure, 130 mm.; stroke, 18 mm.; pulse, 120; respiration, 28.

Dog 2, blood-pressure, 75 mm.; stroke, 10 mm.; pulse, 116; respiration, 52.

Dog 3, blood-pressure, 105 mm.; stroke, 10 mm.; pulse, 116; respiration, 56.

At 12.46, 22 minims of whiskey were injected in dogs 1, 2, and 3.

Dog 1, blood-pressure, 105 mm.; stroke, 12 mm.

Dog 2, blood-pressure, 70 mm.; stroke, 10 mm.

Dog 3, blood-pressure, 100 mm.; stroke, 11 mm.

At 12.53, electrical stimulation was applied to the sciatics, very slight reaction resulting.

At 1.24, dog 1, blood-pressure, 88 mm.; pulse, 120; respiration, 36.

Dog 2, blood-pressure, 56 mm.; pulse, 120; respiration, 52.

Dog 3, blood-pressure, 105 mm.; pulse, 124; respiration, 60.

At 1.25, 22 minims of whiskey were injected in dogs 1, 2, and 3.

Dog 1, blood-pressure, 128 mm.; pulse, 120; respiration, 53.

Dog 3, blood-pressure, 105 mm.; pulse, 124; respiration, 60.

An injection of 22 minims of whiskey was administered to dogs 1, 2, and 3.

Dog 1, blood-pressure, 88 mm.; pulse, 120; respiration, 136.

Dog 2, blood-pressure, 55 mm.; pulse, 116; respiration, 64.

Dog 3, blood-pressure, 102 mm.; pulse, 108; respiration, 52.

At 1.48, dog 1, blood-pressure, 95 mm.; stroke, 9 mm.; pulse, 100; respiration, 36.

Dog 2, blood-pressure, 60 mm.; stroke, 80 mm.; pulse, 116; respiration, 172.

Dog 3, blood-pressure, 110 mm.; stroke, 10 mm.; pulse, 108; respiration, 63.

At 1.49, 1.5 drams of whiskey were injected in dogs 1, 2, and 3. There was a gradual fall in the blood-pressure of each animal.

Dog 1, blood-pressure, 80 mm.; stroke, 11 mm.; pulse, 92; respiration, 36.

Dog 2, blood-pressure, 54 mm.; stroke, 10 mm.; pulse, 80; respiration, 72.

Dog 3, blood-pressure, 105 mm.; stroke, 10 mm.; pulse, 96; respiration, 64.

At 1.53, stimulation of the sciatic, in each animal, was followed by a slight reaction.

At 1.57.30, dog 1, blood-pressure, 92 mm.; stroke, 8 mm.; pulse, 114; respiration, 40.

Dog 2, blood-pressure, 55 mm.; stroke, 9 mm.; pulse, 72; respiration, 68.

Dog 3, blood-pressure, 105 mm.; stroke, 10 mm.; pulse, 88; respiration, 68.

At 1.59, an injection of 1.5 drams of whiskey was given to dogs 1, 2, and 3.

At 2.00, a gradual fall in the blood-pressure was recorded, followed by a rise.

Dog 1, blood-pressure, 90 mm.; stroke, 19 mm.; pulse, 80; respiration, 36.

Dog 2, blood-pressure, 54 mm.; stroke, 10 mm.; pulse, 72; respiration, 72.

Dog 3, blood-pressure, 105 mm.; stroke, 18 mm.; pulse, 92; respiration, 72.

At 2.08.45, dog 1, blood-pressure, 88 mm.; stroke, 12 mm.; pulse, 84; respiration, 36.

Dog 2, blood-pressure, 60 mm.; stroke, 10 mm.; pulse, 100; respiration, 72.

Dog 3, blood-pressure, 95 mm.; stroke, 9 mm.; pulse, 100; respiration, 68.

At 2.09.30, 1.5 drams of whiskey were injected in dogs 1, 2, and 3. Immediately following the injection there occurred a vasomotor break-down.

Dog 1, the blood-pressure fell to the abscissa line.

Dog 2, blood-pressure, 62 mm.; stroke, 8 mm.; pulse, 100; respiration, 72.

Dog 3, blood-pressure, 95 mm.; stroke, 11 mm.; pulse, 96; respiration, 72.

At 2.13.15, electrical stimulation of the sciatics in dogs 2 and 3 was followed by a very slight reaction in the blood-pressure.

At 2.15, dog 2, blood-pressure, 68 mm.; stroke, 10 mm.; pulse, 104; respiration, 72.

Dog 3, blood-pressure, 95 mm.; stroke, 10 mm.; pulse, 104; respiration, 72.

At 2.16, 1.5 drams of whiskey were injected in dogs 2 and 3.

At 2.22, dog 2, blood-pressure, 66 mm.; stroke, 8 mm.; pulse, 88; respiration, 72.

Dog 3, blood-pressure, 93 mm.; stroke, 10 mm.; pulse, 88; respiration, 68.

At 2.24, dogs 2 and 3 were killed by allowing $MgSO_4$ solution to flow into the carotid cannula.

Experiment 9.

Alcohol.

Dog; weight, fifteen kilos. Morphin and ether anesthesia. The animal was reduced to surgical anesthesia by the usual method.

Blood-pressure recorded 146 mm. After the blood-pressure had reached 60 mm. artificial respiration was supplied. One-half dram of brandy was injected into the jugular vein. A slight rise, followed by a fall, a little below the previous level, occurred.

Twenty minutes later, 1 dram of brandy was given An immediate fall followed.

After twenty minutes 2 drams of brandy were administered. A marked fall in the blood-pressure occurred.

Five minutes later 1 ounce of brandy was given. A fall in the blood-pressure was recorded. The animal was then killed by bleeding.

Experiment 10.

Alcohol.

Dog; in good physical condition; weight, fourteen kilos. Morphin and ether anesthesia.

Initial blood-pressure recorded 138 mm. The animal was reduced to surgical shock. Blood-pressure, 42 mm.; respirations, irregular and shallow.

One-half dram of brandy was injected into the jugular vein. No immediate effect was noted. One dram was injected. A considerable decline in the blood-pressure was recorded; the respirations were unchanged. After twenty minutes the blood-pressure increased to 52 mm.

The injection of 1 dram of brandy into the jugular vein was followed by an irregular blood-pressure and a considerable fall. A repetition of the injection was followed by a very marked fall. After ten minutes the blood-pressure rose to the previous level. The animal was then used for other experiments.

Experiment 11.

Alcohol.

Mongrel dog; weight, ten kilos. Morphin and ether anesthesia.

Initial blood-pressure, 124 mm. The blood-pressure was lowered by exposure and manipulation of the nerve-trunks of the extremities. The animal was reduced as low as possible before brandy was given. Blood-pressure, 24 mm.; respiration, short and shallow. One minim of brandy was injected into the jugular vein. No effect was noted. Two minims produced no effect; 4 minims, no effect; 8 minims, but slight effect; 16 minims produced no effect; 32 minims, an increased length in the stroke of the manometer, with a slight decline of the blood-pressure and shallow respiration. One dram increased the fall in the blood-pressure; 2 drams produced a very marked fall, and the animal died.

Experiment 12.

Alcohol.

Dog; weight, twenty kilos. Morphin and ether anesthesia.

Blood-pressure, 139 mm. The animal took the anesthetic very badly. Artificial respiration was necessary from the beginning of the experiment.

Shock was produced by splanchnic and somatic dissection. The animal was reduced to profound shock before any treatment was given. Blood-pressure registered 20 mm.; respiration had ceased several times; artificial respiration was maintained. An injection of ½ dram of brandy was made into the jugular vein without effect. Two drams produced a marked fall in the blood-pressure. Artificial respiration was necessary.

In five minutes 2 more drams were given. The blood-pressure suffered a marked decline. Death soon followed.

Experiment 13.

Alcohol.

Bull dog; good condition; weight, thirteen kilos. Morphin and ether anesthesia.

The animal was reduced to shock as in the preceding experiment; blood-pressure, 80 mm.

After 1 dram of alcohol was injected in the jugular vein there was a temporary rise followed by considerable fall; respiration became shallow. One dram was then given, producing a marked fall in the blood-pressure; respirations were unchanged.

Further dissection reduced the animal to 48 mm. blood-pressure. One dram of brandy produced a slight fall; 2 drams produced a marked fall in the blood-pressure. One-half ounce was then given, and the animal was killed.

Experiment 14.

Alcohol.

Small dog; weight, seven kilos. Morphin and ether anesthesia.

Preliminary blood-pressure, 126 mm. The animal was reduced to surgical shock by splanchnic and somatic dissection and exposure.

When the blood-pressure registered 52 mm. alcohol was injected into the jugular vein. A slight irregularity in the pulse occurred with a very marked irregularity in the respiration. The injection of ½ ounce of brandy was followed by a staggering fall in the blood-pressure, with immediate cessation of respiration.

Experiment 15.

Alcohol.

Small dog; weight, six kilos. Ether and morphin anesthesia.

The animal was reduced to surgical shock. Blood-pressure, 36 mm. Ten minims of brandy were injected into the jugular vein. No change in the respiration or in the blood-pressure was noted. One-half dram of brandy was followed by a fall in the blood-pressure. Two drams of brandy were followed by a decline in the blood-pressure, the strokes becoming a little longer; the respirations were unchanged. Two drams of brandy were followed by a wavering in the blood-pressure, and later by a greater fall. Four drams of brandy produced a very marked fall in the blood-pressure; respirations were greatly slowed. Eight drams of brandy produced almost instantaneous death.

Experiment 16.

Nitroglycerin and Amyl Nitrite.

Bull-dog. Ether anesthesia. The abdomen was opened and the intestines were manipulated, producing shock.

At 5.30, blood-pressure, 90 mm.; pulse, 176; respiration, 40.

At 5.34, blood-pressure, 60 mm.; pulse, 210; respiration, 66.

At 5.35, there was injected into the femoral vein 2.5 minims of a one per cent. solution of nitroglycerin. A slight rise was followed by a slight fall. Pressure then rose again to 60 mm.

At 5.37, blood-pressure, 60 mm.; pulse, 210; respiration, 66. An injection of 2.5 minims of a one per cent. solution of nitroglycerin was made. A slight rise, followed by a marked fall, in the blood-pressure was noted. The stroke was slightly lengthened.

At 5.39, there was injected 10 minims of a one per cent. solution of nitroglycerin.

At 5.39.30, blood-pressure, 60 mm.; pulse, 176; respiration, 80.

At 5.40, blood-pressure, 50 mm.; pulse, 172; respiration, 64.

At 5.42, blood-pressure, 50 mm.; pulse, 132; respiration, 68.

At 5.45, blood-pressure, 50 mm.; pulse, 180; respiration, 36.

At 5.46, there was injected 10 minims of a one per cent. solution of nitroglycerin. The pulse was very irregular and the blood-pressure fell to 45 mm. temporarily.

At 5.47, blood-pressure, 50 mm.; pulse, 180; respiration, 28.

At 5.50, blood-pressure, 40 mm.; pulse, 200; respiration, 24 and irregular.

At 5.52, there was injected 25 minims of a one per cent. solution of nitroglycerin.

At 5.54, blood-pressure, 40 mm.; pulse, 180; respiration, 24. The animal was killed.

Experiment 17.

Nitroglycerin.

Small mongrel pup; weight, three kilos. Morphin and ether anesthesia.

At 12.05, blood-pressure, 120 mm.; pulse, 210; respiration, 60.

At 12.06.30, an intravenous injection of 10 minims of a one per cent. solution of nitroglycerin was made.

At 12.07, blood-pressure, 60 mm.; pulse, 192; respiration, 48.

At 12.10, blood-pressure, 110 mm.; pulse, 210; respiration, 48.

At 12.15, blood-pressure, 100 mm.; pulse, 180; respiration, 36. The animal was then killed.

Experiment 18.

Nitroglycerin; Abdominal Aorta clamped.

Dog; weight, ten kilos. The abdominal aorta was clamped. The strokes became long; respiration almost ceased; artificial respiration was supplied.

Three minutes later the blood-pressure strokes became shortened. The blood-pressure rose to the

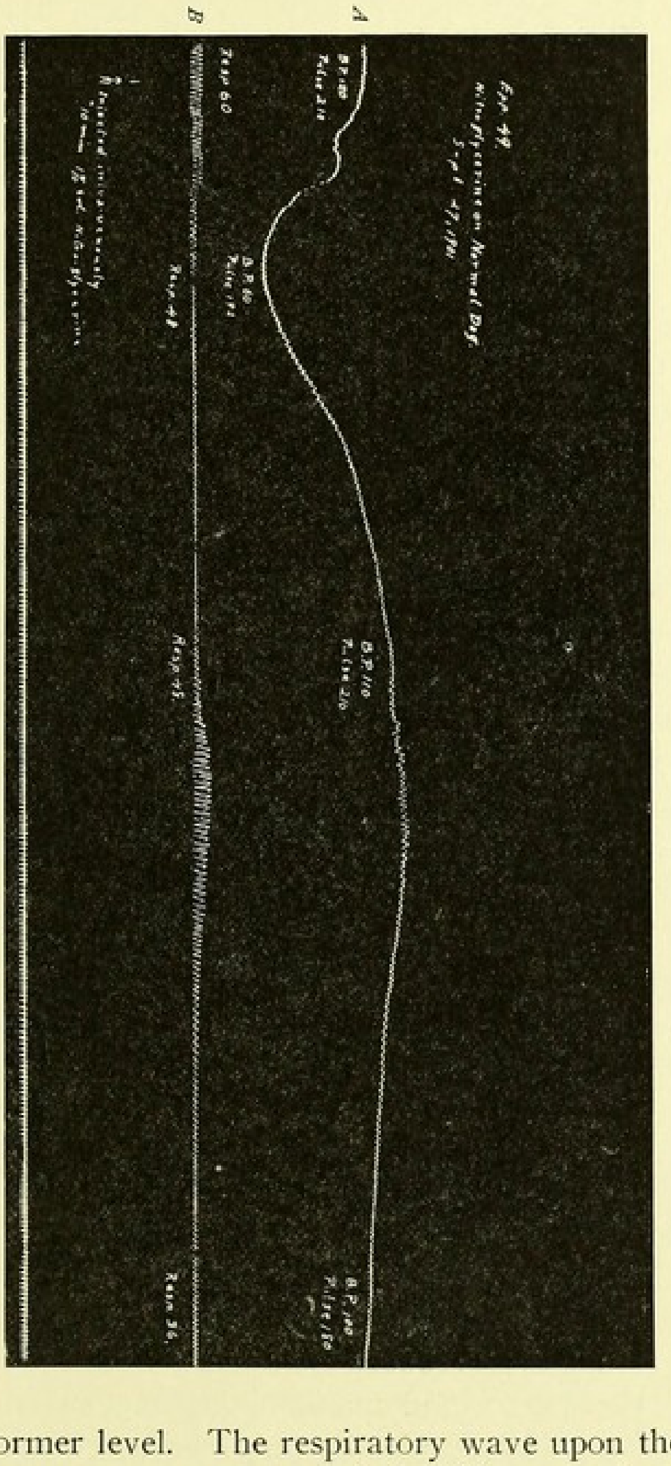

FIG. 3.—EXP. 17.—*A*, blood-pressure; *B*, respiratory tracing. .75 c.c. of a one per cent. solution of nitroglycerin was given intravenously; note the marked fall in the blood-pressure followed by a gradual compensatory rise.

former level. The respiratory wave upon the blood-pressure curve was marked. The aorta in this case was clamped above the splanchnic vessels. One-fourth grain of nitroglycerin was injected. A marked fall in the blood-pressure followed.

Two minutes later 1/4 grain was administered. The blood-pressure showed an additional fall.

One-half minute later 1/4 grain was given. The blood-pressure fell, but rapidly recovered in one-half minute.

Three-fourths of a minute later 1/4 grain of nitroglycerin was given. A marked fall, followed by a recovery, was noted.

One minute later 1/4 grain of nitroglycerin was administered; a fall in the blood-pressure, followed by a recovery, was noted. The respirations were unchanged.

One minute later 1/4 grain was given, and was followed by a fall in the blood-pressure, recovery soon occurring.

Two minutes later 1/4 grain of nitroglycerin was given. A marked fall in the blood-pressure followed.

One-quarter of a minute later the blood-pressure began to recover, at which time 1/2 grain of nitroglycerin was given. A deep fall in the blood-pressure, followed by recovery, was noted. A few drops of chloroform in the trachea caused sudden death.

Experiment 19.

Nitroglycerin and Amyl Nitrite.

Dog; fair physical condition. Ether anesthesia. The blood-pressure cannula was applied in the carotid.

The control blood-pressure recorded 124 mm. The animal was reduced to surgical shock by cutting away the thorax and manipulating the heart and lungs. This was attended by very marked fluctuations of the blood-pressure and an irregularity in the respiration.

The thorax was then closed air-tight. The blood-pressure had fallen to 70 mm. A few drops of amyl nitrite were placed upon the inhaling cone. A fall in the blood-pressure followed, two seconds later; after ten seconds had elapsed a pronounced fall was recorded. The pressure remained low for ten minutes, after which three drops of amyl nitrite were placed upon the inhaling cone. Within five seconds there was a fall of 5 mm. in the blood-pressure. The low level was maintained for ten seconds, after which there occurred a gradual rise.

Five minutes later 5 minims of amyl nitrite were dropped on the cone, and at the expiration of ten seconds the blood-pressure began to fall, the strokes of the writing style being long and fluctuating. The respiration became shallow and the blood-pressure recovered with marked respiratory changes. The dog-board was inverted, head up; the blood-pressure fell. On turning the dog-board in the opposite direction, the blood-pressure reached the former level. The dog was then inverted, head down, and the blood-pressure rose. When the animal was in the horizontal position the blood-pressure fell to the previous level, and the excursions of the writing style became longer and more irregular. Respiration became so infrequent and shallow that artificial respiration was supplied. Three minims of amyl nitrite were administered. There was a marked fall in the blood-pressure, followed by a rise. Ten minims of amyl nitrite were given. A marked fall followed, the strokes became long, the blood dark, respiration failed, and the animal died in one minute.

Experiment 20.

Nitroglycerin.

Mongrel dog; physical condition good; weight, eight kilos. Ether anesthesia.

The blood-pressure cannula was adjusted in the carotid. The initial blood-pressure was 139 mm. The animal was reduced to surgical shock by a double amputation at the hip-joints and long continued manipulation of the sciatic nerve, attended with some loss of blood. Blood-pressure, 38 mm.

An injection of $^1/_{90}$ grain of nitroglycerin was made into the left jugular vein. An immediate fall in the blood-pressure, with rapid compensation, followed.

A second dose of $^1/_{90}$ grain of nitroglycerin was followed by a marked fall with a compensatory rise.

The third dose was administered at the expiration of three minutes. A fall and like compensation was recorded. An injection of $^1/_{20}$ grain was then given into the jugular vein. A slight fall in the blood-pressure followed, after which compensation occurred.

After two minutes had elapsed $^1/_{20}$ grain was given. No effect was noted. The blood-pressure rose slightly after five minutes.

Two minutes later $1/8$ grain of nitroglycerin was administered, after which there was a marked fall in the blood-pressure, followed by a convulsion. The blood-pressure recovered itself, and $1/8$ grain of nitroglycerin was given with no immediate effect.

After one minute there was recorded a slight rise. Respiration failed at this point. One-fourth grain of nitroglycerin was administered. The blood-pressure fell sharply, followed by a rather slow recovery. One-twentieth grain was injected into the jugular vein. The blood-pressure fell, and artificial respiration was necessary. Tracings of the blood-pressure showed a very marked effect of the inspiratory and expiratory phases of respiration. The dog was inverted head down, and the blood-pressure rose quickly. In the horizontal position the blood-pressure fell slightly from the previous level; then the gradual rise occurred. The administration of 1200 c.c. of saline solution was followed by a decided rise. Respirations were increased and the excursions became longer. The injection of ¼ grain of nitroglycerin was followed by a slight fall, after which compensation occurred. Two minutes later convulsions developed. The blood-pressure tracing showed intermittent strokes. The blood-pressure gradually fell until death.

Experiment 21.

Nitroglycerin.

Mongrel dog; weight, eight kilos. Ether anesthesia. Blood-pressure cannula in the carotid. The animal was reduced to surgical shock by manipulation of the splanchnic area and excision of the stomach. There was administered $^1/_{180}$ grain of nitroglycerin into the left jugular vein. The injection was attended by a slight fall, compensation occurring after ten seconds.

At the expiration of five minutes $^1/_{90}$ grain of nitroglycerin was injected into the jugular vein. A marked fall in the blood-pressure immediately followed, after which the pressure rose higher than the previous level.

After fifteen minutes the blood-pressure was 32 mm. After the respirations began to fail and the blood-pressure to fall an injection of $^1/_{64}$ grain of nitroglycerin was given. A very slight fall was noted.

After ten minutes the pressure began to decline, artificial respiration becoming necessary, the animal was given $^1/_{15}$ grain of nitroglycerin, which was attended by a marked fall, after which compensation took place at the end of two minutes. A gradual fall was again inaugurated. No further injections were made and the animal died after ten minutes.

Experiment 22.

Nitroglycerin.

Black mongrel dog; weight, eight kilos.

The blood-pressure cannula was adjusted in the carotid. Owing to excessive ether anesthesia, artificial respirations were necessary. During this time the manometer exhibited long strokes. After respirations became normal, and the blood-pressure tracing became even at 142 mm., the animal was reduced to surgical shock by extensive exposure and bloodless operation upon the intestines and the stomach. Several times it was necessary to maintain artificial respiration after the dog's blood-pressure had reached 36 mm. An injection of $^1/_{120}$ grain of nitroglycerin was followed by a fall in the blood-pressure, with a prompt recovery six seconds later; the respirations became slower. Two minutes later there was administered $^1/_{20}$ grain of nitroglycerin. A fall in the blood-pressure, with a quick recovery, was recorded.

Two minutes later $^1/_{20}$ grain was given; the blood-pressure fell and a prompt recovery followed.

One minute later the injection of $^1/_7$ grain of nitroglycerin was followed by a fall in the blood-pressure more marked than the preceding. A prompt recovery followed.

There was administered one minute and a half later $^1/_7$ grain of nitroglycerin. The blood-pressure fell, followed by recovery.

In one minute and a half another dose of $^1/_7$ grain of nitroglycerin was administered. A very slight fall in the blood-pressure with an immediate recovery followed.

One minute later the injection of $^1/_7$ grain of nitroglycerin was followed by a slight fall and a prompt recovery. A repetition of the foregoing was followed by a slight fall in the blood-pressure. Strokes became longer, the respiration short and shallow.

Two minutes after the last injection a convulsion appeared. During the convulsion the blood-pressure rose and fell with a muscular spasm. The blood-pressure fell to the abscissa line and the animal died.

Experiment 23.

Nitroglycerin.

Dog; spaniel; weight, nine kilos; young and in good physical condition. Ether anesthesia.

The control blood-pressure recorded 138 mm. The animal was reduced to surgical shock by exposing the skull, uncovering the brain extensively, and manipulating the dura mater. During this exposure the blood-pressure and the respirations were extremely irregular. The respirations became embarrassed, the blood-pressure fell, and the animal was in profound shock. An injection of $^1/_{180}$ grain of nitroglycerin into the jugular vein was followed by a slight fall in the blood-pressure, which immediately recovered itself.

Three minutes later, $^1/_{180}$ grain of nitroglycerin was injected into the jugular vein. A fall with immediate compensation was noted. The blood-pressure began to decline after five minutes. The injection of nitroglycerin into the jugular vein was followed by an immediate fall and with compensation. The respirations were improved.

Two minutes later the blood-pressure again began to decline. One-fiftieth grain of nitroglycerin was injected into the jugular vein. A considerable fall, followed by a rise to the level recorded before the injection, was noted.

After four minutes the blood-pressure began to decline.

One-thirtieth grain of nitroglycerin was injected into the jugular vein. There was immediately a marked fall, after which compensation occurred. The heart-beats were slower, the respiration more shallow, and the blood rather dark. The animal was failing. The injection of ⅛ grain of nitroglycerin was followed by a fall in the blood-pressure with partial compensation. Five minutes later the animal died.

Experiment 24.

Nitroglycerin.

Fox terrier; weight, seven kilos; good physical condition. Ether anesthesia.

Blood-pressure cannula in the carotid. The animal was reduced to surgical shock by extensive dissection in the somatic area and the exposure and manipulation of the stomach and intestines. No therapeutic test was made until the respirations were much embarrassed, and the blood-pressure was reduced from the normal (140 mm.) to 22 mm. One one-hundred-and-eightieth grain of nitroglycerin was injected into the jugular vein. An immediate fall followed, after which compensation took place. The respiration remained unchanged and the heart's action was reduced in frequency. The blood-pressure soon began to further decline, and $^1/_{90}$ grain of nitroglycerin was injected into the jugular vein. Again there was a slight fall, after which there was a rise to a point somewhat higher than before the injection. The strokes became longer, the blood dark, and the respiration more embarrassed. Artificial respiration was maintained. The blood-pressure began to decline and $^{1}/_{64}$ grain of nitroglycerin was given. A marked fall followed by partial compensation was noted. The respiration became more embarrassed and the animal died after twelve minutes.

Experiment 25.

Nitroglycerin.

Mongrel dog; weight, ten kilos; fair condition. Ether anesthesia.

Blood-pressure cannula in the right carotid. The dog was reduced to surgical shock by somatic dissection and exposure and manipulation of splanchnic area. One one-hundred-and-eightieth grain of nitroglycerin was injected into the jugular vein with no effect.

Five minutes later $^{1}/_{90}$ grain was given. This was followed by a slight fall in the pressure, and later a rise higher than the former level.

After ten minutes $^{1}/_{64}$ grain of nitroglycerin was given. There was an immediate and a considerable fall. Twelve seconds later the former level had been regained.

In five minutes $^{1}/_{30}$ grain of nitroglycerin was injected into the jugular vein without effect.

Two minutes later $^{1}/_{32}$ grain was administered. A sharp and decided fall in the blood-pressure followed and later convulsions developed. The blood became dark, respiration ceased, and the animal died.

Experiment 26.

Amyl Nitrite.

Bull-dog. Ether anesthesia.

Blood-pressure cannula in the carotid. The animal was reduced to surgical shock by excessive manipulation of the testicle and the abdominal viscera. The

control blood-pressure was 128 mm. After the blood-pressure had fallen to 38 mm. 2 minims of amyl nitrite were dropped upon the inhaler. A slight fall in the blood-pressure followed; the respiration became deeper. In ten seconds the blood-pressure began to rise, regaining its former level.
Five minutes later 3 minims of amyl nitrite were dropped on the inhaler. An immediate fall in the blood-pressure followed. The heart-strokes became long and fluctuating. The effects of respiration on the blood-pressure curve were marked. The respirations were shallow and the blood was dark. The blood-pressure began to decline. Five minims of amyl nitrite were dropped on the inhaler. A marked fall in the blood-pressure occurred, with extremely long and irregular heart-strokes. The respiration became more shallow, and the blood extremely dark. Artificial respiration was supplied. No further therapeutic measures were attempted. The dog lived twenty minutes, the blood-pressure gradually falling. The dog died of respiratory failure.

Experiment 27.

Amyl Nitrite. Asphyxia.

Mongrel dog; weight, eleven kilos; good condition. Ether anesthesia.
The respiratory cannula was adjusted in the trachea and the blood-pressure cannula in the carotid. The trachea was then clamped. The respiratory excursion on the blood-pressure tracing became long and irregular, and the rate markedly decreased. After an increase in the blood-pressure and the respiration, there was a decline in both, and later, total cessation. Fifteen seconds after the heart had stopped artificial respiration was supplied and the dog was inverted, head up, then head down. A sharp and immediate

rise in the blood-pressure followed. When the blood-pressure was approaching the normal, nitrite of amyl was given by inhalation. A sudden fall in the blood-pressure almost to the abscissa followed.

Experiment 28.

Amyl Nitrite. Asphyxia.

Old mongrel bull dog; good condition; weight, thirteen kilos. Ether anesthesia.

The respiratory cannula was adjusted in the trachea, the blood-pressure cannula in the carotid. After a control had been taken a few drops of amyl nitrite were placed on the inhaler. Within two seconds there occurred a fall in the blood-pressure. Ten seconds later the fall was pronounced. The pressure remained low, and after a second dose a further fall occurred, persisting five seconds. The pressure gradually fell during the following ten seconds. It remained low for ten seconds, and then began a gradual rise. The third inhalation of 5 minims was followed by an immediate fall, the style exhibiting long and variable strokes. The respiratory curve on the blood-pressure was very marked. Respiration became shallow and the blood-pressure slowly recovered. When the dog was inverted head up, the blood-pressure rose slowly; when horizontal, it fell to the previous level; when inverted head down, the blood-pressure rose. On assuming a horizontal position the pressure rose gradually and remained fairly constant; the long and irregular excursion became still longer and more irregular. On inverting the dog, head down, a slight rise promptly followed. On resuming a horizontal position, the blood-pressure again fell. Pressure upon the splanchnic area produced an immediate rise, which fell again on removal of the pressure. The trachea was then clamped. A rise occurred, which was followed later by a fall in the blood-pressure, after which the pressure continued to gradually fall until death.

Experiment 29.

Digitalis.

Mongrel dog; weight, eight and one-half kilos; good condition. Ether anesthesia.

At 10.40, the initial blood-pressure was 140 mm.; pulse, 180; stroke, 11.

At 10.45, 1.3 c.c. of tincture of digitalis were injected into the femoral vein.

At 10.46, pulse, 160; stroke, 12 mm.

At 10.48, the foregoing injection was repeated. The blood-pressure remained unchanged. The length of the stroke increased 2 mm.; pulse, 170.

At 10.51, 1.3 c.c. of tincture of digitalis were injected.

At 10.54, 1.3 c.c. of tincture of digitalis were injected.

At 10.56, blood-pressure, 155 mm.; stroke, 20; pulse, 160. The animal was killed.

Experiment 30.

Digitalis.

Mongrel dog; weight, eleven kilos. Morphine and ether anesthesia.

The spinal cord was severed in lower dorsal region.

At 4.10, blood-pressure, 60 mm.; pulse, 210.

At 4.11, an injection of 20 minims of tincture of digitalis was administered.

At 4.14, blood-pressure, 85 mm.; pulse, 180; respiration, 72.

At 4.17, blood-pressure, 100 mm.; pulse, 160; respiration, 148.

Fig. 5 shows the steady rise in the blood-pressure.

Experiment 31.

Digitalis.

Spaniel; weight, twenty-one pounds; good physical condition. Ether anesthesia.

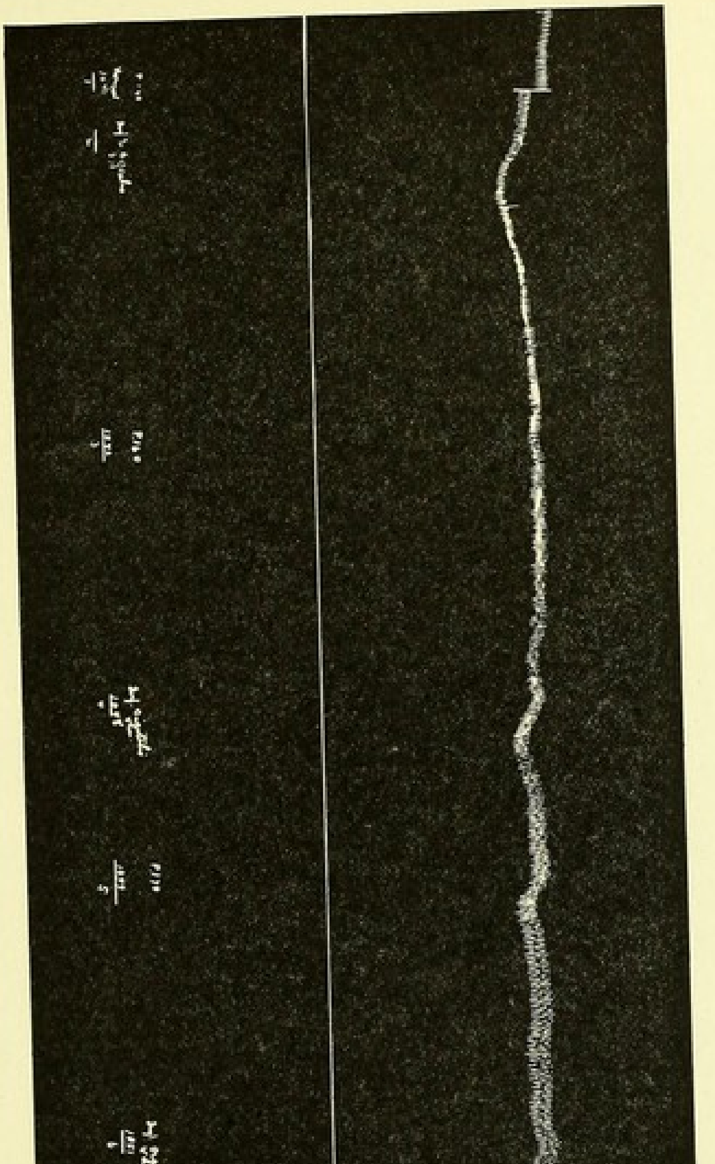

FIG. 4.—EXP. 29.—Note the rise in the blood-pressure, the slowing of the heart-beat, and the increased length of the pulse-wave following therapeutic doses of digitalis in the normal animal.

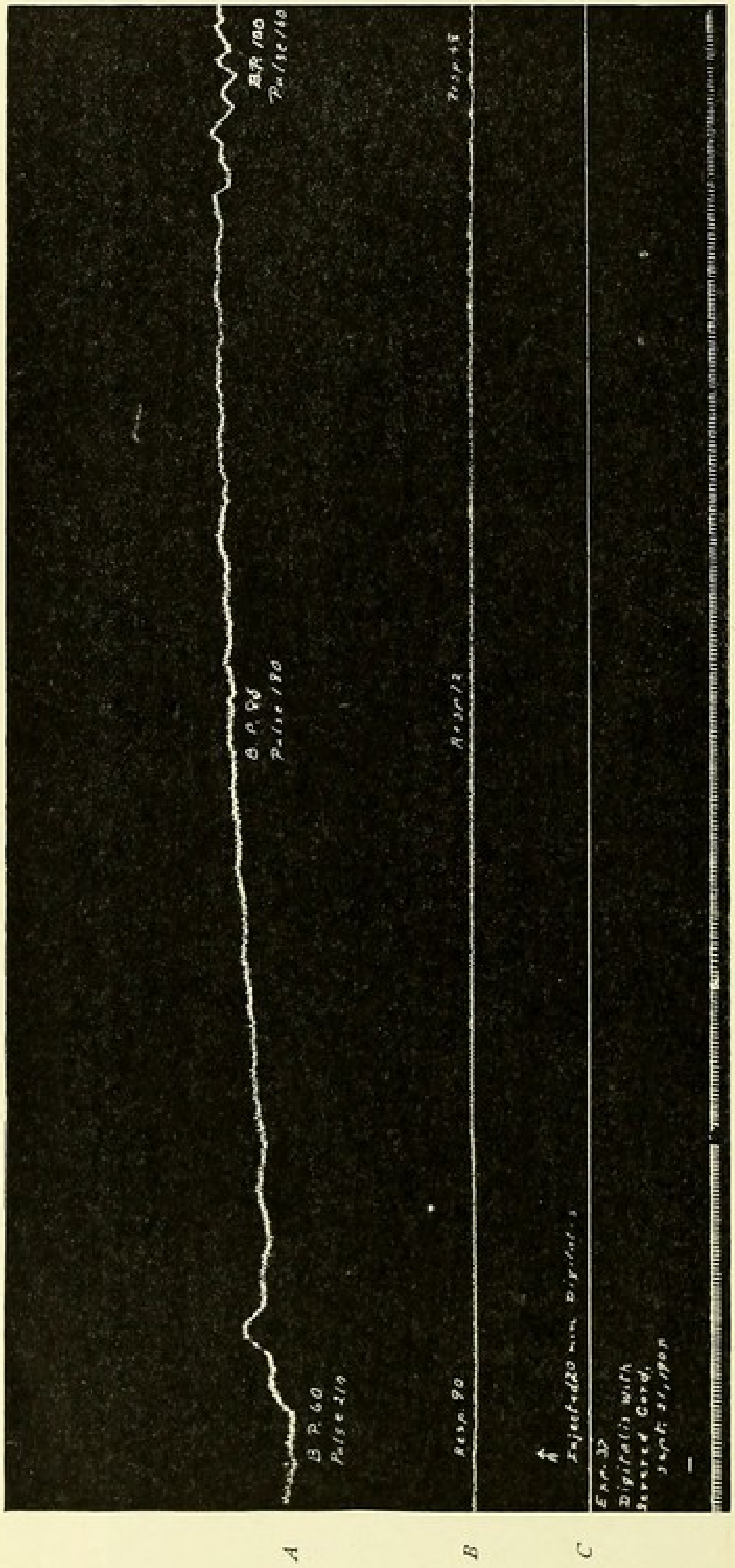

FIG. 5.—EXP. 30.—The effect of digitalis after severing the spinal cord. *A*, arterial pressure; *B*, respiration; *C*, abscissa. On manipulating the intestine, removing the integument, and severing the spinal cord (not shown in this tracing), the blood-pressure fell to 60 mm. On injecting 1.3+ c.c. (20 minims) tincture of digitalis the blood-pressure rose 40 mm., and the pulse-rate fell fifty beats. On the extreme right the effects of an excessive dose are shown. The animal died rather abruptly.

The respiratory cannula was adjusted in the trachea, the blood-pressure cannula in the carotid. Control blood-pressure, 146 mm. The larynx and trachea were exposed. The larynx was opened and the mucosa manipulated. A temporary cessation of respiration and a decided fall in the blood-pressure occurred. Several repetitions were followed by a considerable loss of pressure. Other dissections were made in the somatic area, reducing the blood-pressure to 80 mm. Ten minims of tincture of digitalis injected into the jugular vein was followed by a slight temporary fall in the blood-pressure, after which there was a gradual rise. The blood-pressure rose higher than before the injection.

Five minutes later 10 minims were injected into the jugular vein. There was a slight rise in the blood-pressure, followed by a fall and a gradual rise. The animal was then subjected to extensive manipulation of the splanchnic area. The blood-pressure fell to 26 mm., and respiration became irregular.

An injection of five minims of tincture of digitalis into the jugular vein was followed by a slight fall in the blood-pressure, and later a gradual rise, a little higher than before the injection. Respiration became more shallow and the blood-pressure began to fall.

Fifteen minims of tincture of digitalis injected into the jugular veins produced no effect. Five minutes later the blood-pressure fell.

The injection of 20 minims of digitalis into the jugular vein was followed by no change in the blood-pressure; respiration then failed, and the animal died.

Experiment 32.

Digitalis.

Dog; weight, seven kilos; fair condition. Ether anesthesia.

Control blood-pressure, 132 mm. The animal was reduced to surgical shock by manipulating the splanchnic area. Two minims of tincture of digitalis were injected into the jugular vein. No effect was noted.

Three minutes later, an injection of 4 minims of tincture of digitalis was given into the jugular vein. A slight fall, followed by a temporary rise, was noted.

Ten minutes later, eight minims of digitalis were injected, followed by a temporary cessation in the decline of the blood-pressure. Respirations became more full; the blood-pressure again declined. Thirty minims of tincture of digitalis were injected without effect. The animal died in a few minutes.

Experiment 33.

Digitalis.

Dog; weight, five and one-half kilos; good physical condition. Ether anesthesia.

The blood-pressure cannula was adjusted in the carotid. Initial blood-pressure, 122 mm. The animal was reduced to surgical shock by dissection and manipulation of the somatic and splanchnic areas.

Five minims of tincture of digitalis were injected into the jugular vein without effect. Blood-pressure, 32 mm.

The intestines were exposed, and during the next ten minutes the blood-pressure dropped to 26 mm.

Ten minims of digitalis were injected into the jugular vein. No effect was noted.

Three minutes later 20 minims were injected. The animal died.

Experiment 34.

Digitalis.

Male mongrel dog; weight, ten kilos; good condition. Ether anesthesia.

Blood-pressure cannula in the carotid. The animal was reduced to surgical shock as in the preceding experiment. Blood-pressure, 24 mm.

Ten minims of tincture of digitalis were injected into the jugular vein. No effect was noted.

Five minutes later 30 minims of tincture of digitalis were injected, without effect. Blood-pressure, 18 mm. Respiration failed. The animal died.

Experiment 35.

Digitalis.

Dog; weight, ten kilos. Ether anesthesia.

Initial blood-pressure, 168 mm. The animal was reduced to surgical shock by the removal of one-fourth of the integument, and by exposure and manipulation of the stomach and of the intestines. The spinal cord was severed in the lower dorsal region.

At the expiration of fifty-five minutes the respirations became shallow and the heart action quickened. The carotid artery exhibited a pulse of small volume. The blood-pressure at this time registered 80 mm.; respiration, shallow but regular.

Ten minims of tincture of digitalis were injected into the jugular vein. After a lapse of seven seconds there was a rise in the blood-pressure; the curve was rapid in its ascent. In three or four seconds the blood-pressure began to decline, after which a steady rise was inaugurated, extending through a period of twenty minutes, the blood-pressure finally recording 120 mm. At the time the digitalis was administered the manometer strokes were extremely short, being less than 2 mm. in length.

At the end of this time the manometer excursions were four times as long as at the time of the injection. The respiration assumed a Cheyne-Stokes character. There was a slight fall, followed by a rise in blood-pressure. The heart again beat strongly, and on palpation the carotid pulse was hard. Its ascent was gradual, as was also the descent.

Three hundred and fifty c.c. of normal saline solution were given. There was an immediate rise in the blood-pressure, followed by a marked fall. The heart-strokes became long and less frequent. This irregularity was followed by a steady rise in the blood-pressure until it reached 140 mm. The strokes were long, the pulse full, the heart-beats strong. Respiration during this time continued to be of the Cheyne-Stokes type.

The animal was observed for one hour and thirty minutes, at which time the pulse-rate had somewhat fallen. The pressure was reduced from 140 mm. to 120 mm. The animal was then killed.

Experiment 36.

Digitalis.

Mongrel dog; weight, seven kilos; poor condition. Ether anesthesia.

The animal was reduced to surgical shock by exposing and manipulating the abdominal viscera, together with strong irritation of the sciatic nerve and extensive dissection of the skin of the body.

At the expiration of fifty minutes the blood-pressure was 70 mm., having fallen from 150 mm. Respiration was very shallow and frequent.

Ten minims of tincture of digitalis were injected into the jugular vein. The respiration became more rapid; later, more shallow. The blood-pressure steadily rose to 120 mm., and was well sustained, with a fair and even curve. The animal was killed twenty minutes later.

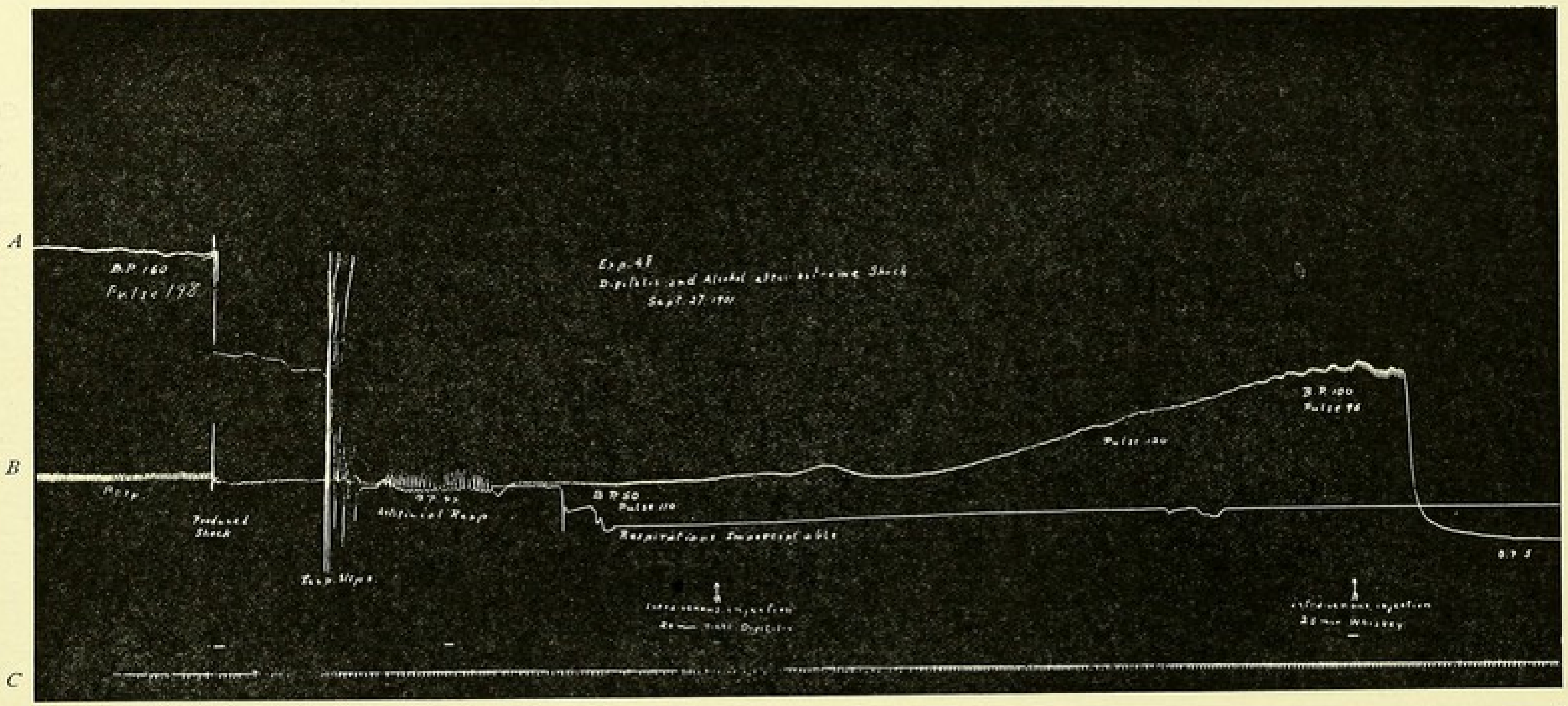

FIG. 6.—EXP. 37.—*A*, blood-pressure; *B*, respiratory tracing; *C*, time in seconds. The animal was reduced to shock. There was a considerable loss of blood. On injecting 1.33 c.c. (20 minims) tincture of digitalis, there was a marked rise in the blood-pressure. Later, 1.66 c.c. (25 minims) of whiskey were given. Note the rapid fall and sudden death after the marked and sustained rise. This illustrates the more sudden death in animals that had been given a considerable dose of digitalis.

Experiment 37.

Digitalis.

Small terrier; weight, four and one-half kilos. Morphin and ether anesthesia.

At 10.38, blood-pressure, 160 mm.; pulse, 198; respiration, 108.

At 10.43, shock was produced by exposing and manipulating the intestines and crushing the feet. Blood-pressure fell to 100 mm.; later, to 45 mm.; respiration ceased and artificial respiration was maintained. The blood-pressure rose very slightly.

At 10.55, 20 minims of tincture of digitalis were injected intravenously. The blood-pressure showed a slight temporary fall, followed by a slow but steady rise until 100 mm. was reached.

At 11.00, blood-pressure, 100 mm.; pulse, 160; respiration, imperceptible. An injection of 25 minims of whiskey was administered; cardiac paralysis followed; blood-pressure fell to 5 mm. The animal died.

Experiment 38.

Digitalis.

Female spaniel; weight, six kilos.

At 11.15, ether anesthesia was given. The tracheal and carotid cannulæ were applied.

At 11.35, normal blood-pressure, 130 mm.; stroke, 8 mm.; pulse, 160; respiration, 80.

At 11.46, the femoral vein was exposed.

At 12.04, the sciatic nerves were exposed.

At 12.06, the intestines were exposed.

At 12.12, the control blood-pressure was 85 mm.; stroke, 9 mm.; pulse, 140; respiration, 112.

At 12.12.30, the sciatic was stimulated; blood-pressure, 93 mm.; stroke, 9 mm.

At 12.16, blood-pressure, 74 mm.; stroke, 8 mm.; pulse, 36; respiration, 76.

At 12.16.30, an injection of 10 minims of tincture of digitalis was given.

At 12.18, blood-pressure, 85 mm.; stroke, 9 mm.; pulse, 116; respiration, 80. The rise was slow and sustained.

At 12.20, the sciatic was stimulated; blood-pressure, 110 mm.; stroke, 10 mm.

At 12.35, blood-pressure, 88 mm.; stroke, 8 mm.; pulse, 132; respiration, 76.

At 12.35.30, an injection of 10 minims of tincture of digitalis was given. A slow and sustained rise in the blood-pressure occurred; stroke, 8 mm.; pulse, 148; respiration 76.

At 12.44, the sciatic nerve was stimulated. There was an abrupt rise in the blood-pressure to 118 mm.

At 12.54, blood-pressure, 94 mm.; stroke, 8 mm.; pulse, 132; respiration, 64.

At 12.54.30, an injection of 10 minims of tincture of digitalis was given. A slight rise occurred, which was sustained. Blood-pressure, 98 mm.; stroke, 10 mm.; pulse, 136; respiration, 72.

At 1.11.30, the hind foot was burned. The blood-pressure rose sharply to 118 mm. A slow fall followed.

At 1.14.30, blood-pressure, 76 mm.; stroke, 8 mm.; pulse, 128; respiration, 60.

At 1.15, an injection of 10 minims of tincture of digitalis was given. Blood-pressure, 94 mm.; stroke, 8 mm.; pulse, 128; respiration, 144.

At 1.20, the sciatic was stimulated. A sharp rise of 17 mm. followed.

At 1.30, blood-pressure, 82 mm.; stroke, 8 mm; pulse, 140; respiration, 72.

At 1.36, an injection of 10 minims of tincture of digitalis was given. Blood-pressure, 92 mm.; stroke, 9 mm.; pulse, 144; respiration, 68.

At 1.42, the foot was burned. A sharp rise in the blood-pressure followed.

At 1.57, blood-pressure, 97; stroke, 2 mm.; pulse, 152; respiration, 78.

At 1.58, an injection of 10 minims of tincture of digitalis was given. Blood-pressure, 109 mm.; stroke, 2 mm.; pulse, 132; respiration, 76.

At 2.32, blood-pressure, 95 mm.; stroke, 5 mm.; pulse, 144; respiration, 64.

At 2.33, an injection of 10 minims of tincture of digitalis was given. Blood-pressure, 99 mm.; stroke, 6 mm.; pulse, 160; respiration, 58.

At 3.15, blood-pressure, 80 mm.; stroke, 2 mm.; pulse, 148; respiration, 44.

At 3.16, an injection of 10 minims of tincture of digitalis was given. Blood-pressure, 88 mm.; stroke, 3 mm.; pulse, 144; respiration, 136. The pulse was irregular and arrhythmic; the diastole was frequently much prolonged.

At 4.09, the dog died of sudden cardiac failure.

Experiments 39, 40.

Digitalis.

Dog 1, male bird-dog; good condition; weight, eleven kilos.

Dog 2, male bird-dog; good condition; weight, ten kilos. Ether anesthesia; tracheal and carotid cannulæ were adjusted.

At 9.35, preliminary observations were as follows:

Dog 1, blood-pressure, 150 mm.; stroke, 16 mm.; pulse, 208; respiration, 68.

Dog 2, blood-pressure, 140 mm.; stroke 10 mm.; pulse, 188; respiration, 76. The animals were reduced to shock.

At 10.00, shock, dog 1, blood-pressure, 115 mm.; stroke, 16 mm.; pulse, 148; respiration, 32.

Dog 2, blood-pressure, 95 mm.; stroke, 5 mm.; pulse, 156; respiration, 80.

At 10.10, dog 1, the sciatic was stimulated. A sharp fall and then a gradual rise, returning to a former level, were recorded.

Dog 2, a slow fall, then a gradual rise, 10 mm. above the former level, were observed.

At 10.21, dog 1, blood-pressure, 130 mm.; stroke, 18 mm.; pulse, 140; respiration, 148.

Dog 2, blood-pressure, 110 mm.; stroke, 5 mm.; pulse, 140; respiration, 80.

At 10.31.30, dog 2, an injection of 10 minims of tincture of digitalis was given.

Dog 1, an injection of 10 minims of tincture of digitalis was given.

At 10.32.15, dog 2, the heart-rate became slow and a slight increase of blood-pressure with irregular action was noted.

Dog 1, the heart-rate lessened. There was a slight rise in the blood-pressure, lasting a brief period. For one and one-half minutes after the injection the heart-rate in both animals became accelerated.

Dog 1, blood-pressure, 135 mm.; stroke, 18 mm.; pulse, 172; respiration, 48.

Dog 2, blood-pressure, 115 mm.; stroke, 4 mm.; pulse, 168; respiration, 80.

At 10.37, the sciatics were electrically stimulated. In both dogs a slight rise was noted, followed by a fall of 10 millimetres, with a prompt return to the former level.

At 11.00, dog 1, blood-pressure, 115 mm.; stroke, 3 mm.; pulse, 152; respiration, 48.

Dog 2, blood-pressure, 115 mm.; stroke, 8; pulse, 148; respiration, 76.

At 11.55, dog 1, blood-pressure, 110 mm.; stroke, 4 mm.; pulse, 56; respiration, 44.

Dog 2, blood-pressure, 114 mm.; stroke, 10 mm.; pulse, 152; respiration, 80.

At 12.10, the pulse and respiration were constant in each dog.

Dog 1, an injection of 5 minims of tincture of digitalis was given.

Dog 2, an injection of 5 minims of tincture of digitalis was given. Immediately following the injection the blood-pressure in each animal rose.

Before the injection:

Dog 1, blood-pressure, 105 mm.; stroke, 4 mm.; pulse, 56; respiration, 49.

Dog 2, blood-pressure, 116 mm.; stroke, 8 mm.; pulse, 152; respiration, 76.

After the injection:

Dog 1, blood-pressure, 108 mm; stroke, 4 mm.; pulse, 144; respiration, 40.

Dog 2, blood-pressure, 125 mm.; stroke, 8 mm.; pulse, 136; respiration, 72.

At 12.15, dog 1, the sciatic was stimulated.

At 12.15.30, dog 2, the sciatic was stimulated. A sharp fall with a gradual rise to the previous level occurred.

At 1.44, dog 1, blood-pressure, 107 mm.; stroke, 8 mm.; pulse, 160; respiration, 44.

Dog 2, blood-pressure, 115 mm.; stroke, 8 mm.; pulse, 172; respiration, 80.

At 1.44.30, dog 1, an injection of 10 minims of digitalis was given.

Dog 2, an injection of 10 minims of digitalis was given.

At 1.46, a gradual rise was recorded.

At 1.47, dog 1, blood-pressure, 112 mm.; stroke, 4 mm.; pulse, 64; respiration, 40.

Dog 2, blood-pressure, 120 mm.; stroke, 8 mm.; pulse, 164; respiration, 76.

At 1.48.30, dog 1, the sciatic was stimulated.

Dog 2, the sciatic was stimulated.

Dog 1 showed a sharp rise with a correspondingly sharp fall, then a gradual recovery to the former level.

Dog 2 showed a sharp rise with a correspondingly sharp fall and a gradual return to the former level.

At 2.20, dog 1, an injection of 10 minims of tincture of digitalis was given.

Dog 2, an injection of 10 minims of tincture of digitalis was given. The results were the same as in the previous injection.

Before the injection:

Dog 1, blood-pressure, 120 mm.; stroke, 4 mm.

Dog 2, blood-pressure, 118 mm.; stroke, 20 mm.

After the injection:

Dog 1, blood-pressure, 122 mm.; stroke, 4 mm.

Dog 2, blood-pressure, 112 mm.; stroke, 20 mm.

At 2.30, stimulation of the sciatics produced a similar effect. For ten minutes there was a slight increase in the blood-pressure.

At 2.40, dog 1, blood-pressure, 150 mm.; stroke, 4 mm.

Dog 2, blood-pressure, 135 mm.; stroke, 20 mm.

After the foregoing the strokes were markedly increased.

Dog 1, blood-pressure, 80 mm.

Dog 2, blood-pressure, 60 mm.

At 2.44, both dogs died of cardiac failure.

Experiments 41, 42.

Digitalis and Saline.

Dog 1, male mongrel; poor condition; weight, six kilos.

Dog 2, female mongrel; fair condition; weight, five kilos. Ether anesthesia.

At 9.45, the tracheal and carotid cannulæ were adjusted.

At 10.27, preliminary observations were as follows:

Dog 1, blood-pressure, 134 mm.; stroke, 6 mm.; pulse, 164; respiration, 68.

Dog 2, blood-pressure, 125 mm.; stroke, 6 mm.; pulse, 168; respiration, 52.

The animals were reduced to shock by exposing and manipulating the intestines. The femoral vein and sciatic nerve of each dog were exposed.

At 10.28, dog 1, blood-pressure, 94 mm.; stroke, 2 mm.; pulse, 152; respiration, 48.

Dog 2, blood-pressure, 75 mm.; stroke, 6 mm.; pulse, 128; respiration, 65.

At 10.30.30, the sciatic nerves were stimulated, with results as follows:

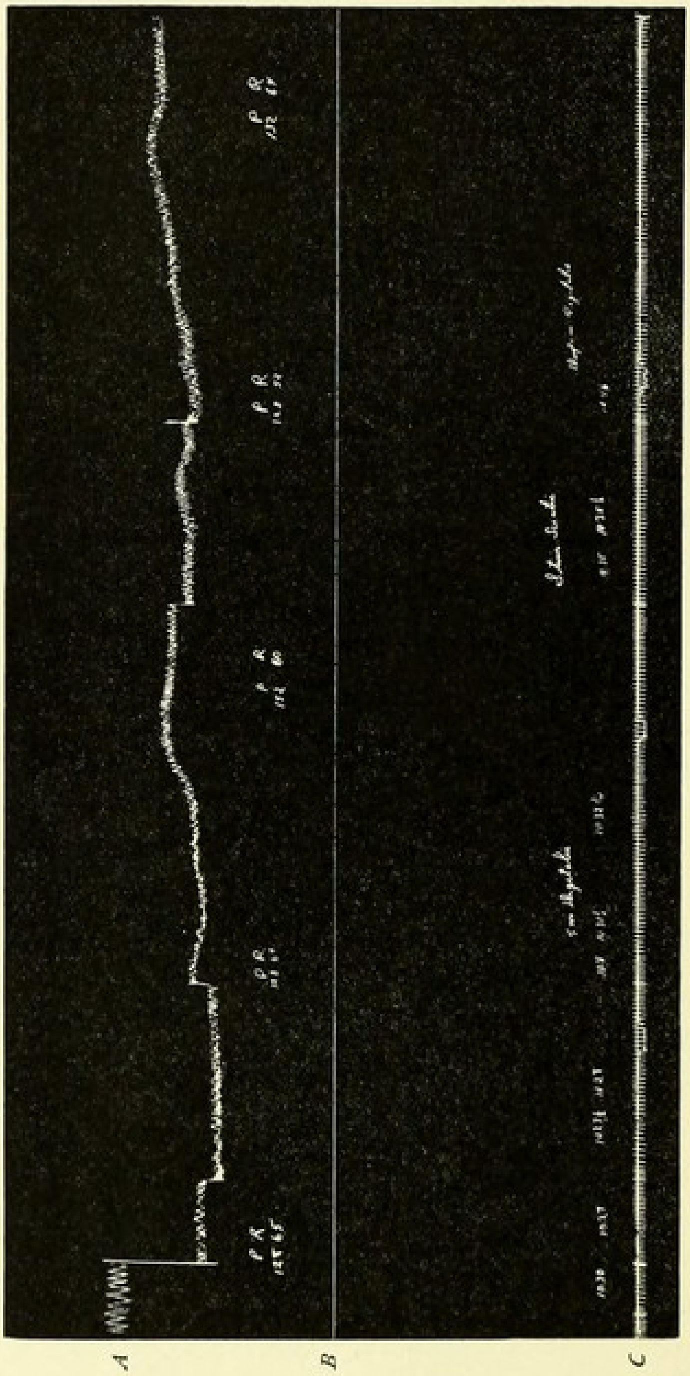

Fig. 7.—Exps. 41, 42.—Normal animal. Digitalis.—Note the continued and the sustained increase of the arterial pressure. *A*, carotid blood-pressure; *B*, abscissa; *C*, seconds.

Dog 1, an abrupt rise in the blood-pressure of 2 mm., followed by a slow decline.

Dog 2, slow rise in the blood-pressure of 2.5 mm.

At 10.31.30, dog 2, 5 minims of tincture of digitalis were injected.

At 10.32, dog 1, an equal amount of normal saline was injected.

Dog 1, blood-pressure, 100 mm.; stroke, 4 mm.; pulse, 160; respiration, 52.

Dog 2, blood-pressure, 98 mm.; stroke, 5 mm.; pulse, 120; respiration, 64.

At 10.35, the sciatics were stimulated.

Dog 1, a rise in the blood-pressure of 8 mm. was noted.

Dog 2, a rise in the blood-pressure of 5 mm. was noted. The rise was more abrupt in dog 1.

At 10.47, dog 1, 20 minims of normal saline were injected.

Dog 2, 5 minims of tincture of digitalis were injected.

In both animals a gradual rise followed.

Dog 1, the blood-pressure rose 8 mm.

Dog 2, the blood-pressure rose 22 mm.

At 10.51, the sciatics were stimulated.

Dog 1, the blood-pressure rose 6 mm.

Dog 2, the blood-pressure rose 5 mm.

At 10.55, dog 2, 5 minims of tincture of digitalis were injected.

Dog 1, 20 minims of saline were injected.

Dog 1, the blood-pressure rose 5 mm.

Dog 2, the blood-pressure rose 5 mm.

At 11.31, the sciatics were stimulated.

Dog 1, a rise in the blood-pressure of 4 mm. followed.

Dog 2, a rise in the blood-pressure of 13 mm. followed.

At 11.55, dog 2, 10 minims of tincture of digitalis were injected.

Dog 1, 20 minims of saline were injected.

At 11.55.30, dog 1, blood-pressure, 96 mm.; stroke, 10 mm.; pulse, 156; respiration, 52.

Dog 2, blood-pressure, 92 mm.; stroke, 4 mm.; pulse, 52; respiration, 144.

At 11.59, dog 1, the sciatic was stimulated.

At 11.59.30, dog 2, the sciatic was stimulated.

At 12.02, dog 1, a rise in the blood-pressure of 8 mm. followed. Dog 2, a rise in the blood-pressure of 5 mm. followed.

Dog 1, repeated clots occurred.

At 1.10, dog 1 died of an excessive dose of $MgSO_4$.

At 1.53.30, dog 2, 10 minims of tincture of digitalis were injected. Blood-pressure, 96 mm.; stroke, 4 mm.; pulse, 144; respiration, 36.

At 1.55, dog 2, the sciatics were stimulated. An abrupt rise in the blood-pressure of 17 mm. occurred.

At 3.00, dog 2, 10 minims of tincture of digitalis were injected. Blood-pressure, 94 mm.; stroke, 4 mm.; pulse, 144; respiration, 40.

At 3.03, the sciatics were stimulated. A rise in the blood-pressure of 9 mm. followed.

At 3.03.30, the sciatics were electrically stimulated. A rise in the blood-pressure of 14 mm. followed.

At 4.39, dog 2, 10 minims of tincture of digitalis were injected. Blood-pressure, 70 mm.; stroke, 6 mm.; pulse, 104; respiration, 20.

At 4.44, the sciatics were stimulated. A rise in the blood-pressure of 2 mm. occurred.

At 5.00, dog 2 died of respiratory failure.

Experiment 43.

Simultaneous Drug Experiments.

Seven small dogs that had been in confinement for a considerable time, and were in poor physical condition, were subjected to simultaneous experiment. The animals were of almost equal weight, and were anesthetized with morphin and ether. They were reduced to surgical shock in a manner as nearly alike as possible. The intestines were removed; the integument was removed from one side of the trunk, and the raw surfaces were sponged. The animals were reduced to a degree of shock as nearly equal as could be determined.

Dog 1 was given 20 minims of tincture of digitalis, in small doses, at intervals until his death.

Dog 2 was treated in like manner.

Dog 3 was used as a control.

Dog 4 was given strychnin, in small doses, at intervals.

Dog 5 was given whiskey, in 25-minim doses, at half-hour intervals.

Dog 6 was treated the same as dog 5.

Dog 7 was given repeated doses of strychnin, but convulsions developed unexpectedly early.

The sequence of their death was:

Strychnin, thirty-three minutes.

Digitalis, three hours and thirty-one minutes.

Strychnin, three hours and fifty-two minutes.

Whiskey, four hours and sixteen minutes.

Digitalis, four hours and twelve minutes.

Control, four hours and fifty-seven minutes.

Whiskey, five hours and ten minutes.

At the conclusion of the experiment it was apparent that simultaneous experiments were not well adapted to the work, and no more were made.

Experiment 44.

Strychnin.

Mongrel dog; weight, fourteen kilos; good condition. Ether anesthesia.

Respiratory cannula was adjusted in the trachea, the blood-pressure in the carotid. The dog was reduced to considerable shock by opening the abdomen and roughly manipulating the intestines while exposing them to the air. It required fifteen minutes to reduce the blood-pressure from 140 mm. (the normal) to 96 mm. At this time the respiration became shallow, and the pause increased in length. An injection of $^1/_{100}$ grain of strychnin was made into the jugular vein.

Following this there was a rise in the blood-pressure of 2 mm.; the blood-pressure curve was rather irregular, but continued a trifle higher than previous to the injection.

Twenty minutes later the intestines were again exposed and roughly manipulated until the animal was in a very low state, the blood-pressure being 30 mm. At this time artificial respiration was occasionally necessary.

On administering $^1/_{90}$ grain of strychnin there followed a slight rise, the strokes becoming a little shorter; after which the blood-pressure fell to the previous level.

Fifteen minutes later, another injection of $^1/_{120}$ grain of strychnin was given, followed in five minutes by slight muscular twitchings. The blood-pressure rose gradually, and convulsions developed. During the convulsions the blood-pressure rose considerably. Following this the blood-pressure fell to a point lower than it was before the administration of the strychnin. The animal soon died.

Experiment 45.

Strychnin.

Old bull-dog; weight, twelve kilos. Ether anesthesia.

Respiratory cannula in the trachea; blood-pressure cannula in the carotid. After a control had been taken, in which the blood-pressure was 146 mm., the animal was subjected to manipulation, operation on the skin, including extensive removal, irritation of the sciatic nerve and the nerves of the tracheal plexus, and finally opening of the abdomen and exposure and manipulation of the intestines during the period of one hour, at which time there was imminent danger of death from shock. The intestines were then replaced, the skin everywhere sutured, after which the blood-pressure recorded 26 mm., it having been as low as 20 mm.

One two-hundredth of a grain of strychnin was then injected into the jugular vein. A rise in the blood-pressure with a rather irregular curve followed, the rise at no time being more than 3 mm.

A second injection of $^1/_{240}$ grain was given fifteen minutes later, with no effect.

Ten minutes later the third injection was given, without effect.

Five minutes later a fourth injection was given. A slight twitching of the muscles and an irregular rise in the blood-pressure, synchronous with the presence of the twitching, appeared.

Five minutes later the fifth injection was given. This was followed by an additional twitching and a slight convulsion, during which the blood-pressure curve exhibited a very irregular line, the regularity being synchronous with the contraction of the muscles. After the convulsions the blood-pressure fell again. A few minutes later the animal died.

Experiment 46.

Strychnin.

Mongrel dog; weight, nine kilos; good condition. Ether anesthesia.

Respiratory cannula was adjusted in the trachea, the blood-pressure cannula in the right carotid. An excessive amount of ether was given at the beginning of an experiment. A rapid fall in the blood-pressure resulted. Artificial respiration became necessary. Extensive operations were then performed on the extremities, such as crushing the paws, breaking the legs, and manipulating the nerve-trunks. This was followed by a rise in the blood-pressure, and later a fall. Extensive cutting of the integument was followed by a fall in the blood-pressure from 134 mm. to 50 mm. The wounds were then closed, and after fifteen minutes had elapsed the blood-pressure rose to 58 mm. At this time there was some hemorrhage. Blood-pressure recorded at 48 mm.

An injection of $^1/_{120}$ grain of strychnin was given into the jugular vein, without effect.

In ten minutes the blood-pressure began a steady decline, and respiration began to fail.

A second injection of $^1/_{120}$ grain of strychnin was given, but no effect was observed.

In five minutes the third injection was given. The blood-pressure continued to fall and respiration failed progressively.

The administration of $^1/_{90}$ grain of strychnin was followed by a convulsion within two minutes. A temporary rise in the blood-pressure was noted. Irregularity in the pressure occurred synchronously with the convulsion, after which the blood-pressure rapidly fell and the animal died.

Experiment 47.

Strychnin.

Mongrel dog; weight, nine kilos; good physical condition. Ether anesthesia.

Respiratory cannula was adjusted in the trachea, blood-pressure cannula in the carotid. The animal was reduced to surgical shock by manipulating and exposing the intestines, and abstracting eight ounces of blood. The initial blood-pressure was 132 mm.

The wounds were closed, and after the blood-pressure had fallen to 28 mm. $^1/_{240}$ grain of strychnin was given. A slight fall was recorded, followed by a corresponding rise in the blood-pressure. This rise was but momentary, after which the blood-pressure fell to 34 mm.

In five minutes the second injection was given; a slight fall in the blood-pressure, followed by a temporary rise, not so high as the previous one, occurred. The blood-pressure now began to decline. The animal was breathing irregularly and the blood was becoming dark.

The administration of $^1/_{20}$ grain of strychnin was almost immediately followed by muscular twitching and spasms. During the spasm respiration failed, after which respiratory excursions became deeper and more regular. There was a slight fall in the blood-pressure immediately after the injection. During the convulsion there was a rise. The curve showing great regularity. The blood-pressure then fell gradually and the muscles became relaxed. Respiration failed and the animal died.

Experiment 48.

Strychnin.

Mongrel dog; weight, six kilos; general condition fair. Ether anesthesia.

Respiratory cannula in the trachea, blood-pressure cannula in the carotid. The extensive dissection of the skin and the abdomen, with some loss of blood, together with manipulation and exposure of intestines, soon reduced the blood-pressure from the control of 121 mm. to 32 mm. At this time respiration was failing, and artificial respiration was maintained. The administration of $^1/_{120}$ grain into the jugular vein was followed by a gradual progressive rise in the blood-pressure. The blood-pressure soon began to fall, the decline being gradual.

The injection of $^1/_{120}$ grain of strychnin ten minutes later produced no appreciable effect. Blood-pressure then recorded 18 mm.

A second and third injection of $^1/_{120}$ grain was followed by no change in the blood-pressure. The animal died.

Experiment 49.

Strychnin.

Dog; weight, six kilos; greatly emaciated; had a purulent ophthalmia and rhinitis. The anesthesia was badly borne, artificial respiration being necessary on several occasions before the experiment began. The control blood-pressure was 68 mm. Incising the skin was attended with but little hemorrhage, as great anemia was present. The blood-pressure soon began to fall, and when it registered 38 mm., $^1/_{240}$ grain of strychnin was given, without effect. Artificial respiration now became necessary, and the blood-pressure began to decline.

An injection of $^1/_{120}$ grain of strychnin was attended by twitching, and a temporary rise in the blood-pressure occurred synchronously with muscular contractions. After the twitching had ceased the blood-pressure fell to a point below the level recorded before injection. The blood-pressure began to decline rapidly.

An injection of $^1/_{120}$ grain was followed by a slight convulsion. As the muscles became relaxed the blood-pressure fell rapidly and the dog died in a few minutes.

Experiment 50.

Strychnin.

Dog; weight, ten kilos, good physical condition. Ether anesthesia.

Respiratory cannula in the trachea, blood-pressure cannula in the carotid. The animal was reduced to surgical shock by skin dissection, irritation of the nerve-trunks, and exposure and manipulation of the intestines. Respiration was extremely irregular during the manipulation. The intestines were replaced and the wounds closed. The blood-pressure gradually fell and respiration became shallow and slow. Blood-pressure fell to 32 mm. and artificial respiration was given for a few minutes.

The injection of $^1/_{240}$ grain of strychnin into the jugular vein was attended by a slight temporary fall, after which a rise occurred. Respiration became a little fuller, and more rapid.

Ten minutes later four ounces of blood were taken from the jugular vein; the blood-pressure fell 5 mm. during the following five minutes. Respiration failed rapidly and the blood-pressure declined.

Injections of $^1/_{120}$ grain of strychnin at intervals of Two minutes were given. No effect was noted until the fourth injection, when a marked muscular twitching occurred, with a rise in the blood-pressure; after relaxation of the muscle the pressure gradually fell to the abscissa line, and respiration failed. The animal died.

Experiment 51.

Strychnin.

Dog; weight, ten kilos, good physical condition. Ether anesthesia.

Respiratory cannula in the trachea, blood-pressure cannula in the carotid. Control blood-pressure, 138 mm.

Tearing, crushing the brachial plexus, sciatic nerve, abstracting six ounces of blood, and performing pylorectomy reduced the dog to profound shock. Respiration was irregular. The blood-pressure fell to 36 mm. The injection of $^1/_{120}$ grain of strychnin was given into the jugular vein. No change was noted in respiration or in the blood-pressure. Later the blood-pressure began to fall, but artificial respiration was not required. No further change was noted.

Two minutes later a second injection of $^1/_{240}$ grain of strychnin into the jugular vein was given; artificial respiration became necessary. A slight rise in the blood-pressure followed.

After a lapse of six minutes there was a fall, at which time a third injection of $^1/_{240}$ grain of strychnin was given into the jugular vein. This was followed by a gradual rise of 2 mm. in the blood-pressure. The pressure became steady and continued so for fifteen minutes without much change, after which a slight decline was inaugurated.

A fourth injection of like amount was then given. A rise in the blood-pressure followed. In eight minutes a decline began.

A fifth injection of $^1/_{240}$ grain of strychnin was followed by a slight twitching and a slight rise in the blood-pressure; a moderate convulsion followed. After the convulsion the blood-pressure declined rapidly. Respiration was improved.

An injection of $^1/_{240}$ grain of strychnin was given, followed by a marked convulsion, after which blood-pressure declined to 24 mm.

An injection of $^1/_{30}$ grain of strychnin was now given into the jugular vein. Convulsion followed, during which the blood-pressure fluctuated greatly, and with muscular relaxation it fell. The animal died in a few minutes.

Experiment 52.

Strychnin.

Young dog; weight, five kilos; excellent physical condition. Ether anesthesia.

Blood-pressure cannula in the carotid, respiratory cannula in the trachea; some difficulty was encountered in inserting the cannula into the carotid. The animal was reduced to shock as in the foregoing experiment, including the abstracting of four ounces of blood.

Blood-pressure fell so rapidly and respiration became so shallow that normal salt solution was given temporarily, to save the animal. There was some rise in the blood-pressure, with increased length of stroke, following the administration of 353 c.c. of the salt solution. A hypodermic of strychnin was given with the salt solution. At first $^1/_{90}$ grain was injected without effect. Another injection of $^1/_{90}$ grain was without effect. A third injection was followed by longer and more rapid respiration. The blood-pressure began to fall, and more salt solution was given. The length of the stroke increased, but the blood-pressure remained unchanged. A hypodermic of $^1/_{30}$ grain of strychnin was given. A convulsion followed, after which the animal died.

Experiment 53.

Strychnin.

Dog, water-spaniel; weight, six kilos; young and in good physical condition. Ether anesthesia; considerable difficulty was encountered in obtaining an even anesthesia.

Control blood-pressure, 124 mm. Resection of about one-half of the small intestines, with some loss of blood, together with excision of the spleen, reduced the animal to deep shock. After the blood-pressure had reached 32 mm. the respiration became very irregular. Normal saline solution was given. Following this there was a rise of 9 mm. in the blood-pressure. Hæmostasis was completed and the abdomen closed.

The blood-pressure had, in the mean time, fallen to

24 mm. The administration of $^1/_{60}$ grain of strychnin was attended by a very marked rise in the blood-pressure. After eight minutes a decline began. The rapidity of the heart was increased and the length of the strokes diminished. The decline then became gradual. Salt solution was again given; strokes increased, temporarily raising the blood-pressure. A second injection of $^1/_{30}$ grain of strychnin was given. A less marked effect than the first was noted. A third injection followed. The blood-pressure was slowly falling. After a lapse of twenty minutes, slight twitching of the muscles was noted. Again there was a slight rise in the blood-pressure. In twenty minutes the blood-pressure fell and the animal died.

Experiment 54.

Strychnin.

Dog. Ether anesthesia. The animal was reduced to shock by exposing and manipulating the intestines.

At 12.26, blood-pressure, 105 mm.; pulse, 168; respiration, 32.
At 12.28, $^1/_{90}$ grain of strychnin was injected. Blood-pressure, 80 mm.; pulse, 148; respiration, 36.
At 12.29, blood-pressure, 100 mm.; pulse, 128; respiration, 32.
At 12.30, the left hind foot was burned.
At 12.31, blood-pressure, 100 mm.; pulse, 128; respiration, 32.
At 12.34, blood-pressure, 110 mm.; pulse, 136; respiration, 40.
At 12.35, blood-pressure, 120 mm.; pulse, 140; respiration, 40. The rise in pressure was gradual and well sustained.

Experiment 55.

Strychnin.

Mongrel dog; weight, 14 kilos; good condition. Morphine and ether anesthesia.

At 1.35, blood-pressure, 140 mm.; pulse, 148; respiration, 24.
At 1.40, blood-pressure, 140 mm.; pulse, 144; respiration, 36.

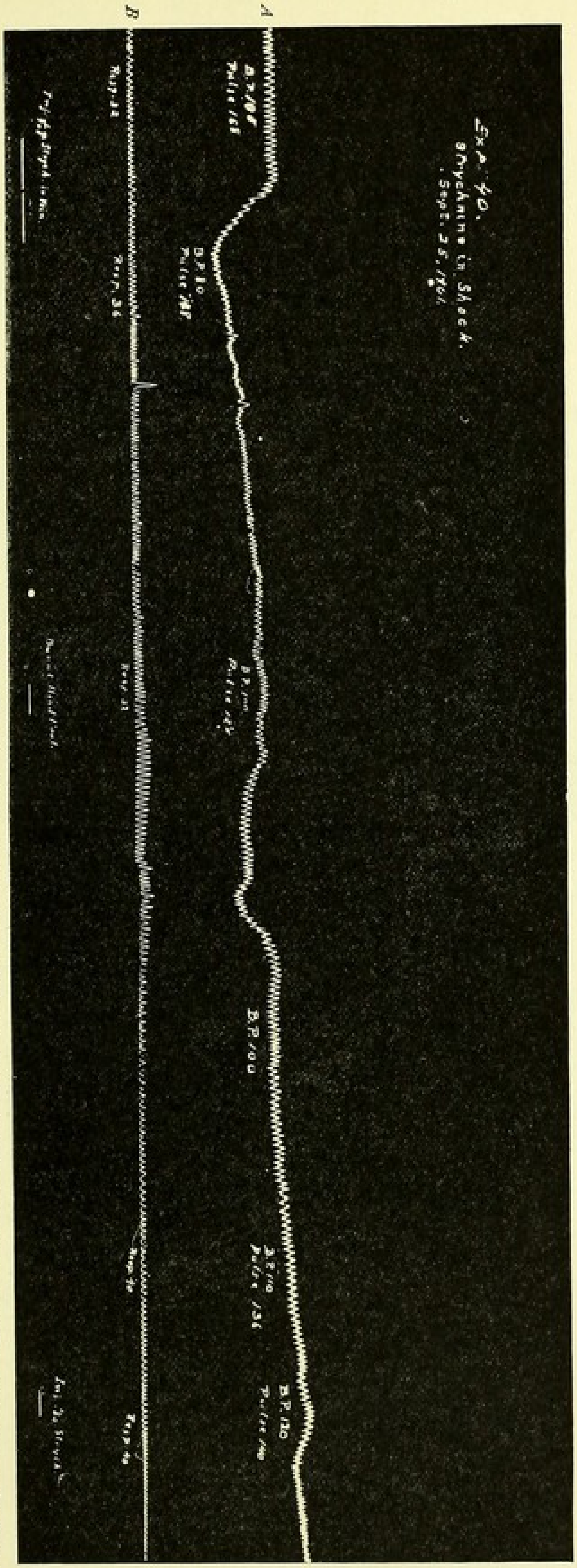

FIG. 8.—EXP. 54.—*A*, blood-pressure; *B*, respiratory tracing. The animal was reduced to moderate shock, then .75 milligramme ($\frac{1}{80}$ grain) of strychnin was intravenously given. Note the immediate fall in blood-pressure, followed by a gradually increasing rise until the pressure had risen 15 mm. higher than the level it was before the strychnin was given.

At 1.42, $^1/_{20}$ grain of strychnin was injected.

After an immediate fall in blood-pressure convulsions appeared, during which the blood-pressure rapidly rose higher than normal. A few minutes after cessation of the convulsion peripheral irritation caused a second convulsion, attended by a marked rise in the blood-pressure with great irregularities.

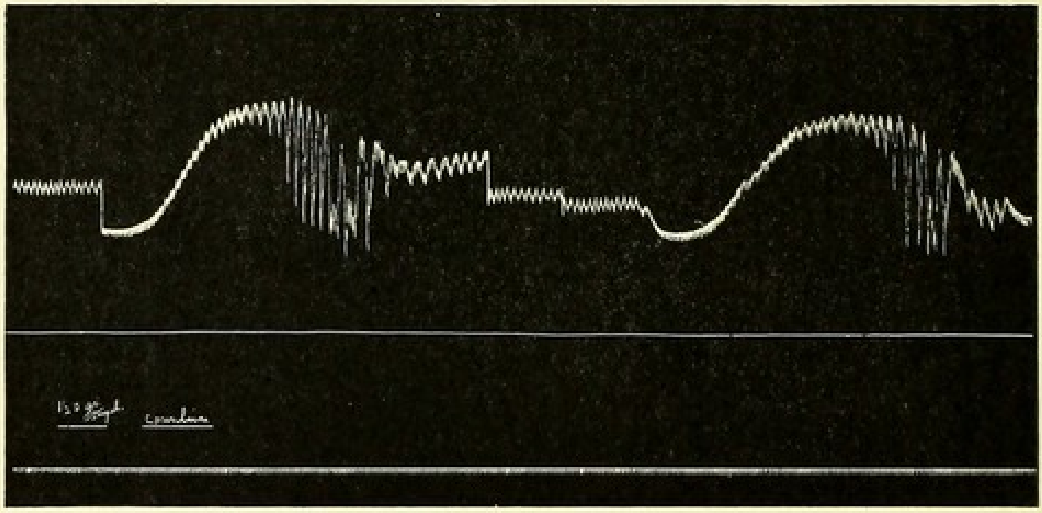

FIG. 9.—EXP. 55.—Note the marked rise in the blood-pressure following the injection of $\frac{1}{20}$ grain of strychnin. The long excursions were caused by the convulsions. After the animal became quiet peripheral stimulation caused a second convulsion.

At 1.47, $^1/_{60}$ grain of strychnin was given.

At 1.50, blood-pressure, 140 mm.; pulse, 144; respiration, 124.

At 1.51, $^1/_{30}$ grain of strychnin was injected.

At 1.55, blood-pressure, 140 mm.; pulse, 180; respiration, 36.

At 2.00, blood-pressure, 140 mm.; pulse, 200; respiration, 36.

At 2.01, $^1/_{15}$ grain of strychnin was injected; convulsions appeared.

At 2.06, blood-pressure, 146 mm.; pulse, 144; respiration, 48.

EXPERIMENT 56.

Strychnin. Asphyxia.

Mongrel dog; good condition; weight, six kilos. Ether anesthesia.

Blood-presure cannula was adjusted in the carotid.

Asphyxia was induced by clamping the trachea. A marked rise in the blood-pressure, with an increased respiratory action, followed. Later, the blood-pressure fell.

Upon the administration of 500 c.c. of saline infusion the pressure rose to almost the previous level.

The trachea was again clamped, following which the previous phenomena were observed. Asphyxia was continued until the heart stopped. At the expiration of sixteen seconds without a heart-beat, ¼ grain of strychnin in saline infusion was injected. The animal was inverted, head up then head down; after which the heart resumed its beat, the blood-pressure rising almost to its previous level. The animal was then killed.

At autopsy the veins were found to be engorged and the intestines cyanotic.

Experiments 57, 58.

Strychnin. Control.

Dog 1, female; fair condition; weight, five kilos.
Dog 2, male; good condition; weight, five kilos.

At 10.30, ether anesthesia was administered.

At 11.02.30, the normal blood-pressure was as follows:
Dog 1, blood-pressure, 148 mm.; stroke, 14 mm.
Dog 2, blood-pressure, 82 mm.; stroke, 10 mm.

At 11.10, the intestines of both dogs were exposed and manipulated.

At 11.24, dog 1, blood-pressure, 102 mm.; stroke, 14 mm.
Dog 2, blood-pressure, 75 mm.; stroke, 14 mm.

At 11.48, dog 1, blood-pressure, 126 mm.; stroke, 14 mm.
Dog 2, blood-pressure, 78 mm.; stroke, 16 mm.

At 11.48.30, dog 2, $^1/_{90}$ grain of strychnin in 25 minims saline was injected.
Dog 1, the same amount of saline was injected.

At 11.54, dog 1, blood-pressure, 112 mm.; stroke, 14 mm.
Dog 2, blood-pressure, 70 mm.; stroke, 18 mm.

At 11.57, dog 1, blood-pressure, 110 mm.; stroke, 12 mm.
Dog 2, blood-pressure, 78 mm.; stroke, 16 mm.

At 12.02.30, dog 1, blood-pressure, 110 mm.; stroke, 14 mm.; clot in the cannula.
Dog 2, blood-pressure, 70 mm.; stroke, 16 mm.

At 12.17, dog 1, blood-pressure, 105 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 68 mm.; stroke, 16 mm.

At 12.20.30, dog 1, blood-pressure, 102 mm.; stroke, 14 mm.; pulse, 144.
Dog 2, blood-pressure, 68 mm.; stroke, 19 mm.; pulse, 92.

At 12.21, dog 2, $^1/_{90}$ grain of strychnin in 25 minims saline was injected.
Dog 1, an equal amount of saline was administered.

At 12.41.30, dog 1, blood-pressure, 90 mm.; stroke, 16 mm.; pulse, 112.
Dog 2, blood-pressure, 60 mm.; stroke, 18; pulse, 96.

At 12.52.30, dog 1, blood-pressure, 95 mm.; stroke, 12 mm.; pulse, 108.
Dog 2, blood-pressure, 70 mm.; stroke, 16 mm.; pulse, 88.

At 1.10, dog 1, blood-pressure, 100 mm.; stroke, 10 mm.; pulse, 116.
Dog 2, blood-pressure, 68 mm.; stroke, 14 mm.; pulse, 84.

At 1.18, dog 1, blood-pressure, 100 mm.; stroke, 10 mm.; pulse, 144.
Dog 2, blood-pressure, 68 mm.; stroke, 14 mm.; pulse, 102.

At 1.19, dog 2, $^1/_{90}$ grain of strychnin in 25 minims saline was injected.
Dog 1, the same amount of saline was injected.

At 1.20, dog 1, blood-pressure, 100 mm.; stroke, 10 mm.; pulse, 142; a clot in the cannula.
Dog 2, blood-pressure, 65 mm.; stroke, 14 mm.; pulse, 104.

At 1.37, dog 1, blood-pressure, 98 mm.; stroke, 3 mm.; pulse, 116.
Dog 2, blood-pressure, 65 mm.; stroke, 15 mm.; pulse, 96.

At 2.00, dog 1, blood-pressure, 78 mm.; stroke, 18 mm.
Dog 2, blood-pressure, 62 mm.; stroke, 14 mm.; pulse, 95.

At 3.10, dog 1, dead, clot and $MgSO_4$ (accident).
Dog 2, blood-pressure, 60 mm.; stroke, 10 mm.

At 4.17, dog 2, blood-pressure, 54 mm.; stroke, 10 mm.

At 4.18, dog 2, an injection of $^1/_{30}$ grain of strychnin was given.

At 4.20, dog 2, blood-pressure, 55 mm.; stroke, 10 mm.

At 4.27, dog 2, blood-pressure, 60 mm.; stroke, 12 mm.
From 4.34 to 4.40 the heart was regular. The dog died of respiratory failure. Blood-pressure, 46 mm.; stroke, 10 mm.

Remarks.—Artificial respiration was maintained forty-five minutes in dog 1. There were irregularities and a gradual fall in the blood-pressure. The reflexes were heightened during this experiment.

Experiment 59.

Strychnin.

Old dog; weight, twelve kilos. Ether anesthesia.

Initial blood-pressure, 166 mm.; stroke, 10 mm.; respiration somewhat irregular. The skin was removed from a portion of the trunk and the raw surfaces sponged. The blood-pressure was reduced to 130 mm.

One-sixtieth grain of strychnin sulphate in solution of 22 minims of water was given at three-minute intervals. Following the injection the respiration became more regular. The length of the stroke was reduced to 2 mm. The respiratory alterations upon the blood-pressure curve were not marked.

After the second injection the blood-pressure fell to

125 mm. The length of the stroke increased to 4 mm.

The third injection caused the blood-pressure to rise abruptly to 160 mm., and convulsions appeared. After ten minutes a decline began and continued until the pressure reached 55 mm. Respiration became spasmodic. The decline renewed and continued until the blood-pressure recorded 26 mm. The animal soon died.

Experiment 60.

Strychnin.

Fox terrier; fair condition; weight, six kilos. Ether anesthesia.

Preliminary blood-pressure, 130 mm.; stroke, 12 mm. The animal was reduced to slight shock. One one-hundred-and-twentieth grain of strychnin was given intravenously. The blood-pressure rose 2 mm., followed by a fall of 8 mm. The length of stroke fell from 12 to 10 mm.

Eight minutes later a second injection of $^1/_{120}$ grain of strychnin was given. The blood-pressure continued to fall, losing 32 mm.

Four minutes later the blood-pressure rose 38 mm., the pulse became more rapid, and respiration slower. After five minutes the blood-pressure lost 10 mm.

One minute later another injection of $^1/_{120}$ grain of strychnin was given. Blood-pressure fell 24 mm. In five minutes it regained 12 mm.

Another injection of $^1/_{120}$ grain of strychnin was administered. The blood-pressure fell to 95 mm.

Five minutes later another injection of $^1/_{120}$ grain of strychnin was given. No change in the blood-pressure followed. After ten minutes the blood-pressure fell 12 points. The reflexes were greatly heightened. Slight convulsions appeared on light irritation.

Three minutes later an injection of $^1/_{120}$ grain of strychnin was followed by convulsions. The blood-pressure at this time recorded 68 mm. It rose rapidly to 152 mm., after which a gradual decline occurred. After twenty-three minutes the blood-pressure fell to 106 mm.

One one-hundred-and-twentieth grain of strychnin was again administered. Convulsions followed. The blood-pressure gradually fell to 30 mm. The animal died three hours after the first injection.

Experiment 61.

Strychnin.

Bull terrier; good condition; weight, fifteen kilos. Ether anesthesia.

Initial blood-pressure, 170 mm.; stroke, 14 mm. The animal was reduced to shock by exposing and manipulating the intestines. Blood-pressure, 128 mm.; stroke, 4 mm.

One one-hundred-and-twentieth grain of strychnin was injected at five-minute intervals. Following the first injection there was a rise in the blood-pressure. Blood-pressure, 140 mm.; stroke, 4 mm.

Following the second injection there was a fall of 5 mm. in the blood-pressure.

Following the third injection there was a slight rise of 5 mm.

Following the fourth injection there was a fall of 6 mm.

Following the fifth injection there was a rise in the blood-pressure of 16 mm.

Following the sixth injection there was a fall of 6 mm., shortly followed by a further fall of 4 mm.

Following the seventh injection the reflexes heightened, with a rise of 25 mm.

Following the eighth injection there was a fall in the blood-pressure of 25 mm.

Following the ninth injection there was a convulsion, accompanied by a rise of 16 mm.

Following the tenth injection, convulsions at regular intervals. During the convulsion there was a slight rise in blood-pressure.

Following the eleventh injection, convulsions, during which time there was a rise of 20 mm. in the pressure.

Following the twelfth injection there was a fall of 20 mm. in the blood-pressure. Convulsions continuous.

Following the thirteenth and fourteenth injections, which were given during the convulsions, the animal died, with a blood-pressure of 10 mm.

Time of experiment, three hours and forty-five minutes.

Experiment 62.

Strychnin.

Mongrel dog; poor condition; weight, two and one-half kilos. Ether anesthesia.

Preliminary blood-pressure, 125 mm.; stroke, 12 mm.

The animal was reduced to shock by skinning the spine and sponging the denuded surface. Blood-pressure, 88 mm.; stroke, 8 mm.

One-twentieth grain of strychnin was injected. A continuous fall in the blood-pressure to the abscissa line followed. Animal's death was due to respiratory failure.

Experiment 63.

Strychnin.

Mongrel dog; weight, nine kilos; good condition. Ether anesthesia.

Preliminary blood-pressure, 106 mm.; stroke, 7 mm.

The animal was reduced to surgical shock. Blood-pressure, 98 mm.; stroke, 8 mm.

One-twentieth grain of strychnin was administered, followed by an immediate fall in the blood-pressure. Blood-pressure, 50 mm.; stroke, 10 mm. A slight convulsion appeared, during which the maximum blood-pressure was 94 mm.; stroke, 10 mm. A fall in the blood-pressure followed.

One-twentieth grain of strychnin was injected. An irregular rise in the blood-pressure followed. A convulsion ensued, after which the blood-pressure steadily fell until the death of the animal.

Experiments 64, 65.

Strychnin. Control.

Dog 1, male bull; excellent condition; weight, ten kilos.

Dog 2, female bull; excellent condition; weight ten kilos.

At 10.00, anesthesia was complete.

At 10.37.30, the following observations were made:

Dog 1, blood-pressure, 130 mm.; stroke, 12 mm.; pulse, 160.

Dog 2, blood-pressure, 100 mm.; stroke, 8 mm.; pulse, 160.

At 10.41, the animals were reduced to shock by exposing the intestines, stomach, and spleen.

At 11.04.30, dog 1, blood-pressure, 145 mm.; stroke, 10 mm.; pulse, 136; respiration, 140.

Dog 2, blood-pressure, 100 mm.; stroke, 6 mm.; pulse, 124; respiration, 80.

At 11.19, the femoral vein in each animal was exposed.

At 11.28, the intestines of both animals were roughly manipulated.

At 11.28.30, dog 1, blood-pressure, 112 mm.; stroke, 8 mm.; pulse, 128; respiration, 108.

Dog 2, blood-pressure, 88 mm.; stroke, 6 mm.; pulse, 112; respiration, 72.

At 12.23, dog 1, blood-pressure, 112 mm.; stroke, 12 mm.; pulse, 132; respiration, 76.

Dog 2, blood-pressure, 90 mm.; stroke, 8 mm.; pulse, 108; respiration, 68.

At 12.27, dog 2, an injection of $^1/_{12}$ grain of strychnin was given.

Dog 1, the same amount of saline was injected.

At 12.28.30, dog 1, blood-pressure, 104 mm.; stroke, 12 mm.; pulse, 124; respiration, 64.

Dog 2, blood-pressure, 84 mm.; stroke, 10 mm.; pulse, 88; respiration, 40.

At 12.37, dog 1, blood-pressure, 105 mm.; stroke, 14 mm.; pulse, 132; respiration, 80.

Dog 2, blood-pressure, 80 mm.; stroke, 10 mm.; pulse, 116; respiration, 80.

At 12.52, dog 1, blood-pressure, 108 mm.; stroke, 14 mm.; pulse, 142; respiration, 68.

Dog 2, blood-pressure, 75 mm.; stroke, 12 mm.; pulse, 96; respiration, 76.

At 12.55, dog 2, an injection of $^1/_{40}$ grain of strychnin was given.

Dog 1, same amount of saline was administered.

Dog 1, blood-pressure, 108 mm.; stroke, 14 mm.; pulse, 144; respiration, 72.

Dog 2, blood-pressure, 75 mm.; stroke, 12 mm.; pulse, 92; respiration, 61.

At 1.07, dog 1, blood-pressure, 110 mm.; stroke, 14 mm.; pulse, 132; respiration, 72.

Dog 2, blood-pressure, 72 mm.; stroke, 14 mm.; pulse, 84; respiration, 64.

At 1.33.30, dog 1, blood-pressure, 110 mm.; stroke, 10 mm.; pulse, 136; respiration, 64.

Dog 2, blood-pressure, 78 mm.; stroke, 10 mm.; pulse, 96; respiration, 64.

At 1.55, dog 1, blood-pressure, 102 mm.; stroke, 12 mm.; pulse, 128; respiration, 72.

Dog 2, blood-pressure, 72 mm.; stroke, 12 mm.; pulse, 92; respiration, 56.

At 2.05, dog 1, blood-pressure, 100 mm.; stroke, 10 mm.; pulse, 140; respiration, 68.

Dog 2, blood-pressure, 80 mm.; stroke, 12 mm.; pulse, 92; respiration, 56.

At 2.53, dog 1, blood-pressure, 90 mm.; stroke, 10 mm.; pulse, 128; respiration, 64.

Dog 2, blood-pressure, 76 mm.; stroke, 12 mm.; pulse, 84; respiration, 60.

At 2.54, an injection of $^1/_{40}$ grain of strychnin dissolved in 22 minims of normal saline solution was given to dog 2; the same amount of normal saline was administered to dog 1.

At 2.55, dog 1, blood-pressure, 85 mm.; stroke, 10 mm.; pulse, 136; respiration, 72.

Dog 2, blood-pressure, 74 mm.; stroke, 12 mm.; pulse, 84; respiration, 52.

At 3.30, dog 1, blood-pressure, 92 mm.; stroke, 10 mm.; pulse, 120; respiration, 64.

Dog 2, blood-pressure, 80 mm.; stroke, 12 mm.; pulse, 84; respiration, 48.

At 4.20, dog 1, blood-pressure, 98 mm.; stroke, 10 mm.; pulse, 128; respiration, 32.

Dog 2, blood-pressure, 80 mm.; stroke, 12 mm.; pulse, 84; respiration, 44.

At 4.23.30, dog 2, $^1/_{40}$ grain of strychnin was injected.

Dog 1, the same amount of normal saline was given.

At 4.46, dog 1, blood-pressure, 95 mm.; stroke, 10 mm.; pulse, 124.

Dog 2, blood-pressure, 72 mm.; stroke, 12 mm.; pulse, 76; respiration, 44.

At 5.05, dog 1, blood-pressure, 108 mm.; stroke, 10 mm.; pulse, 120; respiration, 36.

At 5.06, dog 2, blood-pressure, 76 mm.; stroke, 12 mm.; pulse, 80; respiration, 44.

At 5.18, dog 1, blood-pressure, 108 mm.; stroke, 10 mm.; pulse, 132; respiration, 74.

Dog 2, blood-pressure, 80; stroke, 10 mm.; pulse, 76; respiration, 44. The intestines were manipulated.

At 5.20, blood-pressure, 100 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 65 mm.; stroke, 12 mm. Mechanical stimulations of the sciatic were applied.

At 5.25, dog 1, blood-pressure, 92 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 95 mm.; stroke, 6 mm. The intestines were manipulated.

At 5.28, dog 1, blood-pressure, 86 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 84 mm.; stroke, 6 mm. Both hind feet were burned.

At 5.50, dog 1, blood-pressure, 105 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 78 mm.; stroke, 8 mm. Both hind feet were burned.

From 5.50 to 6.10 the sciatics were stimulated and the intestines were manipulated.

At 6.09, dog 1, blood-pressure, 80 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 102 mm.; stroke, 7 mm. Both animals were killed with $MgSO_4$.

Experiment 66.

Whiskey, Adrenalin, Strychnin, Digitalis.

Male mongrel dog; fair condition; weight, ten kilos.

At 11.45, initial blood-pressure, 124 mm.

At 11.47, an injection of $^1/_{90}$ grain of strychnin was made. The length of the stroke was slightly increased, but no change occurred in the blood-pressure.

At 11.50, 25 minims of whiskey were injected. A greater increase occurred in the stroke without alteration of the blood-pressure.

At 11.52, 10 minims of tincture of digitalis were injected. A slight increase in the blood-pressure occurred.

At 11.57, blood-pressure, 120 mm.

At 12.00, 15 minims of a 1 to 1000 solution of adrenalin chlorid were injected. The blood-pressure rose sharply to 240 mm.; a marked slowing of the heart was inaugurated. The blood-pressure soon fell, but later was maintained at 160 mm. for three hours, by continuous injection of adrenalin in solution 1 to 1000. The digitalis action of the adrenalin, from the heart, was controlled by atropin.

Experiment 67.

Mixed Effect of Drugs.

Dog; weight, eight kilos; good physical condition. Morphin and ether anesthesia.

The animal was reduced to surgical shock by dissection and exposure of the abdominal viscera, manipulation of the somatic area, and crushing of the paws. The blood-pressure was reduced to 46 mm. After twenty minutes it was further reduced to 36 mm. An injection of $^1/_{180}$ grain of strychnin was given into the jugular vein. A slight wavering of the blood-pressure, followed by a rise, was noted. The pressure remained steadily at 38 mm.

Four minims of tincture of digitalis was injected into the jugular vein; in five minutes there was a slight rise, the ascent being very gradual. In ten minutes, 20 minims of brandy were injected into the jugular vein. The heart-strokes became longer and the blood-pressure declined 3 mm. After ten minutes the blood-pressure became steady.

An injection of $^1/_{120}$ grain of nitroglycerin was given into the jugular vein. The blood-pressure immediately fell, followed by a compensatory rise to the previous level. This entire routine was repeated. The strychnin produced a rise, the digitalis a trifle greater rise, the alcohol and nitroglycerin a fall, the final result being a slight elevation in the blood-pressure. After this $^1/_{180}$ grain of strychnin was given. This was followed by a rise. One dram of alcohol was followed by a fall, a little greater than the rise which followed the strychnin. Five minims of digitalis produced a rise, which was steady and well sustained. Ten minutes later $^1/_{90}$ grain of nitroglycerin was followed by a fall. The respiration became extremely irregular, the heart-strokes shorter. The animal died of respiratory failure.

EXPERIMENTS 68, 69.

Strychnin. Control.

Dog 1, male; old and poor condition; weight, five kilos.

Dog 2, mongrel; good condition; middle-aged; weight, eight kilos.

At 10.00, both animals were placed under anesthesia.

At 10.15, dog 1, the control, showed a normal blood-pressure of 112 mm.; stroke, 9 mm.

Dog 2, the experiment animal, blood-pressure, 160 mm.; stroke, 14 mm.

At 10.30, the intestines of both animals were exposed and manipulated.

At 10.45, dog 1, blood-pressure, 98 mm.; stroke, 6 mm.

Dog 2, blood-pressure, 120 mm.; stroke, 8 mm.

At 11.15, dog 1, blood-pressure, 90 mm.; stroke, 9 mm.

Dog 2, blood-pressure, 118 mm.; stroke, 9 mm.

At 11.17, an injection of $^1/_{90}$ grain of strychnin in 22 minims of normal saline was given to dog 2, and an equal quantity of normal saline to dog 1.

At 11.18, dog 1, blood-pressure, 100 mm.; stroke, 10 mm.

Dog 2, blood-pressure, 126 mm.; stroke, 9 mm.

At 11.21, dog 1, blood-pressure, 92 mm.; stroke, 8 mm.

Dog 2, blood-pressure, 105 mm.; stroke, 10 mm.

At 11.28, dog 1, blood-pressure, 82 mm.; stroke, 9 mm.

Dog 2, blood-pressure, 103 mm.; stroke, 10 mm.

At 11.31, dog 1, blood-pressure, 86 mm.; stroke, 10 mm.

Dog 2, blood-pressure, 112 mm.; stroke, 9 mm.

At 11.35, dog 1, blood-pressure, 88 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 110 mm.; stroke, 10 mm.
At 11.40, dog 1, blood-pressure, 83 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 106 mm.; stroke, 9 mm.
At 11.44, dog 1, blood-pressure, 88 mm.; stroke, 12 mm.
Dog 2, blood-pressure, 115 mm.; stroke, 10 mm.
At 11.46, dog 1, an injection of $^1/_{90}$ grain of strychnin in 22 minims of saline solution was given.
Dog 2, the same amount of normal saline was administered.
At 11.47, dog 1, blood-pressure, 80 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 112 mm.; stroke, 12 mm.
At 11.50, dog 1, blood-pressure, 82 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 130 mm.; stroke, 10 mm.
At 11.52, dog 1, blood-pressure, 80 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 133 mm.; stroke, 9 mm.
At 11.55, dog 1, blood-pressure, 78 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 116 mm.; stroke, 10 mm.
At 11.57.30, dog 1, blood-pressure, 78 mm.; stroke, 12 mm.
Dog 2, blood-pressure, 120 mm.; stroke, 12 mm.
At 12.00.30, dog 1, blood-pressure, 80 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 118 mm.; stroke, 10 mm.
At 12.08, dog 1, blood-pressure, 82 mm.; stroke, 12 mm.
Dog 2, blood-pressure, 94 mm.; stroke, 10 mm.
At 12.10, dog 1, blood-pressure, 83 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 94 mm.; stroke, 10 mm.
At 12.11, dog 1, blood-pressure, 83 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 118 mm.; stroke, 10 mm.
At 12.14, dog 1, blood-pressure, 88 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 110 mm.; stroke, 10 mm.
At 12.18, dog 1, blood-pressure, 82 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 97 mm.; stroke, 10 mm.
At 12.21, dog 1, blood-pressure, 82 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 80 mm.; stroke, 10 mm.
At 12.21.30, dog 1, blood-pressure, 82 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 93 mm.; stroke, 10 mm.

At 12.22, dog 1, an injection of 1/90 grain of strychnin was given in 22 minims of normal saline solution.

Dog 2, the same amount of saline was injected.

At 12.31.30, dog 1, blood-pressure, 100; stroke, 10 mm.

Dog 2, blood-pressure, 59 mm.; stroke, 12 mm.

At 12.35.30, dog 1, blood-pressure, 80 mm.; stroke, 10 mm.

Dog 2, blood-pressure, 53 mm.; stroke, 16 mm.

At 12.37, Dog 1, blood-pressure, 80 mm.; stroke, 12 mm.

Dog 2, blood-pressure, 50 mm.; stroke, 15 mm.

At 12.38.30, dog 1, blood-pressure, 80 mm.; stroke, 12 mm.

Dog 2, blood-pressure, 52 mm.; stroke, 18 mm.

At 12.39, dog 1, blood-pressure, 78 mm.; stroke, 10 mm.

Dog 2, blood-pressure, 7 mm.; stroke, 0.

From 12.38 to 12.42 the respiration decreased in rate and volume, and was of a typical vagal character.

Dog 1, blood-pressure, 80 mm.; stroke, 10 mm.

Dog 2, blood-pressure, 42 mm.; stroke, 24 mm.

At 12.43, dog 2 died of respiratory failure.

Dog 1, blood-pressure, 78 mm.; stroke, 10 mm.

Remarks.—A slight corneal reflex was present in each dog.

Dog 1, the blood-pressure was remarkably irregular.

Dog 2, the blood-pressure was remarkably irregular. There occurred a slight rise in the blood-pressure, following the injection of strychnin, but it was not marked, nor well sustained.

Dog 1, in shock. No further manipulation.

At 12.50, dog 1, blood-pressure, 90 mm.; stroke, 10 mm.

At 1.00, dog 1, blood-pressure, 90 mm.; stroke, 10 mm.

At 1.10, dog 1, blood-pressure, 88 mm.; stroke, 12 mm.

At 1.20, dog 1, blood-pressure, 92 mm.; stroke, 10 mm.

At 1.30, dog 1, blood-pressure, 92 mm.; stroke, 10 mm.

At 1.42, dog 1, blood-pressure, 92 mm.; stroke, 10 mm.

At 2.00, dog 1, blood-pressure, 96 mm.; stroke, 10 mm.

At 2.30, dog 1, blood-pressure, 95 mm.; clot.

At 2.31, dog 1, blood-pressure, 78 mm.; stroke, 8 mm.

At 2.35, dog 1, blood-pressure, 65 mm.; stroke, 10 mm.

At 3.00, dog 1, blood-pressure, 58 mm.; stroke, 12 mm.

At 3.10, dog 1, blood-pressure, 64 mm.; stroke, 12 mm.

At 3.37, dog 1, blood-pressure, 58 mm.; stroke, 10 mm.

At 4.42, dog 1, blood-pressure, 74 mm.; stroke, 6 mm. The dog was killed with $MgSO_4$. The animal was in good condition.

Remarks.—After inducing shock, the animals were not further depressed. Both received the same amount of saline, and were manipulated in exactly the same manner.

Experiment 70.

Asphyxia. Strychnin.

Dog; mongrel male; fair condition; old; weight, four kilos.

Initial blood-pressure, 180 mm.; pulse, 176; length of stroke, 10 mm.

While executing the technique for bloodlessly severing the accelerantes and the vagi, the respiration tube was inadvertently kinked, causing the blood-pressure to fall to 10 mm. The pulse recorded 12 and there was extreme cyanosis. The animal was almost dead. Artificial respiration was resorted to, but there was apparently no progress towards recovery.

One-tenth of a grain of strychnin was injected into the jugular vein. Blood-pressure rose to 40 mm.; stroke, 25 mm. Moderate convulsions were noted; these were overcome by the administration of 2.6 drams of .5 per cent. solution of curare. The blood-pressure then continued to rise until it reached 200 mm.

At 12.10, blood-pressure, 200 mm.; pulse, 200; stroke, 40 mm.

At 12.34, blood-pressure, 165 mm.

At 12.54, blood-pressure, 80 mm.

At 1.09, blood-pressure, 50 mm. The animal was then killed.

A

B

C

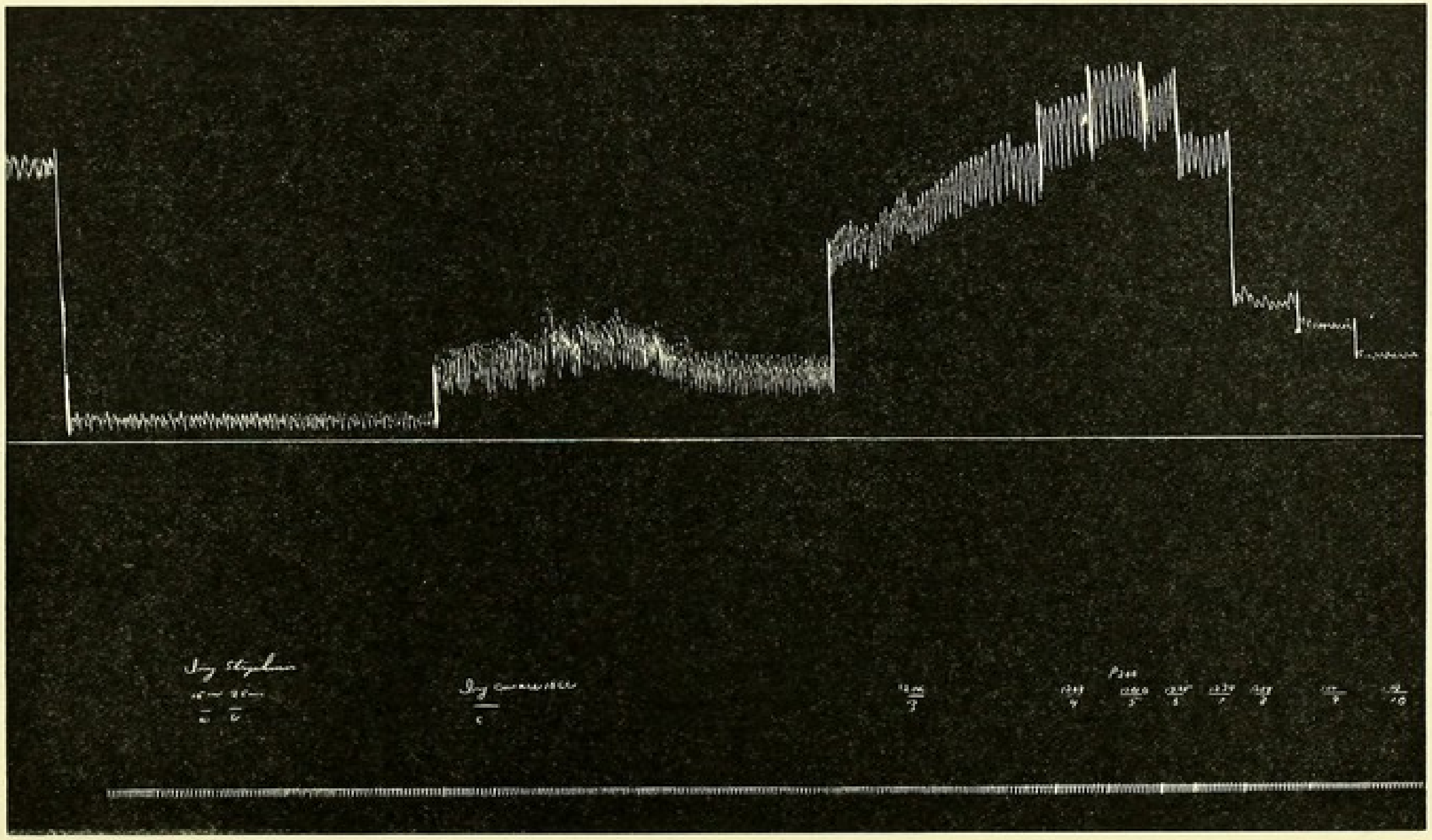

FIG. 10.—EXP. 70.—Extreme collapse from asphyxia.—*A*, carotid pressure; *B*, abscissa; *C*, seconds. After a preliminary injection of curare 6 mg. ($\frac{3}{32}$ gr.) of strychnin was given. Note the rapid rise in the blood-pressure followed by an equal fall during one hour and fourteen minutes. Compare the marked rise (following strychnin) in collapse as compared with the slight rise in other experiments, if any effect at all is noted, in an equally low blood-pressure from pure shock. This is additional evidence that in shock the vasomotor centre is exhausted. Low blood-pressure from causes other than an exhaustion of the vasomotor centre is designated collapse.

Experiment 71.

Mixed Effect of Drugs.

Dog; weight, seven kilos; the animal had a large thyroid gland. Morphin and ether anesthesia.

Initial blood-pressure, 124 mm.

The animal was reduced to surgical shock by exposure and manipulation of the splanchnic area and the nerve-trunks of the limb.

An injection of $^1/_{180}$ grain of strychnin was given into the jugular vein. No effect was observed. In ten minutes the blood-pressure had fallen lower.

Four minims of tincture of digitalis was followed by a momentary fall, after which a steady rise began. After the maximum had been reached, half a dram of brandy was injected into the jugular vein. The blood-pressure immediately fell. The heart-strokes were lengthened and the respiration deepened. After the pressure was partially recovered, $^1/_{180}$ grain of nitroglycerin produced a marked fall in the blood-pressure, with a compensation of 3 mm. The same routine was repeated three times, at the end of which the animal seemed exhausted. The blood-pressure began to decline, and the animal soon died.

Experiment 72.

Mixed Effect of Drugs.

Dog; weight, sixteen kilos. Morphin and ether anesthesia.

Initial blood-pressure, 144 mm.

The dog was reduced to surgical shock after forty-five minutes of severe manipulation.

An injection of $^1/_{180}$ grain of nitroglycerin was made into the jugular vein. This was followed by a fall of 5 mm. in the blood-pressure. The compensation being but partial, 4 minims of tincture of digitalis were given. A slight but steady rise in the blood-pressure followed.

One-half dram of brandy was injected into the jugular vein. This was followed by a momentary rise, after which there was a decline in the blood-pressure, without compensation. An immediate fall, muscular twitchings, and gasping respirations followed the administration of $^1/_{90}$ grain of strychnin. A marked fall in the blood-pressure followed. Respiration failed and the animal died.

Experiment 73.

Mixed Effect of Drugs.

Dog; weight, seven kilos. Morphin and ether anesthesia.

Blood-pressure, 128 mm.

The animal was reduced to surgical shock by somatic and splanchnic manipulation.

Blood-pressure, 36 mm. The animal was rapidly failing. The respirations were irregular.

An injection of $^1/_{180}$ grain of strychnin was given into the jugular vein. No effect beyond a trifling momentary rise was noted.

Four minims of tincture of digitalis were followed by a slight rise.

The administration of $^1/_{180}$ grain of nitroglycerin was followed by a temporary fall, after which compensation occurred.

One-half dram of brandy was followed by a wavering line for ten seconds, then a distinct fall.

The application of the Bunsen flame to the left hind foot for four seconds was followed by a decided rise in the blood-pressure. Compensation, lasting twenty minutes, followed the burning. The blood-pressure was maintained higher by repeated burning.

Experiment 74.

Mixed Effect of Drugs.

Dog; poor condition, weight, five kilos. Morphin and ether anesthesia.

Initial blood-pressure, 106 mm.

The animal was reduced to shock by manipulation of the somatic and splanchnic area.

The administration of $^1/_{360}$ grain of nitroglycerin was followed by a marked fall in the blood-pressure. Compensation was not complete.

An injection of $^1/_{180}$ grain of strychnin was followed by a wavering line, and then a slight rise.

Three minims of tincture of digitalis were injected. A steady rise in the blood-pressure was noted. Gradual burning of the left hind foot produced a very marked rise. This rise was sustained by slowly scorching the paws. After the effect began to wear out in one paw, another was stimulated in similar manner so that the blood-pressure was maintained for twenty minutes. The animal was then killed.

Experiment 75.

Mixed Effect of Drugs,—Strychnin, Digitalis, and Normal Saline.

Dog; male mongrel; weight, six kilos. Morphin and ether anesthesia.

At 11.45, blood-pressure, 120 mm.; pulse, 176; respiration, 116.

At 11.46, the intestines were exposed and manipulated, and the hind feet and tail crushed.

At 11.50, blood-pressure, 75 mm.; pulse, 150; respiration, 108.

At 11.51, $^1/_{30}$ grain of strychnin sulphate was injected into the femoral veins. An immediate fall in the blood-pressure followed.

At 11.52, blood-pressure, 45 mm.; pulse, 144; respiration, 46. Occasional convulsions were noted, and the blood-pressure was slowly rising.

At 11.54, blood-pressure, 75 mm.; pulse, 180; respiration, 76.

At 11.55, 15 minims of tincture of digitalis were injected into the femoral vein. Blood-pressure, 55 mm., the fall being very rapid. Blood-pressure slowly rose to 110 mm. Respiration ceased; artificial respiration was supplied.

At 11.57, blood-pressure, 90 mm.; pulse, 80.

At 12.02, blood-pressure, 100 mm.; pulse, 180; respiration, 60.

At 12.03, 25 minims of whiskey were injected. The blood-pressure rapidly fell to 60 mm., then slowly rose to 100 mm.

At 12.08, blood-pressure, 100 mm.; pulse, 160; respiration, 60.

At 12.09, an injection of 10.75 ounces of normal saline solution was given. Blood-pressure, 120 mm., soon falling to 100 mm.

At 12.11, blood-pressure, 100 mm.; pulse, 156; respiration, 72; the pulse was very much stronger, the excursions greater; the respirations deeper, but irregular and more labored.

At 12.13, the left hind foot was burned. A rise in the blood-pressure followed.

At 12.14, blood-pressure, 130 mm.; pulse, 180; respiration, 84.

Experiment 76.

Mixed Effect of Drugs,—Strychnin, Normal Saline, and Pneumatic Tube.

Dog; male; weight, six kilos; good condition. Morphin and ether anesthesia.

At 9.27, blood-pressure, 100 mm.; pulse, 102; respiration, 72. Shock was produced by exposing and manipulating the intestines, crushing the legs and toes, and lacerating the testicles.

At 9.33, blood-pressure, 70 mm.; pulse, 102; respiration, 84.

At 9.35, blood-pressure, 50 mm.; the animal was in profound shock.

At 9.38, an injection of $^1/_{90}$ grain of strychnin sulphate was made.

At 9.43, blood-pressure, 36 mm.; pulse, 132; respiration, 62. The heart was weak and the excursions were small.

At 9.45, an injection of 10 ounces of normal saline was given into the femoral vein.

At 9.47, blood-pressure, 60 mm.; pulse, 108; respiration, 40 and very labored.

At 9.50, the animal was placed in the tube. blood-pressure, 50 mm.; pulse, 120; respiration, 44.

At 9.55, tube-pressure, 110 mm. A clot in the carotid cannula necessitated removal of the animal.

At 9.58, the pulse and respiration were in good condition.

At 10.00, the animal was replaced in the tube.

At 10.05, tube-pressure, 60 mm.; blood-pressure, 100 mm.; pulse, 72; respiration, 36.

At 10.05, slight convulsions, due to strychnin, appeared.

At 10.20, the animal was removed from the tube in fair condition. Blood-pressure, 70 mm.; pulse, 80; respiration, 48. The animal was used for other experiments.

Experiment 77.

Death from Collapse.

Mongrel dog; fair condition; weight, nine kilos. Ether anesthesia; tracheal and carotid cannulæ were adjusted.

The initial blood-pressure was 120 mm.; stroke, 12 mm.; pulse, 140.

While dissecting out the accelerantes the animal suddenly died. The exact cause of death could not be determined.

Experiment 78.

Chloroform Death.

Mongrel; weight, twelve kilos; good condition. Ether anesthesia.

After the skin dissection over the abdomen was made, chloroform was given, in excess. The blood-pressure fell rapidly. Respiration ceased.

One-fortieth grain of strychnin was injected into the jugular vein. No change in the blood-pressure followed. The animal speedily died.

Experiment 79.

Strychnin, Adrenalin, and other Experiments.

Mongrel dog; good condition; weight, nine kilos.

Control blood-pressure, 130 mm.; pulse, 180; stroke, 8 mm.

The animal was reduced to shock by skinning and sponging the raw surfaces.

At 10.34, blood-pressure, 30 mm.; pulse, 120; stroke, 10 mm.

At 10.36, the sciatic nerve was electrically stimulated; no change occurred in the blood-pressure. Intravenous injection of adrenalin, 1 to 200,000, at the rate of ½ ounce per minute, raised the blood-pressure to 110 mm.

The finger was introduced into the larynx and pressure exerted. The heart immediately stopped and the blood-pressure fell to 40 mm. The rate was greatly diminished, then suddenly increased, the blood-pressure rising to 90 mm., and later recording 110 mm.

The injection of $^{1}/_{120}$ grain of nitroglycerin was given; blood-pressure 80 mm.

The injection was repeated; blood-pressure, 60 mm.

The blood-pressure soon returned to the former level.

The animal was killed.

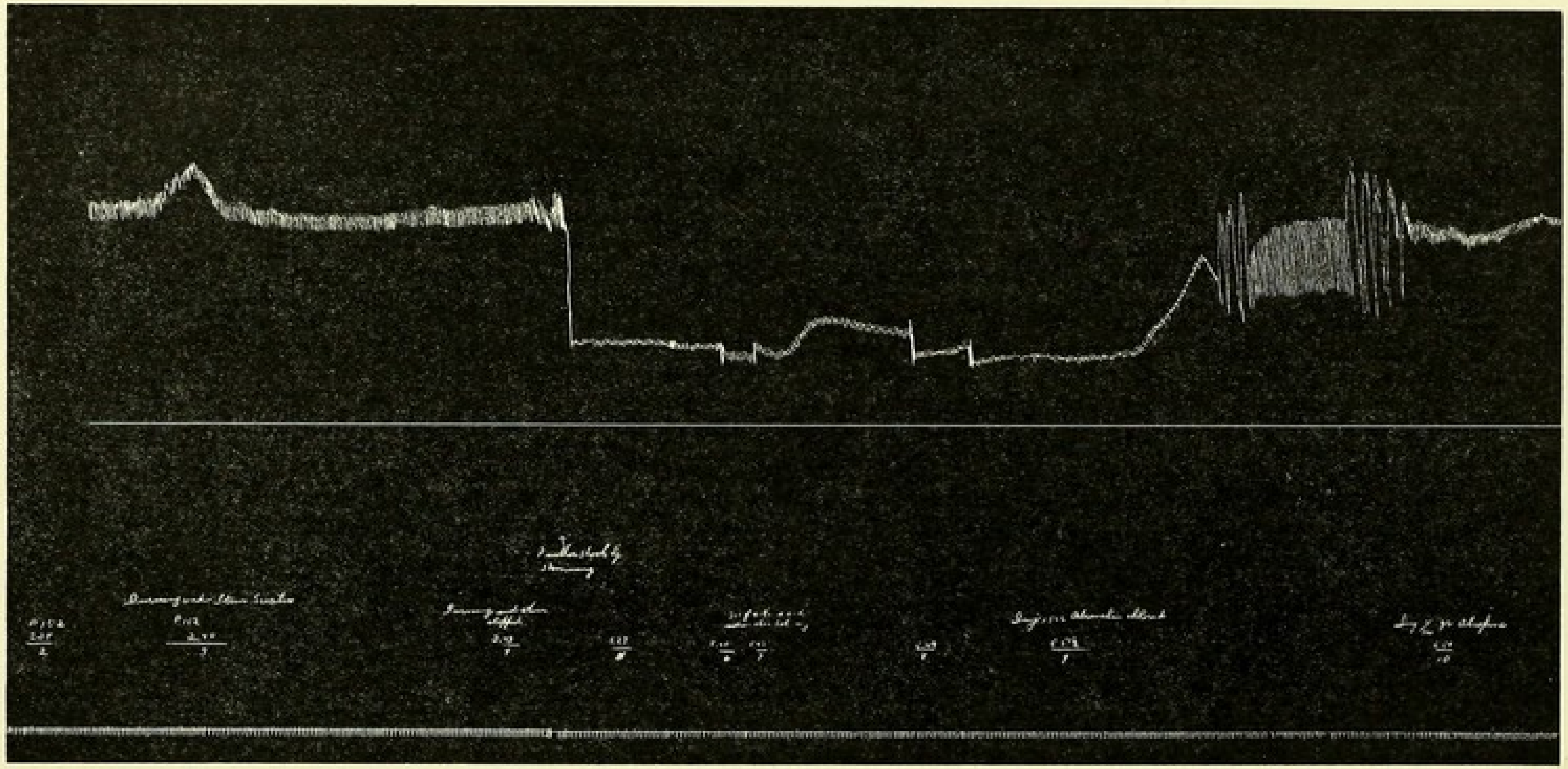

FIG. 11.—EXP. 80.—The animal was reduced to shock; the blood-pressure was then raised by infusion of adrenalin. Note the slowed heart action, indicating an over-stimulation of the cardio-inhibitory mechanism. On injecting atropin the inhibition promptly ceased. Conversely it shows that the cardio-inhibitory mechanism is not exhausted in shock.

Experiment 80.

Adrenalin, Strychnin, and Atropin.

Mongrel dog; good condition; weight, sixteen pounds. Ether anesthesia. The preliminary observations were:

At 2.30, blood-pressure, 140 mm.; pulse, 152; stroke, 11 mm.

At 2.40, the paw was burned and the sciatic nerve stimulated. A sharp rise, followed by a fall, making a curve of 25 mm., resulting.

At 2.43, the integument was removed.

At 5.42, blood-pressure, 55 mm.; stroke, 7 mm.

At 5.51.30, an injection of 22 minims of adrenalin chlorid was given. Blood-pressure, 105 mm.

At 5.53.30, the heart showed excessive stimulation of the vagal mechanism. The length of stroke increased from 5 to 70 mm. One-thirtieth grain of atropin was administered. The strokes immediately decreased to 10 mm., and a gradual fall occurred in the blood-pressure.

At 6.12, blood-pressure, 20 mm.

At 6.17, a continuous injection of adrenalin chlorid in normal saline solution, in the proportion of 1 to 100,000, was given. Blood-pressure, 80 mm.; pulse, 128.

At 6.23, no effect was produced by burning the paw.

At 6.25, the injection of $^1/_{15}$ grain of strychnin produced no change. The animal was killed.

Experiment 81.

Shock, Strychnin, Vasomotor Centre.

Dog; male mongrel; good condition; weight, five kilos.

At 12.05, the initial blood-pressure was 125 mm.; stroke, 8 mm.; pulse, 124.

At 12.37, both vagi and accelerantes were severed. Blood-pressure, 110 mm.; pulse, 134.

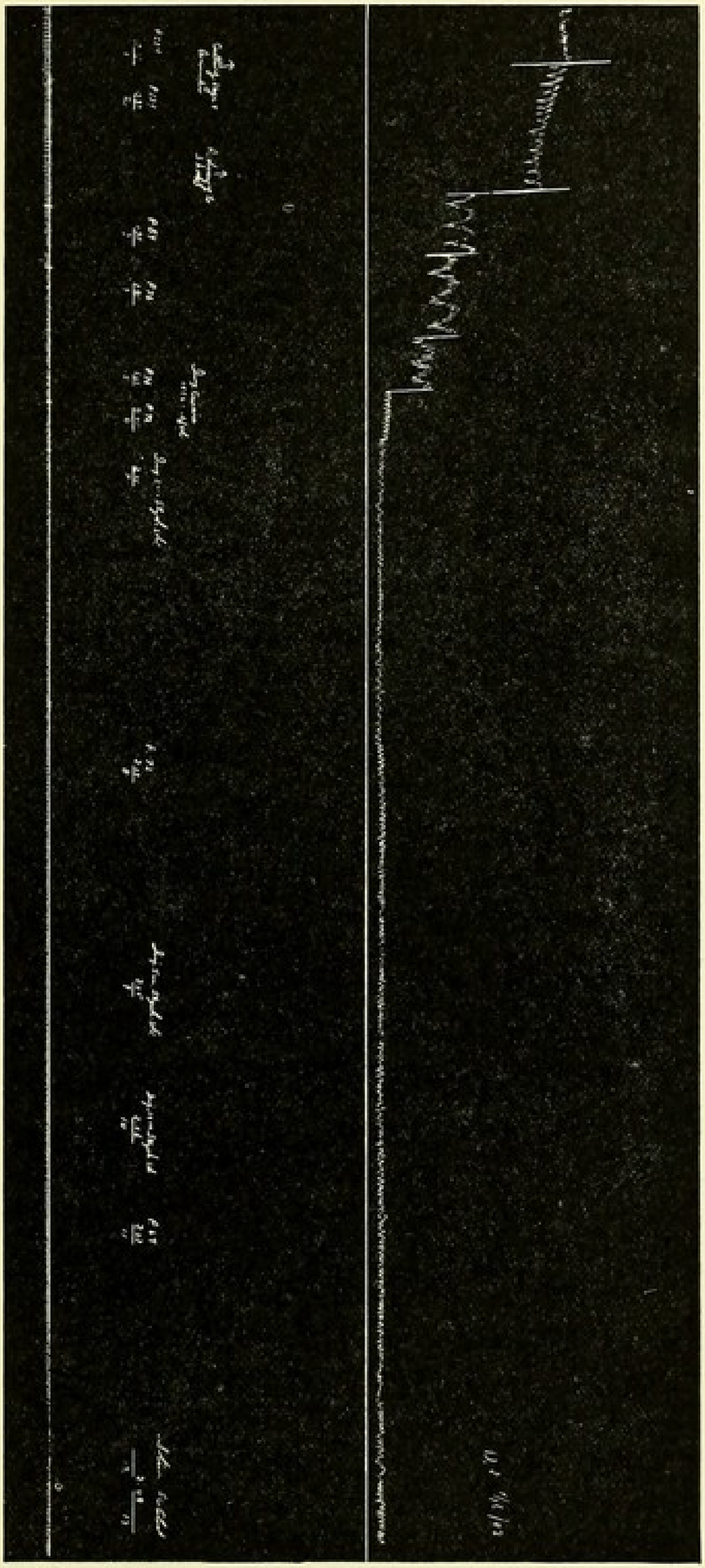

FIG. 12.—EXP. 81.—Both vagi and accelerantes were severed; then the animal was subjected to the usual technique for the production of shock, which appeared as in control experiments. After the shock had become profound, the animal was curarized. Then on burning the paw and stimulating the sciatic nerve and administering physiologic doses of strychnin intravenously, no rise in blood-pressure was noted. Neither did asphyxia cause a rise. This experiment shows that shock may be produced independently of the heart or its nerve-mechanism, and quite as readily as in the controls; also that the vasomotor centres become exhausted.

At 12.45, the animal was reduced to surgical shock by skinning, sponging the denuded surfaces, and manipulating the intestines.

At 1.45, blood-pressure, 50 mm.; pulse, 76.

At 1.49, respiration failed; artificial respiration was begun. Blood-pressure, 35 mm.; pulse, 76.

At 2.00, ½ ounce of a .5 per cent. solution of curare was intravenously injected.

At 2.01.30, $^1/_{90}$ grain of strychnin was intravenously injected. A very slight change in the blood-pressure followed.

At 2.05, $^1/_{90}$ grain of strychnin was intravenously injected. No change in the blood-pressure was obtained.

At 2.06, $^1/_{30}$ grain of strychnin was intravenously injected. A slight fall in the blood-pressure was noted.

At 2.07, blood-pressure, 14 mm.; stroke, 8 mm.; pulse, 68.

At 2.09, the sciatic nerve was electrically stimulated. No change in the blood-pressure was recorded.

At 2.20, stimulation of the splanchnic nerve, peripheral and central, produced no apparent effect.

At 2.25, $^1/_{15}$ grain of strychnin was injected intravenously. No change was observed.

At 2.28, the animal died. Blood-pressure, 5 mm. at the moment of death.

Experiment 82.

Curare, Strychnin, Saline Infusion, Adrenalin.

Female mongrel dog; fair condition; weight, seventeen kilos.

At 10.14, initial blood-pressure, 125 mm.; stroke, 12 mm.; pulse, 172. Both the accelerantes and vagi were severed.

At 10.23, blood-pressure, 140 mm.; pulse, 180. 2.6 drams of a .5 per cent. solution of curare were injected. The blood-pressure fell to 15 mm.

At 10.41, blood-pressure, 28 mm.

At 10.50, blood-pressure, 50 mm.; stroke, 12 mm.

At 10.58, blood-pressure, 70 mm.

At 11.14, blood-pressure, 30 mm.; stroke, 4 mm.

At 11.14.30, $^1/_{15}$ grain of strychnin was injected. No change occurred in the blood-pressure.

At 11.28, the injection of 8.25 ounces of normal saline solution was begun.

At 11.32, burning the paw produced no effect.

At 11.33, $^1/_{30}$ grain of strychnin was injected. No change was observed.

At 11.36, blood-pressure, 35 mm. Twenty-five minims of 1 to 1000 solution of adrenalin chlorid were injected. The blood-pressure recorded 180 mm. The stroke increased.

At 11.40, blood-pressure, 20 mm. Repeated injections of adrenalin caused a similar rise. The animal was killed.

Experiment 83.

Curare, Strychnin, Saline Infusion.

Female dog; good condition; weight, six kilos.

At 1.59, initial blood-pressure, 100 mm.; stroke, 11 mm. Fifteen c.c. of a .5 per cent. solution of curare were injected. Blood-pressure, 30 mm.; stroke, 8 mm.

At 2.15, the injection of $^1/_{30}$ grain of strychnin was given.

At 2.16, a rise occurred in the blood-pressure.

At 2.24, blood-pressure was at its maximum height. Blood-pressure, 130 mm.; stroke, 15 mm.

At 2.33, blood-pressure, 120 mm.; stroke, 8 mm.; pulse, 192.

At 2.36, blood-pressure, 100 mm.; stroke, 8 mm.; pulse, 190.

At 2.41, blood-pressure, 50 mm.; stroke, 6 mm.; pulse, 200. The blood-pressure fell rapidly.

At 2.43, the administration of $^1/_{30}$ grain of strychnin was followed by a gradual fall.

At 2.46, blood-pressure, 30 mm.; stroke, 10 mm.

At 2.47, $^1/_{90}$ grain of strychnin was injected.

At 2.48, blood-pressure, 25 mm.; stroke, 9 mm.

At 2.49, burning the hind foot produced no change.

At 2.52, an infusion of saline was given. A gradual rise followed.

At 2.59, blood-pressure, 140 mm.; stroke, 180 mm.
At 3.00, a gradual fall began.
At 3.15, blood-pressure, 50 mm. The animal was killed.

Experiment 84.

Shock, Curare, Strychnin. Splanchnic Nerve, Vagi, and Accelerantes severed.

Female mongrel dog; good condition; weight, twelve kilos.

At 1.57, initial blood-pressure, 135 mm.; stroke, 12 mm.; pulse, 152.

At 2.10, the accelerantes and vagi were exposed by bloodless dissection and severed. Blood-pressure, 120 mm.; stroke, 15 mm.; pulse, 140.

At 2.19, .75 ounce of a .5 per cent. solution of curare was intravenously injected. Artificial respiration was begun.

At 2.43, blood-pressure, 120 mm.; stroke, 115 mm.; pulse, 120.

At 2.46, $^1/_{75}$ grain of strychnin was given, following which there was a sharp rise in the blood-pressure, reaching 220 mm.; stroke, 20 mm.; pulse, 124.

At 2.47.30, the heart became intermittent. The style executed excursions of 40 mm.

At 2.48.30, blood-pressure, 200 mm.; stroke, 40 mm.; pulse, 136.

At 2.59, blood-pressure, 185; stroke, 30 mm.; pulse, 146.

At 3.03, $^1/_{30}$ grain of strychnin was intravenously injected. A sharp rise in the blood-pressure to 200 mm. was noted.

At 3.11, blood-pressure, 185 mm.; stroke, 35 mm.; pulse, 148.

At 3.14, $^1/_{30}$ grain of strychnin was intravenously injected. No change in the blood-pressure was noted. The stroke decreased in length to 20 mm.

At 3.21, blood-pressure, 175 mm.; stroke, 30 mm.; pulse, 132.

At 3.21.30, $^1/_{30}$ grain of strychnin was intravenously injected; no effect upon the blood-pressure was observed.

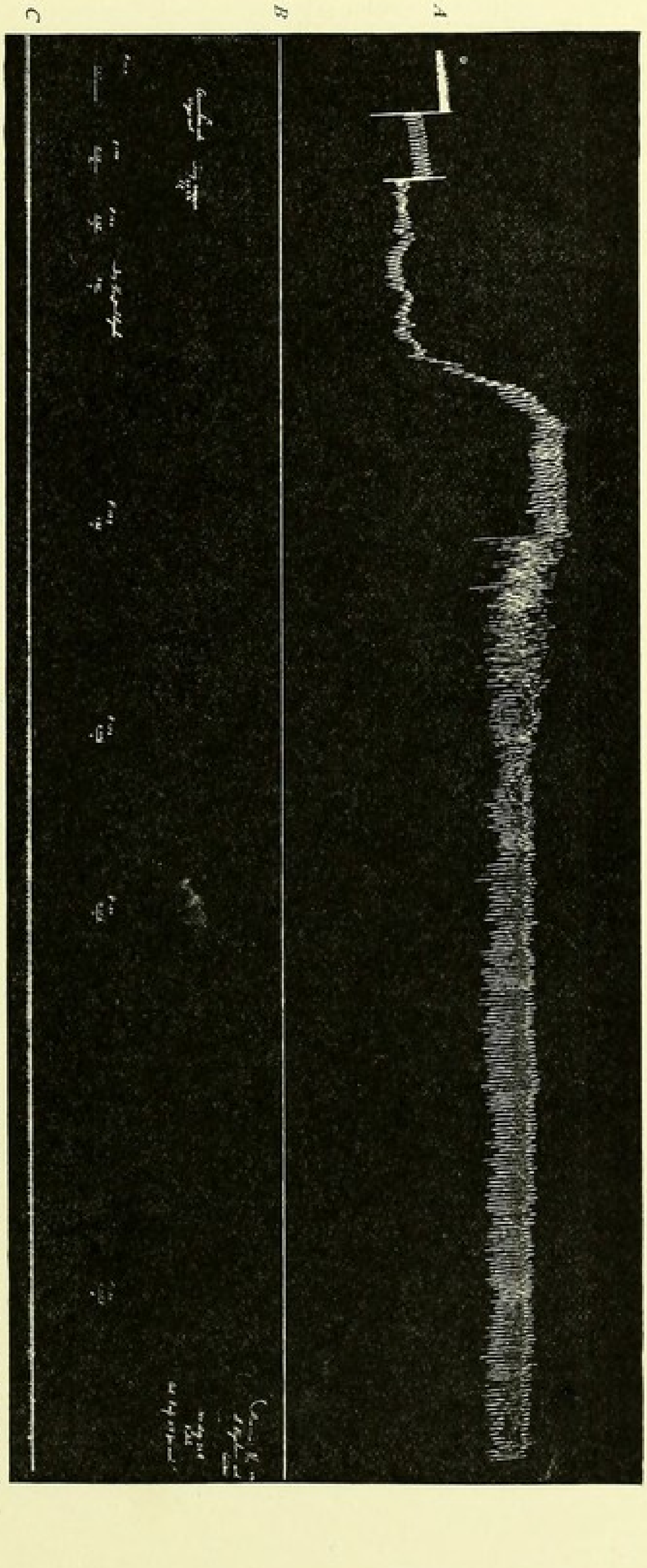

FIG. 13.—EXP. 84.—*A*, arterial blood-pressure; *B*, abscissa line; *C*, time in seconds. This tracing was obtained from a normal animal in which both vagi and both accelerantes had been severed and a physiologic dose of curare given. Two milligrammes of strychnin were given intravenously. Note the abrupt and sustained rise in the blood-pressure; also note the marked increase in the length of the pulse-waves. The two following cuts are continuations of this experiment. This experiment is intended to illustrate the exhaustion of the vasomotor centre by the stimulating effects of strychnin.

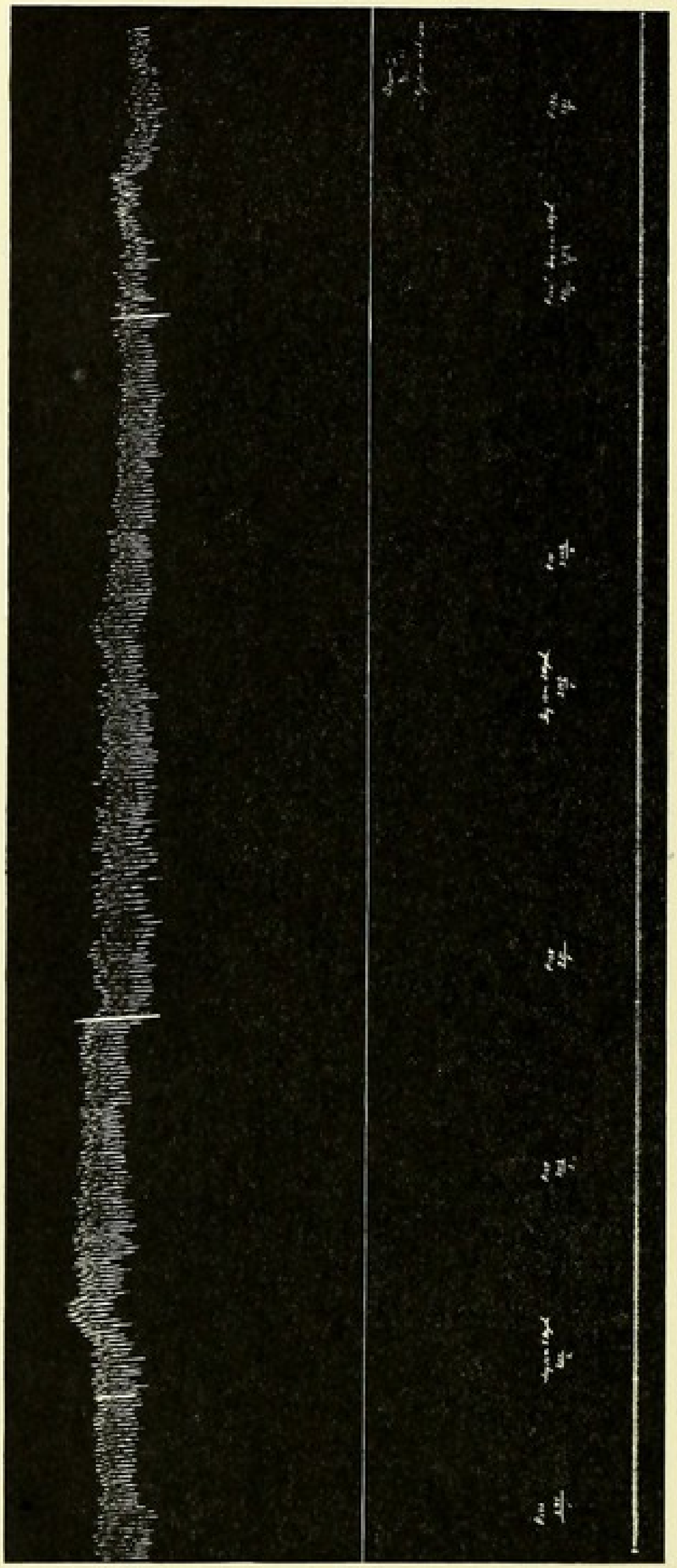

FIG. 14.—EXP. 84 (continued).—Note the continued high pressure, and the gradual decline in the length of the pulse-wave. Three additional doses of strychnin, of two milligrammes each, were given, neither causing more than a slight momentary rise.

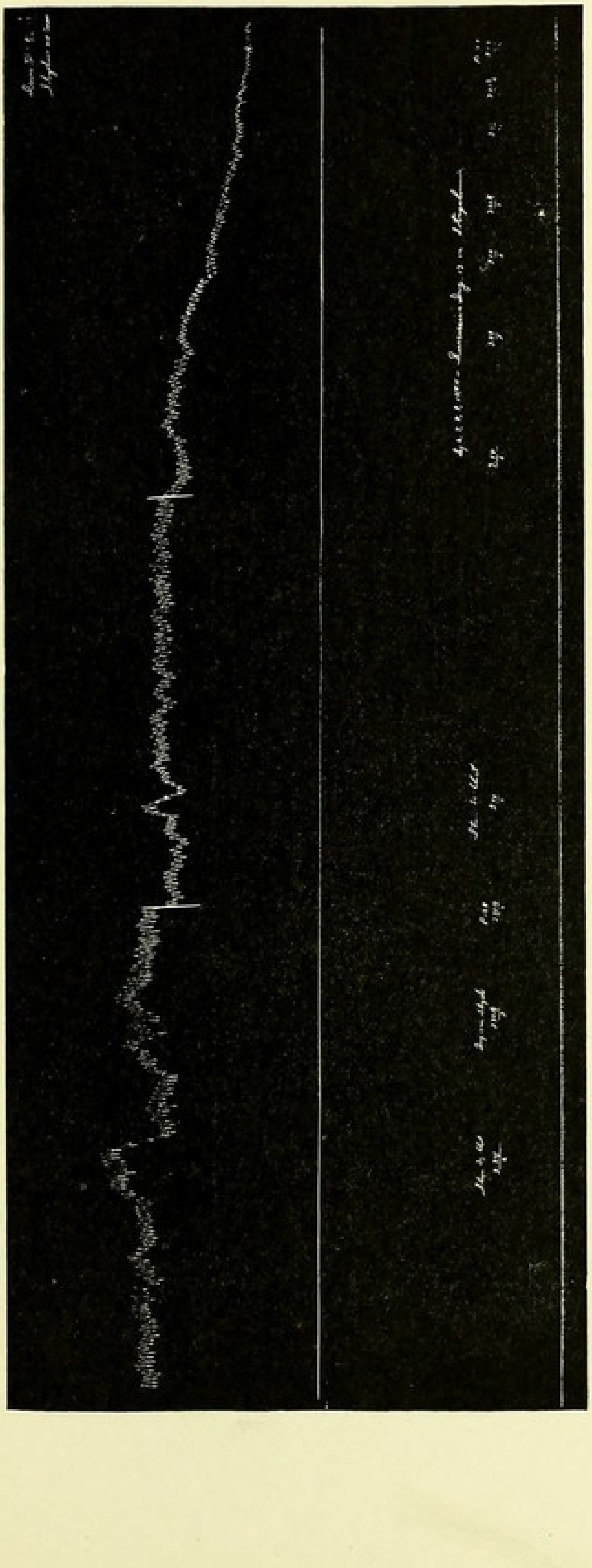

Fig. 15.—Exp. 84 (continued).—Note the markedly irregular blood-pressure curve, the diminution in the length of the pulse-wave, and the rapid decline in the blood-pressure. Repeated injections of strychnin caused no further change in the pressure. Stimulating the sciatic nerve and burning the paw no longer caused a rise in the blood-pressure. The vasomotor centre had become exhausted, being a physiologic equivalent of traumatic shock of corresponding degree.

At 3.23, a steady decline in the blood-pressure began.

At 3.31, blood-pressure, 160 mm.; stroke, 12 mm.; pulse, 132

At 3.31.30, electrical stimulation of the sciatic nerve was followed by a gradual rise of 35 mm. in the blood-pressure; later, an abrupt fall of 45 mm. occurred. The blood-pressure remained constant at 140 mm.

At 3.32.15, 1/30 grain of strychnin was intravenously injected. The blood-pressure rose 20 mm. and fell an equal amount in seven minutes.

At 3.39, blood-pressure, 130 mm. Electrical stimulation of the sciatic nerve caused an abrupt rise of 20 mm., followed by an equal fall.

At 3.45, blood-pressure, 140 mm.

At 3.48, blood-pressure, 120 mm., after which at intervals of one minute six injections of 1/30 grain of strychnin were given intravenously. The blood-pressure declined from 120 to 40 mm.; stroke, 8 mm.; pulse, 104.

At 3.58, blood-pressure rose to 80 mm.; stroke, 10 mm; pulse, 96.

At 3.58.45, six more injections of 1/30 grain of strychnin at intervals of one minute were given intravenously. The blood-pressure fell from 80 to 65 mm.; the pulse, from 104 to 88.

At 4.16, electrical stimulation of the sciatic nerve was followed by a slight rise in the blood-pressure.

At 4.50, similar stimulation produced no effect. The electrical stimulation of the distal end of the splanchnic nerve was followed by an irregular rise and fall. Similar stimulation of the central end produced no effect.

At 5.05.30, blood-pressure, 40 mm.; stroke, 12 mm.; pulse, 140. The right splanchnic nerve was then exposed, severed, and the distal end electrically stimulated. An abrupt rise of 25 mm. in the blood-pressure followed. Similar stimulation of the central end produced no effect.

At 5.08.30, blood-pressure, 30 mm.

At 5.09, 1/15 grain of strychnin was intravenously injected. No change in the blood-pressure was noted.

At 5.13, electrical stimulation of the distal end of the splanchnic nerve was followed by a gradual rise of 15 mm. in the blood-pressure. When the stimulation was withdrawn the blood-pressure declined an equal amount.

At 5.14.30, blood-pressure, 30 mm.; stroke, 8 mm.; pulse, 92.

At 5.16, 1/15 grain of strychnin was intravenously injected. Electrical stimulation of the sciatic nerve now produced no apparent change in the blood-pressure. Eight successive injections of four milligrams each of strychnin were administered intravenously at intervals of one minute. The blood-pressure remained at 30 mm.; stroke, 12 mm.; pulse, 56.

At 6.12, the animal was allowed to die of asphyxia. There was no rise in the blood-pressure during its development. The heart continued to beat six minutes after artificial respiration had been discontinued.

Experiment 85.

Shock, Curare, Strychnin, Saline Solution.

Female mongrel dog; good condition; weight, eight kilos.

At 10.04, initial blood-pressure, 100 mm.; pulse, 164; stroke, 10 mm.

At 10.05, the vagi and accelerantes were severed.

At 10.24, blood-pressure, 115 mm.; pulse, 144; stroke, 20 mm. There were injected ½ ounce of a .5 per cent. solution of curare.

At 11.00, blood-pressure, 33 mm.; pulse, 144; stroke, 15 mm.

At 11.01, 1/30 grain of strychnin was injected.

At 11.02.30, blood-pressure, 145 mm.; pulse, 140; stroke, 12 mm.

At 11.04, blood-pressure, 150 mm.; stroke, 22 mm.

At 11.05, 1/30 grain of strychnin was injected. No variation in the blood-pressure was noted.

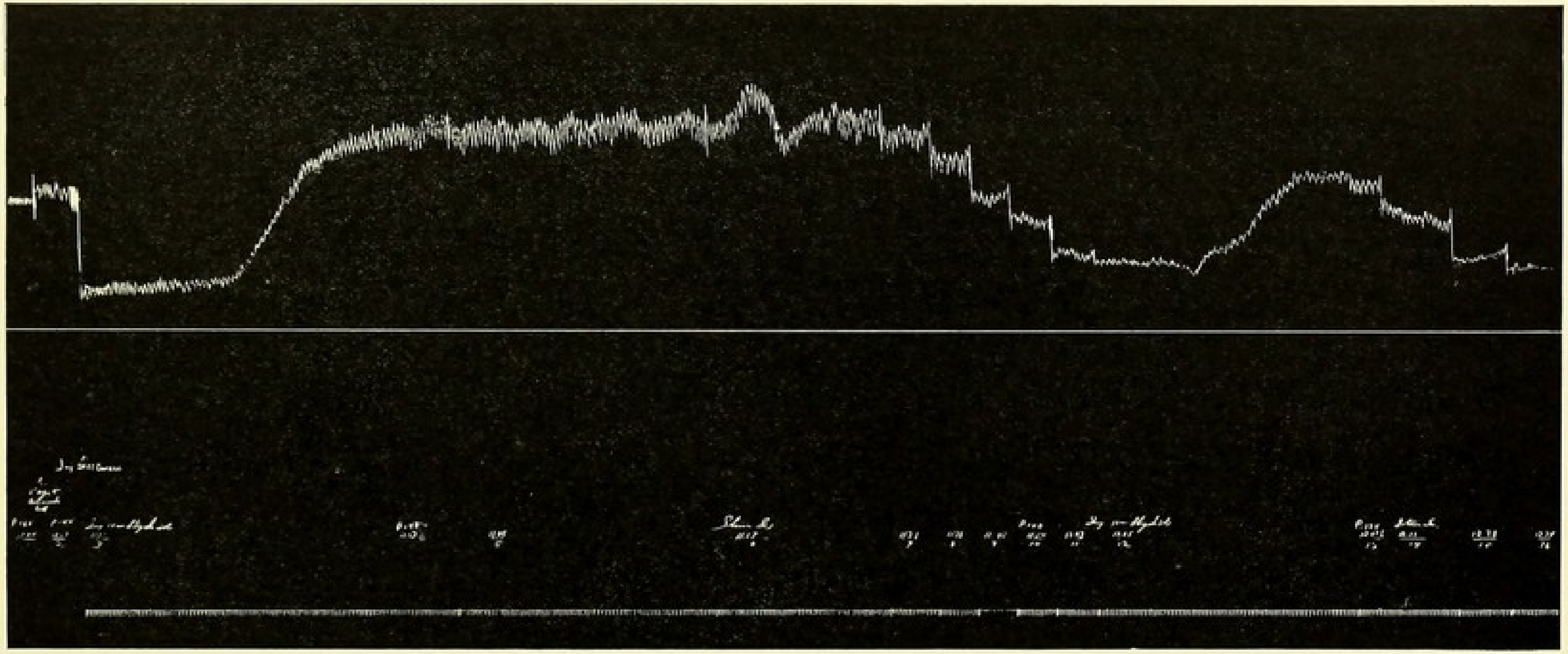

FIG. 16. EXP. 85.—After both vagi and accelerantes were severed, the animal was reduced to *moderate* shock, then curarized. On injecting a physiologic dose of strychnin the blood-pressure rose much higher than the normal, and after becoming irregular fell to about the level it was before the injection. Note the shorter curve following the second injection, while the third injection caused no change. Then on stimulating the sciatic nerve no rise followed. This experiment shows that the potential energy left in the vasomotor centres in moderate shock is discharged by the action of strychnin, leaving the centres in a state of complete exhaustion.

At 11.17, blood-pressure, 150 mm. On stimulating the sciatic nerve the blood-pressure rose 20 mm. It later fell to its former level.

At 11.31, blood-pressure, 146 mm.

At 11.37, blood-pressure, 125 mm.

At 11.45, blood-pressure, 100 mm.

At 11.50, blood-pressure, 85 mm.; pulse, 140.

At 12.03, blood-pressure, 60 mm.

At 12.05, $^1/_{30}$ grain of strychnin was administered.

At 12.06, blood-pressure, 120 mm.

At 12.07.30, blood-pressure, 110 mm. Stimulating the sciatic nerve was followed by a slight rise.

At 12.20, blood-pressure, 55 mm.

At 12.34, blood-pressure, 50 mm.

At 12.37, electrical stimulation of the sciatic nerve was followed by a slight rise.

At 12.37.30, the injection of $^1/_{30}$ grain of strychnin caused no change in the blood-pressure.

At 12.41, the infusion of saline was begun.

At 12.51, 20 ounces of saline solution had been given. Blood-pressure, 140 mm.; pulse, 152; stroke, 12 mm.

At 12.53, blood-pressure, 125 mm.

At 1.00, blood-pressure, 100 mm.

At 1.09, blood-pressure, 80 mm.

At 1.21, blood-pressure, 70 mm.

At 1.22, $^1/_{20}$ grain of strychnin was injected. A slight rise in the blood-pressure followed.

At 1.27, blood-pressure, 53 mm.

At 1.30, blood-pressure, 45 mm.

At 1.38, blood-pressure, 45 mm. The animal was then killed.

Experiment 86.

Shock, Strychnin, Digitalis, Mechanical Support.

Female mongrel dog; good condition; weight, seven kilos.

At 10.07, initial blood-pressure, 110 mm.; pulse, 172; stroke, 12 mm. Vagi and accelerantes were severed. Blood-

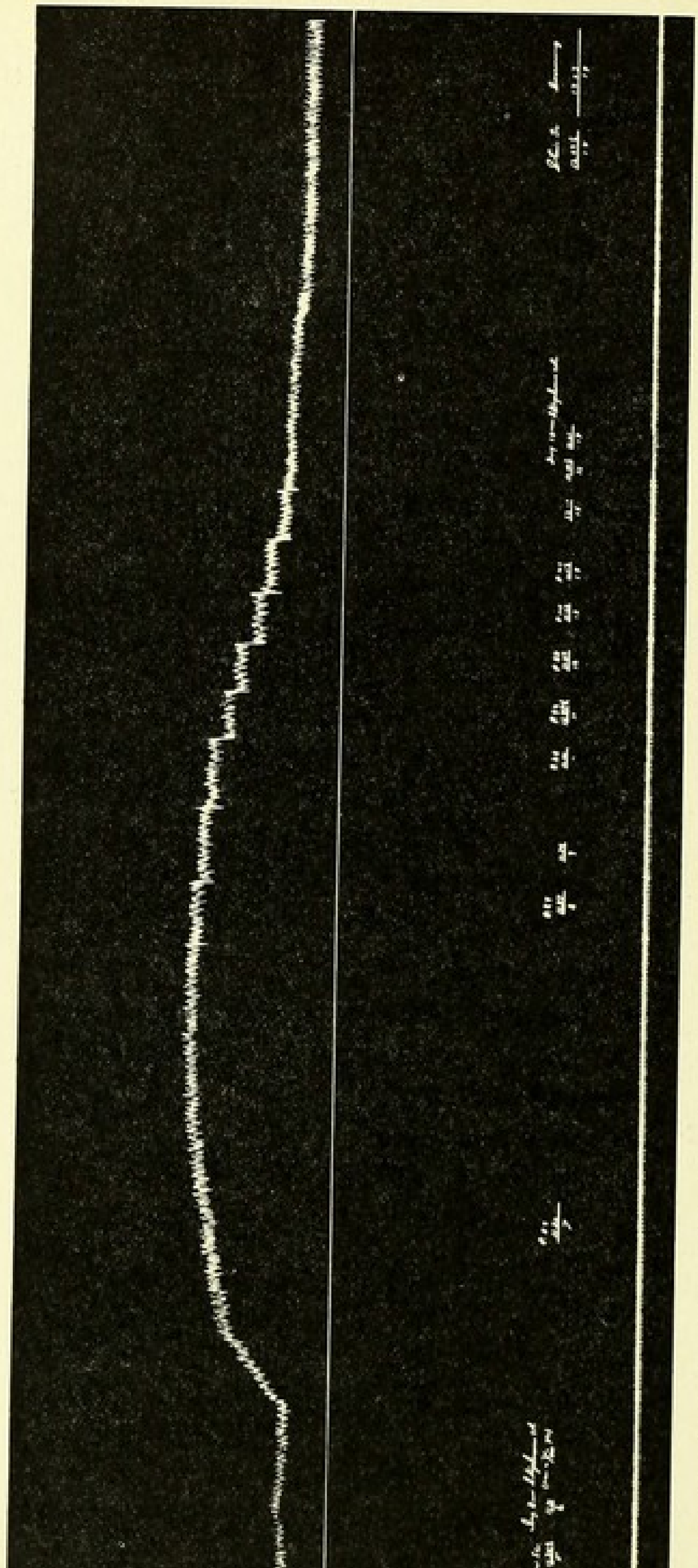

FIG. 17.—EXP. 86.—In this experiment the heart was isolated from the nervous system by severing its nerve-supply. The animal was then as readily reduced to shock as the controls. On injecting strychnin after curare had been given a rise in the blood-pressure followed. The rise was not so high and did not continue so long as in the normal animal or an animal subjected to less shock. On repeating the injection no rise occurred. Burning the paw and stimulating the sciatic caused no rise, though a like stimulation after the shock and before the strychnin caused a slight rise The energy left in the vasomotor centre after the fairly deep shock, was discharged by the stimulation of the strychnin. That is to say the exhaustion of the vasomotor centre begun by shock was completed with strychnin.

pressure, 135 mm.; pulse, 148; stroke, 20 mm; respiration failed. Artificial respiration having been supplied for a few moments, normal respiration was resumed. The animal was then reduced to shock by removing three-fourths of the integument and sponging the raw surfaces.

At 11.21, blood-pressure, 50 mm.; pulse, 96; stroke, 10 mm. Five and one-half drams of a .5 per cent. solution of curare were injected. The blood-pressure fell.

At 11.30, blood-pressure, 30 mm.; pulse, 92; stroke, 11 mm.

At 11.30.30, electrical stimulation of the sciatic nerve produced no appreciable effect.

At 11.31, $^1/_{15}$ grain of strychnin was injected.

At 11.34, blood-pressure, 54 mm.; pulse, 84; stroke 11 mm.

At 11.37, blood-pressure, 90 mm.; pulse, 84; stroke, 11 mm. A gradual fall in pressure now began.

At 11.41, blood-pressure, 85 mm.; pulse, 85; stroke, 11 mm.

At 11.43, blood-pressure, 80 mm.; pulse, 88; stroke, 11 mm.

At 11.43.30, blood-pressure, 75 mm.; pulse, 92; stroke 11 mm.

At 11.47, blood-pressure, 65 mm.; pulse, 88; stroke, 11 mm.

At 11.50, blood-pressure, 55 mm.; pulse, 100; stroke, 11 mm.

At 11.53, blood-presure, 47 mm.; pulse, 104; stroke, 11 mm.

At 12.00, blood-pressure, 40 mm.

At 12.01, $^1/_{30}$ grain of strychnin was injected. The fall in the blood-pressure continued.

At 12.02, blood-pressure, 27 mm.; pulse, 80. Electrical stimulation of the sciatics and burning of the paw produced no change in the blood-pressure.

At 12.07, 10 minims of digitalis were injected. No change in the blood-pressure or pulse was observed.

At 12.09, 5 minims of tincture of digitalis were injected. No effect upon blood-pressure or pulse was obtained.

At 12.15, 5 minims of whiskey were injected. A slight irregularity of the blood-pressure was noted.

At 12.20, burning and stimulating the sciatics and the splanchnics produced no change in the pressure or the pulse.

At 12.26, blood-pressure, 25 mm.; stroke, 10 mm. The animal was then bandaged, including the extremity and the trunk to the diaphragm. The blood-pressure rose to 70 mm., and was well sustained.

Experiment 87.

Collapse, Hemorrhage, Strychnin, Saline Infusion.

Dog; female; young and in good condition; weight, six kilos.

Normal blood-pressure, 110 mm.; pulse, 160; stroke, 10 mm.

At 10.51, both vagi and acceleranti were severed. Blood-pressure, 105 mm.; pulse, 128; stroke, 13 mm.

At 11.01, 4.66 ounces of blood were removed. Blood-pressure, 35 mm.; stroke, 9 mm.

At 11.02, 5.5 drams of a .5 per cent. solution of curare were injected. Blood-pressure, 10 mm.; stroke, 10 mm. Artificial respiration.

At 11.14, $^1/_{90}$ grain of strychnin was injected; the blood-pressure rose 7 mm.; stroke, 8 mm.

At 11.20, blood-pressure, 20 mm; stroke, 9 mm.

At 11.23, blood-pressure, 25 mm.; stroke, 6 mm.; pulse, 120.

At 11.26, blood-pressure, 60 mm.

At 11.28, blood-pressure, 90 mm.; stroke, irregular.

At 11.35, blood-pressure, 115 mm.; stroke, irregular.

At 11.43, blood-pressure, 100 mm.; stroke, irregular.

At 11.48, blood-pressure, 80 mm.; stroke, irregular.

At 11.50, blood-pressure, 50 mm.; stroke, irregular; pulse, 140.

At 11.53, $^1/_{90}$ grain of strychnin was injected. The blood-pressure in the mean time had fallen to 35 mm., and remained constant.

At 11.55, the paw was burned. No change occurred in the blood-pressure.

At 12.02, the infusion of 15 ounces of normal saline solution was begun.

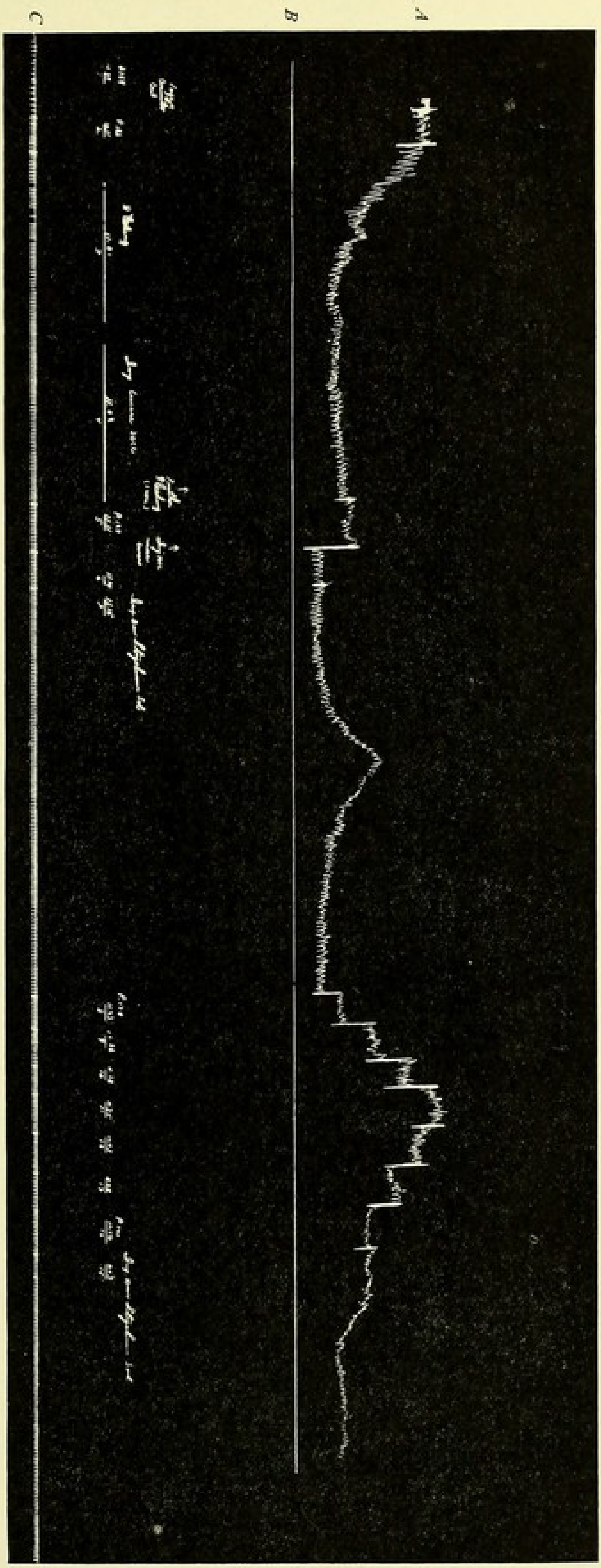

FIG. 18.—EXP. 87.—On the effect of strychnin in severe hemorrhage. *A*, carotid pressure; *B*, abscissa; *C*, seconds. The primary marked fall in the left part of the tracing was due to hemorrhage. At the point indicated at 11.02 A.M. curare was administered, after which 8 mg. of strychnin was administered intravenously. The rise noted on the right and continuing forty minutes followed. Compare the marked effect of strychnin upon the blood-pressure in the collapse from hemorrhage without fatigue of the vasomotor centre in this experiment, with the negative effect in an equally low blood-pressure from exhaustion of the vasomotor centre (shock) in other experiments.

At 12.12, infusion completed. Blood-pressure rose gradually to the normal to 110 mm.; stroke, 21 mm.

At 12.15, blood-pressure, 50 mm.; stroke, 15 mm.

At 12.20, blood-pressure, 40 mm.; stroke, 11 mm.; pulse, 80. The blood-pressure gradually fell to 30 mm.; $^1/_{90}$ grain of strychnin produced no change. A repetition was without effect.

Experiments 88, 89, 90.

Strychnin and Control Experiments.

Dog 1, control, mongrel; good condition; weight, fifteen kilos.

Dog 2, strychnin, mongrel; good condition; weight, sixteen kilos. Ether anesthesia.

Dog 1, preliminary blood-pressure, 160 mm.; stroke, 10 mm.

Dog 2, preliminary blood-pressure, 160 mm.; stroke, 12 mm.

Both animals were reduced to shock by exposing and manipulating the intestines simultaneously, with an equal degree of severity.

Dog 1, blood-pressure, 110 mm.; stroke, 8 mm.

Dog 2, blood-pressure, 110 mm.; stroke, 12 mm.

Following this observation a slight rise in the blood-pressure occurred.

Dog 1, blood-pressure, 128 mm.; stroke, 8 mm.

Dog 2, blood-pressure, 128 mm.; stroke, 15 mm.

Dog 2 was injected with $^1/_{120}$ grain of strychnin. There was a very slight rise in the blood-pressure of the control animal and a fall in the experiment animal.

Dog 1, blood-pressure, 132 mm.; stroke, 10 mm.

Dog 2, blood-pressure, 114 mm.; stroke, 8 mm.

After an interval of ten minutes the blood-pressure of dog 1 was 110 mm.; stroke, 10 mm.

Dog 2, blood-pressure, 104 mm.; stroke, 4 mm.

Dog 2, an injection of $^{1}/_{120}$ grain of strychnin was given.
Dog 1, blood-pressure, 100 mm.; stroke, 5 mm.
Dog 2, blood-pressure, 108 mm.; stroke, 7 mm.
The injections were given at ten-minute intervals, and the observations prior to and immediately following injections were recorded as follows:
Dog 1, blood-pressure, 94 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 102 mm.; stroke, 7 mm.
Dog 2 was injected with $^{1}/_{120}$ grain of strychnin.
Dog 1, blood-pressure, 94 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 95 mm.; stroke, 3 mm.
Dog 1, blood-pressure, 96 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 94 mm.; stroke, 4 mm.
Dog 2 was injected with $^{1}/_{120}$ grain of strychnin.
Dog 1, blood-pressure, 96 mm.; stroke, 10 mm.
Dog 2, blood-pressure, 102 mm.; stroke, 5 mm.
Dog 1, blood-pressure, 90 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 192 mm.; stroke, 9 mm.
Dog 2 was injected with $^{1}/_{120}$ grain of strychnin.
Dog 1, blood-pressure, 86 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 80 mm.; stroke, 8 mm.
Dog 1, blood-pressure, 85 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 80 mm.; stroke, 8 mm.
Dog 2 was injected with $^{1}/_{120}$ grain of strychnin.
Dog 1, blood-pressure, 76 mm.; stroke, 6 mm.
Dog 2, blood-pressure, 77 mm.; stroke, 5 mm.
Dog 1, blood-pressure, 83 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 85 mm.; stroke, 5 mm.
Dog 2 was injected with $^{1}/_{120}$ grain of strychnin.
Dog 1, blood-pressure, 82 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 80 mm.; stroke, 9 mm.
Dog 1, blood-pressure, 108 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 85 mm.; stroke, 8 mm.
The rise in the blood-pressure of dog 1 was due to an uneven anesthesia.
Dog 2 was injected with $^{1}/_{120}$ grain of strychnin.

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Dog 1, blood-pressure, 100 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 78 mm.; stroke, 9 mm.
Dog 1, blood-pressure, 98 mm.; stroke, 8 mm.
Dog 2, blood-pressure, 78 mm.; stroke, 6 mm.
Dog 2 was injected with $^1/_{120}$ grain of strychnin.
Dog 1, blood-pressure, 100 mm.; stroke, 6 mm.
Dog 2, blood-pressure, 50 mm.; stroke, 3 mm.
Dog 2 was injected with $^1/_{120}$ grain of strychnin.
Dog 1, blood-pressure, 100 mm.; stroke, 6 mm.
Dog 2, blood-pressure, 50 mm.; stroke, 3 mm.
Dog 2 was injected with $^1/_{120}$ grain of strychnin.
Dog 1, blood-pressure, 105 mm.; stroke, 7 mm.
Dog 2, blood-pressure, 18 mm.; stroke, 2 mm.
Dog 1, blood-pressure, 98 mm.; stroke, 5 mm.
Dog 2, blood-pressure, 5 mm.; stroke, 0 mm.
Dog 2, dead, having had no convulsion.
Time of experiment, two and one-half hours.
Dog 1, blood-pressure, 96 mm.; stroke, 7 mm.
The control dog was now injected, at intervals of ten minutes, with $^1/_{20}$ grain of strychnin.
Blood-pressure, 120 mm.; stroke, 4 mm.
Blood-pressure, 125 mm.; stroke, 6 mm.
Reflexes became heightened.
Blood-pressure, 125 mm.; stroke, 6 mm.
One-twentieth grain of strychnin was injected.
Blood-pressure, 76 mm.; stroke, 5 mm. The dog's respiration was gasping.
Blood-pressure, 100 mm.; stroke, 3 mm.
One-twentieth grain of strychnin was injected.
Blood-pressure, 98 mm.; stroke, 4 mm. The reflexes were greatly heightened.
Blood-pressure, 100 mm.; stroke, 4 mm.
One-twentieth grain of strychnin was injected. This was immediately followed by convulsions and death of the animal.
Time of experiment three and one-half hours.

EXPERIMENT 91.

Strychnin, Whiskey, Digitalis. Shock and Collapse.

Dog; female mongrel; good condition; weight, eighteen kilos.

At 11.10, initial blood-pressure, 120 mm.; pulse, 148; stroke, 10 mm. Vagi and accelerantes were bloodlessly severed.

At 11.36.30, blood-pressure, 115 mm.; pulse, 128. The administration of 1 ounce of a .5 per cent. solution of curare was followed by a fall of blood-pressure to 40 mm., evidently due to the too rapid administration of the drug.

At 12.08, blood-pressure, 40 mm.; pulse, 128; stroke, 6 mm.

At 12.09, stimulation of the sciatic nerve was followed by a rise of 20 mm. in the blood-pressure; later, by a gradual fall.

At 12.10, 10 minims of tincture of digitalis were intravenously given.

At 12.12, blood-pressure, 40 mm.; pulse, 136; stroke, 10 mm.

At 12.14, blood-pressure, 35 mm.; pulse, 136; stroke, 10 mm. Fifty minims of whiskey were injected.

At 12.15, blood-pressure gradually rose 16 mm.; pulse, 136.

At 12.21, blood-pressure, 60 mm.; pulse, 124; stroke, 6 mm.

At 12.22, $^1/_{30}$ grain of strychnin was injected.

At 12.23, blood-pressure rose to 145 mm.

At 12.26, blood-pressure, 130 mm.

At 12.35, blood-pressure, 40 mm.; pulse, 140; stroke, 10 mm. Electrical stimulation of the sciatic nerve was followed by a slight rise.

At 1.01, an injection of $^1/_{30}$ grain of strychnin was followed by a fall in the blood-pressure to 20 mm.

At 1.02, artificial respiration was discontinued for half a minute. The pressure rose to 25 mm.

At 1.04, blood-pressure, 25 mm.; stroke, 11 mm.

At 1.05, $^1/_{30}$ grain of strychnin was injected.

At 1.06, blood-pressure, 20 mm. Burning the paw caused no change in the blood-pressure.

Artificial respiration was discontinued. The blood-pressure remained at 20 mm.

At 1.14, the animal died, the blood-pressure having remained constant at 20 mm. since the last observation.

Experiment 92.

Strychnin, Nitroglycerin, and Cocain.

Mongrel dog; good condition; weight, six kilos. Ether anesthesia.

Blood-pressure cannula was adjusted in the carotid. The animal did not breathe well during the anesthesia. One one-hundredth grain of strychnin was injected into the jugular vein. A very slight, gradual rise in the blood-pressure followed.

Ten seconds later, $^1/_{20}$ grain of strychnin was injected into the jugular vein. The gradual rise continued.

Fifteen seconds later, $^1/_{10}$ grain of nitroglycerin was given. A slight fall in the blood-pressure followed. The pulse-rate was diminished. The length of the strokes was markedly decreased. Artificial respiration became necessary. Convulsions followed. To test the effect of cocain upon the convulsions, $^1/_{10}$ grain was injected into the jugular vein. The convulsion persisted. A marked fall in the blood-pressure, with shortened strokes, followed. The heart and respiration ceased and the blood-pressure dropped to the abscissa line. The dog was supposed to be dead, and was skinned over the entire central surface and legs, in order to observe the blood distribution in the superficial vessels. The abdomen was then opened by a three-inch incision. At this point the animal began to breathe, and the heart's action was resumed. Convulsions followed immediately, and the blood-pressure rose and fell, synchronous with the muscular contraction and relaxation. The dog was inverted head up, then head down. In the mean time artificial respiration was maintained. For a short time the heart beat only during inspiration. A few seconds later the heart began to beat independent of respiratory action, and the blood-pressure rose. The abdominal incision and the skin were then sutured together. Both vagi were severed almost simultaneously, the heart beating slowly. Violent convulsions appeared. The blood-pressure excursions became slow and feeble. The animal died from respiratory failure.

Experiment 93.

Nitroglycerin, Strychnin, Saline Infusion, Cocain.

Mongrel dog; good condition; weight, nine kilos. Ether anesthesia.

Blood-pressure cannula was adjusted in the right carotid. An excess of anesthetic was given, the blood-pressure fell and respiration ceased. Artificial respiration was given. The dog was inverted head up, then brought to the horizontal posture, the blood-pressure rapidly regaining its normal level.

One-thirtieth grain of strychnin was injected into the left jugular vein. A gradual, slight rise in the blood-pressure followed.

One-thirtieth grain of strychnin was again injected. In forty-five seconds convulsions developed. After the convulsions subsided, pinching the foot caused a sharp rise in the blood-pressure, and the convulsion was renewed. This was repeated several times.

The injection of $^1/_{10}$ grain of nitroglycerin resulted in a fall of the blood-pressure, followed by a rapid rise to its former level. An injection of $^1/_{30}$ grain of nitroglycerin was followed by a similar phenomenon. One-thirtieth grain of strychnin, then $^1/_{20}$ grain, was injected; a slight rise in the blood-pressure ensued. The blood-pressure was well sustained for forty seconds.

One-twelfth grain of nitroglycerin was given. A sharp fall in the blood-pressure followed and convulsions developed. The blood-pressure again recovered.

One-tenth grain of nitroglycerin was then administered without effect.

Both vagi were next severed, following which there was some rise in the blood-pressure and failure of respiration. Artificial respiration was supplied.

On injecting $^1/_5$ grain of nitroglycerin, the blood-pressure fell sharply, with slow recovery. The injection of $^1/_{20}$ grain of strychnin was followed by a gradual rise in the blood-pressure. The respiratory waves on the blood-pressure curves were increasingly marked.

Forty ounces of normal saline solution were given, the blood-pressure rising and respiration improving. Convulsions appeared at intervals.

One-fifth grain of cocain was injected, following which there occurred repeated convulsions and some rise in the blood-pressure. The animal died from respiratory failure.

Experiment 94.

Shock.

Male dog; fair condition; weight, eight kilos.

Initial blood-pressure, 110 mm.

Vagi were severed. No change in the blood-pressure. Strokes became long and sweeping. The animal was then extensively burned. A fall in the blood-pressure to 50 mm. was noted. Respiration failed and the animal died.

Experiment 95.

Shock, Strychnin, Splanchnic Circulation.

Dog; male mongrel; good condition; weight, thirteen kilos.

At 2.30, initial blood-pressure, 120 mm.; stroke, 13 mm.; pulse, 126. The vagi and accelerantes were exposed by bloodless dissection and severed.

At 2.45, blood-pressure, 130 mm.; stroke, 20 mm.; pulse, 132. The integument was removed from three-fourths of the body and the denuded surface sponged.

At 3.13, blood-pressure, 80 mm.; stroke, 14 mm.; pulse, 136.

At 3.14, burning the hind paw caused an abrupt rise of 55 mm. in the blood-pressure, subsequently an equal fall. The denuded surfaces were then roughly sponged for a considerable time.

At 4.10, blood-pressure, 58 mm.; stroke, 20 mm.; pulse, 128.

At 4.11, 4 drams of a .5 per cent. solution of curare were intravenously injected. Artificial respiration was supplied.

At 4.17, electrical stimulation of the sciatic nerve produced no appreciable effect upon the blood-pressure. Blood-pressure, 20 mm.; stroke, 8 mm.; pulse, 130.

At 4.18, $^1/_5$ grain of strychnin solution was intravenously injected.

At 4.20, the injection was repeated. The blood-pressure gradually rose.

At 4.22, blood-pressure, 80 mm.; stroke, 12 mm.; pulse, 128.

At 5.02, blood-pressure, 55 mm.; burning of the paw and electrical stimulation of the sciatic nerve produced a very slight rise in the blood-pressure.

At 5.04, $^1/_{30}$ grain of strychnin was intravenously injected. No change in the blood-pressure was obtained. On opening the abdomen, the color of the intestines was found to be normal. The injection of 1.5 drams of tincture of digitalis produced no change upon the blood-pressure or in the pulse-rate. The blood-pressure continued at 30 mm.

At 5.17, the animal died.

Experiment 96.

Shock, Strychnin, and Bandaging.

Dog; male mongrel; fair condition; weight, twelve kilos.

At 8.42, initial blood-pressure, 140 mm.; stroke, 12 mm.; pulse, 196.

At 8.47, stimulation of the sciatic nerve was followed by a sharp fall of 18 mm. in the blood-pressure, and later by a rise to its former level. Both vagi and accelerantes were severed.

At 9.09, blood-pressure, 140 mm.; pulse, 148.

At 9.10, respiration failed. Artificial respiration was maintained for forty minutes. Normal respiration was not resumed.

At 10.00, burning a hind paw produced a rise in the blood-pressure to 60 mm. The animal was then skinned and the denuded surface sponged.

At 10.32, blood-pressure, 30 mm.; pulse, 116.

At 10.33, 9.5 drams of a .5 per cent. solution of curare were intravenously injected.

At 10.43.30, blood-pressure, 25 mm.; stroke, 7 mm.; pulse, 112.

At 10.44, $^1/_{30}$ grain of strychnin was intravenously injected. The blood-pressure rose to 25 mm.; stroke, 7 mm.; pulse, 110. Within fifteen minutes after the injection the pressure had again fallen to 20 mm. Burning the paw produced no effect upon the blood-pressure.

At 11.03, $^1/_{12}$ grain of strychnin was intravenously injected. No rise in the blood-pressure occurred.

At 11.05, the animal was bandaged, causing the blood-pressure to rise to 40 mm., at which level it was maintained.

At 11.29, the dog died, the blood-pressure being 45 mm. The intestines were not exposed until the moment of death, when they were inspected and found to be pale. There was no evidence of an accumulation of blood in the splanchnic area.

Experiment 97.

Shock, Curare, and Strychnin.

Dog; female mongrel; good condition; weight, fifteen kilos. Ether anesthesia.

Tracheal and carotid cannula were adjusted.

At 9.50, initial blood-pressure, 125 mm.; stroke, 10 mm.; pulse, 122.

At 9.55, both vagi and accelerantes were severed. Blood-pressure, 55 mm.; stroke, 15 mm.; pulse, 130. Shock was produced by removal of the integument, manipulation of the intestines, and crushing the paws.

At 10.27, the intestines were returned to the abdomen and the wound was closed.

At 10.32, blood-pressure, 50 mm.; stroke, 12 mm.; pulse, 136.

From 10.32 to 10.43, 5.5 drams of a .5 per cent. solution of curare were injected into the femoral vein. During this time the blood-pressure gradually rose to 60 mm.

At 10.44, $^1/_{30}$ grain of strychnin was injected into the femoral vein. The blood-pressure rose to 155 mm.; stroke, 14; pulse, 124. The blood-pressure curve continued at about this height for a little more than an hour. The curve exhibited a considerable number of waves entirely independent of the respiratory effects. These waves increased towards the end of the hour.

At 12.28, blood-pressure, 140 mm.; stroke, 10 mm.; pulse, 120. A gradual decline in the blood-pressure now began, but the pulse and the strokes remained constant.

At 12.45, blood-pressure, 120 mm.; the curve was very irregular.

At 1.14, blood-pressure, 110 mm.

At 2.30, blood-pressure, 90 mm.; stroke, 10 mm.; pulse, 100.

At 2.31, the sciatic nerve was electrically stimulated. An abrupt rise of 40 mm. followed, but an equal fall was noted.

At 2.34, 1/30 grain of strychnin was injected into the femoral vein. An abrupt rise in the blood-pressure to 175 mm. was noted; stroke, 15 mm.; pulse, 96. The marked undulations in the blood-pressure curve again appeared. When the blood-pressure was at its maximum height the sciatic nerve was electrically stimulated, resulting in a rise of 30 mm. in the blood-pressure, followed by an equal fall.

At 2.49, 1/30 grain of strychnin was injected into the femoral vein. This was followed by a rise of 20 mm.; later, by an abrupt fall to the former level.

At 2.50.30, 1/30 grain of strychnin was again injected, after which a similar rise and fall in the blood-pressure was observed.

At 2.53, blood-pressure, 110 mm.; stroke, 18 mm.; pulse, 80.

At 2.54, 1/30 grain of strychnin was injected into the femoral vein. A sharp fall of 40 mm. in the blood-pressure occurred.

At 2.57, blood-pressure, 150 mm.; stroke, 12 mm.; pulse, 80.

At 2.57.30, 1/30 grain of strychnin was again injected. A slight fall in the blood-pressure followed. The sciatic nerve was electrically stimulated, the blood-pressure rising 10 mm.

At 3.05, blood-pressure, 60 mm. The sciatic nerve was stimulated, but no appreciable effect followed. The splanchnic nerves were then electrically stimulated. A slight rise in the blood-pressure followed, after which the pressure rapidly fell.

At 3.11, the animal died.

Experiment 98.

Shock, Curare, Strychnin.

Dog; male mongrel; weight, nine kilos. Ether anesthesia.

Blood-pressure, 145 mm.; pulse, 120; stroke, 10 mm.

At 9.57, both vagi and accelerantes were severed. Blood-pressure, 125 mm.; pulse, 120; stroke, 15 mm. Respiration was greatly slowed and deepened. The animal was reduced to surgical shock by intestinal manipulation and crushing the paws.

At 10.19, blood-pressure, 80 mm.; pulse, 120; stroke, 10 mm.

At 10.23, 3 drams of a .5 per cent. solution of curare were injected.

At 11.27, blood-pressure, 30 mm.; pulse, 120; stroke, 10 mm.

At 11.35, $^1/_{64}$ grain of strychnin was injected.

At 11.36, blood-pressure, 60 mm.; pulse, 120; stroke, 18 mm.

At 11.38.30, blood-pressure, 75 mm.; pulse, 120; stroke, 11 mm. The blood-pressure curve exhibited great irregularity. The rise in the blood-pressure following the injection of strychnin continued forty-five minutes. The maximum rise, five minutes.

At 12.34, blood-pressure, 40 mm.; pulse, 88; stroke, 7 mm.

At 12.35, $^1/_{90}$ grain of strychnin was injected.

At 12.36, blood-pressure, 80 mm.; pulse, 98 mm.; stroke, 10 mm. The waves now measured about 15 mm.

At 12.58, blood-pressure, 25 mm.; pulse, 100; stroke, 10 mm. The effect of the second dose continued for twenty-five minutes.

At 1.00, blood-pressure, 45 mm.; pulse, 100; stroke, 10 mm.

At 1.01, $^1/_{120}$ grain of strychnin was administered. No effect upon the blood-pressure was obtained.

At 1.03, $^1/_{120}$ grain of strychnin was injected without effect.

At 1.09, a slow decline began. Repeated injections of $^1/_{60}$ grain of strychnin were given at one-minute intervals, the blood-pressure gradually declining.

At 1.19, blood-pressure, 15 mm.; pulse, 84. Curve irregular.

At 1.21, the dog died.

EXPERIMENT 99.

Shock, Strychnin, Curare.

Dog; male mongrel; good condition; weight, twenty-two kilos.

The tracheal carotid and femoral cannulæ were adjusted. Preliminary observations were then made.

At 2.45, blood-pressure, 130 mm.; pulse, 180.

At 2.50, the sciatic nerve was electrically stimulated. This was followed by an abrupt rise and fall in the blood-pressure.

At 3.12, 10.5 ounces of a .5 per cent. solution of curare were injected into the femoral vein.

At 3.50, the sciatic nerve was electrically stimulated, following which an abrupt rise in the blood-pressure occurred. The intestines were exposed and manipulated. Blood-pressure, 98 mm.; pulse, 156.

At 3.54, blood-pressure, 158 mm.; pulse, 107.

At 3.54.30, $^1/_{64}$ grain of strychnin was injected into the femoral vein.

At 3.55.30, blood-pressure, 155 mm.; pulse, 196.

At 3.59.30, blood-pressure, 140 mm.; pulse, 180.

At 4.01, the sciatic nerve was electrically stimulated. This was followed by an abrupt rise and fall in the blood-pressure.

At 4.03, blood-pressure, 142 mm.; pulse, 148.

At 4.04, $^1/_{64}$ grain of strychnin was injected into the femoral vein.

At 4.07, blood-pressure, 157 mm.; pulse, 192.

At 4.07.30, the sciatic nerve was electrically stimulated, causing an abrupt rise and fall in the blood-pressure.

At 4.14, blood-pressure, 140 mm.; pulse, 180.

At 4.15, $^1/_{64}$ grain of strychnin was injected into the femoral vein, causing an abrupt rise in the blood-pressure, reaching a maximum of 160 mm.

At 4.17, the sciatic nerve was electrically stimulated. This was followed by an abrupt rise and fall in the blood-pressure.

At 4.25, blood-pressure, 140 mm.; pulse, 192.

At 4.32.30, blood-pressure, 125 mm.; pulse, 176.

At 4.33, 1/64 grain of strychnin was injected into the femoral vein, causing a rise. Blood-pressure, 160 mm.; pulse, 204.

At 4.38.30, blood-pressure, 156 mm.; pulse, 200.

At 4.39, the sciatic nerve was stimulated. An abrupt rise, followed by a fall, was observed in the blood-pressure.

At 4.44, blood-pressure, 110 mm.; pulse, 198.

At 4.44.30, 1/64 grain of strychnin was injected into the femoral vein.

At 4.46.30, blood-pressure, 165 mm.; pulse, 180.

The animal was under observation until 5.48.

At 5.48, blood-pressure, 135 mm.; pulse, 184.

At 5.52, the sciatic nerve was electrically stimulated. An abrupt rise and fall in the blood-pressure followed.

At 5.54, blood-pressure, 140 mm.; pulse, 182.

At 5.54.30, 1/64 grain of strychnin was injected into the femoral vein.

At 5.55.30, blood-pressure, 163 mm.; pulse, 180.

At 6.03, blood-pressure, 165 mm.; pulse, 188.

At 6.14, the sciatic nerve was electrically stimulated. An abrupt rise and fall in the blood-pressure was noted.

At 6.15, blood-pressure, 140 mm.; pulse, 160.

At 6.15.15, 1/64 grain of strychnin was injected into the femoral vein.

At 6.16, blood-pressure, 165 mm.; pulse, 176.

At 6.19, the sciatic nerve was electrically stimulated, following which there occurred an abrupt rise and fall in the blood-pressure.

At 6.21, blood-pressure, 155 mm.; pulse, 176.

At 6.23, 1/64 grain of strychnin was injected into the femoral vein.

At 6.24, blood-pressure, 160 mm.; pulse, 184.

At 6.52, blood-pressure, 150 mm.; pulse, 180.

At 6.53.45, the sciatic nerve was electrically stimulated. An abrupt rise and fall in the blood-pressure was obtained.

At 6.54, blood-pressure, 135 mm.; pulse, 178.

At 6.54.30, $^1/_{64}$ grain of strychnin was injected into the femoral vein.

At 6.55.15, blood-pressure, 156 mm.; pulse, 176.

At 7.01, blood-pressure, 150 mm.; pulse, 160.

At 7.01.15, $^1/_{20}$ grain of strychnin was injected.

At 7.02, blood-pressure, 160 mm.; pulse, 176.

At 7.05, the sciatic nerve was electrically stimulated. This was followed by an abrupt rise and fall in the blood-pressure.

At 7.25, blood-pressure, 110 mm.; pulse, 140.

At 7.45, blood-pressure, 60 mm.; pulse, 136.

At 8.15, blood-pressure, 40 mm.; pulse, 150.

At 8.30, blood-pressure, 40 mm.; pulse, 148. The animal was killed by allowing $MgSO_4$ to flow into the femoral vein.

Experiment 100.

Strychnin and Curare.

Male mongrel; good condition; weight, eleven kilos. Ether anesthesia.

Tracheal and carotid cannulæ were applied, and exposure of both femoral veins was made.

At 10.35, preliminary blood-pressure, 110 mm.; stroke, 10 mm.; pulse, 100. A cannula was introduced into the femoral vein, and attached to a burette containing a .5 per cent. solution of curare.

At 10.45, an injection of 3.33 ounces of curare was administered at the rate of 2.6 drams per ten minutes. A primary fall, then a rise, followed by a secondary fall in the blood-pressure, were noted.

At 12.20, blood-pressure, 50 mm.; stroke, 4 mm.; pulse, 144.

At 12.25, the injection of $^1/_{10}$ grain of strychnin was made into the opposite femoral veins. This was followed by a sharp rise in the blood-pressure, an increase in the length of stroke, and an increase in the pulse-rate.

At 12.28, blood-pressure, 165 mm.; stroke, 20 mm.; pulse, 228.

At 12.29, blood-pressure, 160 mm.; stroke, 20 mm.; pulse, 204.

At 12.30, blood-pressure, 160 mm.; stroke, 20 mm.; pulse, 205.

At 12.39, blood-pressure, 160 mm.; stroke, 22 mm.; pulse, 180.

At 12.55, both vagi were severed. This was followed by a fall in the blood-pressure. Blood-pressure, 144 mm.; stroke, 20 mm.; pulse, 180.

At 1.05, an injection of 2.6 drams of a .5 per cent. solution of curare was made into the femoral vein.

At 1.18, blood-pressure, 38 mm.; stroke, 4 mm.; pulse, 108.

At 1.22, an injection of $^1/_{10}$ grain of strychnin was made into the femoral vein. This was followed by a primary rise in the blood-pressure, which now recorded 50 mm.; stroke, 6 mm.; pulse, 108.

At 1.31, blood-pressure, 30 mm.; stroke, 4 mm.; pulse, 108. The sciatic was stimulated electrically without effect. The injection of $^1/_{10}$ grain of strychnin produced no effect upon the blood-pressure. The pulse remained constant at 112.

At 1.57, blood-pressure, 20 mm.; stroke, 5 mm.; pulse, 112. The sciatic was electrically stimulated without effect. The animal was killed by allowing $MgSO_4$ to flow into the carotid cannula.

Experiment 101.

Strychnin and Curare.

Male mongrel dog; good condition; weight, nine kilos. Ether anesthesia.

The tracheal carotid and femoral cannulæ were adjusted.

Preliminary observations were as follows:

At 2.27, blood-pressure, 108 mm.; pulse, 120. The vagi and accelerantes were severed.

At 2.34, blood-pressure, 95 mm.; pulse, 144.

At.2.37, the sciatic was stimulated electrically, a sharp rise in the blood-pressure following.

At 2.40, 10 c.c. of a .5 per cent. solution of curare were injected into the femoral vein. This resulted in a regular blood-pressure.

At 2.42, artificial respiration was supplied.

At 2.45, the above injection was repeated, producing similar results. Electrodes were applied to the muscles and the sciatic nerves were stimulated, no muscular reaction being observed. Immediately following stimulation, there was a sharp rise in the blood-pressure, with a corresponding fall.

At 3.02, blood-pressure, 115 mm.; pulse, 148. One-sixty-fourth grain of strychnin was then injected into the femoral vein. After a period of two minutes there was a sharp rise in the blood-pressure to 130 mm., and an increase of 40 in the pulse-rate.

At 3.10, blood-pressure, 155 mm.; pulse, 188.

At 3.12, $^1/_{64}$ grain of strychnin was injected into the femoral vein. One minute later the blood-pressure recorded 255 mm.; pulse, 208.

At 3.20, blood-pressure, 155 mm.; pulse, 204.

At 3.25.30, $^1/_{64}$ grain of strychnin was injected into the femoral vein.

At 3.27, blood-pressure, 200 mm.; pulse, 212.

At 3.46, blood-pressure, 160 mm.; pulse, 212.

At 4.13.30, blood-pressure, 50 mm.; pulse, 160, very irregular.

At 4.14, $^1/_{64}$ grain of strychnin was injected into the femoral vein.

At 4.18, blood-pressure, 150 mm.; pulse, 200.

At 4.19, the sciatic was stimulated electrically, producing a very irregular blood-pressure.

At 4.42, blood-pressure, 150 mm.; pulse, 176. The animal was killed by allowing $MgSO_4$ to flow into the carotid cannula. No convulsions were in evidence during this experiment.

Experiment 102.

Shock, Strychnin.

Dog; mongrel male; good condition; weight, eleven kilos. Ether anesthesia.

Normal pressure, 140 mm.; pulse, 160; stroke, 15 mm.

Both vagi and accelerantes were bloodlessly severed. The blood-pressure fell 5 mm. during the operation. The pulse decreased from 160 to 120. The animal was then reduced to surgical shock by intestinal manipulation, removal of one-fourth of the integument, and crushing the paws.

Blood-pressure, 40 mm.; pulse, 118; stroke, 8 mm. The injection of 6.6 drams of a .5 per cent. solution of curare was made.

Blood-pressure, 35 mm.; pulse, 116; stroke, 7 mm. One-tenth grain of strychnin was injected into the femoral vein.

At the expiration of one minute and a half the blood-pressure rose to 85 mm., then gradually fell to 60 mm., at which level it was maintained for fifteen minutes. A repetition of the foregoing injection was followed by a fall, which continued until death.

Experiment 103.

Strychnin and Curare.

Dog; male mongrel; excellent condition; weight, ten kilos. Ether anesthesia.

The tracheal carotid and femoral cannulæ were adjusted. Preliminary observations were then made.

At 10.30, blood-pressure, 130 mm.; stroke, 12 mm.; pulse, 152. The vagi and accelerantes were then divided. This caused a slight fall in the blood-pressure, followed by recovery. The respirations were of the vagal type.

At 10.40, blood-pressure, 125 mm.; stroke, 16 mm.; pulse, 120. An injection of 10.6 drams of a .5 per cent. solution of curare was then given into the femoral vein. Artificial respiration was then supplied.

At 11.11, blood-pressure, 130 mm.; stroke, 10 mm.; pulse, 108.

At 11.11.15, $^1/_{64}$ grain of strychnin was injected into the femoral vein, having no effect on the blood-pressure.

At 11.12.30, the above injection was repeated. This was followed by a rise of 10 mm. in the blood-pressure.

At 11.14, a repetition of the foregoing produced no effect.

At 11.16, there was a rise of 100 mm. in the blood-pressure, followed by long sweeping strokes 80 mm. in length. A fall in the blood-pressure, which subsequently remained constant at 203 mm., occurred.

At 11.20, $^1/_{10}$ grain of strychnin was injected into the femoral vein. This was followed by an irregular rise and fall in the blood-pressure, which recorded 200 mm. From 11.47 to 12.54 the blood-pressure was very irregular, during which time there was a gradual fall.

At 12.57, blood-pressure, 70 mm.; pulse, 108.

At 2.01, blood-pressure, 45 mm. The animal was killed with $MgSO_4$.

From 1.21 to 2.01 the intestines were exposed and manipulated. This produced an alternate rise and fall in the blood-pressure. Convulsions were not in evidence during the experiment.

Experiment 104.

Shock, Strychnin, and Saline Infusion.

Dog; male mongrel; good condition; weight, eleven kilos.

At 11.09, initial blood-pressure, 125 mm.; pulse, 176; stroke, 9 mm. Both vagi and accelerantes were severed.

At 11.26, blood-pressure, 120 mm.; pulse, 124; stroke, 15 mm. The animal was reduced to surgical shock by removing the integument and mechanically irritating the raw surface.

At 11.36, blood-pressure, 90 mm.; pulse, 120; stroke, 20 mm. One ounce of a .5 per cent. solution of curare was administered.

At 11.57, blood-pressure, 40 mm.; pulse, 120.

At 11.58, electrical stimulation of the sciatic was followed by a rise of 20 mm. in the blood-pressure.

At 12.02, blood-pressure, 40 mm.; pulse, 120; stroke, 11 mm.

At 12.02.30, $^1/_{30}$ grain of strychnin was injected.

At 12.03.30, blood-pressure, 155 mm.; pulse, 116; stroke, 13 mm.

At 12.13, blood-pressure, 140 mm.; pulse, 120; stroke, 15 mm.

At 12.22, blood-pressure, 130 mm.; pulse, 120; stroke, 13 mm.

At 12.33, blood-pressure, 118 mm.; pulse, 116; stroke, 13 mm.

At 12.33.30, blood-pressure, 130 mm.; pulse, 120; stroke, 13 mm.

At 12.35, blood-pressure, 94 mm.

At 12.44, blood-pressure, 70 mm.; pulse, 116.

At 12.48, blood-pressure, 55 mm.; pulse, 118. Stimulation of the sciaitic nerve was followed by a rise of 10 mm.; latér, by a corresponding fall.

At 12.51, blood-pressure, 51 mm.; stroke, 8 mm.

At 12.51.30, $^1/_{30}$ grain of strychnin was injected. The blood-pressure rose sharply to 120 mm.

At 12.58, blood-pressure, 100 mm.; pulse, 108.

At 1.02, blood-pressure, 70 mm.; pulse, 120.

At 1.09, blood-pressure, 40 mm.

At 1.12, blood-pressure, 35 mm. Electrically stimulating the sciatic nerve caused a rise of 5 mm. in the blood-pressure, which was followed by an equal fall.

At 1.13, $^1/_{30}$ grain of strychnin was injected. Some irregularity, showing a decline in the blood-pressure, followed.

At 1.18, blood-pressure, 20 mm.

At 1.27, the infusion of normal saline was inaugurated. A gradual rise in the blood-pressure, varying with the rate of flow, was obtained.

During thirteen minutes, 33.33 ounces were administered.

Blood-pressure, 110 mm.; stroke, 16 mm.

Twenty minutes later, blood-pressure recorded 80 mm.; pulse, 120; stroke, 14 mm.

Fifteen minutes later, blood-pressure, 55 mm.; pulse, 120.

Ten minutes later blood-pressure, 30 mm.

At 2.40, the animal died. At autopsy, fluid was found in the pleural, pericardial, and peritoneal cavities.

Experiment 105.

Shock, Strychnin, Adrenalin.

Dog; male mongrel; weight six kilos.

An injection of $^1/_{360}$ grain of strychnin was given every two minutes until five doses had been administered. A rise of 28 mm. in the blood-pressure was recorded.

Four drams of curare in a .5 per cent. solution were given.

An injection of $^1/_6$ grain of strychnin in fractional doses was given. A rise in the blood-pressure of 74 mm. followed.

The dog was reduced to shock by removing the integument and sponging the raw surfaces.

Twelve minims of a 1 to 1000 solution of adrenalin was followed by an abrupt rise in the blood-pressure to 50 mm. Repeated doses of adrenalin were given without effect. Later a continuous injection of a 1 to 100,000 solution of adrenalin maintained an even blood-pressure for more than one hour. The animal was killed.

Experiment 106.

Shock, Strychnin, Adrenalin.

Dog; male mongrel; good condition; weight, seven kilos.

At 9.14, initial blood-pressure, 140 mm.; pulse, 156; stroke, 15 mm. The animal was reduced to shock by removal of the integument and irritation of the denuded surface. Tracings were taken at intervals, showing a gradual decline in the blood-pressure. The accelerantes and vagi were severed while the animal was in but a slight degree of shock.

At 10.55, blood-pressure, 30 mm.; stroke, 10 mm. 2.6 drams of a .5 per cent. solution of curare were injected into the femoral vein. Blood-pressure, 20 mm.; stroke, 8 mm. A gradual recovery to the former level occurred. Neither burning nor stimulating the sciatic produced a change in the blood-pressure. 2.6 drams of curare were injected into the femoral vein. Blood-pressure, 15 mm.

At 11.41, blood-pressure, 15 mm.; stroke, 8 mm. One-thirty-third grain of strychnin was administered intravenously.

At 11.42, blood-pressure, 65 mm.; stroke, 12 mm.

At 11.48, blood-pressure, 45 mm.; stroke, 14 mm.

At 11.49, $^1/_{30}$ grain of strychnin was administered.

At 11.50, blood-pressure, 50 mm.; stroke, 14 mm.

At 11.51, $^1/_{30}$ grain of strychnin was given. A slight fall in the blood-pressure was recorded.

At 11.52, $^1/_{30}$ grain of strychnin was administered; blood-pressure, 44 mm.

At 12.00, $^1/_{30}$ grain of strychnin was given; blood-pressure 20 mm. Burning of the paw and electrical stimulation of the sciatic produced no change.

At 12.34, $^1/_{30}$ grain of strychnin was injected. No effect was observed.

At 12.36, $^1/_{30}$ grain of adrenalin was given; blood-pressure, 95 mm.; stroke, 60 mm. The blood-pressure fell. The animal died.

Experiment 107.

Shock, Strychnin, Vagi, Adrenalin.

Dog; fair condition; weight, eight kilos. Ether anesthesia.

At 11.56, blood-pressure, 120 mm.; pulse, 212. The animal was reduced to shock by skinning and then irritating the denuded surfaces.

At 12.18, blood-pressure, 45 mm.; pulse, 132.

At 2.27, on burning the paws the blood-pressure rose to 30 mm.; pulse, 124.

At 2.35, blood-pressure, 40 mm.; pulse, 124. One-thirtieth grain of strychnin was given, which produced convulsions. The convulsion caused a rise of 10 mm. in the blood-pressure. Respiration failed. Curare was administered and artificial respiration supplied. Burning the paw and electrically stimulating the sciatic produced no effect upon the blood-pressure. Mechanical stimulation of the larynx caused a reflex inhibition of the heart.

At 2.50, both vagi were severed; blood-pressure, 40 mm.; pulse, 132.

At 3.03, blood-pressure, 35 mm.; pulse, 132. On injecting 2.6 drams of a 1 to 1000 solution of adrenalin, the blood-pressure rose to 105 mm., with no change in the pulse-rate. The animal was then killed.

Experiments 108, 109, 110.

Strychnin, Whiskey, and Bandaging.

Dog 1, good condition; weight, fifteen kilos.

Dog 2, fair condition; weight, eleven kilos.

Dog 3, splendid condition; weight, sixteen kilos.

At 11.20, the dogs were reduced to surgical anesthesia and prepared for the experiment.

At 12.10, preliminary observation:

Dog 1, blood-pressure, 112 mm.; stroke, 20 mm.; pulse, 118; respiration, 56.

Dog 2, blood-pressure, 140 mm.; stroke, 16 mm.; pulse, 152; respiration, 68.

Dog 3, blood-pressure, 120 mm.; stroke, 25 mm.; pulse, 160; respiration, 52.

At 12.25, the femoral veins were exposed.

At 12.35, the intestines of all the animals were exposed and manipulated, with results as follows:

Dog 1, blood-pressure, 66 mm.; stroke, 6 mm.; pulse, 152; respiration, 40.

Dog 2, blood-pressure, 120 mm.; stroke, 10 mm. pulse, 160; respiration, 60.

Dog 3, blood-pressure, 100 mm.; stroke, 16 mm.; pulse, 160; respiration, 148.

At 1.01, the sciatic nerves of each animal were mechanically stimulated, with the results as follows:

Dog, 1, a rise of 10 mm.

Dog 2, a rise of 16 mm.

Dog 3, a rise of 20 mm.

At 1.03, on burning the hind foot of each animal, the following changes in the blood-pressure were noted:

Dog 1, a rise of 5 mm.

Dog 2, a rise of 40 mm.

Dog 3, a rise of 15 mm.

At 1.20, dog 1, pulse, 148.

Dog 2, pulse, 148.

Dog 3, pulse, 130.

The respiration of dog 1 was 56; dog 2, 148; dog 3, 130.

At 1.25, a clot formed in the cannula of dog 2, owing to over-anesthesia; respiration failed, but recovered when artificial respiration was supplied.

At 1.45, dog 1, blood-pressure, 78 mm.; stroke, 8 mm.; pulse, 160; respiration, 60.

Dog 2, blood-pressure, 98 mm.; stroke, 4 mm.; pulse, 168; respiration, 46.

Dog 3, blood-pressure, 92 mm.; stroke, 15 mm.; pulse, 160; respiration, 40.

At 1.59, dog 1, $^1/_{30}$ grain of strychnin in solution, 22 minims of normal saline were injected into the femoral vein.

At 2.02, dog 2, the extremities, lower abdomen, and head were bandaged.

Dog 3, 22 minims of whiskey were injected into the femoral vein. The results were as follows:

Dog 1, no change occurred.

Dog 2, the blood-pressure rose 15 mm.

Dog 3, no change occurred in the blood-pressure. The pulse decreased twelve beats.

At 2.26, dog 1, a rise of 10 mm. occurred.

Dog 2, the blood-pressure remained constant.

Dog 3, a slight fall occurred.

At 2.57, dog 1, $^1/_{30}$ grain of strychnin was injected into the femoral vein.

Dog 2, no change in treatment.

Dog 3, 22 minims of whiskey were given intravenously.

Dog 3, a slight fall in the blood-pressure occurred.

Dog 1, a fall of 10 mm. in the blood-pressure occurred.

At 3.15, burning the hind foot of each animal was followed by a rise in the blood-pressure.

At 3.20, dog 1, $^1/_{30}$ grain of strychnin was given intravenously.

Dog 1, a slight rise in the blood-pressure resulted.

Dog 3, 22 minims of whiskey were administered intravenously; the blood-pressure fell slightly.

From 3.20 to 4 the intestines of all the animals were manipulated.

At 4.04, dog 1, or the strychnin experiment, died.

Dog 3, or the whiskey experiment, respiration ceased. Artificial respiration was supplied, and the abdomen and head were bandaged. Blood-pressure rose to 50 mm., and the animal continued to live thirty minutes. Dog 2, or the bandage experiment, remained about the same. The bandage was removed, and an abrupt fall in the blood-pressure resulted. The animal died.

Experiments 111, 112, 113.

Strychnin, Digitalis, and Bandaging.

Dog 1, old mongrel; good condition; weight, twenty-four kilos.

Dog 2, hound; good condition; weight, twenty-three kilos.

Dog 3, bull; fair condition, very fat; weight, eighteen kilos.

Ether anesthesia. Tracheal and carotid cannulæ were applied as nearly simultaneously as possible.

Preliminary observation showed the following:

At 11.23, dog 1, blood-pressure, 170 mm.; pulse, 164; respiration, 80; stroke, 10 mm.

Dog 2, blood-pressure, 120 mm.; pulse, 164; respiration, 148; stroke, 4 mm.

Dog 3, blood-pressure, 170 mm.; pulse, 168; respiration, 176; stroke, 12 mm.

At 11.54, the animals were simultaneously reduced to shock by exposing and manipulating the intestines. The femoral vein of each was exposed.

At 12.11, dog 1, blood-pressure, 108 mm.; pulse, 152; respiration, 80; stroke, 10 mm.

At 12.15, the hind paw of each dog was burned, and the following changes were noted.

Dog 1, a rise of 6 mm. in the blood-pressure was followed by a secondary rise of 10 mm.; respiration and pulse were increased and the stroke lengthened. Dog 2, a rise in the blood-pressure of 15 mm. occurred. Both the respiration and pulse were slightly decreased.

Dog 3, a rise of 6 mm. in the blood-pressure occurred.

A

B

C

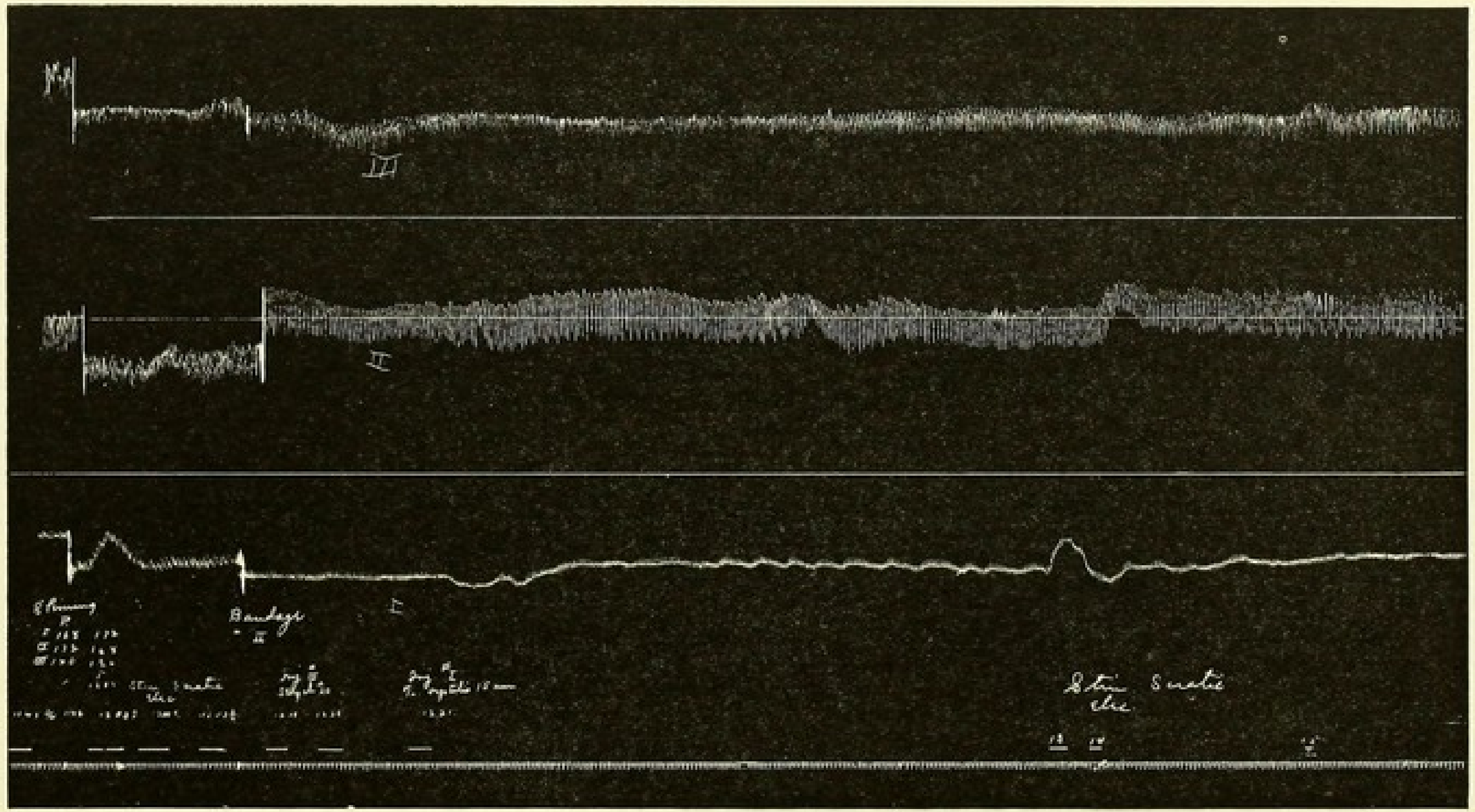


FIG. 19.—EXPS. 111, 112, 113.—Moderate shock. Simultaneous with strychnin, bandaging, and digitalis.

I. *Digitalis.*—Following the injection of 1 c.c. of tincture of digitalis the blood-pressure gradually rose. Note the vasomotor curves later appearing.

II. *Bandaging.*—Note the abrupt rise in the blood-pressure on bandaging the extremities firmly and the abdomen lightly. Note how well the rise was sustained.

III. *Strychnin.*—Note the immediate fall followed by a compensatory rise after the injection of 1.5 mg. of strychnin. The mean blood-pressure after the first effect was unchanged. Contrast the effect of these three means of controlling the blood-pressure.

Dog 1, blood-pressure, 98 mm.; pulse, 164; respiration, 90; stroke, 77 mm.

Dog 2, blood-pressure, 55 mm.; pulse, 176; respiration, 70; stroke, 8 mm.

Dog 3, blood-pressure, 88 mm.; pulse, 152; respiration, 80; stroke, 10 mm.

Dog 1 retained fifty-eight per cent. of its original blood-pressure.

Dog 2 retained forty-six per cent. of its original blood-pressure.

Dog 3 retained fifty per cent. of its original blood-pressure.

During the following ten minutes dog 1 lost 10 mm. in blood-pressure.

Dog 2 lost 8 mm. in blood-pressure.

Dog 3 lost 9 mm. in blood-pressure.

At 12.26, dog 3 was bandaged.

At 12.35, dog 1 was given $^1/_{20}$ grain of strychnin into the femoral vein.

At 12.36, dog 2 was given 35 minims of tincture of digitalis into the femoral vein.

At 12.37.30, the following observations were made:

Dog 1, blood-pressure, 106 mm.; pulse, 160; respiration, 168; stroke, 8 mm. The absolute rise was 8 mm.

Dog 2, blood-pressure, 60 mm.; pulse, 184; respiration, 56; stroke, 5 mm. The absolute rise was 6 mm.

Dog 3, blood-pressure, 110 mm.; pulse, 156; respiration, 48; stroke, 9 mm. The absolute rise was 24 mm.

At 12.48, dog 1, blood-pressure, 107 mm.; stroke, 10 mm.

Dog 2, blood-pressure, 46 mm.; stroke, 6 mm.

Dog 3, blood-pressure, 108 mm.; stroke, 8 mm.

At 12.49, the abdominal viscera were severely manipulated in the order one, two, three.

At 12.50, dog 1, blood-pressure, 72 mm., showing an absolute loss of 25 mm.

Dog 2, blood-pressure, 24 mm., showing an absolute loss of 12 mm.

Dog 3, blood-pressure, 88 mm., showing an absolute loss of 20 mm.; dog 2 showed a marked tendency towards respiratory failure.

At 12.57, the hind paws of each animal were burned, with the results as follows:

Dog 1, blood-pressure, 86 mm.; stroke, 8 mm.

Dog 2, no effect produced.

Dog 3, blood-pressure, 94 mm.

At 12.59, dog 2 died.

At 1.22, dog 1, blood-pressure, 95 mm.; pulse, 50; respiration, 60; stroke, 8 mm.

Dog 3, blood-pressure, 93 mm.; pulse, 46; respiration, 45; stroke, 10 mm.

At 1.31.30, dog 1, blood-pressure, 82 mm.; pulse, 74; respiration, 72; stroke, 8 mm.

Dog 3, blood-pressure, 73 mm.; pulse, 50; respiration, 48; stroke, 9 mm.

At 1.32, dog 1, $^1/_{20}$ grain of strychnin was injected. Convulsions followed.

At 1.38, the intestines were again manipulated.

Dog 1, blood-pressure, 105 mm.

Dog 3, blood-pressure, 90 mm.

At 1.59, dog 1, blood-pressure, 70 mm.

Dog 3, blood-pressure, 50 mm. The bandages were removed. Blood-pressure, 38 mm.

At 2.00, dog 1, the blood-pressure remained constant.

Dog 3, the hind paw was burned. Blood-pressure, 45 mm.; respiration, slow and spasmodic.

At 2.03.30, dog 1, the sciatic nerve was stimulated. Blood-pressure rose to 80 mm.; both the respiration and pulse were quickened.

At 2.07.30, dog 1, blood-pressure, 68 mm.; stroke, 7 mm.

At 2.08.30, dog 1, the intestines were manipulated. Blood-pressure, 52 mm.

At 2.09, dog 3 died.

At 2.10, dog 1, the paw was burned, blood-pressure, 53 mm.

At 2.11, the sciatic was electrically stimulated. A rise of 7 mm. in the blood-pressure was recorded.

At 2.15, manipulation of intestines caused a rise of 3 mm., followed by a fall to the former level.

At 2.30, blood-pressure, 34 mm.

At 2.30.30, dog died.

Experiments 114, 115, 116, 117.

Whiskey, Digitalis, and Bandaging.

Dog 1, young mongrel; splendid condition; weight, fourteen kilos.

Dog 2, mongrel; fair condition; weight, twelve kilos.

Dog 3, mongrel; fair condition; weight, ten kilos.

Dog 4, mongrel; fair condition; weight, fifteen kilos.

All reduced to surgical anesthesia; tracheal and carotid cannulæ were then adjusted.

At 10.59, preliminary observations:

Dog 1, blood-pressure, 125 mm.; pulse, 168; respiration, 20.

Dog 2, blood-pressure, 109 mm.; pulse, 132; respiration, 18.

Dog 3, blood-pressure, 109 mm.; pulse, 136; respiration, 19.

Dog 4, blood-pressure, 95 mm.; pulse, 128; respiration, 122.

At 11.30, dog 4 died.

At 11.38, the intestines, sciatic nerve, and femoral vein of each animal were exposed.

At 11.42, dog 1, blood-pressure, 99 mm.; pulse, 160; stroke, 4 mm.

Dog 2, blood-pressure, 82 mm.; pulse, 168; stroke, 26 mm.

Dog 3, blood-pressure, 103 mm.; pulse, 125; stroke, 14 mm.

At 11.45, electrical stimulation of the sciatic nerve of each animal was made, resulting as follows:

Dog 1, rise in blood-pressure from 108 mm. to 115 mm.

Dog 2, rise in blood-pressure from 84 mm. to 98 mm.

Dog 3, there was no apparent change in the blood-pressure.

At 12.00, dog 1, blood-pressure, 95 mm.

Dog 2, blood-pressure, 65 mm.

Dog 3, blood-pressure, 60 mm.

The sciatic nerve of each animal was electrically stimulated, after which the following observations were made:

Dog 1, blood-pressure, 115 mm.

Dog 2, blood-pressure, 72 mm.

Dog 3, blood-pressure, 68 mm.

At 12.10, dog 2 was bandaged.

At 12.19, dog 1, blood-pressure, 92 mm.

Dog 2, blood-pressure, 100 mm.

Dog 3, blood-pressure, 56 mm.

At 12.19.30, dog 1, 15 minims of tincture of digitalis were injected into the femoral vein.

Dog 3, $^1/_{20}$ grain of strychnin was injected into the femoral vein.

Dog 3, a sustained rise at the time of injection, followed by a fall of the original pressure, occurred.

Dog 1, a gradual and sustained rise of 8 mm. occurred one minute after injection.

At 12.21, dog 1, blood-pressure, 95 mm.; pulse, 44; stroke, 4 mm.

Dog 2, blood-pressure, 90 mm.; pulse, 46; stroke, 24 mm.

Dog 3, blood-pressure, 60 mm.; pulse, 32; stroke, 12 mm.

At 12.23, the sciatics were stimulated.

Dog 1, blood-pressure, 95 mm.

Dog 2, blood-pressure, 98 mm.

Dog 3, blood-pressure, 57 mm.

The blood-pressure remained fairly constant.

At 1.00, dog 1, blood-pressure, 102 mm.; pulse, 168; stroke, 4 mm.

Dog 2, blood-pressure, 97 mm.; pulse, 172; stroke, 22 mm.

Dog 3, blood-pressure, 92 mm.; pulse, 120; stroke, 16 mm.

At 1.19, dog 3, $^1/_{64}$ grain of strychnin was injected. This caused a rise in the blood-pressure of 6 mm. at the time of injection.

At 1.19.30, dog 1, 7 minims of tincture of digitalis were injected, causing a rise at time of injection of 10 mm.

At 1.23, dog 1, blood-pressure, 108 mm.

Dog 2, blood-pressure, 92 mm.

Dog 3, blood-pressure, 44 mm.

At 1.25, the sciatic nerves were stimulated.

At 1.26, dog 1, blood-pressure, 110 mm.; pulse, 176; stroke, 4 mm.

Dog 2, blood-pressure, 90 mm.; pulse, 184; stroke, 22 mm.

Dog 3, blood-pressure, 42 mm.; pulse, 144; stroke, 15 mm.

At 1.29, dog 1, blood-pressure, 110 mm.; pulse, 184; stroke, 10 mm.

Dog 2, blood-pressure, 85 mm.; pulse, 184; stroke, 21 mm.

Dog 3, blood-pressure, 45 mm.; pulse, 124; stroke, 22 mm.

At 2.19, dog 3, $^1/_{30}$ grain of strychnin was injected, causing a rise in the blood-pressure at the time of injection of 5 mm.

At 2.20.30, dog 1, 45 minims of tincture of digitalis were injected. No change occurred in the blood-pressure.

Dog 1, blood-pressure, 110 mm.; pulse, 192.

Dog 2, blood-pressure, 152 mm.

Dog 3, blood-pressure, 46 mm.; pulse, 176.

At 2.28, the sciatic nerve of each animal was stimulated. An abrupt rise and fall in the blood-pressure was recorded.

At 3.22, dog 1, blood-pressure, 116 mm.; pulse, 184.
Dog 2, blood-pressure, 182 mm.; pulse, 160.
Dog 3, blood-pressure, 40 mm.; pulse, 124.

At 3.26, dog 3, $^1/_{64}$ grain of strychnin was injected.
Dog 1, 7 minims of digitalis were injected.

At 3.28, dog 1, blood-pressure, 122 mm.; pulse, 176.
Dog 2, blood-pressure, 82 mm.; pulse, 136.
Dog 3, blood-pressure, 48 mm.; pulse, 120.
Dog 1, in convulsions.

At 3.32, dog 1, blood-pressure, 115 mm.
Dog 2, blood-pressure, 80 mm.
Dog 3, blood-pressure, 86 mm.
The sciatics were stimulated and a rise and fall in the blood-pressure occurred.

At 4.15, dog 1, blood-pressure, 105 mm.; pulse, 176.
Dog 2, blood-pressure, 72 mm.; pulse, 116.
Dog 3, blood-pressure, 26 mm.; pulse, 128.

At 4.16, the sciatics were stimulated.
Dog 1, blood-pressure, 120 mm., falling to 105 mm.
Dog 2, blood-pressure, 78 mm., falling to 72 mm.
Dog 3, no effect.

At 4.21, dog 3 manifested evidence of respiratory failure.

At 4.27, dog 1, blood-pressure, 105 mm.
Dog 2, blood-pressure, 74 mm.

At 4.28, dog 1, 10 minims of tincture of digitalis were injected.
Blood-pressure, 114 mm.; pulse, 148.

At 4.30, dog 3 died of respiratory failure.

At 4.34, the sciatics were stimulated, causing an abrupt rise and fall in the blood-pressure of each animal.

At 4.52, dog 1, blood-pressure, 97 mm.; pulse, 172.
Dog 2, blood-pressure, 70 mm.; pulse, 140.

At 4.53, the sciatics were stimulated. The usual rise and fall followed.

At 5.23, dog 1, blood-pressure, 79 mm.; pulse, 175.
Dog 2, blood-pressure, 63 mm.; pulse, 176.

At 5.27, dog 1, 10 minims of tincture of digitalis were injected The blood-pressure rose 6 mm. and was maintained.

At 5.28, the sciatics were again stimulated, showing active vasomotor functions in each animal.

At 5.43, dog 2 showed evidence of respiratory failure.

At 5.45, dog 2 died.

At 5.47, dog 1, the sciatic was stimulated; the vasomotors were active.

From 5.49 to 6.36, dog 1 received three injections of tincture of digitalis,—10 minims, 15 minims, and 22 minims. Following each injection there was a rise of 8 millimetres. Three stimulations of the sciatics gave results similar to the preceding.

At 5.49, blood-pressure, 78 mm.; pulse, 156.

At 6.36, blood-pressure, 80 mm.; pulse, 184.

From 6.44 to 7.10, 22 minims of tincture of digitalis were injected. A rise of 14 mm. in the blood-pressure occurred.

At 7.10, while stimulating the sciatic nerve, the heart suddenly stopped. Blood-pressure, 58 mm.; respiration continued for two minutes.

At 7.12, the dog died.

Experiments 118, 119, 120, 121.

Strychnin, Digitalis, Whiskey.

Dog 1, male mongrel; good condition; weight, seven kilos.

Dog 2, female mongrel; good condition; weight, forty-five kilos.

Dog 3, male mongrel; good condition; weight, forty-five kilos.

Dog 4, female mongrel; weight, forty-five kilos.

At 12.25, ether anesthesia. Tracheal and carotid cannulæ were adjusted.

Dog 1, blood-pressure, 133 mm.; pulse, 168.

Dog 2, blood-pressure, 118 mm.; pulse, 156.

Dog 3, blood-pressure, 134 mm.; pulse, 172.
Dog 4, blood-pressure, 135 mm.; pulse, 160.
The animals were reduced to shock by exposing the intestines, the sciatic nerve, and the femoral vein.
Dog 4 died.

At 1.34, dog 1, blood-pressure, 112 mm.
Dog 2, blood-pressure, 85 mm.
Dog 3, blood-pressure, 85 mm.

At 1.36, dog 2, an injection of 1/64 grain of strychnin was given. Convulsions appeared almost immediately. A rise of 5 mm., followed by a fall, was noted at the time of injection. After the convulsion a rise of 40 mm. in the blood-pressure occurred.

At 1.48, dog 1, blood-pressure, 90 mm.
Dog 2, blood-pressure, 94 mm.
Dog 3, blood-pressure, 93 mm.

At 1.49, the sciatics were stimulated.

At 1.49.45, dog 1, the blood-pressure rose about 2 mm., falling again and remaining at the former level.
Dog 2, the blood-pressure rose, due to convulsions.
Dog 3, the blood-pressure rose, and then fell, remaining at the former level.
Dog 1, blood-pressure, 88 mm.; pulse, 180.
Dog 2, blood-pressure, 95 mm.; pulse, 160.
Dog 3, blood-pressure, 83 mm.; pulse, 166.

At 1.52.30, dog 1, an injection of 10 minims of digitalis was given. The blood-pressure rose to 96 mm. and was maintained; pulse, 184.

At 2.07, dog 1, blood-pressure, 88 mm.; pulse, 186.
Dog 2, blood-pressure, 72 mm.; pulse, 164.
Dog 3, blood-pressure, 78 mm.; pulse, 112.

At 2.10, the sciatics were stimulated with the following results:
Dog 1, a rise of 2 mm. occurred, followed by a fall.
Dog 2, a fall of 5 mm. was noted.
Dog 3, a rise of 2 mm., followed by a fall of 5 mm.

At 2.43, dog 1, blood-pressure, 58 mm.; pulse, 188.
Dog 2, blood-pressure, 65 mm.; pulse, 172.
Dog 3, blood-pressure, 85 mm.; pulse, 112.

At 2.44.30, dog 1, an injection of 10 minims of tincture of digitalis was made. There occurred a rise of 4 mm., which was maintained; pulse, 184.

At 2.45, dog 2, an injection of $^1/_{12}$ grain of strychnin was given. A fall of 14 mm., followed by a rise to the former level, was observed; pulse, 164.

At 2.48, dog 3, respiratory failure occurred, due to $MgSO_4$ at the time of removing the clot.

At 2.50, dog 1, blood-pressure, 67 mm.

Dog 2, blood-pressure, 60 mm.

At 2.51, the sciatics were stimulated with results as follows:

Dog 1, a rise of 1 mm. occurred, followed by a fall to the former level.

Dog 2, a rise of 1 mm. occurred, followed by a fall to the former level; pulse, 168.

At 3.05, dog 1 died from respiratory and heart failure.

At 3.08, dog 2, repeated convulsions occurred.

At 3.27, dog 2 died.

Experiments 122, 123, 124, 125.

Strychnin, Digitalis, Whiskey, and Bandaging.

Dog 1, male; good condition; weight, eleven kilos.

Dog 2, male mongrel; poor condition; weight eight kilos.

Dog 3, female spaniel; poor condition; weight, eight kilos.

Dog 4, female spaniel; poor condition; weight, eight kilos.

Ether anesthesia; tracheal and carotid cannulæ.

At 11.55, dog 1, blood-pressure, 145 mm.; stroke, 8 mm.; pulse, 148.

Dog 2, blood-pressure, 98 mm.; stroke, 9 mm; pulse, 108.

Dog 3, blood-pressure, 134 mm.; stroke, 8 mm.; pulse, 180.

Dog 4, blood-pressure, 90 mm.; pulse, 180.

At 12.36.30, dog 4, $^1/_{64}$ grain of strychnin was injected; respiration was very poor. Convulsions occurred shortly after injection.

At 12.37, dog 1 was given an injection of 10 minims of tincture of digitalis. A gradual rise in the blood-pressure from 95 to 118 mm. followed and was maintained. The stroke at first increased from 4 to 5 mm., then decreased to 4 mm. The pulse increased from 212 to 220.

At 12.38, dog 2 was injected with 22 minims of whiskey into the femoral veins. A gradual rise in the blood-pressure occurred from 104 to 112 mm. The stroke increased from 7 to 8 mm., and the pulse decreased from 128 to 124.

At 12.44, dog 3 was bandaged. A rise in the blood-pressure from 128 to 133 was recorded; pulse, 180; stroke, 5 to 14 mm.

Dog 1, pulse, 212.

Dog 2, pulse, 140.

Dog 3, pulse, 128.

Dog 4, pulse, 180.

At 1.01, the sciatic nerve was mechanically stimulated.

Dog 1, the blood-pressure rose from 88 to 100 mm.

Dog 2, the blood-pressure rose from 108 to 112 mm.

Dog 3, the blood-pressure rose from 125 to 140 mm.

Dog 4, the blood-pressure rose from 125 to 140 mm.

Dogs 1 and 3 responded with an abrupt rise in the blood-pressure, followed by a sudden fall.

Dog 1, the fall was slow.

Dog 3, the blood-pressure returned to its former level.

Dog 2 responded with a slight rise in the blood-pressure, followed by a fall of 5 mm. below the former level.

Dog 1, pulse, 188.

Dog 2, pulse, 148.

Dog 3, pulse, 180.

At 1.35, dog 2, blood-pressure, 113 mm.; stroke, 7 mm.
Dog 3, blood-pressure, 140 mm.; stroke, 2 mm.; long respiratory waves.

At 1.36, the sciatic nerves were mechanically stimulated.
Dog 1, blood-pressure, 76 mm.; stroke, 5 mm.
Dog 2, blood-pressure, 124 mm.; stroke, 8 mm.
Dog 3, blood-pressure, 142 mm.; stroke, 2.5 mm.

At 1.39, dog 1 was injected with 10 minims of tincture of digitalis into the femoral vein. A fall in the blood-pressure from 58 to 56 mm. was recorded. The stroke increased from 4 to 6 mm.

Dog 2 was injected with 22 minims of whiskey into the femoral vein. The blood-pressure rose from 60 to 76 mm., and the stroke increased from 6 to 7.5 mm.

From 1.47 to 1.48, the sciatic nerve was mechanically stimulated. In dog 1 the blood-pressure rose from 60 to 72 mm.; the stroke increased from 4 to 5 mm.

In dog 2 the blood-pressure rose from 64 to 78 mm.; stroke, 67 mm.

In dog 3 the blood-pressure rose from 124 to 125 mm.

Dog 1 was injected with 10 minims of tincture of digitalis into the femoral vein. The blood-pressure increased from 58 to 66 mm.; stroke, 4 to 5 mm.

Dog 2 was injected with 50 minims of whiskey into the femoral vein; a rise in the blood-pressure from 109 to 111 mm. followed; stroke, 9 mm.

From 3.21 to 3.22, the sciatic nerves were mechanically stimulated.

At 3.22, dog 1, the blood-pressure rose from 67 to 80 mm.; stroke from 5 to 6 mm.

Dog 2, the blood-pressure rose from 58 to 67 mm.; the stroke fell from 8 to 7 mm.

Dog 3, no change occurred in the blood-pressure.

At 3.38, dog 1, blood-pressure, 68 mm.; stroke, 4 mm.
Dog 2, blood-pressure, 111 mm.; stroke, 8 mm.
Dog 3, blood-pressure, 117 mm.; stroke, 5 mm.

At 3.43, the sciatic nerves were stimulated.
The following was noted:
Dog 1, the blood-pressure rose from 67 to 78 mm.; stroke, 4 to 8 mm.
Dog 2, the blood-pressure rose from 111 to 123 mm.; stroke, 8 mm.
Dog 3, blood-pressure, 117 mm.

At 4.03, 10 minims of whiskey were given intravenously. A rise in the blood-pressure from 108 to 120 mm. was noted. The stroke registered 7 mm., then fell to 6 mm.

At 4.41, dog 1 was given 10 minims of tincture of digitalis intravenously. A rise in the blood-pressure from 55 to 67 mm. followed; stroke, 7 mm.
Dog 2 was given 22 minims of whiskey intravenously. A rise in the blood-pressure of 2 mm. followed; stroke, 7 mm.

At 4.48, the animals were killed by $MgSO_4$ solution.

Experiment 126.

Is the Cardio-inhibitory Centre exhausted in Shock?

Dog; male; good condition; weight, nine kilos.

At 9.48, blood-pressure, 130 mm.; stroke, 8 mm.; pulse, 180. The animal was reduced to shock.

At 10.34, blood-pressure, 30 mm.; stroke, 10 mm.; pulse, 120. Electrical stimulation of the sciatic nerve produced a slight rise in the blood-pressure.

At 10.36.30, an infusion of adrenalin, 1 to 200,000, was begun, the rate of flow being ½ ounce per minute. A slight rise in the blood-pressure followed. The blood-pressure rose to 110 mm.; mechanical stimulation of the laryngeal mucosa produced a reflex inhibition of the heart. The blood-pressure dropped to 40 mm., after which the heart beat slowly and the blood-pressure gradually rose to 90 mm.; later the blood-pressure fell. The animal was then killed.

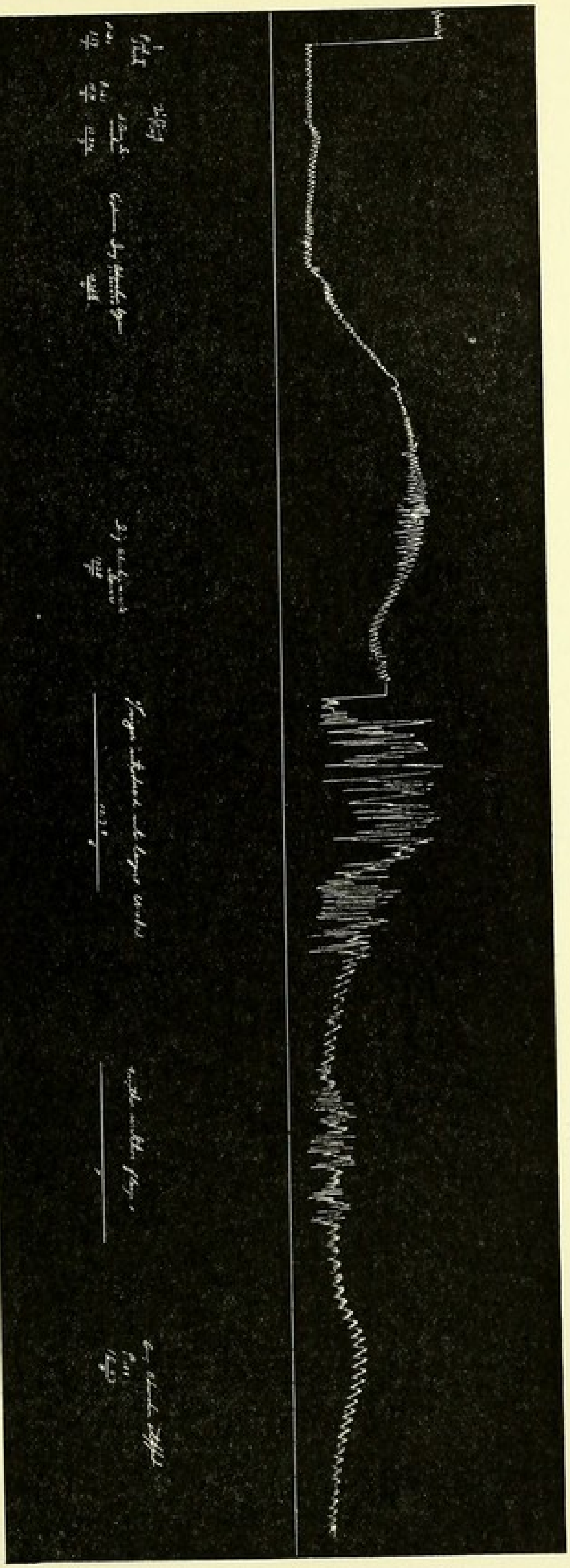


FIG. 20.—EXP. 126.—Profound shock. The vasomotor centre showed no response to stimulation. It was exhausted. The blood-pressure was raised to about the normal level by means of a continuous infusion of a solution of 1 to 200,000 adrenalin. On introducing the finger into the larynx and making mechanical irritation a striking reflex inhibition was produced. This demonstrates the incorrectness of the theory that the vagal centre is exhausted in shock.

Experiment 127.

Digitalis, Atropin.

Dog; male; weight, twenty-six kilos.

At 11.24, there was injected $^1/_{120}$ grain of atropin into the jugular vein; pulse, 132; respiration, 64.

At 12.03, both accelerantes were severed.

At 12.04, blood-pressure, 124 mm.; pulse, 172.

At 12.05, both vagi were severed; blood-pressure, 120 mm.; pulse, 148. On burning the hind foot the blood-pressure rose 6 mm. Repetition of the burning, exposure, and manipulation of the intestines were followed by a progressive fall in the blood-pressure, the dog passing into deep shock. After the blood-pressure had fallen to 30 mm. electrical stimulation of the sciatic nerve produced no rise in the blood-pressure. The animal was then killed.

Experiment 128.

Does an Increase in the Heart-Beat cause a Rise in the Blood-Pressure? Shock induced in an Animal in which the Nerve Connection of the Heart is severed.

Dog; male; weight, fifteen kilos. Morphin and ether anesthesia.

Preliminary blood-pressure, 150 mm.; pulse, 140. On severing the right vagus the blood-pressure rose 20 mm., followed by a compensatory fall. On severing the opposite vagus another rise occurred. On severing both accelerantes the blood-pressure fell.

After both vagi and accelerantes had been severed, burning the feet and electrical stimulation of the sciatic nerve caused a rise in the blood-pressure. Exposing and manipulating the intestines, skinning the dog, etc., caused a decline in the blood-pressure, the animal passing into deep shock.

Experiment 129.

Shock produced in an Animal whose Nerve-Supply has been cut off. On the Effect of Severing the Vagi and Accelerantes.

Dog, male; weight, fifteen kilos. Morphin and ether anesthesia.

Preliminary blood-pressure, 144 mm.; pulse, 152.

On burning the hind foot the blood-pressure rose to 200 mm.; pulse, 206 mm.

On severing both vagi simultaneously the blood-pressure rose 5 mm.; the pulse increased 14.

On severing both accelerantes the blood-pressure fell 30 mm.; the pulse, 6 mm.

The animal was reduced to surgical shock by burning, skinning, and crushing. The animal was then killed.

Experiment 130.

Repetition of Experiment 129.

Dog; young female mongrel; weight, eleven kilos. Morphin and ether anesthesia.

Preliminary blood-pressure, 115 mm.; pulse, 168.

On severing the vagi the blood-pressure rose to 120 mm.; pulse, 136.

After severing both accelerantes the blood-pressure registered 140 mm.; then fell to 115 mm.; pulse, 116.

On burning the paw and stimulating the sciatic nerve, the blood-pressure rose. Mechanical stimulation of the sciatic nerve was followed by a rise in the blood-pressure, but no change in the pulse. The animal was reduced to shock and then killed.

Experiment 131.

Repetition of the Preceding.

Dog; male; weight, sixteen kilos. Morphin and ether anesthesia.

Blood-pressure, 106 mm.; pulse, 140. On severing the right vagus the blood-pressure rose to 130 mm.; pulse to 140 mm.

On severing the right accelerantes the blood-pressure recorded 80 mm.; pulse, 128.

On severing the left accelerantes the blood-pressure recorded 80 mm.; pulse, 110.

Burning the hind foot was followed by a rise in the blood-pressure.

Skinning the abdomen was followed by a fall to 45 mm. in the blood-pressure. Exposing and manipulating the intestines and crushing the feet produced a fall in the blood-pressure which continued until the animal died of shock.

Experiment 132.

Shock, Curare, Vagi severed.

Mongrel dog; fair condition; weight, eleven kilos. Ether anesthesia.

At 9.05, initial blood-pressure, 135 mm.; pulse, 180. The animal was reduced to shock by skinning and sponging the denuded surface.

At 9.50, blood-pressure, 80 mm.; pulse, 164.

At 10.06, 50 minims of a .5 per cent. solution of curare were injected into the femoral vein. This produced a fall in the blood-pressure, followed by a rise to the former level. Artificial respiration was now supplied.

At 10.09, blood-pressure, 100 mm.; pulse, 142.

At 10.10, both vagi were severed; a momentary inhibition of the heart was noted, followed by a gradual rise in the blood-pressure.

At 10.13, blood-pressure, 150 mm.; pulse, 160.
At 10.50, neither the blood-pressure nor the pulse showed variations.
At 11.00, the animal was killed.

Experiment 133.

Vagi severed.

Male mongrel; fair condition; weight, thirteen kilos.
Ether anesthesia.
Initial blood-pressure, 140 mm.; pulse, 150.
An injection of 1 dram of a .5 per cent. solution of curare was given intravenously, artificial respiration being supplied.
Blood-pressure, 140 mm.; pulse, 150; both vagi were severed.
Blood-pressure, 150 mm.; pulse, 160.
The blood-pressure and pulse remained constant. For a short time there was a gradual rise to 155 mm., then a fall to 150 mm., at which height it remained for thirty minutes. The animal was then killed with $MgSO_4$.

Experiment 134.

Vagi severed, Curare, Adrenalin.

Mongrel male; good condition; weight, eleven kilos.
Ether anesthesia.
Two drams of a .5 per cent. solution of curare were injected into the femoral vein.
Blood-pressure, 125 mm.; pulse, 135.
Artificial respiration was supplied.
Both vagi were then severed.
Blood-pressure, 134 mm.; pulse, 147.
The rise in the blood-pressure was not sustained, and fell to 125 mm.
An injection of adrenalin, 1 to 1000, was followed by a rise in the blood-pressure to 210 mm.; pulse, very rapid.

This blood-pressure was maintained for one minute, after which it fell to 120 mm.; pulse, 160.
The animal was then killed by $MgSO_4$.

Experiment 135.

Vagi severed, Curare, Adrenalin.

Male mongrel; good condition; weight, nine kilos. Ether anesthesia.
An injection of 1 dram of a .5 per cent. solution of curare was given into the femoral vein. Artificial respiration was supplied.
Blood-pressure, 125 mm.; pulse, 150. The animal was skinned and the denuded surface sponged. Blood-pressure, 30 mm.; pulse, 112. Both vagi were severed.
Blood-pressure, 28 mm.; pulse, 125. The character of the stroke prior to severing the vagi was respiratory. After severing the vagi, the stroke was slightly modified by respiration.
Blood-pressure, 28 mm.; pulse, 125 to 130, which was maintained for twenty minutes.
An injection of 7.5 minims of 1 to 1000 adrenalin was given intravenously. This was followed by a sharp rise in the blood-pressure to 225 mm. This height was maintained for two minutes. The pulse became slow and the stroke was greatly increased in length. Atropin in $^1/_{120}$ grain doses decreased the length of the stroke to 12 mm. The blood-pressure rapidly fell to 25 mm.; pulse, 120. Repeating the above injection of adrenalin, a similar result was observed, the length of the strokes being controlled by atropin. The blood-pressure gradually fell to 25 mm.; pulse, 196. The animal was killed. Duration of experiment, three hours and forty minutes.

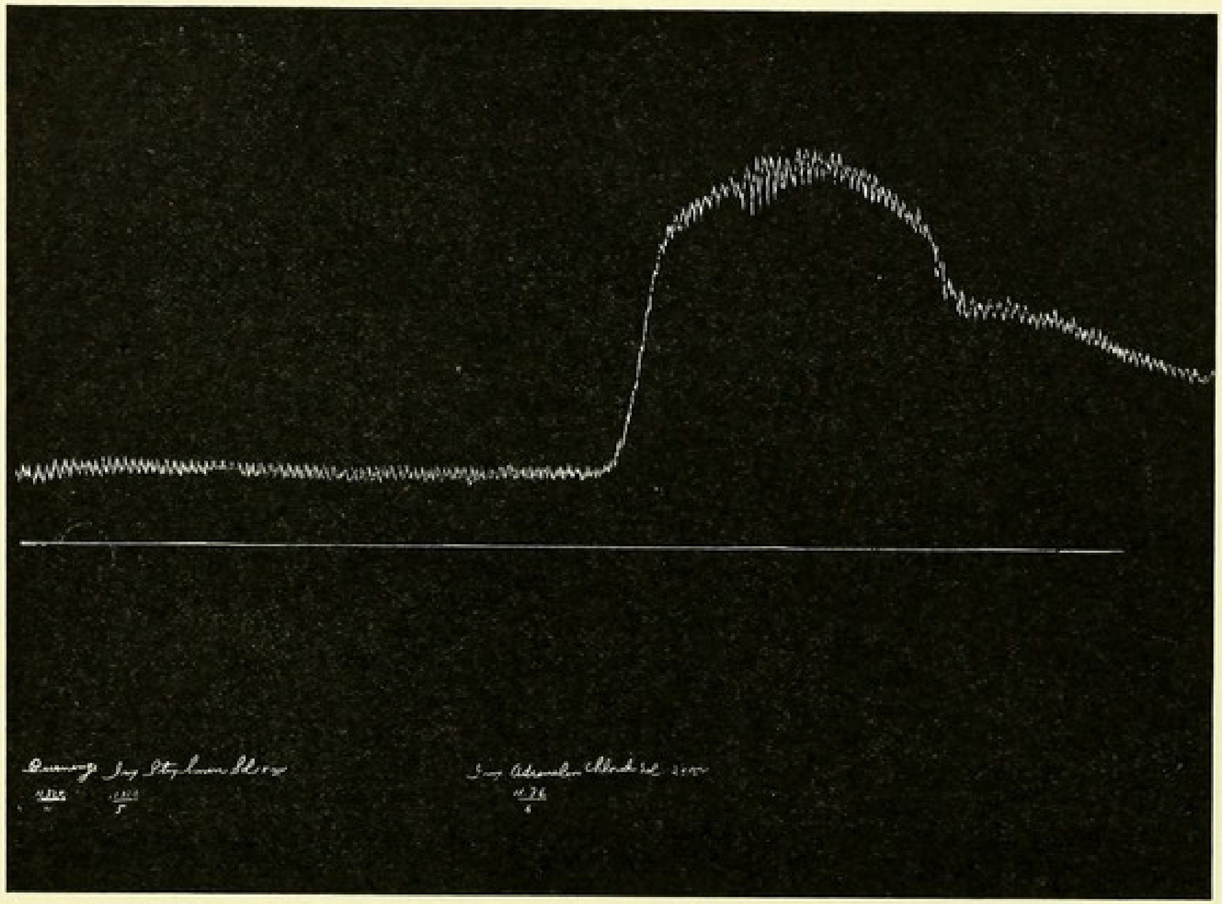


FIG. 21.—EXP. 135.—On the effect of adrenalin in profound shock. Burning the paw, electrical stimulation of the sciatic, and large doses of strychnin produced no change in the blood-pressure. Note the abrupt rise in the blood-pressure on injecting adrenalin chlorid. The pressure rose to 250 mm., almost twice as high as the normal. The heart performed its increased work in a normal manner. This furnishes almost conclusive proof that in shock the heart and the periphery are quite unaffected and the vasomotor mechanism is exhausted.

Experiment 136.

Cord and Vagi severed.

Mongrel female; good condition; weight, seventeen kilos. Ether anesthesia.

Blood-pressure, 120 mm.; stroke, 10 mm.; pulse, 136. The cord was severed on a level with the second cervical vertebra. Artificial respiration was supplied.

Blood-pressure, 70 mm.; stroke, 18 mm.; pulse, 134. Both vagi were severed.

Blood-pressure fell to 60 mm.; pulse, 106.

Thirty minims of tincture of digitalis were injected into the jugular vein.

A rise in the blood-pressure to 110 mm. occurred; pulse, 96. A gradual fall soon followed; pulse, 88; no change in the length of strokes.

The injection was repeated. The blood-pressure rose to 75 mm., but was not sustained. The pulse varied from 82 to 86. The strokes increased in length to 20 mm.

The injection of 15 minims of adrenalin into the femoral vein was followed by a sharp rise in the blood-pressure to 150 mm.; stroke, 8 mm.; pulse, 130.

A repetition of the injection of adrenalin produced a similar result.

The animal was killed. Duration of experiment, one hour and twenty minutes.

Experiment 137.

Decapitation.

Female mongrel; fine condition; weight, seventeen kilos. Ether anesthesia.

Normal blood-pressure, 132 mm.

The animal was decapitated, the blood-pressure falling to 40 mm. Artificial respiration was maintained, and a continuous infusion from 1 to 500,000 adrenalin in normal saline solution was made into the femoral vein. A considerable amount of blood was lost during the dissection.

The blood-pressure remained at 60 mm., but responded in proportion to the rate of flow. Prior to adjusting the rate of flow the blood-pressure rose to 200 mm. This was one hour and thirty minutes after the animal was decapitated. Intravenous injections of strychnin and digitalis produced no result. The animal was killed, the blood-pressure recording 45 mm.

Duration of experiment, two hours and thirty minutes.

Experiment 138.

Decapitation.

Mongrel male; weight, nine kilos. Ether anesthesia. Initial blood-pressure, 125 mm.

At 10.02, the animal was decapitated by a bloodless dissection. Blood-pressure, 35 mm. Artificial respiration supplied.

At 10.22, a continuous injection of 1 to 1000 adrenalin in normal saline solution was begun. The blood-pressure varied from 40 to 200 mm., which was proportionate to the rate of flow of the solution. Hot-water bottles were placed about the animal. There were occasional twitchings of the forelegs and three apparently normal defecations.

At 7.30, the heart began to show a slight degree of arrhythmia.

At 7.45, the blood-pressure reacted sluggishly to the solution. Symptoms were progressive. The heart was very arrhythmic, and the blood-pressure did not respond to adrenalin.

At 8.30, the animal died.

Autopsy.—The tissues were anemic. Free fluid, of a fecal odor, was in the abdominal cavity. The intestines

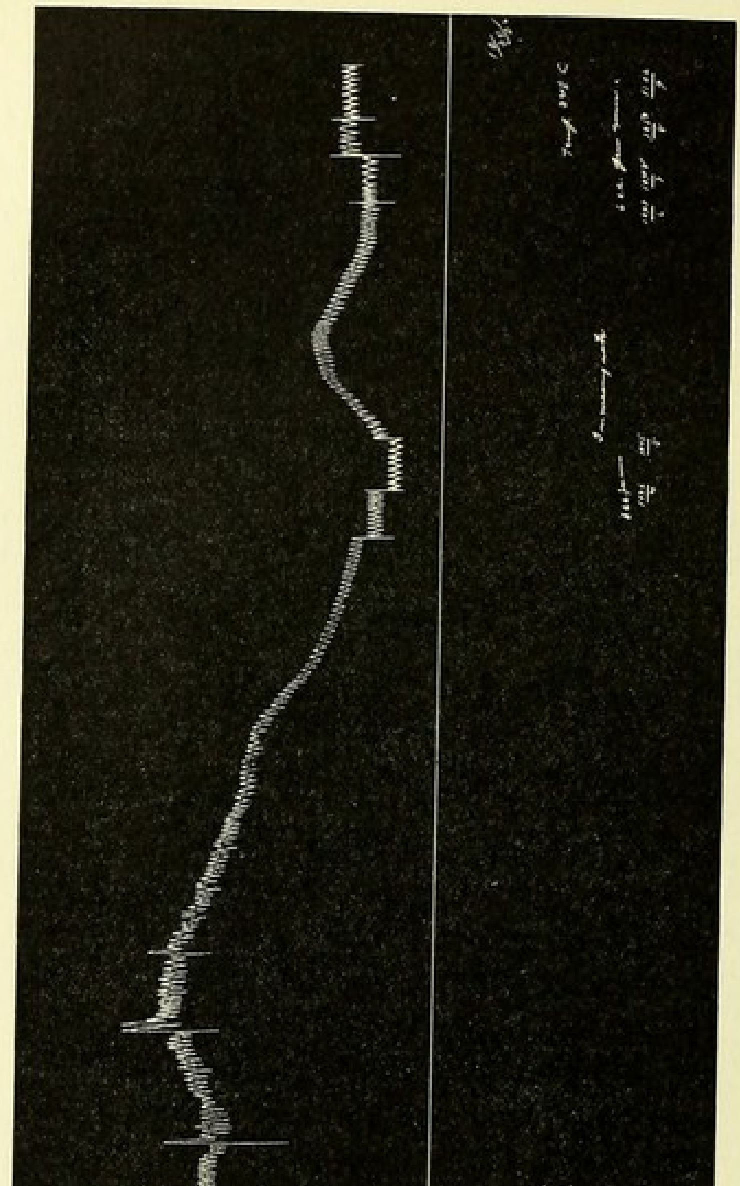


FIG. 22.—EXP. 138.—Normal animal decapitated, after which the animal was kept alive (?) for ten and one-half hours. Note the marked fall in the blood-pressure when decapitation was made. By altering the rate of intravenous injection of the solution of adrenalin the blood-pressure could be controlled at will. The pressure was raised even higher than the normal. The circulation was maintained ten and one-half hours by continuous administration of the adrenalin solution.

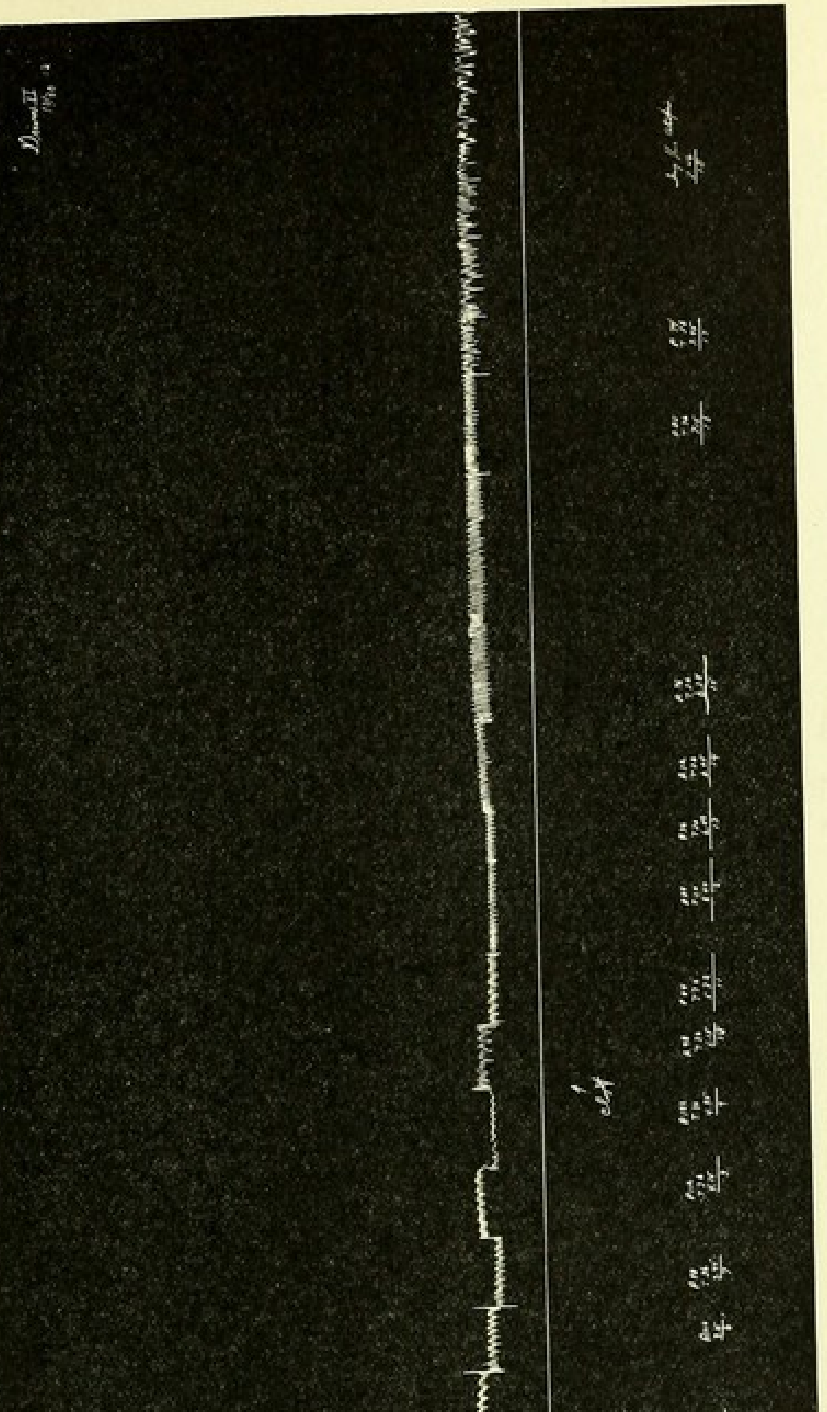


FIG. 23.—EXP. 138 (continued).—Note the vasomotor curves. The blood-pressure was maintained at a moderately low level by a continuous infusion of adrenalin in 1 to 100,000 dilution in salt solution at a rate of 3 c.c. per minute. Animal finally died of air emboli.

were moderately distended with fluid and were very pale. The mesenteric vessels were filled with air emboli. The stomach contained a small amount of fluid. The liver was pale and the vessels contained air emboli. The kidneys were anemic and the capsule was elevated by fluid. The spleen was pale, and the vessels were filled with air emboli. The lungs were also pale and edematous. The heart was pale and there was free fluid in the pericardium. The cardiac vessels were filled with emboli. The spinal chord was edematous, and its vessels contained emboli. The total amount of normal saline solution injected was 1125 c.c.

Experiment 139.

Decapitation.

Mongrel male; good condition; weight, nine kilos. Ether anesthesia.

Initial blood-pressure recorded 125 mm.

The animal was decapitated by bloodless dissection.

Artificial respiration was supplied.

The blood-pressure fell to 30 mm.

A continuous injection of a 1 to 500,000 infusion of adrenalin into the femoral veins was begun.

The blood-pressure reacted in proportion to the rate of flow of the solution.

The animal died, and at autopsy the vessels were found to contain air emboli.

Duration of experiment, three hours and forty minutes.

Experiment 140.

Decapitation.

Mongrel male; good condition; weight, eight kilos. Deep anesthesia.

Initial blood-pressure, 130 mm.

The animal was decapitated by bloodless dissection.

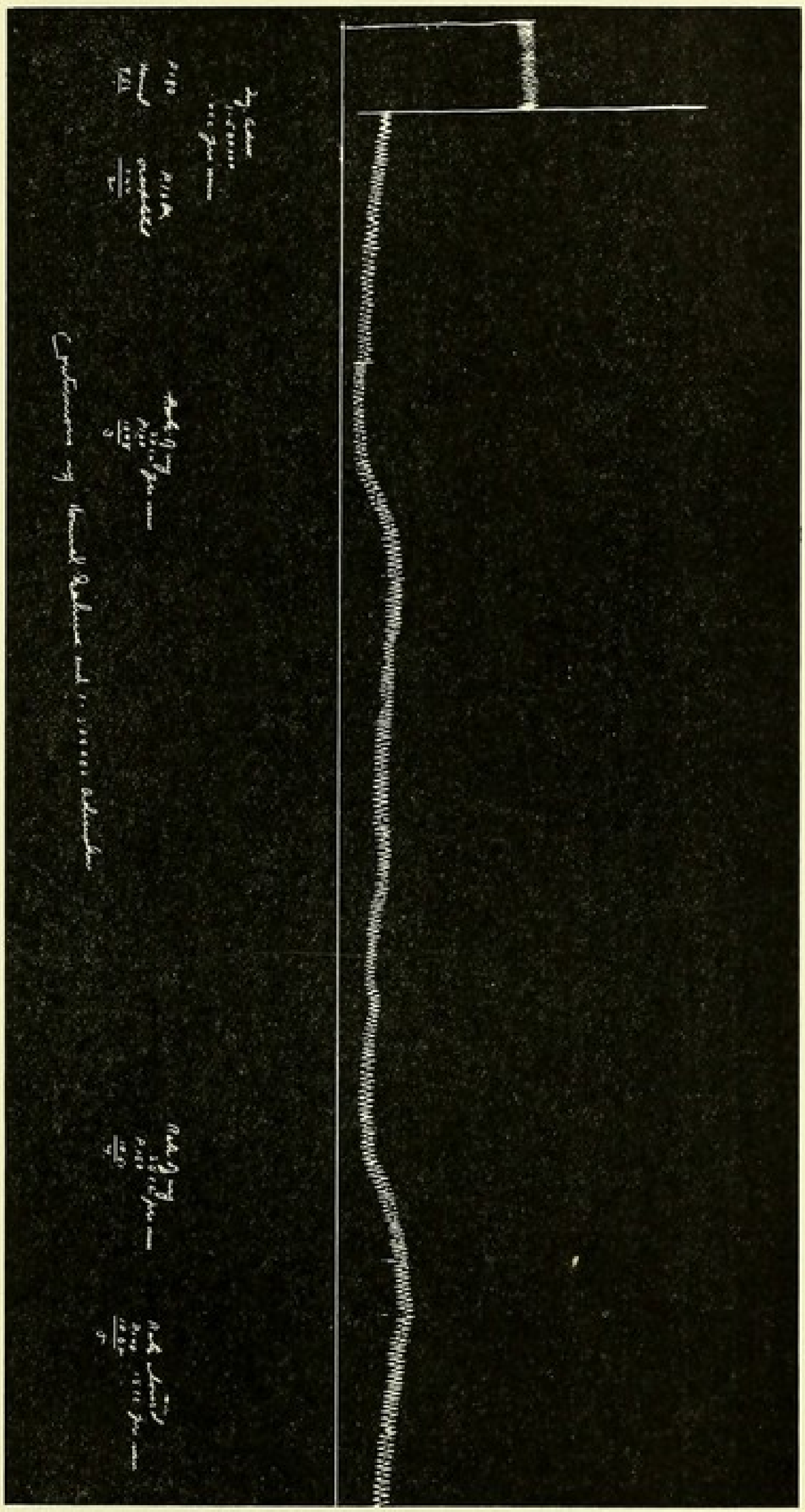


FIG. 24.—EXP. 139.—Note the normal blood-pressure recorded on the extreme left. On decapitating the animal the blood-pressure fell to approximately the same level as in extreme shock. An infusion of 1 to 500,000 of adrenalin in salt solution was continuously administered. The blood-pressure varied with the variations in the rate of administration of the solution of adrenalin.

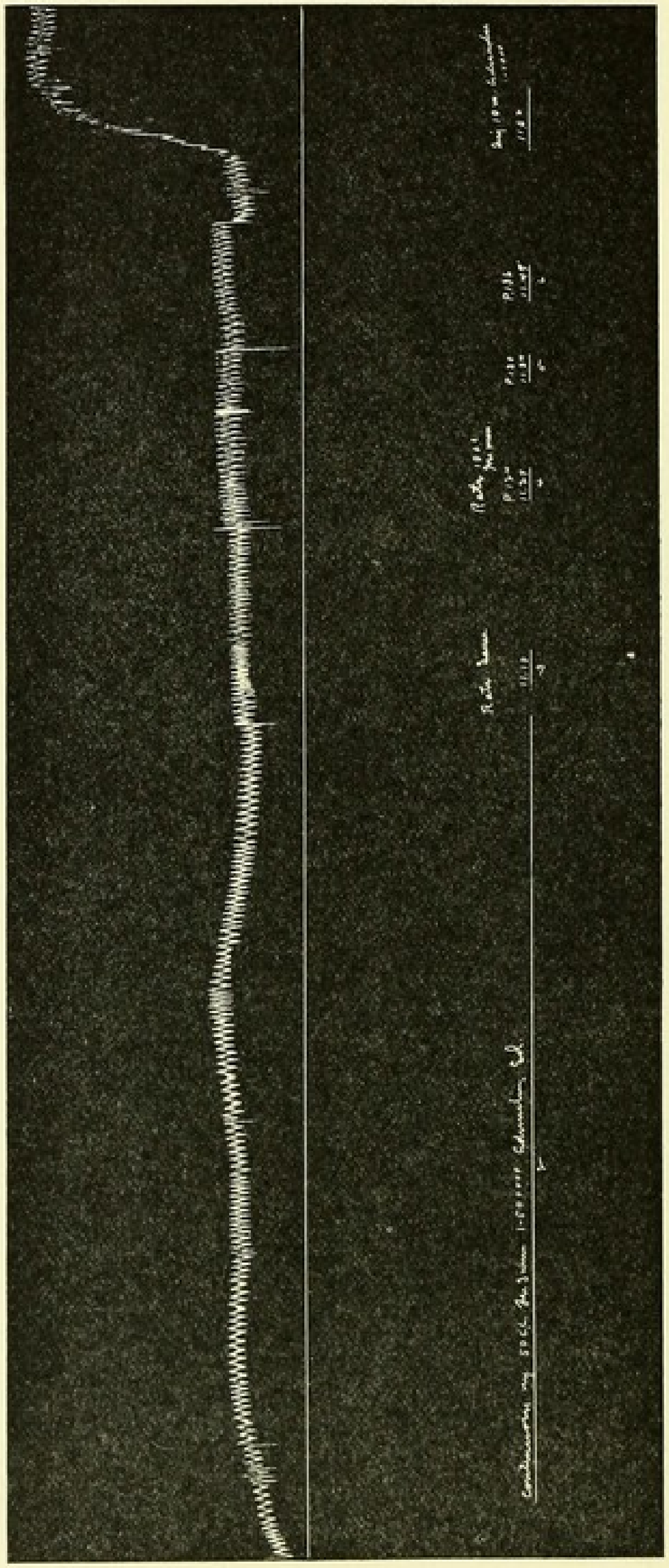


FIG. 25.—EXP. 139 (continued).—Note the marked rise in the blood-pressure in administering adrenalin.

Artificial respiration was supplied.

A continuous injection of a solution of adrenalin into the femoral veins was begun. The blood-pressure was proportionate to the rate of flow, which was such that the blood-pressure was maintained at 60 mm.

After four hours and ten minutes the dog died.

Experiment 141.

Decapitation.

Mongrel male; good condition; weight, nine kilos.

Ether anesthesia.

Initial blood-pressure, 125 mm.

The animal was decapitated by bloodless dissection, artificial respiration being supplied.

The blood-pressure fell to 40 mm.

A continuous injection of 1 to 100,000 infusion of adrenalin in the femoral vein was begun. The blood-pressure was maintained at 70 mm. During the time prior to accurate adjustment of the rate of flow the blood-pressure alternately rose and fell, having a maximum height of 200 mm. and a minimum fall to 40 mm.

The animal died.

Autopsy.—The vessels were found to contain air emboli.

Duration of experiment, two hours and twenty minutes.

Experiment 142.

Decapitation.

Mongrel female; good condition; weight, fifteen kilos.

Initial blood-pressure, 135 mm.

The technique employed in this experiment was the same as that in the previous experiment.

The results obtained agree in every particular with the previous decapitation experiment.

Death was due to air emboli.
Duration of experiment, six hours and fifteen minutes.

Experiment 143.

Cocainizing the Medulla.

Mongrel dog; weight, eleven kilos. Ether anesthesia.
Initial blood-pressure recorded 115 mm.
The triangular space at the base of the skull was exposed at the membrane punctured with a hypodermic needle.
An injection of 22 minims of a two per cent. solution of cocain was made. Withdrawing the needle caused some cerebrospinal fluid to escape. Immediately following the injection the blood-pressure fell to 50 mm. and respiration ceased. Artificial respiration was supplied.
Burning the paw and electrically stimulating the sciatic nerve produced no effect upon the blood-pressure. No change occurred when the finger was introduced into the larynx or when the box of the larynx was crushed.
The blood-pressure soon rose to 65 mm. When $^1/_{40}$ grain of strychnin was injected into the femoral vein, stiffening of the muscles ensued and a slight convulsion, two minutes' duration, occurred. There was no change in the blood-pressure. Following the injection of 22 minims of adrenalin the blood-pressure rose to 250 mm. and was sustained nearly two minutes; subsequent injections produced similar changes. The animal was killed by asphyxia.

A

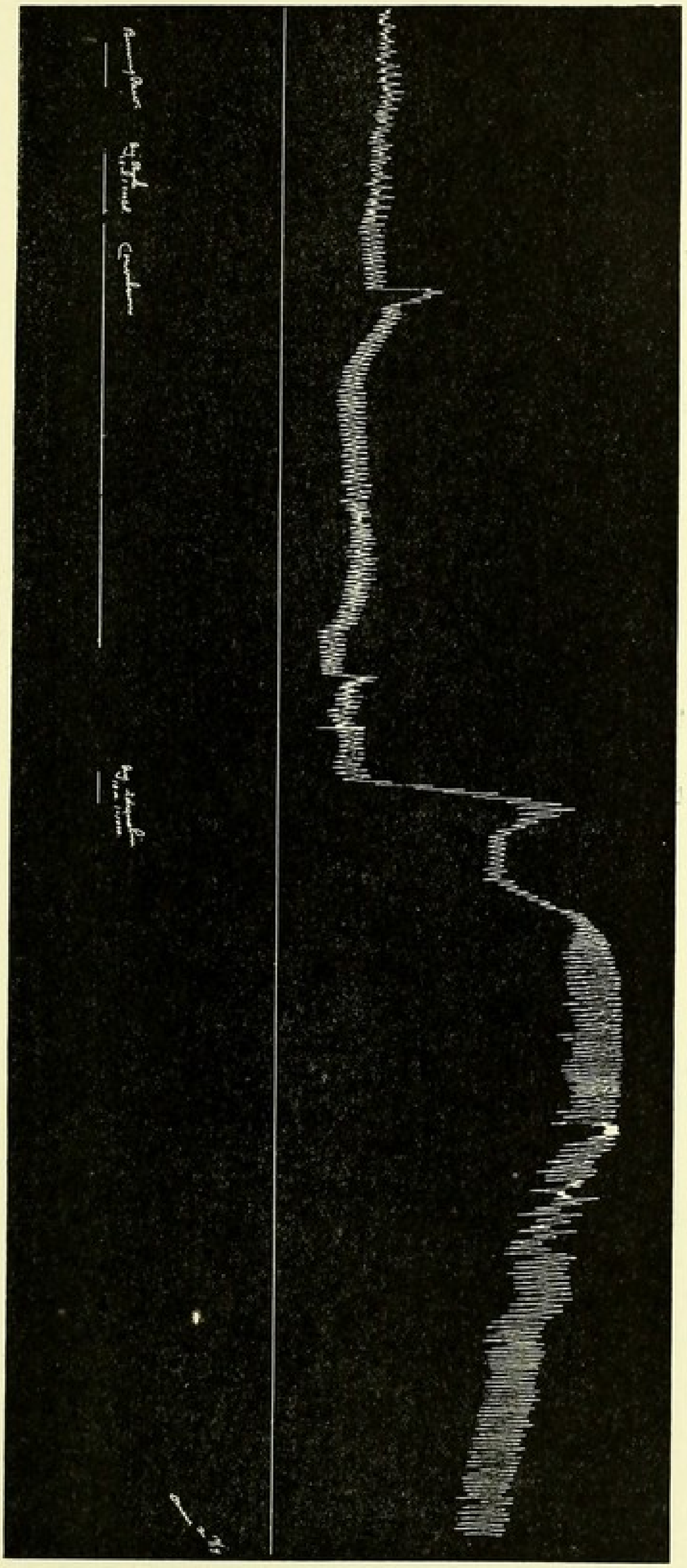


FIG. 26.—EXP. 143.—*A*, arterial pressure. The vasomotor centre in a normal animal was cocainized, causing a fall in blood-pressure corresponding to profound shock. Four mg. ($\frac{1}{16}$ gr.) of strychnin was intravenously given. There was no change in the blood-pressure excepting a transitory rise followed by an equal fall during active convulsions. This change in pressure was probably purely mechanical. Note the marked rise—higher than the normal—following the injection of .75 c.c. of adrenalin.

Experiment 144.

Cocainizing the Medulla.

Male hound; good condition; weight, fifteen kilos. Ether anesthesia.

At 9.30, initial blood-pressure, 130 mm.

At 10.00, the medulla was exposed. No change occurred in the blood-pressure. A considerable amount of cerebrospinal fluid escaped.

At 10.02, 22 minims of a two per cent. solution of cocain were dropped upon the exposed medulla. The blood-pressure immediately fell to 70 mm.

Another application of 22 minims of a two per cent. solution of cocain was made. Complete paralysis followed. Artificial respiration was supplied. The blood-pressure momentarily rose, then fell to the former level.

At 10.04, the right paw was burned. No change occurred in the blood-pressure.

At 10.06, the left sciatic was electrically stimulated. No change was noted.

Blood-pressure, 55 mm. The integument was removed. The blood-pressure fell slightly.

The intestines were exposed and manipulated, after which there occurred a gradual fall in the blood-pressure.

At 10.17, blood-pressure, 35 mm.

At 10.45, blood-pressure, 32 mm. Burning the paw produced no change.

At 11.10, blood-pressure, 30 mm.

At 11.32, blood-pressure, 30 mm. The sciatic nerve was stimulated, causing no alteration in the blood-pressure.

At 11.50, $^1/_{30}$ grain of strychnin was injected.

At 11.51, tetanic contractions occurred; the blood-pressure rapidly fell to 30 mm. where it continued unchanged. During this later period there were many convulsions,

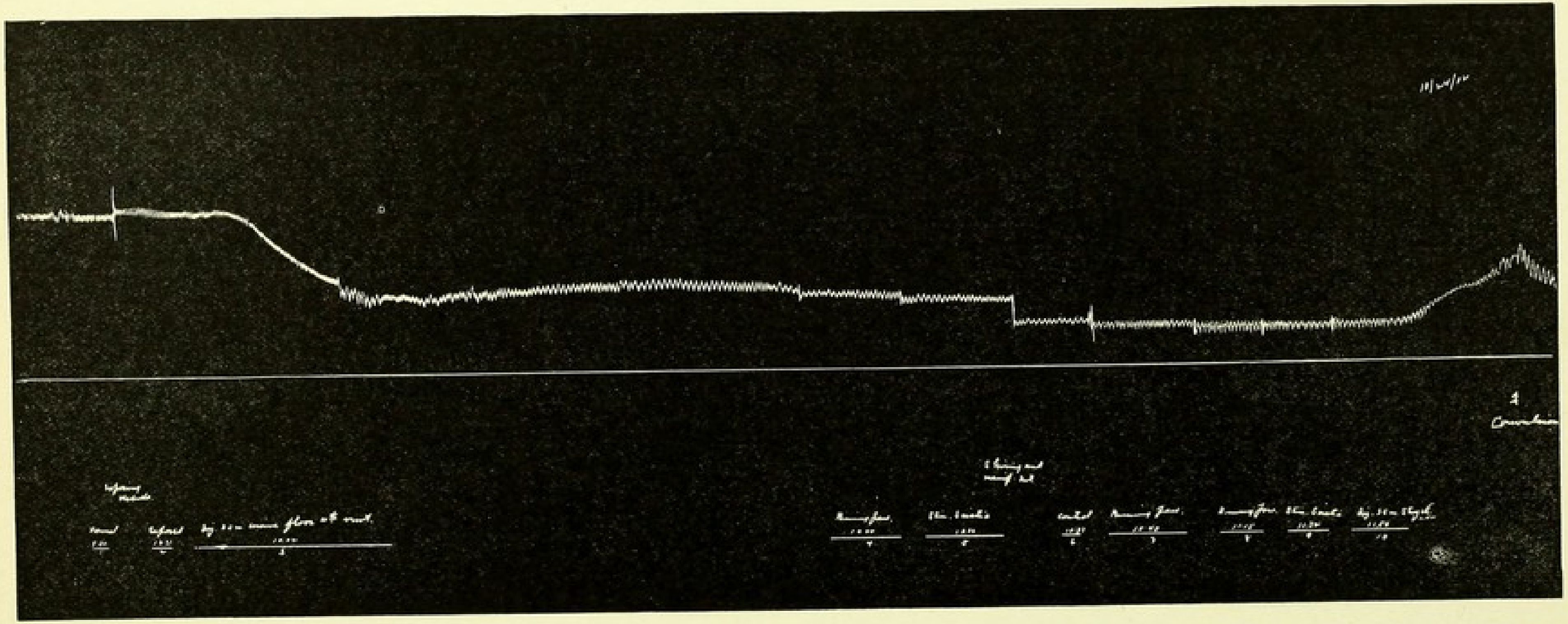


FIG. 27.—EXP. 144.—Note the marked fall in the blood-pressure following the application of a two per cent. solution of cocaine upon the floor of the fourth ventricle and the medulla. Total sensory paralysis as well as motor paralysis followed. Burning the paw, cutting the soft parts, and stimulating the sciatic caused no change in the blood-pressure. On injecting strychnin, convulsions followed and the blood-pressure rose. This effect was presumably largely due to the stimulation of the spinal cord, suggesting that the minor centres in the cord may also be exhausted in shock, since the administration of strychnin when shock is complete does not cause any rise in the blood-pressure.

but the blood-pressure remained unchanged. The animal was killed. The blood-pressure recorded 30 mm.

Experiment 145.

Cord and Medulla cocainized.

Male dog; good condition; weight, eleven kilos. Ether anesthesia.

The medulla was bloodlessly exposed as in the previous experiment. The cord was bloodlessly exposed on a level with the fourth lumbar vertebra. The carotid cannula was adjusted.

At 11.52, blood-pressure, 105 mm. The animal was elevated, allowing the cerebrospinal fluid to escape from the wound, thus facilitating cocainization of the cord.

At 11.55, 22 minims of a two per cent. solution of cocain were injected into the subarachnoid space, the animal being inclined feet downward. The injection was repeated, the animal being placed on the right side.

Fifteen minims were dropped upon the medulla. The application of cocain was followed by a sharp fall in the blood-pressure, to 45 mm.

At 11.58, a gradual rise in the blood-pressure began.

At 11.59.30, burning the paw produced no change.

At 12.00, electrical stimulation of the sciatic nerve caused no change.

At 12.01, $^1/_{12}$ grain of strychnin was injected into the femoral vein. The blood-pressure was unchanged.

At 12.04, burning the paw caused no change. Blood-pressure, 70 mm. This rise, which was inaugurated at 11.58, attained its maximum.

At 12.05, slight twitchings were observed in the left hind foot when lightly tapped. There was no response in other parts of the body following stimulation, the paralysis being complete with the exception of the leg. The blood-pressure began a gradual decline.

At 12.06, blood-pressure, 50 mm.

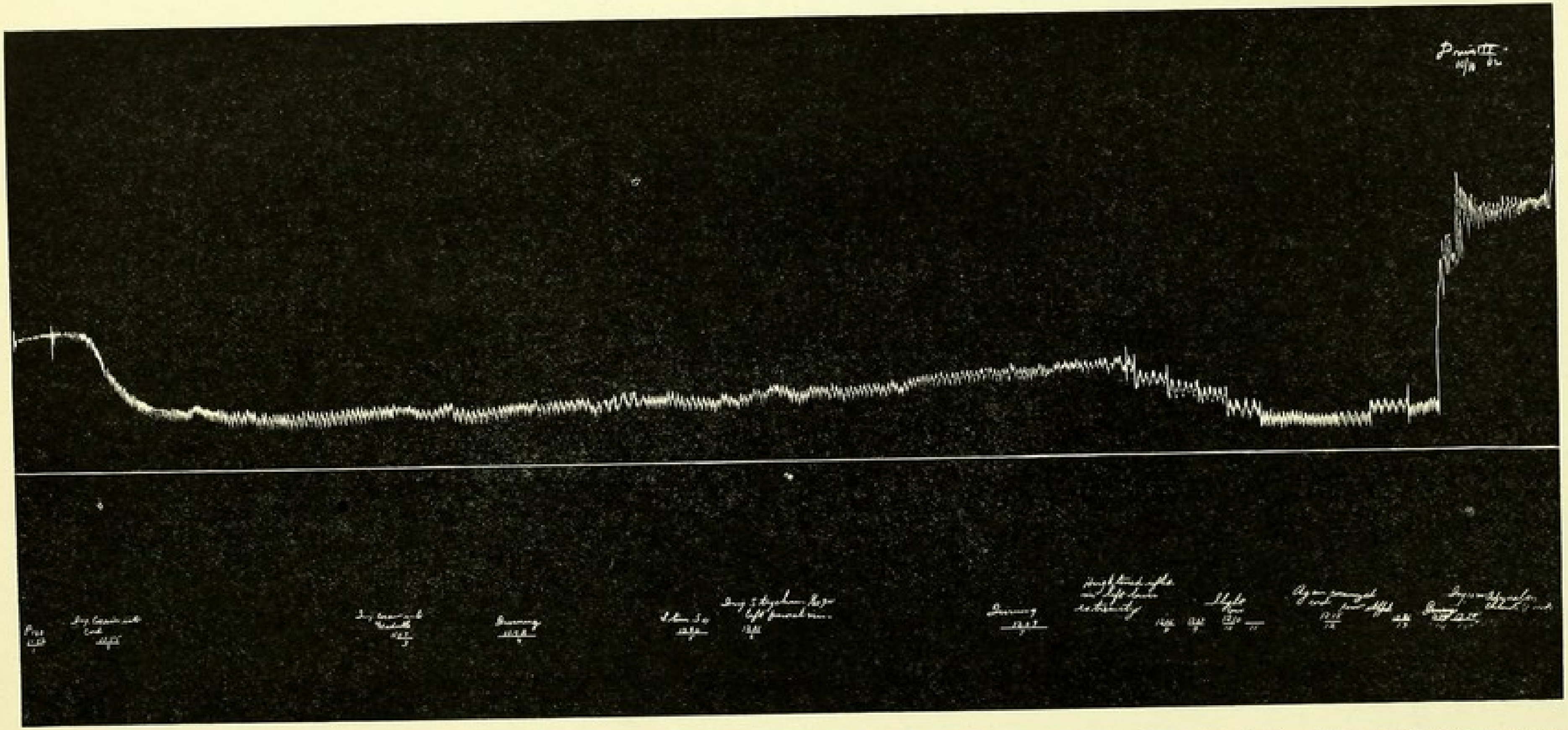


FIG. 28.—EXP. 145.—In this experiment both the spinal cord and the medulla were cocainized. On burning the paw and stimulating the sciatic no change in the blood-pressure was noted. On injecting strychnin there was but a slight convulsion and but slight rise in the blood-pressure. As compared with Fig. 27, Exp. 144, in which the medulla and the fourth ventricle alone were cocainized, the blood-pressure in this experiment fell lower, to the level of most profound shock, and there was but little rise on injecting a physiologic dose of strychnin' resembling in this respect a case of profound shock. This strongly suggested the exhaustion of the subsidiary centres in the spinal cord in profound shock.

At 12.07, blood-pressure, 40 mm.; slight reflexes were noted.

At 12.10, blood-pressure, 30 mm. Slight typical convulsions occurred.

At 12.15, blood-pressure, 22 mm. Burning the paw produced no change. The cord was again cocainized without change of the conditions. Slight convulsions occasionally occurred.

At 12.29, blood-pressure, 30 mm. Burning produced no change in the blood-pressure and the muscular twitching had discontinued.

At 12.29.30, $^{1}/_{12}$ grain of adrenalin was injected into the femoral vein. The blood-pressure rose abruptly to 185 mm. The heart executed a regular action.

At 12.30, blood-pressure, 210 mm.

At 12.31, blood-pressure, 185 mm.

At 12.34, blood-pressure, 185 mm. A steady decline in blood-pressure began.

At 12.41, blood-pressure, 70 mm. Continuous twitchings of the muscle were present.

At 12.42, burning of the paw caused slight momentary rise in the blood-pressure.

At 12.44, blood-pressure, 60 mm. Burning the paw caused a slight rise in the blood-pressure, followed by an equal fall.

At 12.46, blood-pressure, 50 mm.; the stroke suddenly became very short. No further tracings of the heart beats were obtainable. The blood-pressure remained at 50 mm.

There were no clots. The pulse was rapid. The animal remained in this condition for thirty minutes and was then killed.

Cocainization of the Stellate Ganglia.

The object of this series of experiments was to determine whether or not the suspension of the function of the stellate ganglia prevented shock. At first the ganglia were exposed and cocain applied directly.

Later, by means of a long needle, cocainization was attempted by penetrating the first intercostal space and injecting the cocain into the ganglia. In order to determine at autopsy the success in properly placing the injection, the cocain solution was colored with methylene blue.

Experiment 146.

Mongrel dog; fair condition; weight, seventeen kilos. Morphin and ether anesthesia.

Preliminary blood-pressure, 165 mm.; pulse, 170.

A two per cent. solution of cocain stained with methylene-blue was injected into the stellate ganglia.

During the injection of 22 minims of a two per cent. solution of cocain the blood-pressure fell to 80 mm. and the pulse to 156.

Both vagi were then cocainized. The blood-pressure in the mean time had risen to 120 mm.

To test whether or not the afferent impulses were interrupted, the hind paw was burned. A temporary rise in the blood-pressure followed, after which it fell to a point lower than it was before the burning. The abdomen was then extensively incised. No change in the blood-pressure followed.

On skinning the abdomen and flanks the blood-pressure fell to 55 mm.; pulse, 114. Further bloodless dissection was followed by an increased fall in the blood-pressure and the pulse-rate. Shock developed approximately with the same facility as with the control animals.

Autopsy.—The stellate ganglia were carefully exposed, and found to have been stained blue, showing a successful application of the cocain upon them.

Experiment 147.

Cocainization of the Stellate Ganglia.

Small dog; fair condition; weight, nine kilos. Morphin and ether anesthesia.

Preliminary blood-pressure recorded 135 mm.; pulse, 188.

During the injection of 22 minims of a two per cent. solution of cocain into the right stellate ganglion the blood-pressure rose to 140 mm., the pulse falling to 162.

During the injection of the left stellate ganglion the blood-pressure rose to 145 mm., the pulse falling to 152.

Both vagi were severed.

Blood-pressure, 170 mm.; pulse, 172.

The integument of the abdomen was then removed.

Blood-pressure, 155 mm.; pulse, 174.

The animal was further skinned and the raw surface irritated.

Blood-pressure, 125 mm.; pulse, 154.

The fore-foot was burned.

Blood-pressure, 150; pulse, 180.

The opposite hind foot was burned.

Blood-pressure, 160 mm.; pulse, 168.

On account of the change in the pulse-rate upon application of the flame, it was apparent that there was a defect in the cocanization.

The animal was killed.

Autopsy.—Staining of the tissues around the ganglia was observed. Previous to the two experiments here recorded a number of dissections were made for the purpose of more accurately fixing the location and the landmarks of the ganglia. In several experiments the ganglia were exposed by deep dissection of the neck, and cocain was directly applied. This necessitated such extensive bilateral dissection that the animals were reduced to such a degree of shock before the means of prevention could be applied, that even if the experiments, from this point of view, had been successful, these still would have been inconclusive. Through respiratory failure and the rapid development of shock, which was not modified by injection of cocain into the stellates, the animals were lost.

On the Effect upon the Circulation of Various Forms of Pressure.

Description of Special Apparatus.—In the preliminary experiments of water-pressure a water-tight box was arranged, with openings through which the tubes passed recording the blood-pressure and the respiration, and affording means of respiration to the animal. This was immediately found to be impractical. Rubber bags were then experimented upon in an attempt to give mechanical assistance to the general circulation. This likewise proved impractical. A cast-iron cylinder five feet in length and two feet in diameter was then used. The ends were closed with large metal caps, resting against gaskings, and fastened by twelve heavy bolts. Holes were drilled through the metal cylinder, through which tubes might be passed. At first the pressure gauge communicated with the interior of the cylinder, indicating, but not recording, the pressure. Later on, a mercurial manometer was attached, recording the pressure on a drum. In these experiments a respiratory apparatus could not be successfully employed. The difficulty was finally overcome by placing a small rubber bag upon the thorax of the animal, over which an encircling band was snugly pinned. The tubing was connected with a mercurial manometer which recorded the respiration. The pressure was increased by using a hand air-pump, and lowered by means of an escape cock. Fresh air was introduced at frequent intervals.

Experiment 148.

Mongrel dog; good condition; weight, 5.73 kilos. Morphin and ether anesthesia. The carotid cannula was connected with the manometer.

At 10.40, pulse, 172; respiration, 48.

At 10.54, tube-pressure, 0 mm; blood-pressure, 110 mm.; pulse, 168; respiration, 52.

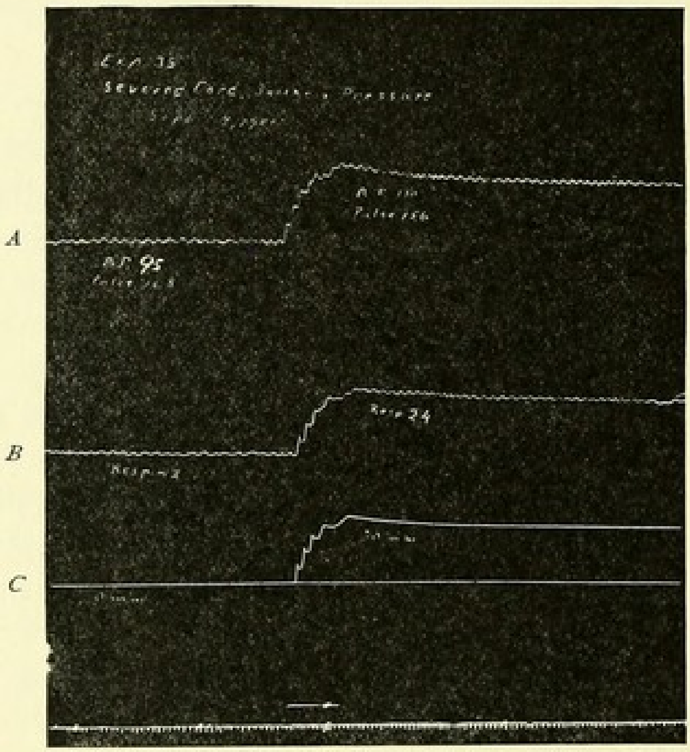


FIG. 29.—EXP. 148.—*A*, arterial pressure; *B*, intrathoracic pressure; *C*, pressure in the tube. Note the correspondence among the pressures.

At 10.57, tube-pressure, 44 mm.; blood-pressure, 160 mm.; pulse, 164; respiration, 40.

At 11.00, tube-pressure, 20 mm.; blood-pressure, 135 mm.; pulse, 132; respiration, 48.

At 11.01, tube-pressure, 0 mm.; blood-pressure, 115 mm.; pulse, 144; respiration, 56.

At 11.02, tube-pressure, 40 mm.; blood-pressure, 160 mm.; pulse, 166; respiration, 144.

At 11.05, tube-pressure, 60 mm.; blood-pressure, 180 mm.; pulse, 132; respiration, 48.

At 11.06, tube-pressure, 20 mm.; blood-pressure, 130 mm.; pulse, 144; respiration, 48.

At 11.07, tube-pressure, 0 mm.; blood-pressure, 110 mm.; pulse, 120; respiration, 56.

At 11.20, the spinal cord was severed in the upper dorsal region.

At 11.25, tube-pressure, 0 mm.; blood-pressure, 80 mm.; pulse, 150; respiration, 42.

At 11.26, tube-pressure, 40 mm.; blood-pressure, 130 mm.; pulse, 138; respiration, 40.

At 11.30, tube-pressure, 20 mm.; blood-pressure, 110 mm.; pulse, 156; respiration, 136.

Severe shock followed the severing of the cord, the blood-pressure falling rapidly to 40 mm. Pressure in the tube improved with the force of the heart and the depth of the respiration.

At 11.43, tube-pressure, 10 mm.; blood-pressure, 100 mm.; pulse, 136; respiration, 36.

At 11.45, tube-pressure, 0 mm.; blood-pressure, 85 mm.; pulse, 160; respiration, 20.

At 11.47, the injection of 40 ounces of normal saline into the abdominal cavity was followed by trembling in the forelegs and neck.

At 11.48, the injection was discontinued and the animal was replaced in the tube; pulse, 136; respiration, 36.

At 11.50, tube-pressure, 0 mm.; blood-pressure, 95 mm.; pulse, 168; respiration, 42.

At 11.51, tube-pressure, 30 mm.; blood-pressure, 110 mm.; pulse, 156; respiration, 24.

At 11.54, tube-pressure, 25 mm.; blood-pressure, 100 mm.; pulse, 168; respiration, 32.

At 11.57, tube-pressure, 30 mm.; blood-pressure, 110 mm.; pulse, 156; respiration, 28.

At 11.59, tube-pressure, 0 mm.; blood-pressure, 53 mm.; pulse, 152; respiration, 28.

At 12.01, tube-pressure, 35 mm.; blood-pressure, 110 mm.; pulse, 160; respiration, 28.

At 12.04, tube-pressure, 30 mm.; blood-pressure, 105 mm.; pulse, 160; respiration, 32.

At 12.05, tube-pressure, 0 mm.; blood-pressure, 75 mm.; pulse, 156; respiration, 32.

At 12.07, tube-pressure, 40 mm.; blood-pressure, 115 mm.; pulse, 144; respiration, 26.

At 12.11, tube-pressure, 0 mm.; blood-pressure, 75 mm.; pulse, 144; respiration, 20.

At 12.13, tube-pressure, 40 mm.; blood-pressure, 120 mm.; pulse, 144; respiration, 24.

At 12.14, tube-pressure, 0 mm.; blood-pressure, 75 mm.; pulse, 134; respiration, 24.

At 12.15, tube-pressure, 40 mm.; blood-pressure, 120 mm.; pulse, 140; respiration, 24.

At 12.17, tube-pressure, 32 mm.; blood-pressure, 110 mm.; pulse, 136; respiration, 24.

At 12.19, tube-pressure, 0 mm.; blood-pressure, 70 mm.; pulse, 140; respiration, 28.

At 12.23, tube-pressure, 0 mm.; blood-pressure, 70 mm.; pulse, 144; respiration, 24.

At 12.24, tube-pressure, 40 mm.; blood-pressure, 115 mm.; pulse, 148; pulse, 24.

At 12.25, tube-pressure, 0 mm.; blood-pressure, 75 mm.; pulse, 144; respiration, 24.

At 12.27, tube-pressure, 0 mm.; blood-pressure, 110 mm.; pulse, 136; respiration, 24.

At 12.30, tube-pressure, 0 mm.; blood-pressure, 72 mm.; pulse, 144; respiration, 24.

At 12.32, tube-pressure, 42 mm.; blood-pressure, 115 mm.; pulse, 128; respiration, 28.

At 12.33, tube-pressure, 0 mm.; blood-pressure, 70 mm.; pulse, 140; respiration, 24.

At 12.40, tube-pressure, 0 mm.; blood-pressure, 70 mm.; pulse, 150; respiration, 36.

At 12.42, tube-pressure, 40 mm.; blood-pressure, 120 mm.; pulse, 144; respiration, 26.

At 12.45, tube-pressure, 35 mm.; blood-pressure, 110 mm.; pulse, 140; respiration, 26.

At 12.47, tube-pressure, 0 mm.; blood-pressure, 70 mm.; pulse, 136; respiration, 28.

At 12.50, tube-pressure, 0 mm.; blood-pressure, 70 mm.; pulse, 144; respiration, 24.

At 12.54, tube-pressure, 0 mm.; blood-pressure, 70 mm.; pulse, 120; respiration, 20.

At 12.55, the dog was removed from the tube; the front legs were stiff and trembling.

Blood-pressure, 60 mm.; pulse, 132; respiration, 20.

At 1.00, blood-pressure, 60 mm.; pulse, 120; respiration, 22. The heart-beats were spasmodic and vagal in character; the respirations were spasmodic. The heart ceased before the respirations.

At the moment of death the blood-pressure was 0 mm.

Autopsy.—There was general congestion of the splanchnic area. No fluid was in the intestines or stomach. The bladder and gall-bladder were distended. The spleen and pancreas were normal. There was no fluid in the thoracic cavity and no congestion of the thorax. The vessels of the ribs and the heart were dilated. Five hundred c.c. were recovered from the abdominal cavity. More than 100 c.c. were absorbed.

Experiment 149.

Pneumatic Pressure.

Mongrel dog; good condition; weight, 7.88 kilos. Ether and morphin anesthesia. The carotid was connected with the blood-pressure manometer and the respiratory apparatus attached.

At 3.55, blood-pressure, 120 mm.; pulse, 180; respiration, 60. The dog was placed in the tube.

At 3.58, tube-pressure, 85 mm.; blood-pressure, 200 mm.; pulse, 160; respiration, 52.

At 4.00, tube-pressure, 0 mm.; blood-pressure, 110 mm.; pulse, 128; respiration, 56.

At 4.08, the dog was removed from the tube.

At 4.20, the spinal cord was severed in the upper dorsal region. The breathing was labored.

Blood-pressure, 90 mm.; pulse, 176; respiration, 72.

At 4.29, tube-pressure, 0 mm.; blood-pressure, 100 mm.; pulse, 168; respiration, 60.

At 4.34, tube-pressure, 100 mm.; blood-pressure, 205 mm.; pulse, 200; respiration, 48.

At 4.36, tube-pressure, 0 mm.; blood-pressure, 100 mm.; pulse, 200; respiration, 60.

At 4.45, tube-pressure, 0 mm.; blood-pressure, 90 mm.; pulse, 192; respiration, 40.

The dog was removed from the tube.

At 4.50, 600 c.c. of normal saline were injected into the abdominal cavity. The animal was replaced in the tube.

At 4.52, tube-pressure, 0 mm.; blood-pressure, 90 mm.; pulse, 184; respiration, 36.

At 4.56, tube-pressure, 0 mm.; blood-pressure, 90 mm.; pulse, 200; respiration, 40.

At 4.58, tube-pressure, 0 mm.; blood-pressure, 80 mm.; pulse, 192; respiration, 40.

At 5.01, tube-pressure, 100 mm.; blood-pressure, 192 mm.; pulse, 196; respiration, 32.

At 5.07, tube-pressure, 0 mm.; blood-pressure, 60 mm.

At 5.23, the dog appeared to be dying; the contractions of the heart were increased in force and of the vagal type.

Autopsy.—The subcutaneous tissues were anemic; the bladder was distended and contained 105 c.c. of fluid. The intestines were pale and contracted. The stomach contained about 100 c.c. of fluid, and was very pale. The spleen was smaller than usual, the color normal. The liver was normal, and bled freely on cutting. The superior and inferior vena cavi were much distended; the gall-bladder was full; the thoracic vessels and the lungs were congested; the heart was distended and stopped in diastole. Five hundred c.c. of fluid were removed from the peritoneal cavity. Twenty c.c. were absorbed in thirty-three minutes.

Experiment 150.

Pneumatic Pressure.

Mongrel dog; good condition; weight, twenty pounds. Morphin and ether anesthesia.

At 11.25, tube-pressure, 0 mm.; blood-pressure, 150 mm.; pulse, 196; respiration, 36.

At 11.26, tube-pressure, 66 mm.; blood-pressure, 200 mm.; pulse, 186; respiration, 36.

At 11.28, tube-pressure, 0 mm.; blood-pressure, 150 mm.; pulse, 182; respiration, 40.

At 11.30, tube-pressure, 60 mm.; blood-pressure, 200 mm.; pulse, 168; respiration, 36.

At 11.32, tube-pressure, 30 mm.; blood-pressure, 180 mm.; pulse, 168; respiration, 36.

At 11.34, tube-pressure, 0 mm.; blood-pressure, 150 mm.; pulse, 180; respiration, 40.

Experiment 151.

Pneumatic Pressure. External Respiration.

The same dog that was used in the previous experiment. The tube was arranged for external respiration.

At 11.50, tube-pressure, 0 mm.; blood-pressure, 145 mm.; pulse, 180; respiration, 36.

At 12.02, tube-pressure, 0 mm.; blood-pressure, 140 mm.; pulse, 180; respiration, 40.

At 12.03, tube-pressure, 150 mm.; blood-pressure, 280 mm.; pulse, 140 spasmodic.

The pulse was of the vagal type.

The blood-pressure ranged from 240 mm. to 300 mm.

At 12.06, tube-pressure, 0 mm.; blood-pressure, 100 mm.; pulse, 75; respiration, irregular.

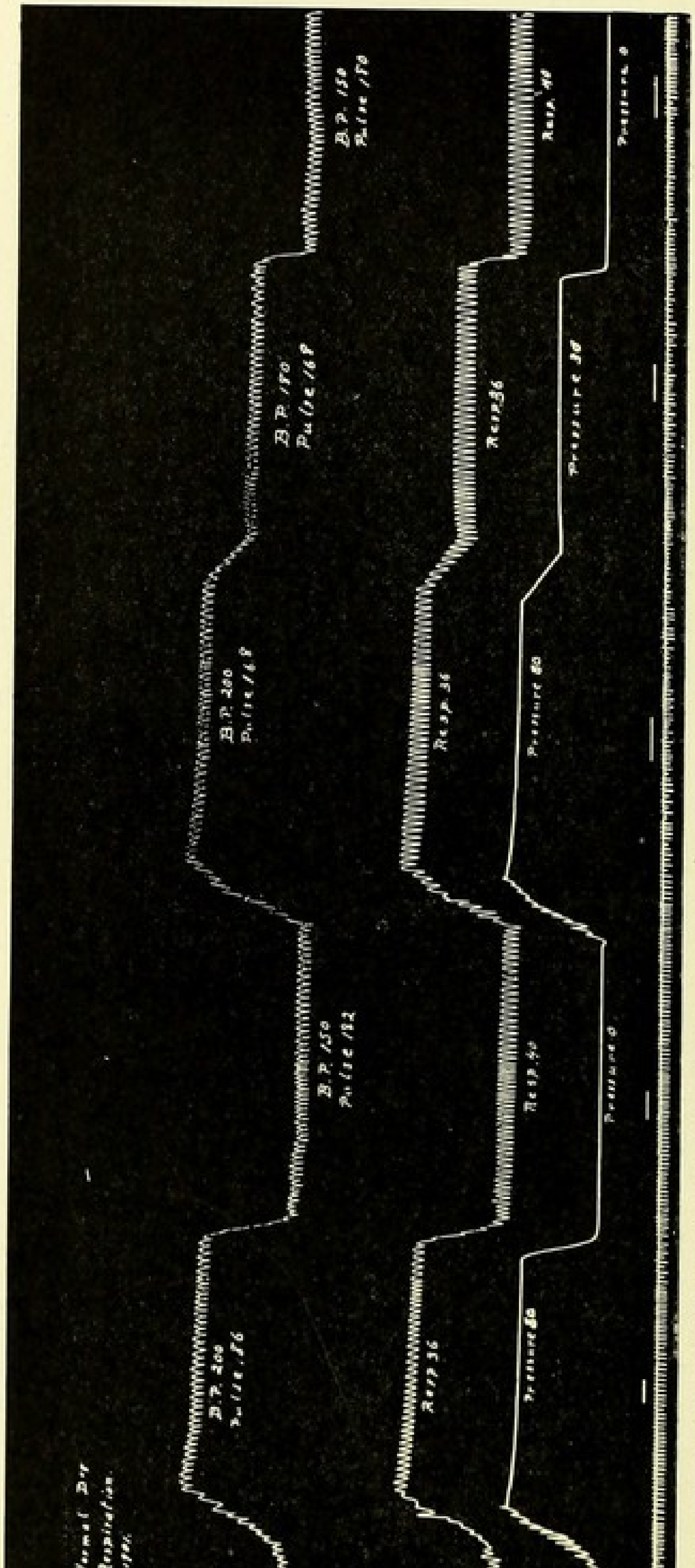


FIG. 30.—EXP. 150.—*A*, blood-pressure; *B*, respiratory tracing; *C*, tube. Note the alteration in the blood-pressure corresponding to the changes of pressure in the iron cylinder.

A *B* *C*

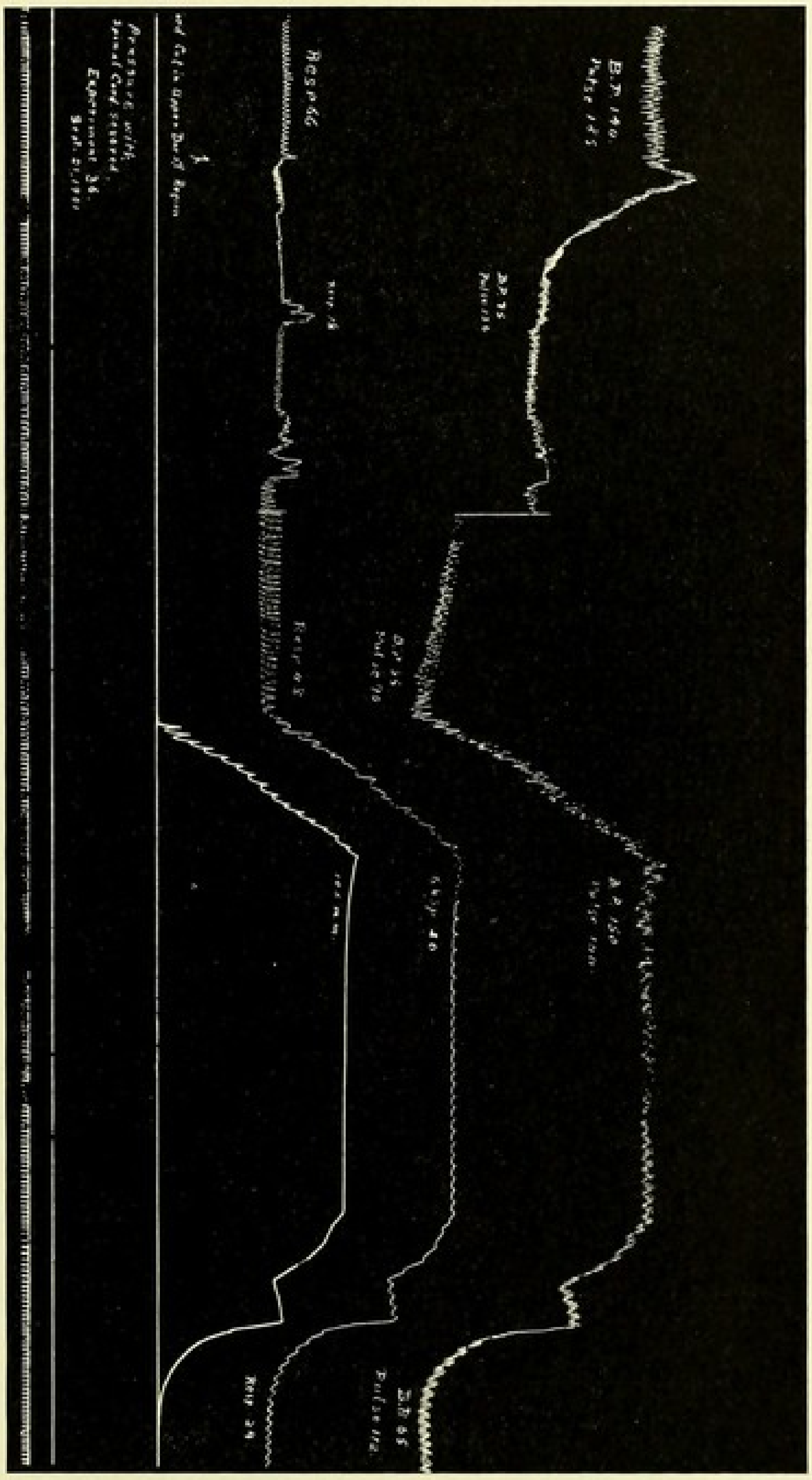


FIG. 31.—EXP. 152.—*A*, blood-pressure; *B*, respiratory tracing; *C*, tube. The spinal cord was severed in upper dorsal region, and the animal subjected to alterations of pressure in the tube. Note the marked fall in pressure on severing the cord. Note the control of the paralleling of the pressures on varying the pressure in the tube.

At 12.10, tube-pressure, 100 mm.; blood-pressure, 170 mm.; pulse, 96; respiration, 16.

Experiment 152.

Pneumatic Pressure. Spinal Cord Severed.

Mongrel dog; weight, twenty-four pounds. Morphin and ether anesthesia.

The respiratory and blood-pressure apparatus were connected.

At 3.05, normal tracing: blood-pressure, 140 mm.; pulse, 186; respiration, 66.

At 3.30, the cord was severed in the dorsal region. A momentary rise, then a fall, in the blood-pressure followed.

At 3.32, blood-pressure, 85 mm.; pulse, 136; respiration, 78.

At 3.40, blood-pressure, 55 mm.; pulse, 90; respiration, 48.

At 3.43, tube-pressure, 105 mm.; blood-pressure, 150 mm.; pulse, 100; respiration, 20.

At 3.47, tube-pressure, 0 mm.; blood-pressure, 65 mm.; pulse, 112; respiration, 34.

At 3.52, tube-pressure, 100 mm.; blood-pressure, 150 mm.; pulse, 100; respiration, 20.

At 3.55, tube-pressure, 0 mm.; blood-pressure, 65 mm.; pulse, 96; respiration, 20.

Experiment 153.

Pneumatic Pressure.

Mongrel dog; good condition; weight, sixteen kilos. Morphin and ether anesthesia.

At 12.12, blood-pressure, 120 mm.; pulse, 148; respiration, 144.

At 12.47, tube-pressure, 120 mm.; blood-pressure, 240 mm.; pulse, 132; respiration, 29.

At 12.51, tube-pressure, 85 mm.; blood-pressure, 200 mm.; pulse, 140; respiration, 30.

At 12.53, tube-pressure, 50 mm.; blood-pressure, 170 mm.; pulse, 140; respiration, 32.

At 12.54, tube-pressure, 0; blood-pressure, 120 mm.; pulse, 148; respiration, 32.

At 1.00, tube-pressure, 120 mm.; blood-pressure, 240 mm.; pulse, 136; respiration, 30.

At 1.07, tube-pressure, 50 mm.; blood-pressure, 170 mm.; pulse, 136; respiration, 30.

At 1.09, no tube-pressure; blood-pressure, 120 mm.; pulse, 136; respiration, 32.

Experiment 154.

Pneumatic Pressure.

Bull dog; good condition; weight, sixteen kilos. Morphin and ether anesthesia.

A thin rubber bag filled with water was placed in the abdomen and connected with a rigid tube, which was connected in turn with a mercury manometer. The tube was supplied with a small stop-cock.

At 4.45, tube-pressure, 0 mm.; abdominal pressure, 0 mm.; blood-pressure, 160 mm.; pulse, 128; respiration, 16.

At 4.47, tube-pressure, 47 mm.; abdominal pressure, 60 mm.; blood-pressure, 280 mm.; pulse, 132; respiration, 24.

At 4.50, tube-pressure, 0 mm.; abdominal pressure, 0 mm.; blood-pressure, 160 mm.; pulse, 132; respiration, 116.

At 4.52, tube-pressure, 80 mm.; abdominal pressure, 70 mm.; blood-pressure, 280 mm.; pulse, 144; respiration, 20.

At 4.55, tube-pressure, 0 mm.; abdominal pressure, normal; blood-pressure, 160 mm.; pulse, 200; respiration, 24.

At 5.00, tube-pressure, 90 mm.; abdominal pressure, 90 mm.; blood-pressure, 260 mm.; pulse, 152; respiration, 20.

At 5.02, tube-pressure, 0 mm.; abdominal pressure, normal; blood-pressure, 160 mm.; pulse, 162; respiration, 20.

At 5.04, tube-pressure, 90 mm.; abdominal pressure, 90 mm.; blood-pressure, 260 mm.; pulse, 160; respiration, 18.

At 5.07, tube-pressure, 80 mm.; abdominal pressure, normal; blood-pressure, 150 mm.; pulse, 188; respiration, 36, of Cheyne-Stokes character.

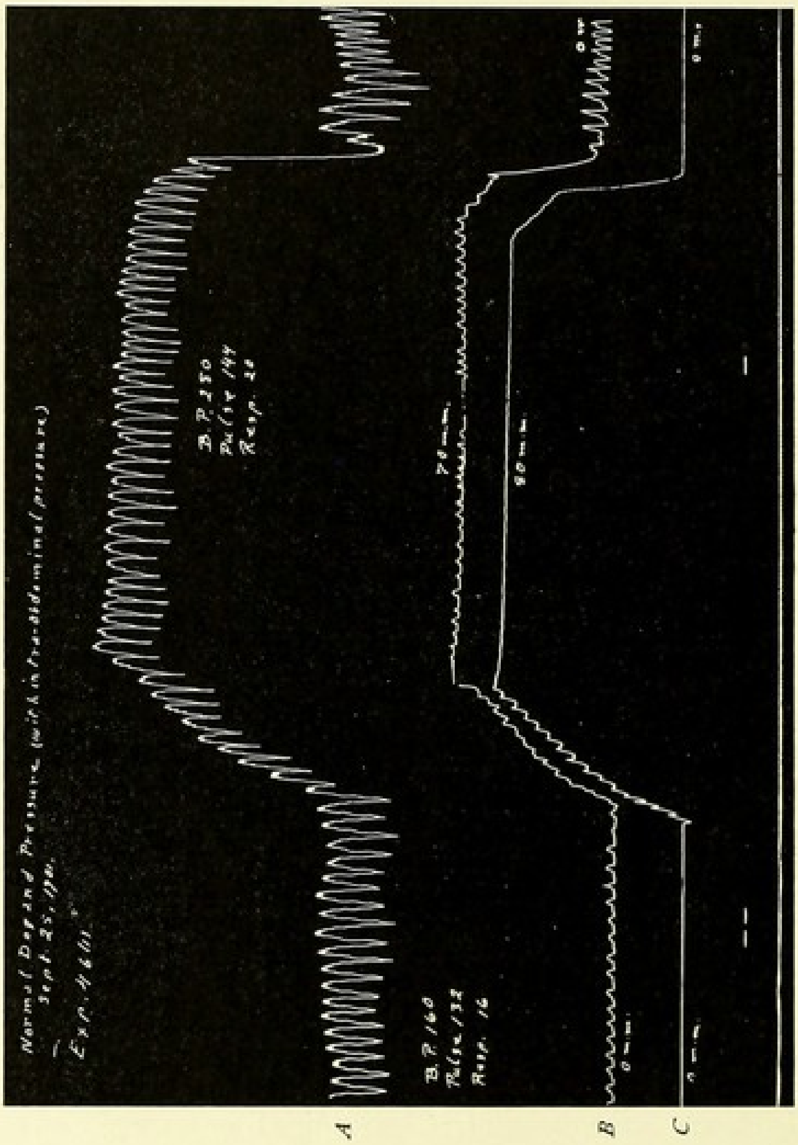


FIG. 32.—EXP. 154.—*A*, arterial pressure; *B*, intra-abdominal pressure; *C*, pressure in the tube. The arterial pressure rose proportionately higher than the other pressures. The intra-abdominal did not rise as high as the tubal pressure.

EXPERIMENT 155.

Pneumatic Pressure. External Respiration.

Dog; good condition; weight, sixteen kilos. Morphin and ether anesthesia.

Preliminary blood-pressure, 120 mm.; respiration, 55; pulse, 160.

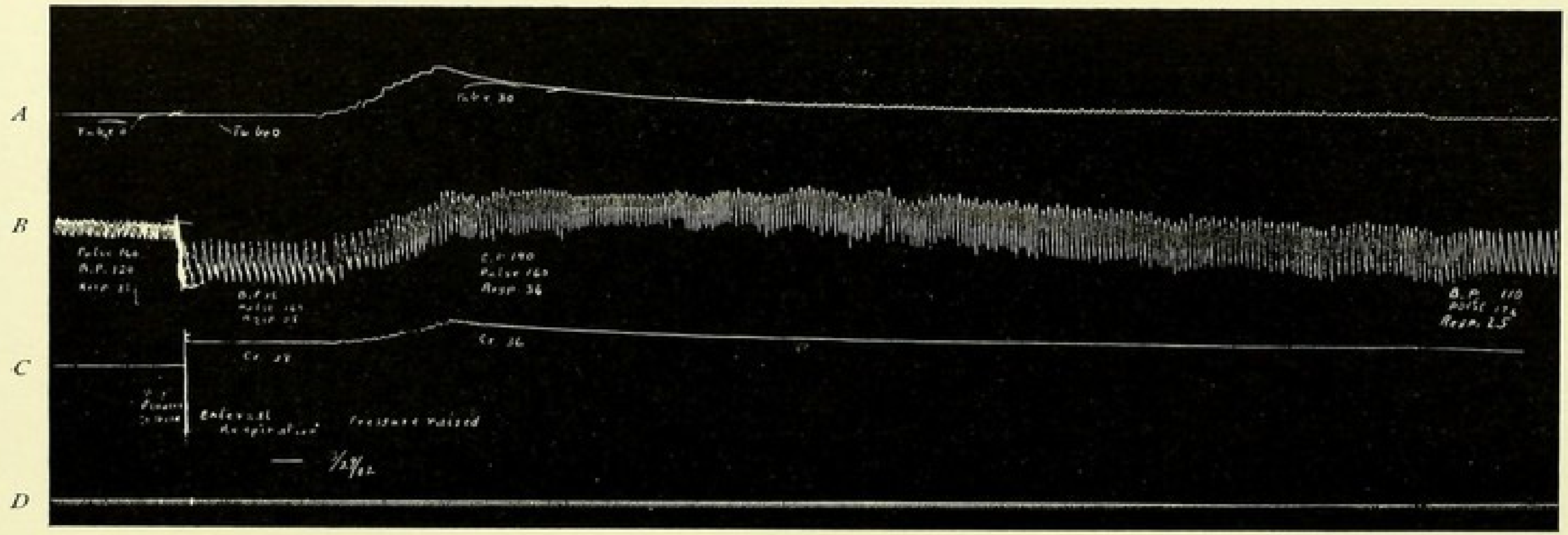


FIG. 33.—EXP. 155.—Dog in moderate shock subjected to an increased atmospheric pressure, during which the animal breathed the external air (normal pressure). *A*, pressure within the tube; *B*, carotid pressure; *C*, intracranial pressure; *D*, seconds. Note the immediate increase in the pulse-wave and the decrease in the frequency of the beat. The intracranial pressure closely paralleled the carotid. The difference between the pressure in the pulmonary tract and that of the remainder of the body caused an accumulation of blood in the latter.

The blood-pressure was reduced to 95 mm.

Intracranial pressure, 28 mm.; pulse, 160; respiration, 28.

The animal was placed in a pneumatic tube and the trachea connected through an opening in the tube with the external air. The animal was then subjected to a gradually increasing atmospheric pressure.

When the pressure in the tube had reached 30 mm. the blood-pressure was 140 mm.; the intracranial pressure, 36 mm.; pulse, 160; respiration, 36. Respiration, at this point, became so shallow and labored that the animal was killed.

Experiment 156.

Effect of Pneumatic Pressure upon the Intracranial Circulation.

Dog; good condition; weight, fifteen kilos. Morphin and ether anesthesia. The apparatus was arranged as in Experiment 6.

Preliminary blood-pressure, 134 mm.; pulse, 150; respiration, 28.

The blood-pressure was reduced to 100 mm. The cranial bag registered 0 mm.; pulse, 160; respiration, 20.

The animal was placed in the tube and the respiratory cannula was connected with the external atmosphere. The atmospheric pressure within the tube was gradually raised to 30 mm.

Blood-pressure, 140 mm.; pulse, 200; respiration, 40; cranial bag, 50 mm.

The atmospheric pressure in the tube was reduced to 10 mm.

Blood-pressure, 130 mm.; pulse, 190; respiration, 35; cranial bag, 45 mm.

The pressure in the tube was released.

Blood-pressure, 118 mm.; cranial bag, 35 mm.; pulse, 185; respiration, 32.

It was noticed that as the pressure was increased in the tube, respiration became more shallow and labored, with increased rapidity.

Experiment 157.

Treatment of Shock by Means of Pneumatic Pressure.

Dog; good condition; weight fourteen kilos. Morphin and ether anesthesia.

General blood-pressure, 130 mm.; intracranial blood-pressure, artificially placed, 40 mm.; pulse, 160.

At 11.00, the animal was reduced to surgical shock by dissection and mechanical stimulation.

At 11.55, blood-pressure, 100 mm.; intracranial pressure, artificially placed, 0 mm.; pulse, 165.

Bandages were applied as in the previous experiment.

At 12.10, blood-pressure, 130 mm.; intracranial pressure, 10 mm.; pulse, 160.

At 12.15, blood-pressure, 140 mm.; intracranial pressure, 15 mm.; pulse, 180.

At 12.25, blood-pressure, 140 mm.; intracranial pressure, 16 mm.; pulse, 186.

At 12.30, blood-pressure, 140 mm.; intracranial pressure, 16 mm.; pulse, 176.

At 12.35, blood-pressure, 140 mm.; intracranial pressure, 12 mm.; pulse, 204; respiration, 50.

At 12.40, blood-pressure, 140 mm.; intracranial pressure, 12 mm.; pulse, 208; respiration, 26.

At 12.50, blood-pressure, 148 mm.; intracranial pressure, 115 mm.; pulse, 216; respiration, 52.

At 12.55, blood-pressure, 146; intracranial pressure, 15 mm.; pulse, 214; respiration, 52.

At 1.00, blood-pressure, 146 mm.; intracranial pressure, 115 mm.; pulse, 196.

At 1.05, blood-pressure, 146 mm.; intracranial pressure, 16 mm.; pulse, 172.

At 1.10, blood-pressure, 140 mm.; intracranial pressure, 16 mm.; pulse, 180.

At 1.15, the bandages were removed. Blood-pressure, 100 mm.; intracranial pressure, 8 mm.

At 1.20, blood-pressure, 110 mm.; intracranial pressure, 6 mm.; pulse, 196.

It was found necessary to reduce the pressure in the cranial bag to 0 after shock had been induced.

Experiment 158.

Shock treated by bandaging.

Mongrel dog; good condition; weight, fifteen kilos.

Morphin and ether anesthesia.

Preliminary general blood-pressure, 132 mm.; intracranial pressure, 0 mm.

The animal was reduced to shock.

Blood-pressure, 104 mm.; bandages were applied.

General blood-pressure, 136 mm.; intracranial pressure, 11 mm.

The respiration was unimpaired.

Both pressures were maintained during the application of the bandages. The animal was killed, placed in the tube, and subjected to varying pressures. The variation of the blood-pressure, the intra-abdominal, the intracranial, and the intrathoracic were quite the same as in the living animal.

Experiment 159.

Shock treated by bandaging.

Mongrel dog; fair condition; weight, eleven kilos.

Morphin and ether anesthesia.

Preliminary blood-pressure, 120 mm.; pulse, 132; respiration, 54.

Intracranial pressure, as well as the general blood-pressure was taken. The animal was reduced to shock, the blood-pressure recording 90 mm.

Bandages were then applied firmly upon the extremities and head, and lightly upon the abdomen and thorax. The blood-pressure promptly rose to 135 mm., the cranial pressure to 8 mm., and respiration became labored and rapid.

There was no gastric discharge.

The blood-pressure and intracranial pressure were maintained indefinitely.

Removal of the bandages was followed by a fall in the general blood-pressure, as well as the intracranial pressure, to their former level. Reapplication of the bandages was followed by a rise in the blood- and intracranial pressures.

Experiment 160.

Shock treated by bandaging.

Male dog; fair condition; weight, nine kilos. Morphin and ether anesthesia.

Preliminary blood-pressure, 110 mm.; pulse, 155; respiration, 45. The animal was reduced to surgical shock.

Blood-pressure, 60 mm.; pulse, 186; respiration, 52. Rubber bandages were then firmly applied over the extremities and lightly over the abdomen and thorax. Blood-pressure, 110 mm.; pulse, 190; respiration labored.

The gastric contents were not discharged.

The bandages were allowed to remain during the period in which compensation usually occurred. The blood-pressure in that period remained constant, with a tendency towards a slight gradual rise. When the bandages were removed the blood-pressure fell to the point it was before the application. During this time an intracranial pressure was taken and it responded precisely to the changes that occurred in the general blood-pressure. During the application of the bandages it rose, and fell with their removal.

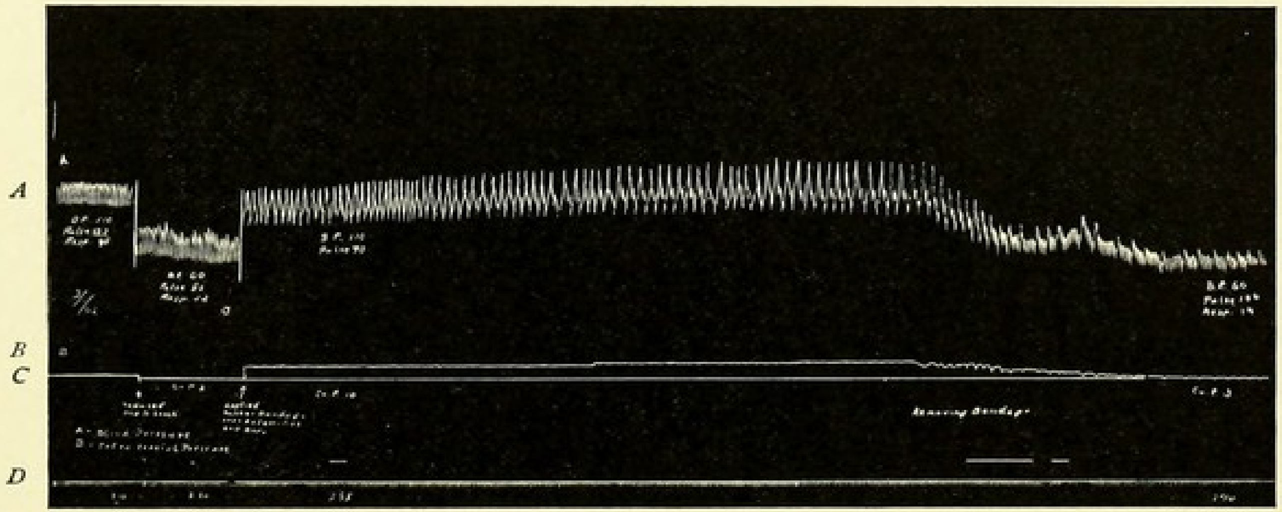


FIG. 34.—EXP. 160.—*Moderate shock.* *A*, carotid pressure; *B*, intracranial pressure; *C*, abscissa; *D*, seconds. On bandaging the extremities, the abdomen, and the head, the blood-pressure was raised from 60 to 110, and sustained at that level until the bandages were removed. Note the corresponding rise in the intracranial pressure. Compare the definite and well-sustained rise with the indefinite and uncertain effect of drugs.

Experiment 161.

Shock treated by Pneumatic Pressure.

Male mongrel dog; good condition; weight, thirteen kilos. Morphin and ether anesthesia.

Preliminary blood-pressure, 140 mm. (femoral artery).

Cranial pressure was placed at 20 mm. The animal was reduced to moderate shock and placed in a tube.

Tube-pressure, 35 mm.; blood-pressure, 150 mm.; cranial pressure, 50 mm.

Tube-pressure, 0 mm.; blood-pressure, 120 mm.; cranial pressure, 20 mm.

Tube-pressure, 50 mm.; blood-pressure, 155 mm.; cranial presure, 55 mm.

Tube-pressure, 0 mm.; blood-pressure, 120 mm.; cranial pressure, 20 mm.

Tube-pressure, 47 mm.; blood-pressure, 155 mm.; cranial pressure, 55 mm.

Tube-pressure, 22 mm.; blood-pressure, 152 mm.; cranial pressure, 38 mm.

Tube-pressure, 0 mm.; blood-pressure, 130 mm.; cranial pressure, 20 mm.

As the pressure increased, the normal stroke of 10 mm. decreased to an irregular line. When the pressure was rapidly reduced the blood-pressure fell, the stroke increasing to the normal 10 mm, but when reducing the pressure slowly, the blood-pressure remained high, the strokes increasing in size until normal conditions were again established.

Experiment 162.

Pneumatic Pressure.

Male mongrel dog; good condition; weight, twelve kilos. Morphin and ether anesthesia.

The preliminary blood-pressure was taken in the carotid artery.

Blood-pressure, 150 mm.; pulse, 164.

The cranial bag was placed at 22 mm.

Both common carotids were ligated.

A rise of 25 mm. in the blood-pressure followed; no change was recorded in the cranial bag. The animal was subjected to pneumatic pressure in the tube.

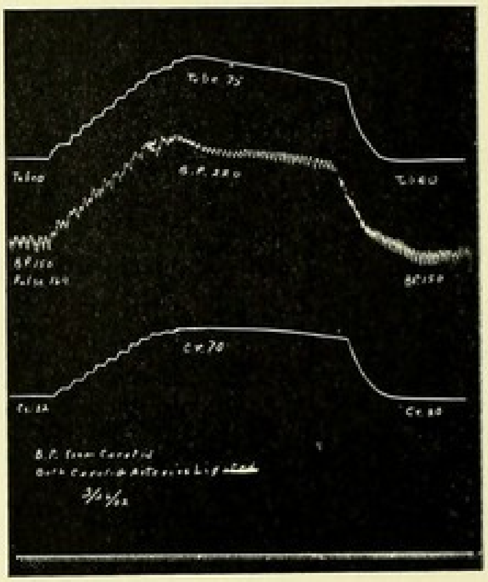


FIG. 35.—EXP. 162.—Normal animal, with both carotid arteries ligated, subjected to an increased atmospheric pressure. *A*, tube pressure; *B*, carotid pressure; *C*, intracranial pressure; *D*, seconds. It will be noted that the general arterial pressure rose proportionately higher than the intracranial. The effect of this divergence is presumably to increase the determination of the blood to the brain. This experiment also shows that the increased intracranial pressure responding to the increase in the general pressure is but little, if at all, dependent upon the carotid circulation.

Tube-pressure, 75 mm.; blood-pressure, 220 mm.; cranial pressure, 70 mm.

Tube-pressure, 0 mm.; blood-pressure, 150 mm.; cranial pressure, 20 mm.

Tube-pressure, 75 mm.; blood-pressure, 210 mm.; cranial pressure, 70 mm.

Tube-pressure, 70 mm.; blood-pressure, 150 mm.; cranial pressure, 20 mm.

At the conclusion of this experiment the intracranial pressure recorded a fall of 2 mm.

A

B

C

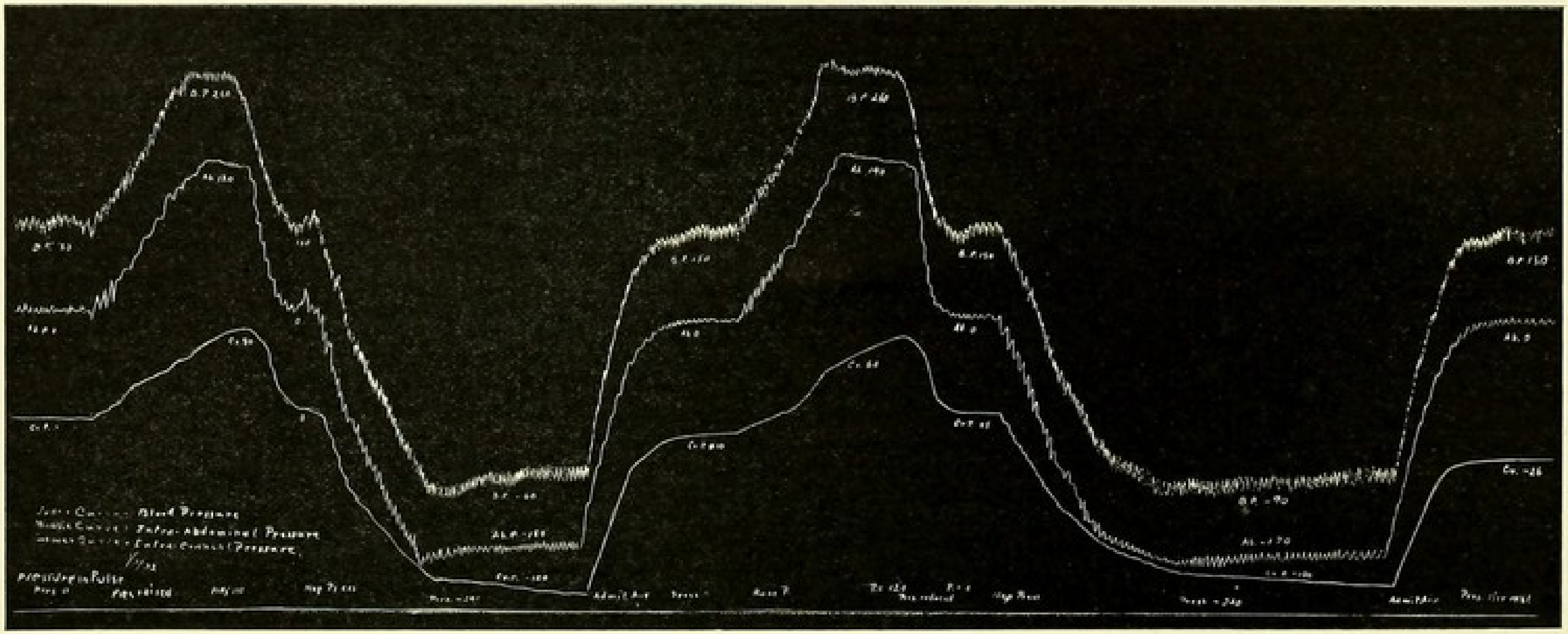


FIG. 36.—EXP. 163.—Showing effects of positive and negative atmospheric pressure. *A*, blood-pressure; *B*, abdominal pressure; *C*, cranial pressure. Note the parallelism between the intra-abdominal pressure and the carotid; also note the divergence between the intracranial and the arterial and the intra-abdominal, tending to increase the amount of blood determined to the brain. The intracranial pressure on reducing the atmospheric pressure below that registered by the barometer for this altitude did not fall as much as did the general blood-pressure, or the intra-abdominal pressure, thus tending to diminish the circulation through the brain. This may throw some light upon the effects of high altitude upon the circulation, such as are commonly experienced by tourists, and such as have been noted by surgeons. (Powers, of Denver.)

Experiment 163.

Effect of Increased Atmospheric Pressure upon the Intracranial Circulation.

Male dog; Morphin and ether anesthesia.

Tube-pressure, 0 mm.; blood-pressure, 150 mm.; cranial pressure, 0 mm.; abdominal pressure, 0 mm.

At 2.22, tube-pressure, 100 mm.; blood-pressure, 260 mm.; cranial pressure, 80 mm.; abdominal pressure, 100 mm.

At 2.24, tube-pressure, 0 mm.; blood-pressure, 150 mm.; cranial pressure, 0 mm.; abdominal pressure, 0 mm.

At 2.26, tube-pressure, 240 mm.; blood-pressure, 60 mm.; cranial pressure, 120 mm.; abdominal pressure, 180 mm.

At 2.27, tube-pressure, 0 mm.; blood-pressure, 150 mm.; cranial pressure, 0 mm.; abdominal pressure, 0 mm.

At 2.28, tube-pressure, 0 mm.; blood-pressure, 150 mm.; cranial pressure, 0 mm.; abdominal pressure, 0 mm.

At 2.30, tube-pressure, 120 mm.; blood-pressure, 260 mm.; cranial pressure, 60 mm.; abdominal pressure, 140 mm.

At 2.32, tube-pressure, 0 mm.; blood-pressure, 150 mm.; cranial pressure, 0 mm.; abdominal pressure, 0 mm.

At 2.38, tube-pressure, 240 mm.; blood-pressure, 90 mm.; cranial pressure, 100 mm.; abdominal pressure, 170 mm.

At 2.50, tube-pressure, 0 mm.; blood-pressure, 150 mm.; cranial pressure, 5 mm.; abdominal pressure, 0 mm.

At 3.02, tube-pressure, 360 mm.; blood-pressure, 220 mm.; cranial pressure, 240 mm.; abdominal pressure, 250 mm.

At 3.10, tube-pressure, 0 mm.; blood-pressure, 130 mm.; cranial pressure, 0 mm.; abdominal pressure, 0 mm.

At 3.40, tube-pressure, 400 mm.; blood-pressure, 500 mm.; cranial pressure, 500 mm.; abdominal pressure, 340 mm.

Experiment 164.

On the Effect of Atmospheric Pressure upon the Intracranial Pressure.

Male dog; weight, thirty-two kilos. Morphin and ether anesthesia.

At 9.20, tube-pressure, 0 mm.; blood-pressure, 140 mm.; intracranial pressure, 0 mm.

At 9.30, tube-pressure, 100 mm.; blood-pressure, 250 mm.; intracranial pressure, 40 mm.

At 9.35, tube-pressure, 0 mm.; blood-pressure, 140 mm.; intracranial pressure, 0 mm.

At 9.40, tube-pressure, 160 mm.; blood-pressure, 300 mm.; intracranial pressure, 130 mm.

At 9.50, tube-pressure, 0 mm.; blood-pressure, 150 mm.; intracranial pressure, 10 mm.

At 10.00, tube-pressure, 0 mm.; blood-pressure, 150 mm.; intracranial pressure, 0 mm.

At 10.05, tube-pressure, 100 mm.; blood-pressure, 260 mm.; intracranial pressure, 36 mm.

At 10.15, tube-pressure, 160 mm.; blood-pressure, 130 mm.; intracranial pressure, 134 mm.

At 10.20, tube-pressure, 0 mm.; blood-pressure, 150 mm.; intracranial pressure, 10 mm.

The animal was killed.

Experiment 165.

Shock. Effect of Variation in Atmospheric Pressure upon the Circulation in the Several Cavities of the Body.

Male dog; weight, thirteen kilos. Morphin and ether anesthesia.

The apparatus was arranged as in the previous experiment.

Preliminary blood-pressure, 130 mm. The animal was reduced to a moderate degree of surgical shock.

Blood-pressure, 105 mm.; abdominal pressure, 0 mm.; thoracic pressure, 0 mm.; cranial pressure, 0 mm.

The animal was subjected to 90 mm. pressure in the tube.

Blood-pressure was 195 mm.; abdominal pressure, 88 mm.; thoracic pressure, 80 mm.; cranial pressure, 50 mm.

The pressure in the tube was released.

Blood-pressure, 100 mm.; abdominal pressure, 0 mm.; thoracic pressure, 0 mm.; cranial pressure, 0 mm.

The animal was killed.

Experiment 166.

On the Effect of Varying Atmospheric Pressure upon the Circulation in the Various Positions of the Body when the Animal is in Shock.

Male dog; twenty kilos. Morphin and ether anesthesia.

The apparatus was arranged for simultaneous tracing of the blood-pressure, the intrathoracic pressure, and the intracranial pressure.

Normal blood-pressure, 120 mm.

The intracranial bag was subjected to 44 mm. pressure prior to the experiment. The intrathoracic pressure was 18 mm.

The pressure in the tube was raised to 150 mm.

Blood-pressure, 220 mm.; thoracic pressure, 136 mm.; cranial pressure, 130 mm.

The pressure in the tube was released.

Blood-pressure, 120 mm.; intracranial, 34 mm; thoracic pressure, 18 mm.

The absolute rise of the blood-pressure was 100 mm.; of the cranial pressure, 86 mm.; of the thoracic pressure, 118 mm.

The dog was then reduced to surgical shock.

Blood-pressure, 70 mm.

In raising the tube-pressure to 80 mm. the blood-pressure rose.

Blood-pressure, 140 mm.; cranial pressure, 25 mm.; thoracic pressure, 60 mm.

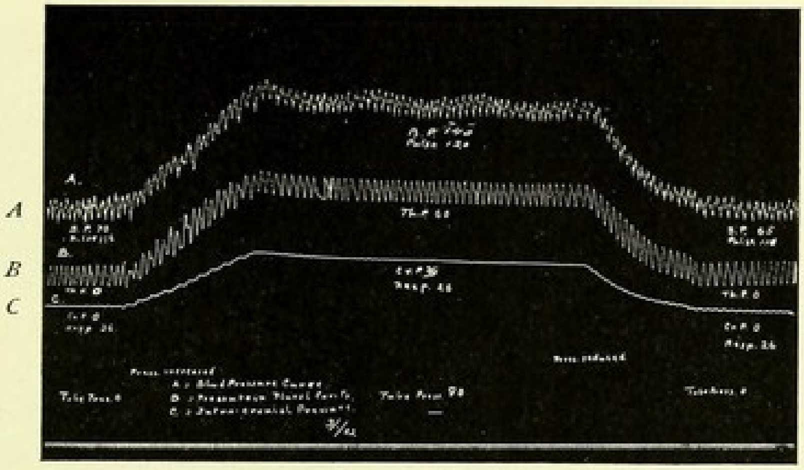


FIG. 37.—EXP. 166.—On the effect of increased atmospheric pressure in moderate shock. *A*, carotid pressure; *B*, intrathoracic pressure; *C*, intracranial pressure. The net change in the circulation was not appreciable.

Pressure in the tube was released.

Blood-pressure, 65 mm.; cranial pressure, 0 mm.; thoracic pressure, 0 mm.

The intracranial pressure curve recorded the pulse and the respiratory wave.

EXPERIMENT 167.

Showing the Effect of communicating the Pulmonary Tract with the Pressure Tube, the Animal remaining Outside.

Mongrel dog; good condition; weight, twenty-two kilos. Morphin and ether anesthesia. The dog was outside of the tube. The carotid cannula was connected with the manometer.

At 10.35, blood-pressure, 130 mm.; pulse, 180; respiration, 20. The pressure in the tube was increased to 150 mm. and the tracheal tube was connected with the compression tube. The stop-cock was opened, and air suddenly admitted into the trachea. There was a slight leak in the trachea. The blood-pressure fell to 50 mm. The lungs ruptured, the blood-pressure rose slightly, then fell to 30 mm. The pulse, which had temporarily ceased, again resumed action.

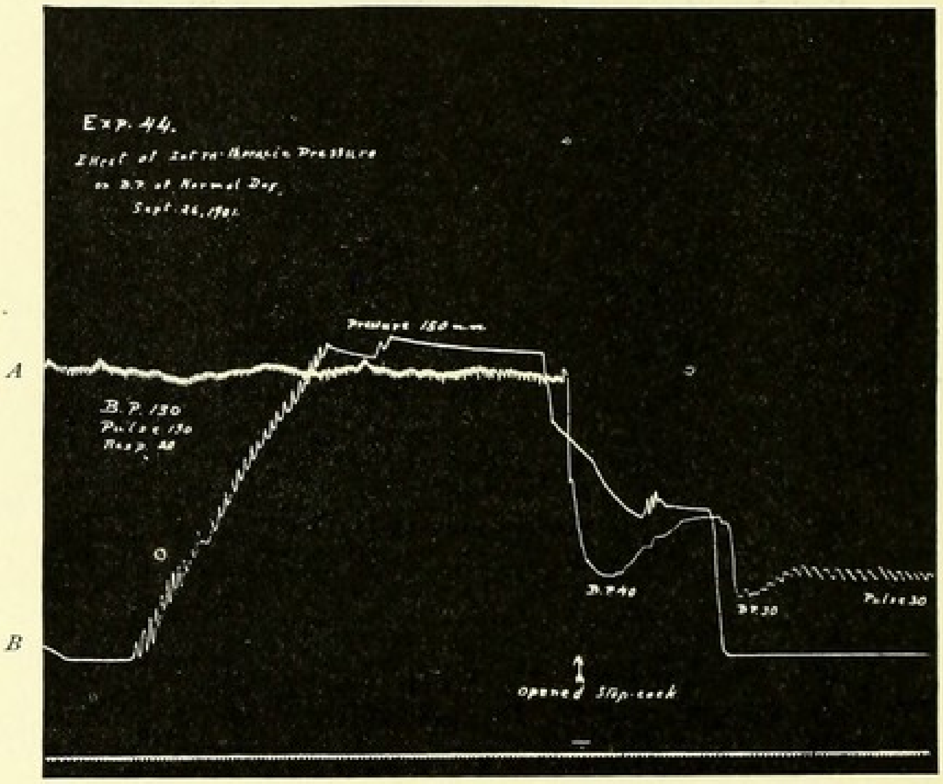


FIG. 38.—EXP. 167.—*A*, blood-pressure; *B*, tube-pressure. The tracheal cannula was connected with the tube in which there were 150 mm. air-pressure. Note the sudden fall in blood-pressure and death. The cause of this fall was the increase of the pressure within the alveoli of the lungs until it was higher than the pressure within the capillaries in the walls of the alveoli, causing a complete arrest of the circulation at this point.

At 10.42, blood-pressure, 45 mm.; pulse, 30; respiration ceased.

The dog died from failure of respiration.

Autopsy.—Rupture of the right lung was found; both lungs contained much air; the pulmonary vessels were congested; the heart was distended and in diastole. The blood-vessels of the splanchnic area were enormously distended. The posterior peritoneum was forced upward among the intestines, and a large quantity of air was beneath. The air came from the ruptured lung and dissected downward into the abdominal cavity, behind the peritoneum, having followed the right crus in its course through the diaphragm. The dog had but one testicle in the scrotum; an undescended testicle apparently functional was found.

Experiment 168.

On the Effect of Increased Atmospheric Pressure when the Blood-Pressure has been reduced by severing the Spinal Cord.

Male mongrel dog; good physical condition. Ether anesthesia.

The blood-pressure cannula was adjusted in the carotid. The cord was severed in the upper dorsal region.

The blood-pressure fell to 20 mm. The dog was placed in the tube, and on increasing the atmospheric pressure 90 mm. the blood-pressure rose to the level recorded before the cord was divided. It was maintained there for a period of ten minutes. On removing the dog from the tube the blood-pressure fell to the point it was before the cord was cut.

Experiment 169.

Differential Pressures.

Male mongrel dog; fair condition.

Blood-pressure cannula was placed in the carotid, the respiratory cannula in the trachea, external connections having been made. The animal was placed in the tube and the atmospheric pressure was increased rapidly to 250 mm. The blood-pressure was raised so high that it forced the mercury out of the manometer. Before the animal could be removed from the tube it died of hemorrhage.

Experiment 170.

Differential Pressures.

Male mongrel dog; poor condition; weight, seven kilos. The injection of 1 dram of one per cent. solution of morphin was given. Ether anesthesia.

The animal was placed in the tube and respiration was connected with the external atmosphere. The pressure in the tube was rapidly increased 200 mm. Respiration became shallow and labored. The respiratory effect on the blood-pressure was marked. As the pressure rose the excursions of the manometer became higher and *pari passu* with the increase of the atmosphere in the tube.

The animal died in ten minutes, the manometer exhibited enormous excursions, showing the tendency to distention of the heart.

Autopsy.—The splanchnic and somatic areas were cyanotic. The heart was distended almost to the point of bursting. The lungs and the large venous trunks, also the pulmonary circulations, were over-distended.

Experiment 171.

Differential Pressures.

Male mongrel dog; weight, six kilos.

Blood-pressure, 118 mm.

The animal was placed in the tube and by means of a rubber tube and cannula respiration was connected with the outside air.

The atmospheric pressure in the tube was increased to 100 mm. The pressure rose *pari passu* with the increase of the atmospheric pressure. Respiration became shallow and more labored and in a few minutes failed. The heart finally ceased beating, each pulsation becoming shorter than the preceding.

Autopsy.—All the vessels within the thorax were enormously congested. Other arteries of the body were anemic.

EXPERIMENT 172.

Differential Pressures.

Mongrel dog; good condition; weight, nineteen pounds.

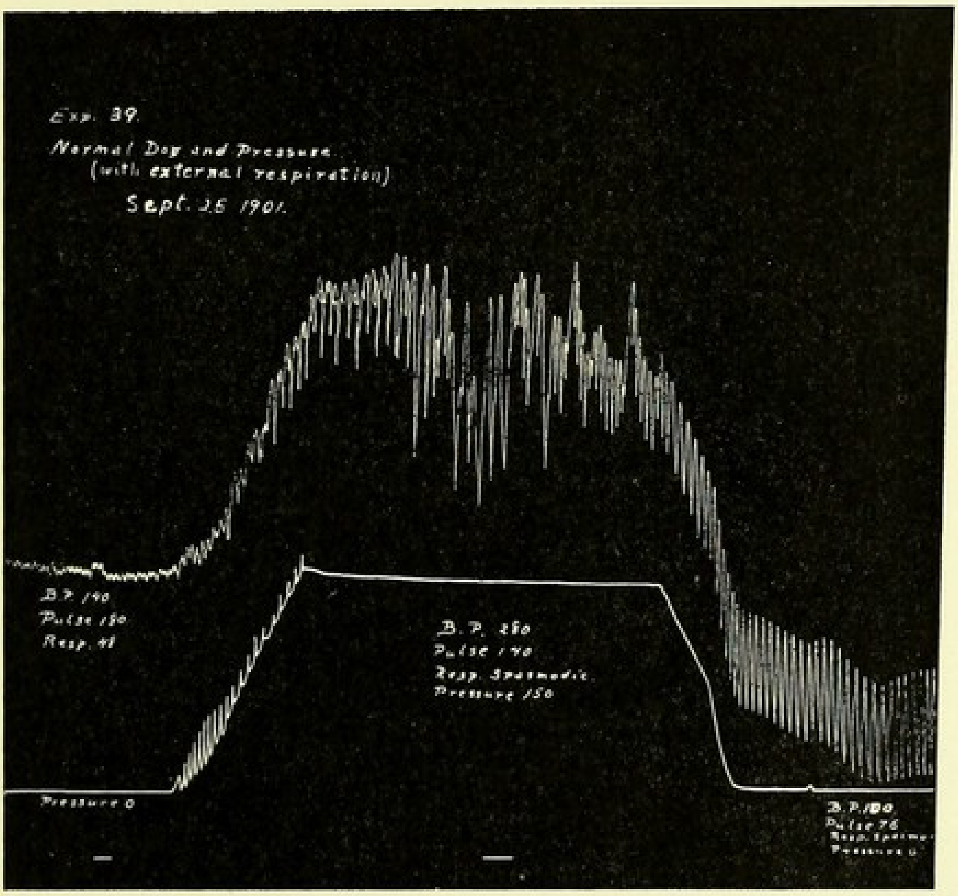


FIG. 39.—EXP. 172.—*A*, arterial pressure; *B*, tube-pressure. In this animal the tracheal cannula was connected with the outer air, so that while the remainder of the body was subjected to the increased pressure in the tube the lungs were subjected to the pressure of the outer air only. Note the enormous increase in the pulse-wave and the rapidly failing circuation. The blood in quantity was driven into the pulmonary system where the pressure was lowest.

Respiratory apparatus connected with the air of the room. The pressure in the tube was increased rapidly to 150 mm. The animal died in seven minutes.

the excursions in the manometer becoming longer and longer. The respiratory effect on the blood-pressure was very marked as the atmospheric pressure in the tube was increased.

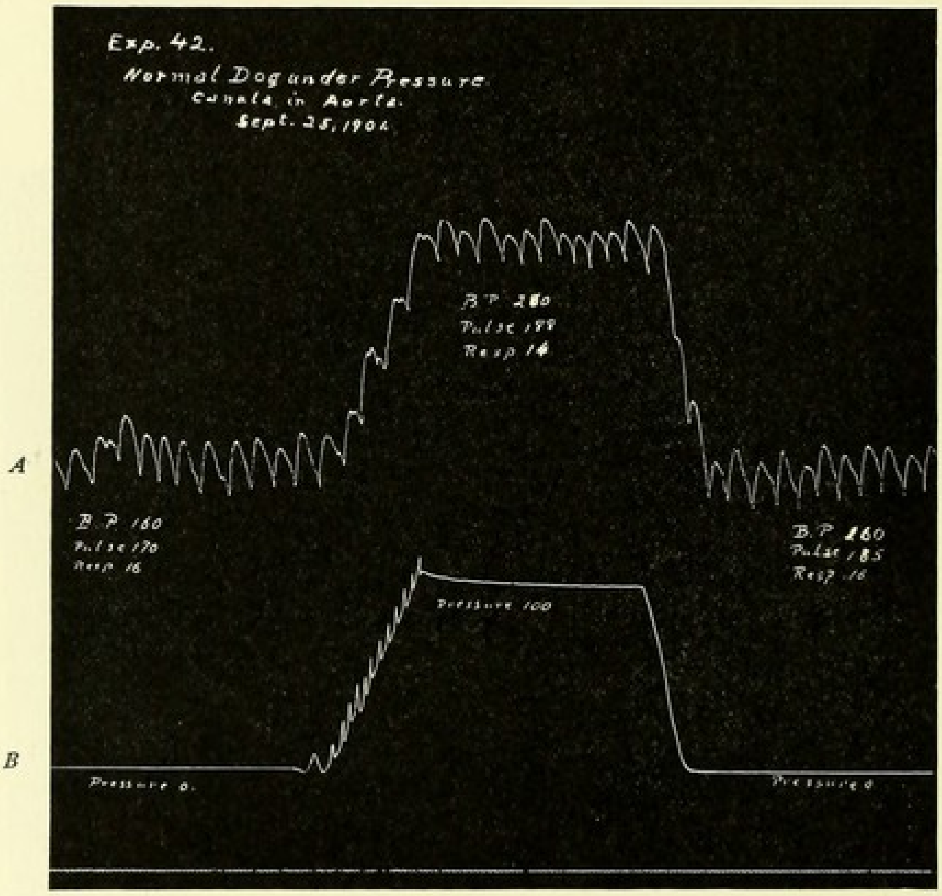


FIG. 40.—EXP. 173.—*A*, aortic pressure; *B*, tube-pressure. On increasing the pressure in the tube the aortic pressure rose higher than that of the tube.

EXPERIMENT 173.

On the Effect of Changes in the Atmospheric Pressure upon the Aortic Pressure.

Bull dog; weight, thirty-five pounds; good condition. Morphin and ether anesthesia. A long cannula reaching to the aorta was inserted into the carotid.

At 4.30, blood-pressure, 160 mm.; tube-pressure, 0 mm.; pulse, 170; respiration, 16.

At 4.33, tube-pressure, 100 mm.; blood-pressure, 260 mm.; pulse, 188; respiration, 14.

At 4.36, tube-pressure, 0 mm.; blood-pressure, 160 mm.; pulse, 185; respiration, 16.

At 4.40, tube-pressure, 120 mm.; blood-pressure, 280 mm.; pulse, 148; respiration, 12. A clot developed in the cannula. The dog was removed from the tube and prepared for another experiment.

Experiment 174.

Ligation of both Vertebral and the Carotid Arteries, the Animal being then subjected to Varying Atmospheric Pressures.

Male mongrel dog; good condition; weight, ten kilos. Morphin and ether anesthesia.

Preliminary blood-pressure, 120 mm.; cranial pressure, 40 mm.; pulse, 100; respiration, 25.

Both vertebral arteries were ligated as they entered the vertebral foramen.

The pulse-rate was reduced to 96, and the excursion to about half the former height. Blood-pressure, 120 mm.; respiration, 23.

The animal was then placed in a pneumatic tube. Blood-pressure, 120 mm.; cranial pressure, 40 mm. The left carotid was ligated.

The blood-pressure rose 10 mm. and the cranial pressure fell 12 mm.; the falling curve was quite similar to an asphyxial curve. Tube-pressure, 0 mm., blood-pressure, 80 mm. The fall was due to manipulation. Cranial pressure, 30 mm.

Tube-pressure, 45 mm.; blood-pressure, 130 mm.; cranial pressure, 38 mm.

The cranial pressure did not show the usual rise, otherwise the phenomena corresponded to previous results. This was repeated several times with the same result.

Duration of experiment, two hours and twenty minutes. Blood-pressure at the close of the experiment, without the tube-pressure, recorded 118 mm.

The dog was in fair condition at the end of the experiment.

Experiment 175.

Comparing Pressure in Various Parts of the Body.

Female dog; weight, fourteen kilos. Morphin and ether anesthesia.

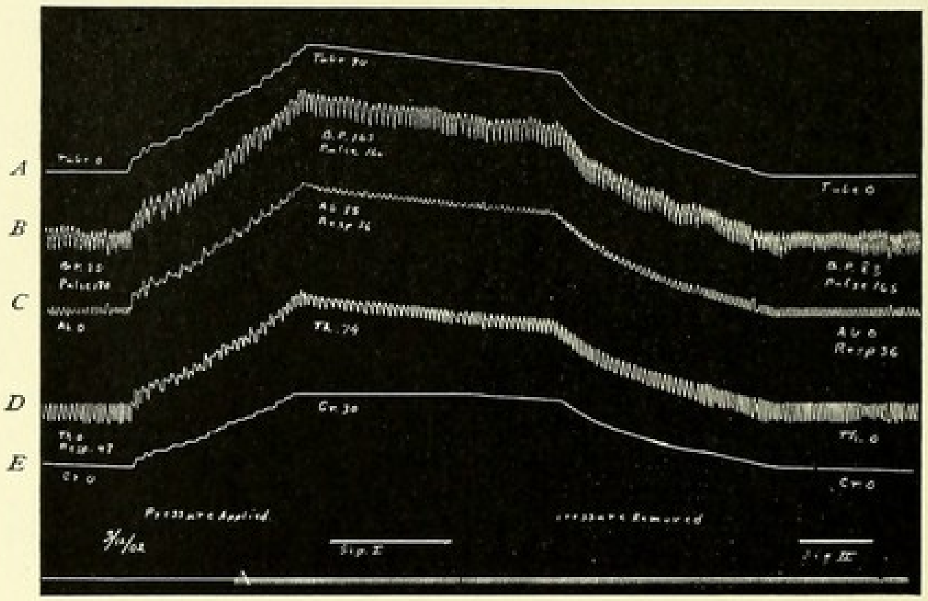


Fig. 41.—Exp. 175.—*A*, tube-pressure; *B*, blood-pressure; *C*, abdominal pressure; *D*, thoracic pressure; *E*, cranial pressure. Animal in moderate shock. Note the corresponding changes in the pressures on varying the pressure in the tube. The advantage was in favor of the cranial circulation.

The apparatus was arranged for recording the blood-pressure, intracranial pressure, the thoracic, the abdominal, and the tube-pressure.

Preliminary blood-pressure, 135 mm.

The animal was reduced to moderate surgical shock.

When subjected to a pressure of 90 mm. the pressure rose.

Blood-pressure, 165 mm.; abdominal pressure, 85 mm.; thoracic pressure, 74 mm.; cranial pressure, 30 mm.

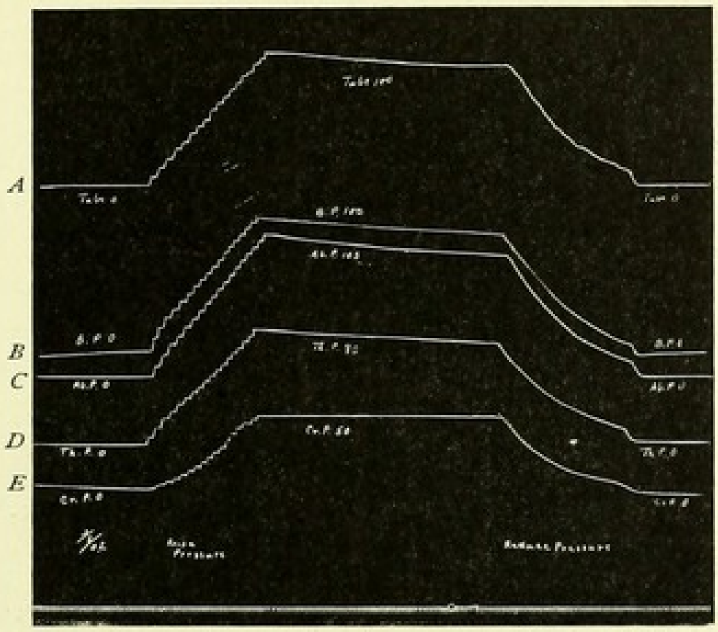


FIG. 42.—EXP. 175 (continued).—*A*, pressure in the tube; *B*, blood-pressure; *C*, intraabdominal; *D*, intrathoracic; *E*, intracranial. This experiment was made upon the dead animal, showing the slight relative loss of force in the transmission of pressure through the walls of the various cavities.

On releasing the tube-pressure, blood-pressure, 83 mm.; abdominal pressure, 0 mm.; thoracic pressure, 0 mm.; cranial pressure, 0 mm.

Respiration and the pulse were recorded upon the intracranial curve.

EXPERIMENT 176.

On the Changes in the Intracranial Circulation.

Male dog; weight, eighteen kilos. Morphin and ether anesthesia.

At 12.00, tube-pressure, 0 mm.; blood-pressure, 140 mm.; intracranial pressure, 0 mm.

At 12.02, tube-pressure, 90 mm.; blood-pressure, 230 mm.; intracranial pressure, 20 mm.

At 12.10, tube-pressure, 160 mm.; blood-pressure, 10 mm.; intracranial pressure, 120 mm.

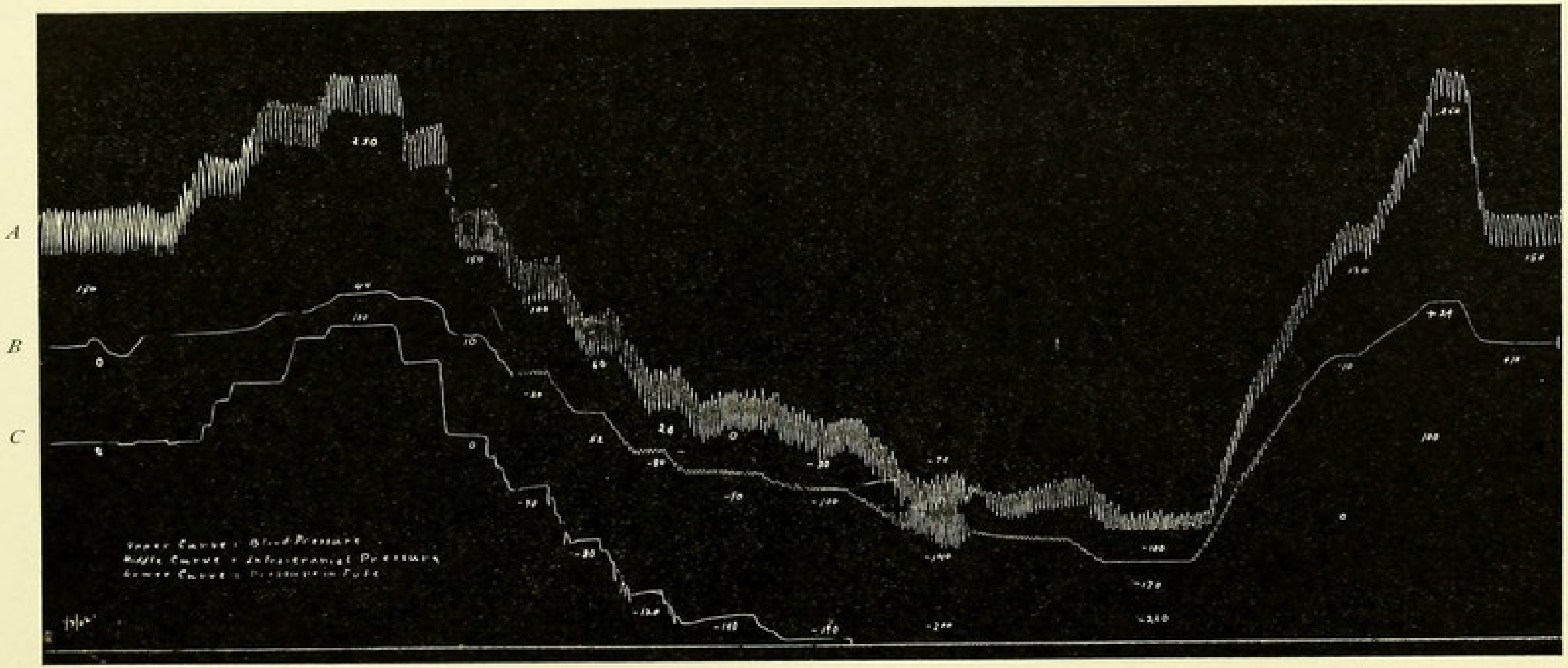


FIG. 43.—EXP. 176.—*A*, carotid blood-pressure; *B*, intracranial pressure; *C*, pressure in tube. Note the divergence between the carotid and the intracranial pressures, thus favoring the circulation of the blood in the brain during increased pressure in the tube and *vice versa*, at least increasing the amount of blood circulating through the brain.

At 12.16, tube-pressure, 0 mm.; blood-pressure, 10 mm.; intracranial pressure, 10 mm.

At 12.32, tube-pressure, 120 mm.; blood-pressure, 260 mm.; intracranial pressure, 20 mm.

At 12.36, tube-pressure, 150 mm.; blood-pressure, 20 mm.; intracranial pressure, 15 mm.

At 12.50, tube-pressure, 0 mm.; blood-pressure, 140 mm.; intracranial pressure, 4 mm.

The dog was killed.

Experiment 177.

As in Experiment 176.

Male mongrel dog; weight, eleven kilos. Morphin and ether anesthesia. Intracranial observations.

At 11.00, tube-pressure, 0 mm.; blood-pressure, 120 mm.; intracranial pressure, 0 mm.

At 11.05, tube-pressure, 70 mm.; blood-pressure, 72 mm.; intracranial pressure, 16 mm.

At 11.06, tube-pressure, 0 mm.; blood-pressure, 110 mm.; intracranial pressure, 0 mm.

At 11.16, tube-pressure, 60 mm.; blood-pressure, 160 mm.; intracranial pressure, 16 mm.

At 11.19, tube-pressure, 0 mm.; blood-pressure, 110 mm.; intracranial pressure, 0 mm.

At 11.23, tube-pressure, 20 mm.; blood-pressure, 80 mm.; intracranial pressure, 10 mm.

At 11.25, tube-pressure, 100 mm.; blood-pressure, 0 mm.; intracranial pressure, 80 mm.

At 11.55, tube-pressure, 0 mm.; blood-pressure, 110 mm.; intracranial pressure, 40 mm.

Experiment 178.

As in Experiment 177.

Mongrel dog; weight, twenty-one kilos; good condition. Morphin and ether anesthesia. A button of bone was removed from the skull and a rubber cork, through which a tube passed, and on the end of which a rubber bag was attached, was connected with the manometer.

Normal pressure, 120 mm.; pulse, 140; cranial pressure, 0 mm.; tube-pressure, 0 mm.

At 6.20, blood-pressure, 220 mm.; pulse, 110; cranial pressure, 10 mm.; tube-pressure, 80 mm.

At 6.30, tube-pressure, 110 mm.; blood-pressure, 240 mm.; intracranial pressure, 28 mm.

At 6.35, tube-pressure, 40 mm.; blood-pressure, 180 mm.; intracranial pressure, 18 mm.

At 6.45, tube-pressure, 80 mm.; blood-pressure, 70 mm.; intracranial pressure, 42 mm.

At 6.50, tube-pressure, 120 mm.; blood-pressure, 20 mm.; intracranial pressure, 75 mm.

At this point the heart stopped and the animal was killed.

Experiment 179.

On the Effect of Atmospheric Pressure upon the Circulation of the Various Parts of the Body when the Animal is in Shock.

Male dog; weight, eleven kilos. Morphin and ether anesthesia. The apparatus was arranged as in the previous experiment.

Preliminary blood-pressure, 122 mm.; pulse, 88; respiration, 28.

The animal was reduced to considerable shock.

Blood-pressure, 80 mm.; abdominal pressure, 0 mm.; thoracic pressure, 0 mm.; cranial pressure, 40 mm.

The cranial bag was placed under the preliminary pressure.

On raising the pressure in the tube to 150 mm. the following results were obtained:

Blood-pressure, 240 mm.; abdominal pressure, 150 mm.; thoracic pressure, 140 mm.; cranial pressure, 94 mm.

On reducing the pressure in the tube to 0 mm., blood-pressure registered 85 mm.; abdominal pressure, 0 mm.; thoracic pressure, 0 mm.; cranial pressure, 40 mm.

The animal was killed.

Experiment 180.

As in Experiment 179.

Dog; weight, eighteen kilos. Morphin and ether anesthesia. The apparatus was arranged as in the previous experiment.

Preliminary blood-pressure, 135 mm.

The animal was reduced to moderate shock.

Blood-pressure, 115 mm.; abdominal pressure, 10 mm.; thoracic pressure, 7 mm.; intracranial pressure, 16 mm.

The tube-pressure was reduced to 70 mm.

Blood-pressure, 160 mm.; abdominal pressure, 60 mm.; thoracic pressure, 70 mm.; cranial pressure, 50 mm.

On removing the pressure the dog died.

Upon reapplying 100 mm. pressure to the dead animal the results were as follows:

Blood-pressure, 100 mm.; abdominal pressure, 105 mm.; thoracic pressure, 85 mm.; cranial pressure, 50 mm.

On releasing the tube-pressure the manometer recorded 0 mm.

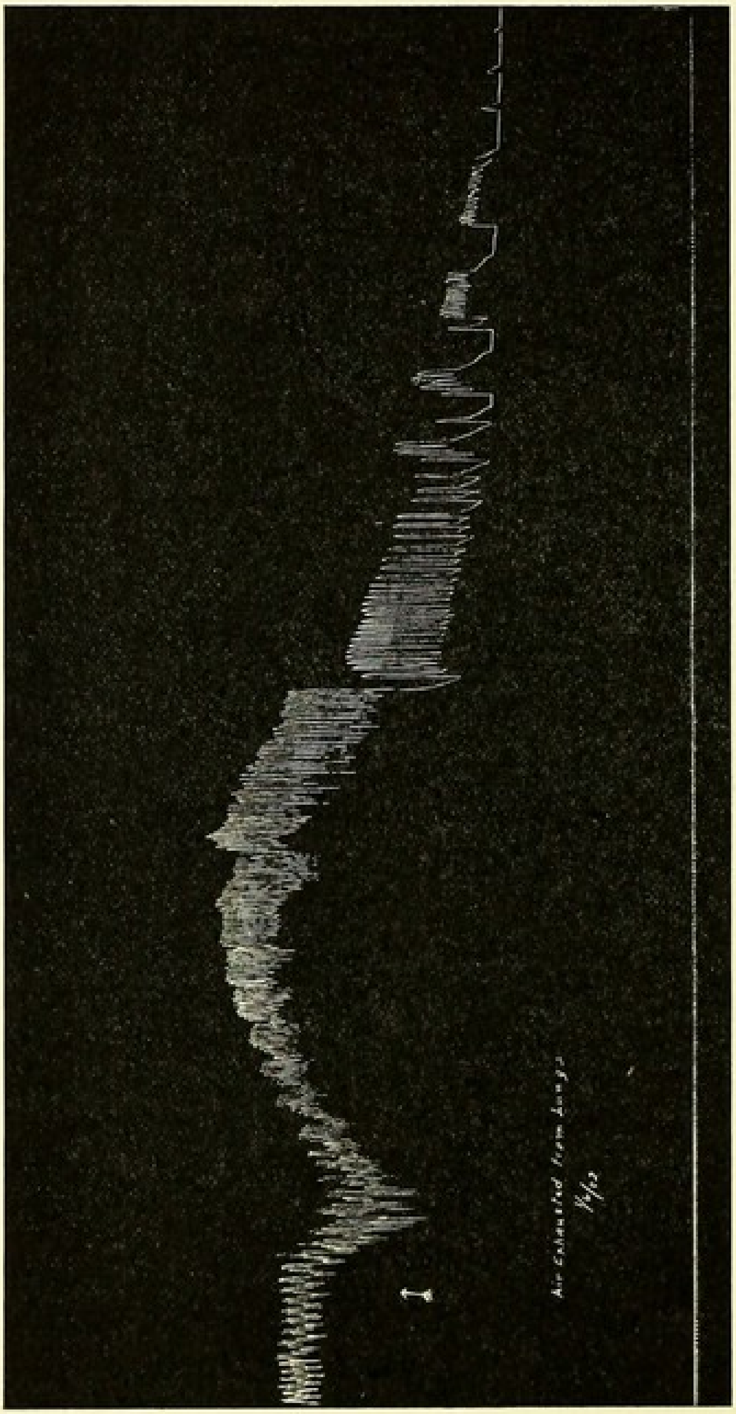
Experiment 181.

On the Effect of breathing Rarefied Air.

Male dog; weight, twelve kilos. Morphin and ether anesthesia. The apparatus was arranged for exhausting the pulmonary tract.

Normal blood-pressure, 150 mm.

On exhausting the pulmonary tract, by connecting the



A

FIG. 44.—EXP. 181.—*A*, arterial pressure. Tracheal tube connected with an exhaust-pump and the air exhausted from the lungs. The diminution of the intrapulmonary pressure induced the accumulation of an excessive amount of blood in the pulmonary circulation which rapidly overcame the circulation causing death within a few minutes.

trachea with the tube with a low negative pressure, the heart rate was slow, the force and output greatly increased, the length of the stroke greatly amplified, the blood-pressure curve declined, and the heart in a few minutes stopped in diastole.

Experiment 182.

Repetition of Experiment 181.

Male dog; weight fourteen kilos. Morphin and ether anesthesia. The apparatus was arranged for a negative experiment upon the pulmonary tract.

Primary blood-pressure, 140 mm.

On connecting the trachea with the tube, with a low negative pressure, the pulse-waves were enormously increased, the heart beat slower, and in a few minutes was arrested in diastole.

Experiment 183.

Observation of Variations in the Atmospheric Pressure upon the Length of the Pulse-Wave.

Male mongrel dog; weight six kilos; fair condition. Morphin and ether anesthesia.

The blood-pressure was taken in the femoral artery.

Preliminary blood-pressure, 120 mm.; stroke, 10 mm.

As the pressure in the tube was increased there was a decrease in the length of the stroke.

Tube-pressure, 100 mm.; blood-pressure, 210 mm.; stroke, 6 mm.

Tube-pressure, reduced to 0 mm.

Blood-pressure, 120 mm.; length of stroke, 6 mm.

Experiment 184.

Repetition of Experiment 183.

Female mongrel dog; weight, seven kilos; fair condition. Morphin and ether anesthesia.

Preliminary blood-pressure, 130 mm.; length of stroke, 8 mm.

Tube-pressure, 100 mm.; length of stroke, 4 mm.

Tube-pressure, 0 mm.; blood-pressure, 130 mm.; length of stroke, 8 mm.

Experiment 185.

Asphyxia. Pressure.

Female mongrel dog; weight, nine kilos; good condition. Morphin and ether anesthesia.

Preliminary blood-pressure recorded 128 mm.

At the closing of the tube the blood-pressure tracing resembled an asphyxial curve.

The increased atmospheric pressure caused no delay in the death from asphyxia.

When opening the tube the dog was found to be dead, due to kinking of the respiratory tube.

Experiment 186.

Shock. Pressure.

Male mongrel dog; good condition; weight, fifteen kilos. Ether anesthesia.

Carotid blood-pressure, 125 mm.; femoral pressure, 123 mm.; tube-pressure, 0 mm.

The animal was subjected to shock by the usual means, and was then placed in the tube.

Tube-pressure, 100 mm.; carotid pressure, 230 mm.; femoral pressure, 228 mm.

Tube-pressure, 0 mm.; carotid pressure, 128 mm.; femoral pressure, 125 mm.

During forty-five minutes the dog was allowed to remain in the tube, at the expiration of which time the blood-pressure had fallen in the carotid artery to 80 mm. The pressure from the femoral artery recorded an irregular line. The animal was replaced in the tube and subjected to pressure.

The femoral pressure rose 20 mm.

The carotid pressure recorded 100 mm.; tube, 30 mm.

The pressure was released.

Both the carotid and the femoral pressure fell.

Carotid pressure, 84 mm.; femoral pressure, 82 mm.; tube-pressure, 0 mm.

Carotid pressure, 200 mm.; femoral pressure, 130 mm.; tube, 110 mm.

As the pressure was released from the tube the femoral pressure was not affected until the tube-pressure recorded 80 mm.

The carotid pressure was 180 mm. The dog was then removed from the tube and the femoral artery and cannula examined for a clot, none being found. Duration of experiment, two hours and fifty-five minutes.

In this experiment it was noticed that when the dog was in partial shock, the femoral and carotid pressures were similar, but when in complete shock the femoral stroke was diminished to a wavy line, the pressure being the same as the carotid.

Experiment 187.

Shock. Pressure.

Female mongrel dog; good condition; weight, 5.5 kilos. Ether anesthesia.

Preliminary carotid blood-pressure, 143 mm.; femoral blood-pressure, 143 mm.

The animal was reduced to moderate shock.

Tube-pressure, 0 mm.; carotid blood-pressure, 130 mm.; carotid stroke, 20 mm.; femoral blood-pressure, 130 mm.; femoral stroke, 18 mm.

Tube-pressure, 110 mm.; carotid blood-pressure, 240 mm.; carotid stroke, 20 mm.; femoral blood-pressure, 240 mm.; femoral stroke, 16 mm.

Tube-pressure, 0 mm.; carotid blood-pressure, 115 mm.; carotid stroke, 20 mm.; femoral blood-pressure, 115 mm.; femoral stroke, 18 mm.

Tube-pressure, 104 mm.; carotid blood-pressure, 230 mm.; carotid stroke, 20 mm.; femoral blood-pressure, 230 mm.; femoral stroke, 16 mm.

Tube-pressure, 0 mm.; carotid blood-pressure, 120 mm.; carotid stroke, 120 mm.; femoral blood-pressure, 120 mm.; femoral stroke, 18 mm.

The animal was removed from the tube and reduced to a greater degree of shock.

Carotid blood-pressure, 86 mm.; femoral blood-pressure, 86 mm.; carotid stroke, 10 mm.; femoral stroke, an irregular line. No clot was found in the femoral artery. The animal was replaced in the tube.

Tube-pressure, 0 mm.; carotid blood-pressure, 96 mm.; carotid stroke, 20 mm.; femoral blood-pressure, 94 mm.; femoral stroke, irregular line.

Tube-pressure, 100 mm.; carotid blood-pressure, 195 mm.; carotid stroke, 10 mm.; femoral blood-pressure, 109 mm.; femoral stroke, irregular line.

Tube-pressure, 0 mm.; carotid blood-pressure, 96 mm.; carotid stroke, 10 mm.; femoral blood-pressure, 94 mm.; femoral stroke, irregular line.

The dog was removed from the tube, no clots being found in the cannula. It was observed that the femoral pressure did not rise synchronously with the carotid pressure, or as the tube-pressure was increased. Similar phenomena were observed when the pressure was released. The strokes of the carotid were slightly reduced when subjected to pressure, while the femoral strokes were obliterated.

Experiment 188.

On the Effects of Variation in Pressure upon the Length of Pulse-Wave in the Carotid and Femoral Arteries.

Female mongrel dog; good condition; weight, twelve kilos. Ether anesthesia.

Preliminary blood-pressure in the carotid, 100 mm.; stroke, 8 mm.; femoral blood-pressure, 99 mm.; stroke, 10 mm. The animal was reduced to moderate shock.

Carotid blood-pressure, 90 mm.; stroke, 10 mm.

Femoral blood-pressure, 89 mm.; stroke, 10 mm.

The intestines and denuded surfaces were again manipulated to obtain a greater degree of shock. Carotid blood-pressure, 40 mm.; femoral blood-pressure, 36 mm.

The animal was placed in a tube and subjected to pressure.

Tube-pressure, 100 mm.; carotid blood-pressure, 140 mm.; stroke, 10 mm.; femoral blood-pressure, 128 mm.; stroke, 4 mm.

Femoral blood-pressure did not rise parallel with the carotid pressure, the strokes being diminished to a heavy irregular line. When the pressure in the tube was released the femoral blood-pressure was several millimetres lower than the carotid pressure.

Experiment 189.

Repetition of Experiment 188.

Male dog; good condition; weight, nine kilos. Ether anesthesia.

Preliminary blood-pressure in the carotid, 105 mm.; stroke, 4 mm.; femoral blood-pressure, 104 mm.; stroke, 5 mm.

The animal was reduced to shock.

Carotid blood-pressure, 95 mm.; stroke, 3 mm.;

femoral blood-pressure, 94 mm.; stroke, 1 mm.

The animal was subjected to pressure in the tube.

Tube-pressure, 130 mm.; carotid blood-pressure, 236 mm.; stroke, 4 mm.; femoral blood-pressure, 235 mm. The stroke was somewhat irregular. The pressure in the tube was reduced to 0 mm.

The carotid blood-pressure, 100 mm.; femoral blood-pressure, 99 mm.

The pressure experiment was repeated, the femoral showing an irregular line. There was no irregularity when subjected to pressure.

The femoral pressure did not rise parallel to the carotid pressure, a slight lagging being characteristic.

Experiment 190.

On the Mechanical Support of the Circulation.

The following experiments were made to determine whether or not the application of pressure upon the extremities and trunk would, in cases of shock, raise the blood-pressure. If the pressure were raised, would it be sustained, and would the application of pressure be accompanied by injurious side effects.

Experiment 191.

Mongrel dog; weight, twenty-one kilos. Morphin and ether anesthesia.

Preliminary blood-pressure recorded 130 mm.

The animal was reduced to shock by the usual method.

Blood-pressure, 70 mm.

Pressure with the hands was then applied upon the abdomen. A rise in the blood-pressure followed. Compensation soon occurred, the pressure falling to the previous level.

On repeating the pressure, a similar effect was noted. Grasping one or more paws firmly with the hands was followed by a rise in the blood-pressure, in proportion to the pressure exerted, and to the number of paws compressed. Compensation soon occurred, and the blood-pressure returned to the former level. Rubber elastic bandages were then applied over the extremities, the head, the neck, the abdomen, and the thorax. The blood-pressure rose from 70 mm. to 102 mm. as the bandages were applied.

Dyspnœa became very marked, and the contents of the stomach were discharged. The blood-pressure was maintained at the level to which it was raised, so long as respiration was not interfered with to a dangerous degree. It was so apparent that the animal would die of asphyxia that the thoracic bandages were released.

The animal was then killed.

Experiment 192.

Differential Pressure.

Male mongrel dog; good condition; weight, twenty kilos; 15 milligrams of morphin were injected. Ether anesthesia.

The tracheal and carotid cannula were inserted. The dog was reduced to deep shock by skinning, crushing, and burning, after which he was placed in the pressure-tube. The tracheal cannula was connected with an external air-chamber in which the pressure was maintained 10 mm. below that of the tube. It was so arranged that simultaneous tracings of the blood-pressure, the tube-pressure, and the respiratory pressure could be taken. When the pressure in the tube was raised the blood-pressure rose proportionately. The excursions of the writing style were increased from 10 to 40 mm. in length. By changing the pressure in the respiration chamber and the tube the length of the pulse-wave could be varied. The heart, however, beat irregularly, with a varying rhythm. The dog was then removed from the tube, a cannula introduced into the femoral vein and connected with a burette. Curare, normal saline, and adrenalin, 1 to 100,000, were injected. Artificial respiration was supplied. The blood-pressure rose to 130 mm, and was there maintained. On decapitating the animal the pressure fell to 30 mm., remaining at that level for seventeen minutes, during which adrenalin and saline solution were continuously injected. At the end of seventeen minutes artificial respiration was discontinued and the heart beat for two minutes.

Experiment 193.

Male spaniel; fair condition; weight, ten kilos. Morphin and ether anesthesia.

At 10.40, pulse, 144; respiration, 136.

At 10.50, pulse, 80; respiration, 20.

At 11.00, pulse, 116; respiration, 28; blood-pressure, 120 mm.

At 11.02, the animal was placed in the tube.

At 11.04, tube-pressure, 100 mm.; blood-pressure, 140 mm.

At 11.08, tube-pressure, 0 mm.; blood-pressure, 120 mm.; pulse, 106; respiration, 20.

At 11.10, tube-pressure, 0 mm.; blood-pressure, 120 mm.; pulse, 106; respiration, 20.

At 11.13, the animal was removed from the tube and the cord was severed in the dorsal region.

At 11.15, the blood-pressure fell to 90 mm.

At 11.20, tube-pressure, 0 mm.; blood-pressure, 65 mm.; pulse, 128; respiration, 28.

At 11.30, blood-pressure slowly rose to 80 mm. and was sustained.

At 11.33, the animal was replaced in the tube.

At 11.35, tube-pressure, 0 mm.; blood-pressure, 70 mm.; pulse, 140; respiration, 24.

The pulse was weak and the excursions small.

At 11.37, tube-pressure, 80 mm.; blood-pressure, 140 mm.; pulse, 128; respiration, 24.

At 11.39, tube-pressure, 0 mm.; blood-pressure, 80 mm.; pulse, 132; respiration, 36.

The respiratory waves in the blood-pressure tracings were very marked. The pulse was of a vagal type, and the heart was markedly weakened.

At 11.42, the dog was removed from the tube and found to be dying. Artificial respiration and sciatic stimulation failed.

The animal died.

Autopsy.—The intestines were contracted, and the vessels of the splanchnic area were dilated. The bladder was distended, and the stomach contained about one hundred c.c. of fluid. The lungs were pale, the heart empty, having stopped in systole. The heart was smaller than normal and the walls were very thin. During the experiment the dog bled profusely from the vertebral artery, severed while cutting the cord. Blood was found in the spinal canal.

Experiment 194.

Male mongrel dog; good condition; weight, 7.45 kilos. Morphin and ether anesthesia.

At 10.18, pulse, 168; respiration, 60.

At 10.32, pulse, 208; respiration, 40. The blood-pressure manometer was connected with the carotid artery, and the apparatus for taking the respiratory tracing was applied.

The animal was placed in the tube.

At 10.40, tube-pressure, 0 mm.; blood-pressure, 110 mm.; pulse, 180; respiration, 50.

At 10.50, tube-pressure, 50 mm.; blood-pressure, 170 mm.; pulse, 200; respiration, 36.

At 10.54, tube-pressure, 75 mm.; blood-pressure, 190 mm.; pulse, 176; respiration, 44.

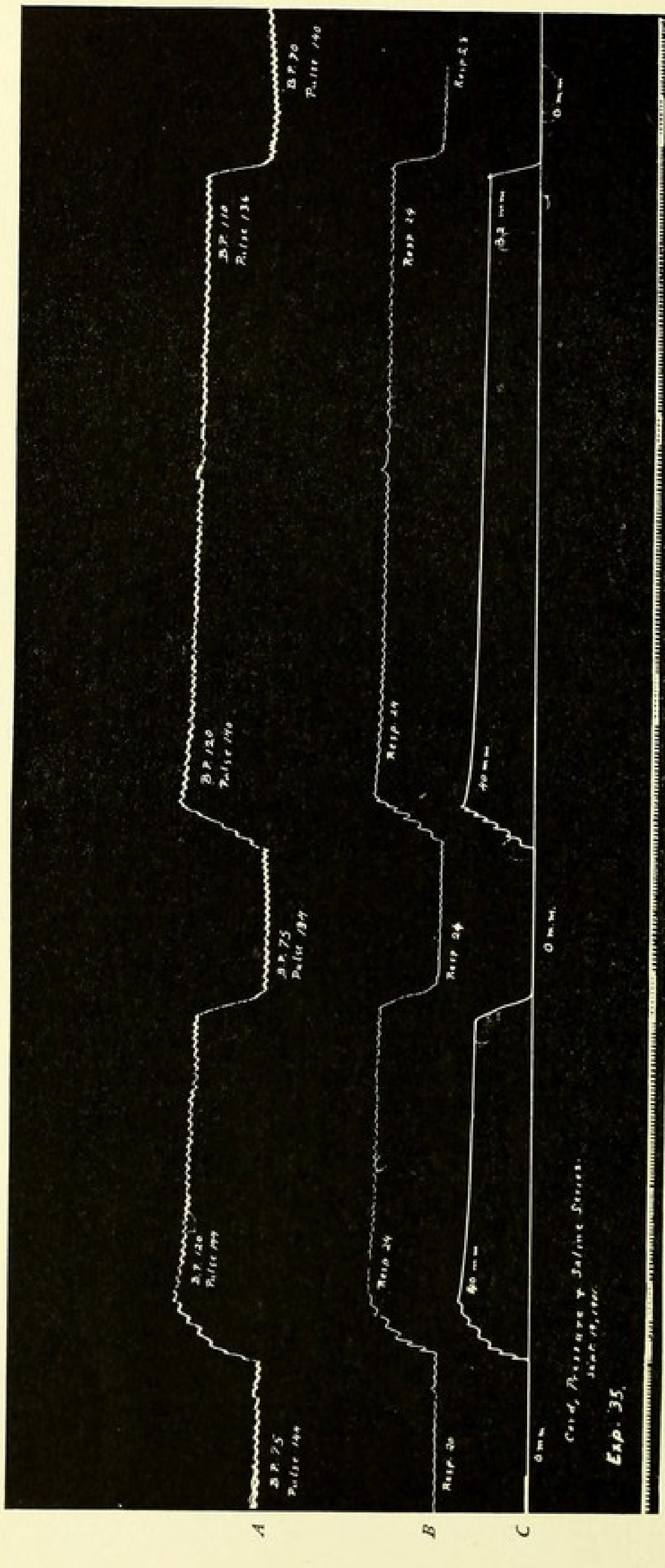


FIG. 45.—EXP. 194.—*A*, blood-pressure; *B*, intrathoracic pressure; *C*, tube-pressure. Animal, in moderate shock, was subjected to an increased atmospheric pressure in the chamber. Note the paralleling of the various pressures.

At 10.55, tube-pressure, 105 mm.; blood-pressure, 220 mm.; pulse, 180; respiration, 60.

At 10.57, tube-pressure, 0 mm.; blood-pressure, 110 mm.; pulse, 176; respiration, 40.

The animal was removed from the tube and the cord exposed and severed in the upper dorsal region. The animal was then replaced in the tube.

At 11.37, tube-pressure, 0 mm.; blood-pressure, 90 mm.; pulse, 180; respiration, 36.

At 11.43, tube-pressure, 0 mm.; blood-pressure, 90 mm.; pulse, 124; respiration, 36.

At 11.45, tube-pressure, 20 mm.; blood-pressure, 110 mm.; pulse, 126; respiration, 28.

At 11.49, tube-pressure, 50 mm.; blood-pressure, 150 mm.; pulse, 120; respiration, 36.

At 11.51, tube-pressure, 100 mm.; blood-pressure, 200 mm.; pulse, 126; respiration, 36.

At 11.54, tube-pressure, 125 mm.; blood-pressure, 220 mm.; pulse, 125; respiration, 30.

At 11.56, tube-pressure, 0 mm.; blood-pressure, 90 mm.; pulse, 126; respiration, 36. The animal was removed from the tube and 710 c.c. of normal saline solution was injected into the peritoneal cavity.

At 12.23, blood-pressure, 90 mm.; pulse, 150; respiration, 24.

At 12.30, the animal was replaced in the tube.

At 12.33, tube-pressure, 0 mm; blood-pressure, 100 mm.; pulse, 136; respiration, 24.

At 12.35, tube-pressure, 25 mm.; blood-pressure, 140 mm.; pulse, 138; respiration, 24.

At 12.38, tube-pressure, 100 mm.; blood-pressure, 190 mm.; pulse, 138; respiration, 24.

At 12.40, tube-pressure, 75 mm.; blood-pressure, 160 mm.

At 12.41, tube-pressure, 0 mm.; blood-pressure, 90 mm.

At 12.45, tube-pressure, 25 mm.; blood-pressure, 110 mm.; pulse, 140; respiration, 24.

At 12.50, the air was changed, and the blood-pressure rose. Blood-pressure, 110 mm.; pulse, 140; respiration, 28.

At 1.06, the air was changed.
Blood-pressure, 110 mm.; pulse, 140; respiration, 32.

At 1.15, the air was changed.
Blood-pressure, 110 mm.; pulse, 136; respiration, 24.

At 1.25, tube-pressure, 0 mm.; blood-pressure, 80 mm.; pulse, 136; respiration, 28.

At 1.26, tube-pressure, 30 mm.; blood-pressure, 110 mm.

At 1.35, the air was changed.

At 1.36, tube-pressure, 0 mm.; blood-pressure, 75 mm.; pulse, 144; respiration, 20.

At 1.46, the air was changed.

At 1.47, tube-pressure, 40 mm.; blood-pressure, 120 mm.; pulse, 144; respiration, 24.

At 2.00, tube-pressure, 0 mm.; blood-pressure, 75 mm.; pulse, 134; respiration, 24.

At 2.02, tube-pressure, 40 mm.; blood-pressure, 120 mm.; pulse, 136; respiration, 24.

At 2.12, tube-pressure, 0 mm.; blood-pressure, 70 mm.; pulse, 124; respiration, 22.

At 2.15, tube-pressure, 40 mm. blood-pressure, 120 mm.; pulse, 120; respiration, 24.

At 2.30, the air was changed; tube-pressure, 40 mm.; blood-pressure, 120 mm.

At 2.45, the tube was opened and the animal appeared to be in good condition.

At 2.48, respiration became spasmodic and the blood-pressure gradually fell.

At 2.50, blood-pressure, 50 mm.; pulse, 52. The pulse was vagal. The excursions were large. Respiration, spasmodic. The heart became slower and respiration ceased.

Autopsy.—The intestines were pale and much contracted. The large mesenteric vein was much engorged; bladder was distended and contained 95 c.c. of fluid; spleen, normal; kidneys, normal; liver, somewhat paler than normal; gall-bladder, quite full; the stomach contained 125 c.c. of fluid. The heart was distended and had stopped in diastole; the lungs and thoracic veins were congested. The inferior and superior vena cava and the right heart were distended with venous blood. There was injected 710 c.c. of fluid, of which 620 c.c. was recovered, therefore 90 c.c. was absorbed.

Experiment 195.

Mongrel dog; good condition. Ether anesthesia. The blood-pressure cannula was adjusted in the carotid; the respiratory cannula in the trachea.

The dog was placed in the tube and subjected to .9 kilos pressure. The respiratory cannula was connected with the external air. On increasing the atmospheric pressure in the tube the blood-pressure rose synchronously with the strokes of the piston of the air-pump. The pressure was sustained for a few moments when it was noted that the heart was beating slowly and exhibiting enormous curves. No respiratory apparatus having been supplied, respiration soon ceased, and the animal died of asphyxia.

Experiment 196.

Mongrel dog; good condition. Ether anesthesia. Blood-pressure cannula was adjusted in the carotid and the respiratory cannula in the trachea.

The respiratory system did not communicate with the outside air, but the animal breathed through the tube. Upon increasing the atmospheric pressure in the tube the blood-pressure rose proportionately to the increased atmospheric pressure, as indicated by the gauge. The respirations continued without change. The excursion of the manometer was slightly diminished in length. The frequency of the heart-beat was also diminished. The pressure was raised to the greatest possible height, and upon lowering the atmospheric pressure in the tube the blood-pressure fell correspondingly. On removing the entire pressure the blood-pressure fell to the height recorded before the experiment was begun.

Experiment 197.

Mongrel dog; good condition. Ether anesthesia. Blood-pressure cannula in the carotid; respiratory cannula in the trachea.

The cord was exposed and severed in the lower cervical region. The dog was placed in the tube and subjected to a two-pound pressure. An increase in the atmospheric pressure was followed by a corresponding rise in the blood-pressure. On closing the cocks the blood-pressure remained at a level. On lowering the pressure the blood-pressure fell correspondingly.

Experiment 198.

Mongrel dog; fair condition. Blood-pressure cannula in the carotid; respiratory cannula in the trachea. The spinal cord was exposed and severed in the lower cervical region. The dog was placed in the tube and subjected to varying pressure.

One-half pound caused a rise in the blood-pressure, two pounds twice the rise, and two and one-half pounds a corresponding increase. When the pressure was lowered half a pound at a time, the blood-pressure fell accordingly.

The animal breathed in the tube, respiration being unaffected. The marked fall in the blood-pressure was due to the severing of the spinal cord, but was easily overcome by the increased atmospheric pressure. The blood-pressure was raised to the height recorded before the severing of the cord and remained steady in that position for half an hour. On removing the dog from the tube the blood-pressure remained at the same level it was after section of the cord.

Experiment 199.

Shock. Pressure.

Mongrel dog; good condition. Ether anesthesia. Blood-pressure cannula in the carotid. The intestines were exposed and manipulated until the animal was in profound shock.

It was necessary to continue the dissection and expose and manipulate the splanchnic area for twenty minutes before the blood-pressure was reduced to 42 mm. At this time respiration became irregular. The blood was dark in color and the pressure was rapidly declining.

The animal was immediately placed in the tube, atmospheric pressure was increased, and the blood-pressure returned to normal. The animal remained in the tube one hour and fifteen minutes. Respiration was unchanged, and the condition of the animal was the same. The intestines were freely exposed during this time.

The animal was removed and killed by bleeding.

Experiment 200.

Shock. Pressure.

Small dog; fair condition; ether anesthesia. Blood-pressure cannula in the carotid. The animal was reduced to profound shock by extensive dissection and exposure of the skin and manipulation of the stomach and intestines. The blood-pressure was reduced to 24 mm., the animal was gasping and the blood was becoming very dark.

The dog was placed in the tube and the atmospheric pressure was increased to one and one-third pounds, which was sufficient to bring the blood-pressure to the level recorded at the beginning of the experiment. The animal remained in the tube two hours. When placed in the tube the intestines were livid, and upon removal two hours later, they were pale red.

The animal was bled to death.

Experiment 201.

Shock. Pressure.

Mongrel dog; fair condition; ether anesthesia; cannula in the carotid. The blood-pressure was 146 mm. The animal was reduced to surgical shock by opening the abdomen, exposing and manipulating the intestines, and removing the integuments. In thirty minutes the blood-pressure was reduced to 50 mm. The intestines were extremely livid and congested. The blood-pressure was rapidly falling, and recorded 32 mm. Respiration was shallow and irregular, death being imminent. The animal was placed in the tube and atmospheric pressure increased.

The blood-pressure rose to the control,—*i.e.*, 46 mm. Five minutes later it recorded 150 mm.

The animal was allowed to remain in the tube for three hours and twenty minutes, at the expiration of which time its condition had not changed. Upon removal from the tube the intestines appeared to be normal. The cyanosis and congestion had entirely disappeared.

The blood-pressure remained as high as the normal and the heart beat strongly.

The animal was killed by bleeding.

Autopsy.—The brain, spinal cord, heart, and lungs were found to be normal.

Experiment 202.

Shock. Pressure.

Mongrel dog; fair condition; blood-pressure cannula in the carotid. External respiration was supplied. Two and one-half c.c. of morphin was administered. Ether anesthesia.

Blood-pressure, 155 mm.; pulse, 145.

The abdomen was opened, the intestines exposed and manipulated.

Blood-pressure, 125 mm. The intestines were livid, and the veins enormously congested. The animal was placed in a tube and atmospheric pressure was increased, after which the blood-pressure rose to 208 mm. The pulse decreased from 145 to 105, the strokes were somewhat lengthened. The animal was allowed to remain in the tube one hour and fifteen minutes, and upon removal the intestines were found to be almost normal in color.

The blood-pressure continued at 150 mm. A few minutes after removal from the tube the intestines increased in lividity and in ten minutes were the same color that they were before the animal was placed in the tube.

Autopsy.—The brain, spinal cord, heart, and lungs were found to be normal.

Experiment 203.

Shock. Pressure.

Mongrel dog; good condition; weight, 4.5 kilos. The blood-pressure cannula was adjusted in the carotid, the respiratory cannula in the trachea.

Five c.c. of one per cent. solution of morphin was injected. Ether anesthesia.

Initial blood-pressure, 160 mm.; pulse, 150.

At 3.50, the abdomen was opened and the intestines were manipulated, becoming livid and congested.

At 3.56, resection of the hip-joint was performed.

At 4.10, the sciatic nerve was severed and the proximal end was mechanically stimulated.

Respiration failed.

At 4.13, artificial respiration was supplied.

At 4.16, the skin was dissected from the base of the tail to the thorax.

The superficial veins were greatly dilated.

Blood-pressure was 140 mm.

At 4.18, the skin was dissected from the thorax.

At 4.20, the kidneys and diaphragm were manipulated.

The blood-pressure fell to 100 mm.

At 4.27, the brachial plexus was manipulated. The blood-pressure fell to 70 mm.

The pulse was small and irregular and the blood-pressure continued to fall.

At 4.32, the animal was placed in the tube.

At 4.41, the blood-pressure had increased somewhat, but a corresponding fall followed.

At 4.42, by increasing the atmospheric pressure the blood-pressure was raised to 160 mm.

At 4.51, the dog was removed from the tube, and the following observations were made. The intestines were red, the veins small, the cyanosis and congestion had disappeared. No hemorrhage had occurred.

At 5.00, the animal was replaced in the tube.

Blood-pressure, 160 mm.

The animal remained in the tube thirty minutes, maintaining an even blood-pressure.

At 5.30, the dog was removed from the tube; he was in good condition, there having been no hemorrhage.

The animal was killed by bleeding.

Autopsy.—The heart and lungs were found normal, the dura slightly congested, and the brain and cord normal.

Experiment 204.

Shock. Pressure.

Mongrel dog; poor condition; weight, nine kilos; morphin and ether anesthesia.

Pulse, 123; respiration, 63.

At 3.10, the abdomen was opened; the intestines exposed and manipulated; the skin dissected from the back, abdomen, and thorax; the sciatic nerve was exposed and manipulated. Spasmodic respiration occurred.

The blood-pressure dropped to 46 mm.

The animal was placed in the tube, breathing the air of the tube. The blood-pressure was raised to 140 mm.

The dog remained in the tube for two hours, after which the blood-pressure fell to 68 mm.

The animal was killed.

Autopsy.—Negative.

Experiment 205.

Shock. Pressure.

Male mongrel dog; weight, eight kilos. A preliminary injection of 4 c.c. of one per cent. solution of morphin was given. Ether anesthesia.

Pulse, 160; respiration, 33; blood-pressure, 120 mm.

The abdomen was opened; the intestines exposed and manipulated; the skin of the back and thorax dissected.

Blood-pressure fell to 70 mm.

The animal was placed in the tube and subjected to one and one-third pounds pressure. Blood-pressure rose to 130 mm., the heart strokes became slightly smaller, and the respiratory action was unchanged.

The animal was allowed to remain in the tube for one hour and thirty minutes; after which it became asphyxiated. Upon removal from the tube there followed an improvement of respiration, the blood-pressure fell to 84 mm. The animal was killed.

Autopsy.—Negative.

Experiment 206.

Shock. Pressure.

Mongrel dog; fair condition; weight, fifteen pounds.

Ether anesthesia; respiration, 60.

Blood-pressure, 110 mm.

The abdomen was opened; the intestines exposed and manipulated, and the skin dissected from the abdomen, back, and thorax. The sciatic nerve was exposed and manipulated. The pulse became greatly accelerated and irregular, the blood-pressure falling to 50 mm.

The animal was placed in a tube and the blood-pressure raised to 120 mm. Asphyxia caused the death of the animal.

Experiment 207.

On the Effect of Increased Atmospheric Pressure upon Absorption of Saline Solution.

Mongrel dog; good condition; weight, 11.25 kilos.

Morphin and ether anesthesia.

At 2.24, 500 c.c. of normal saline solution, 37° C., was injected into the subcutaneous tissue of the abdomen.

At 2.41, the animal was subjected to one and two-thirds pounds atmospheric pressure within the tube.

At 3.11, the dog was removed and killed by puncturing the heart.

Autopsy.—An incision was made over the point of injection and the skin was laid back from each side. The tissues were somewhat anemic. No hemorrhage occurred on cutting through the skin. The subcutaneous tissue was translucent and boggy.

Four hundred and twenty-five c.c. of saline were recovered, 75 c.c. having been absorbed.

Experiment 208.

Absorption. Pressure.

Mongrel dog; poor condition; weight, ten kilos. Morphin and ether anesthesia.

At 10.25, the cord was exposed in the second dorsal area. Blood-pressure, 110 mm.

At 10.32, the cord was divided, the blood-pressure falling from 126 mm. to 100 mm. The heart was weak and respiration shallow.

At 10.33, 125 c.c. of saline solution at 25° C. were injected into the peritoneal cavity, the blood-pressure falling to 66 mm.

At 10.36, the dog was subjected to one and one-half pounds pressure.

Blood-pressure, 100 mm.; the heart, very weak.

At 10.40, the animal died.

Blood-pressure, 40 mm.

Death was due to respiratory failure.

Experiment 209.

The Effect of Pressure upon Absorption of Fluids when the Spinal Cord has been severed.

Mongrel dog; fair condition; weight, fourteen kilos. Morphin and ether anesthesia.

The cord was severed between the second and third dorsal vertebræ.

At 10.43, pulse, 132; respiration, 24.

An injection of 875 c.c. of saline solution at 25° C. was made into the peritoneal cavity.

At 11.05, the animal was placed in the tube and subjected to one and one-half pounds pressure. The air was renewed every ten minutes.

At 12.40, the dog was removed in good condition.

Pulse, 100; respiration, 18.

The animal was killed by puncturing the heart.

Autopsy.—The intestines were constricted, the gall and urinary bladders were not distended. Forty c.c. of fluid were found in the stomach, which was otherwise normal. Eight hundred c.c. of fluid were recovered, the absorption being about 35 c.c.

Experiment 210.

Preceding Experiment repeated.

Mongrel dog; good condition; weight, 7.2 kilos. Morphin and ether anesthesia.

Pulse, 150; respiration, 35.

At 2.25, the cord was exposed and divided in the dorsal region.

At 2.27, respiration, 30; pulse, 108, irregular.

At 2.35, 1450 c.c. of saline solution at 37° C. were injected. Pulse, 80; respiration, 23.

At 2.36, the animal was subjected to one and one-half pounds pressure and the air was renewed every ten minutes.

At 4.40, the dog died of respiratory failure. Fluid escaped from the mouth, nose, and anus. The abdomen was opened, there was general congestion. The heart was distended. Death was probably due to asphyxia. Fourteen hundred c.c. of solution were recovered, about 50 c.c. having been absorbed.

Experiment 211.

Preceding Experiment repeated.

Bull terrier; good condition; weight, 12.2 kilos. Morphin and ether anesthesia.

Pulse, 66; respiration, 30; the cord was exposed and severed at the third dorsal vertebra.

Pulse, 138; respiration, 18.

At 5.02 to 5.16, 1340 c.c. of saline solution at 37° C. were given. Pulse, 138; respiration, 24.

At 5.18, the animal was subjected to one and one-half pounds pressure in the tube, the air being renewed every ten minutes.

At 6.51, the animal was removed from the tube.
Pulse, 156; respiration, 18.
The animal was killed by puncturing the medulla.

Autopsy.—There was slight edema of the subcutaneous tissues. No fluid was found in the intestines or the stomach. The splanchnic vessels were dilated. The gall and urinary bladders were empty; the lungs and heart slightly congested. Twelve hundred and seventy c.c. of the solution were recovered, about 70 c.c. having been absorbed.

Experiment 212.

Repetition of the Preceding.

Mongrel dog; good condition; weight, twenty-two kilos. Morphin and ether anesthesia.

Initial blood-pressure, 155 mm.; pulse, 168; respiration, 30.

At 2.03, tube-pressure, 2 pounds; blood-pressure, 260 mm.; pulse, 160; respiration, 22.

At 2.05, tube-pressure, 1½ pounds; blood-pressure, 230 mm.; pulse, 160; respiration, 30.

At 2.07, tube-pressure, 0; blood-pressure, 150 mm.; pulse, 158.

At 2.08, the dog was removed from the tube in good condition.

At 2.32, the cord was severed in the upper dorsal region.
Blood-pressure, 110 mm.; pulse, 144; respiration, 19.

At 2.44, tube-pressure, 1½ pounds; blood-pressure, 100 mm.; pulse, 130 mm.; respiration, 38.

At 2.48, the animal was removed from the tube.

At 2.50 to 2.54, 1620 c.c. of saline solution at 37° C. were injected into the peritoneal cavity.
Blood-pressure, 100 mm.; pulse, 177; respiration, 16.
The animal was replaced in the tube.

At 3.05, tube-pressure, ¾ pound; blood-pressure, 140 mm.; pulse, 160; respiration, 20.

At 3.08, tube-pressure, 1 pound; blood-pressure, 150 mm.; pulse, 150; respiration, 34.

At 3.12, the air was renewed.

Blood-pressure, 90 mm.; pulse, 148; respiration, 36.

At 3.16, tube-pressure, 1¼ pounds; blood-pressure, 150 mm.; pulse, 152; respiration, 18.

At 3.25, the air was renewed.

Blood-pressure, 90 mm.; pulse, 140; respiration, 20.

At 3.26, tube-pressure, 1¼ pounds; blood-pressure, 150 mm.; pulse, 140; respiration, 20.

At 3.37, the air was renewed.

Blood-pressure, 80 mm.; pulse, 128; respiration, 20.

At 3.39, tube-pressure, 1½ pounds; blood-pressure, 150 mm.; pulse, 122; respiration, 20.

At 3.45, blood-pressure, 120 mm.; respiration, spasmodic.

At 3.47, tube-pressure, 0; blood-pressure, 50 mm.; respiration, 9.

At 3.49, tube-pressure, 1 pound; blood-pressure, 120 mm.

At 3.50, the animal was killed.

Autopsy.—The intestines were empty; the veins dilated. The bladder was not filled; the stomach was empty. The heart was distended and there was no congestion of the lungs. Fourteen hundred and seventy c.c. of solution were recovered, about 150 c.c. having been absorbed.

Experiment 213.

Repetition of the Preceding.

Mongrel dog; good condition; weight, seven kilos. Morphin and ether anesthesia.

At 8.40, pulse, 184, strong, regular, and rhythmic; respiration, 52.

At 9.08, pulse, 180, small and regular; respiration, 36.

At 9.25, the cord was severed in the upper dorsal region.

At 9.27, pulse, 176; respiration, 22.

At 9.33, 730 c.c. of normal saline were injected into the abdominal cavity.

At 9.35, pulse, 150; respiration, 52.

At 9.50, pulse, 200; respiration, 24.

Twitching of the fore-legs and neck was noted.

At 10.45, pulse, 220; respiration, 24.

At 11.10, pulse, 196; respiration, 22.

At 11.35, pulse, 200; respiration, 24.

At 1.40, air was forced into the femoral vein, killing the animal.

Autopsy.—There was general vascular congestion of the entire splanchnic area. The intestines were contracted; the bladder distended; veins of the mesentery were very greatly congested. The large intestine contained a small amount of fluid; the stomach and ilium contained about 100 c.c. of fluid, the vessels of the kidney were congested; liver normal; gall-bladder moderately full; the pancreas and the spleen were normal; the veins of the diaphragm were dilated. The pulmonary vessels were dilated as was also the heart and its vessels. There was general congestion of the thoracic cavity. The cancellous tissue of the skull bled freely when cut. The vessels of the pia were congested. The brain, negative. Six hundred and fifty-five c.c. of the fluid were recovered, about 75 c.c. being absorbed.

Experiment 214.

Repetition of the Preceding.

Mongrel dog; good condition; weight, thirteen kilos. Morphin and ether anesthesia.

At 10.05, pulse, 152; respiration, 40.

At 10.10, the cord was severed in the upper dorsal region.

At 10.15, pulse, 118; respiration, 40.

At 10.20, 1070 c.c. of normal saline were injected.

At 10.22, pulse, 110; respiration, 30.

At 10.45, pulse, 168; respiration, 32.

At 11.15, pulse, 118; respiration, 28.

At 12.00, pulse, 92; respiration, 32.

At 12.20, pulse, 112; respiration, 24.

The animal was killed by forcing air into the femoral vein.

Autopsy.—General congestion existed in the entire splanchnic area. The intestines were contracted; the stomach contained about 120 c.c. of fluid; there was a small amount of fluid in the ilium; the spleen, pancreas, and liver were normal; the gall-bladder and urinary bladder were somewhat distended. The thoracic cavity was congested and the heart distended. Nine hundred and ten c.c. of fluid were recovered, about 160 c.c. having been absorbed.

Experiment 215.

On the Rapidity of Subcutaneous Absorption of Saline when the Spinal Cord has been severed.

Dog; fair condition; weight, fifteen kilos. Morphin and ether anesthesia. The respirations were very rapid.

At 10.30, pulse, 152; respiration, 30.

At 10.36, the cord was severed in the upper dorsal region.

At 10.38, pulse, 148; respiration, 100.

At 10.40, 620 c.c. of saline were injected.

At 10.41, pulse, 140; respiration, 72.

At 11.15, pulse weak and rapid; respiration, 50.

At 11.25, respiration, 58.

At 12.33, pulse, 128; respiration, 80.

At 12.35, the animal was killed by an overdose of ether.

Autopsy.—The subcutaneous tissues were anemic and filled with fluid, of which 410 c.c. were recovered and about 210 were absorbed. General splanchnic congestion existed. A small amount of fluid was in the peritoneal cavity; the thoracic cavity was congested and the heart distended.

Experiment 216.

On Normal Absorption when the Spinal Cord has been severed.

Mongrel dog; good condition; weight, twelve kilos. Morphin and ether anesthesia.

At 10.55, pulse, 124; respiration, 24.

At 11.00, the cord was severed in the upper dorsal region.

At 11.03, pulse, 140; respiration, 32.

At 11.06, 880 c.c. of saline were injected into the abdominal cavity.

At 11.08, pulse, 116; respiration, 24.

At 12.10, the animal was killed by forcing air into the jugular vein.

Seven hundred and forty c.c. of fluid were recovered; about 140 c.c. were absorbed.

Some Experiments showing the Effect of Increased Atmospheric Pressure on Hemorrhage.

Experiment 217.

Mongrel dog; weight, ten kilos; ether anesthesia.

Cannula in the carotid.

Blood-pressure, 125 mm. One-fourth grain of morphin sulphate was administered.

One hundred and fifty c.c. of blood were drawn.

Blood-pressure fell to 80 mm.

The animal was placed in the tube and two-thirds of a pound of atmospheric pressure applied. Blood-pressure rose to 130 mm. The volume of the pulse was not increased.

Experiment 218.

Mongrel dog; weight, eight kilos. Ether anesthesia.

Three c.c of a one per cent. solution of morphin were injected.

One hundred and eighty c.c. of blood were abstracted from the jugular vein.

Blood-pressure fell from 136 mm. to 76 mm. The animal was placed in the tube and one pound of atmospheric pressure applied.
Blood-pressure rose to 140 mm. The volume of the pulse was unchanged.

Experiment 219.

Hemorrhage. Pressure.

Dog; good condition; weight, ten kilos. Ether anesthesia.
Blood-pressure, 121 mm. The animal was bled from the jugular vein until no more blood flowed. Death was so imminent that the dog was placed with the greatest haste in the tube. Atmospheric pressure was raised, which in turn raised the blood-pressure. Although the manometer excursions could scarcely be seen, the blood-pressure was raised to 120 mm. and allowed to remain there twenty minutes. The heart and respiration during this time remained the same. On removing the animal from the tube the blood-pressure fell to 26 mm.
The dog was killed by excessive anesthesia.

Experiment 220.

Hemorrhage. Pressure.

Male mongrel dog; good condition; weight, eighteen kilos.
Blood-pressure, 125 mm. The animal was bled until there was no longer a flow. Blood-pressure, 30 mm. The animal was placed in the tube and atmospheric pressure raised, the blood-pressure rose proportionately. The excursions of the writing style indicated that the heart-beats continued undiminished for forty-five minutes, after which the animal was removed and the blood-pressure fell. Respiration was distinctly improved.

Experiment 221.

Barometric Effects.

The following experiments were performed in the compression chamber at Lakeside Hospital.

Male mongrel dog; weight, fifty pounds. Morphin and ether anesthesia.

The carotid was connected with the manometer.

At 12.15, barometer, 29.6 inches; pulse, 104; respiration, 28; blood-pressure, 140 mm.

At 12.20, the pressure in the chamber was raised.

At 12.45, barometer, 29.6 inches; pulse, 160; respirations, 40; blood-pressure, 140 mm. The blood-pressure excursions were 6 mm. at each beat.

At 12.55, barometer, 30.4 inches; pulse, 154; respirations, 40; blood-pressure, 140 mm.

At 1.12, the integument was removed from one side of the trunk.

During the operation the blood-pressure rapidly fell to 80 mm., then slowly rose to 120 mm.

At 1.15, barometer, 30.5 inches; blood-pressure, 120 mm.

During the manipulation of the skin, the blood-pressure rose to 140 mm.

At 1.20, the intestines were exposed.

Barometer, 30.5 inches; pulse, 144; respirations, 50; blood-pressure, 120 mm.

At 1.23, the intestines were manipulated.

Blood-pressure, 110 mm.

The manipulation of the intestines was continued.

At 1.24, blood-pressure, 90 mm.

The manipulation was continued.

At 1.26, blood-pressure, 60 mm.

The manipulation was continued.

Hemorrhage from ruptured spleen occurred.

The spleen was tied off.

The animal was then killed.

Experiment 222.

Pneumatic Pressure.

The barometric reading was 29.45 inches in the pneumatic chamber with normal atmosphere. The pressure in the chamber could not be raised above 30.45 inches by the barometer. That amount of pressure was reached in each case two minutes after closing the escape-pipe. Air was forced into the chamber continuously. With the escape-pipes closed a constant pressure of one inch above the normal pressure could be maintained. The readings of the mercurial manometer contain a negative error of 25.7 mm. while under maximum pressure, since the free end of the mercurial manometer was exposed to the pressure of the chamber. Corrected readings are placed in parenthesis following the recorded blood-pressure. Male dog; good condition; twenty-two kilos. Morphin and ether anesthesia.

The carotid was connected with the manometer and a tracheal cannula was inserted.

At 3.25, barometer, 29.45 inches. Blood-pressure, 105 mm.; pulse, 180; respiration, 80.

At 3.28, the pressure was raised.

At 3.30, barometer, 30.40 inches; blood-pressure, 105 mm. (128).

At 3.45, barometer, 30.45 inches; blood-pressure, 105 mm. (130.5); pulse, 184; respiration, 172.

At 3.55, the pressure was released.

At 4.00, barometer, 29.45 inches; blood-pressure, 100 mm.; pulse, 200; respiration, 80.

At 4.01, the pressure was raised.

At 4.05, the intestines were exposed and manipulated. Barometer, 30.45 inches; blood-pressure, 80 mm. (105.5); pulse, 180.

At 4.06, barometer, 30.45 inches; blood-pressure, 90 (115.5); pulse, 180.

At 4.07, toes and testicles were crushed. Barometer, 30.45 inches; blood-pressure, 90 mm. (115.5); pulse, 176; respiration, 72.

At 4.13, the tail was crushed. Barometer, 30.45 inches; blood-pressure, 90 mm. (115.5); pulse, 156; respiration, 76.

At 4.15, heavy blows were exerted in the legs.

At 4.17, barometer, 30.45 inches; blood-pressure, 80 mm. (105.5); the fall in the blood-pressure was probably due to hemorrhage from the tail.

At 4.22, barometer, 30.45 inches; blood-pressure, 80 mm. (115.5).

At 4.24, burning the hind foot was followed by a temporary rise to 90 mm. (115.5).

At 4.25, repetition of burning the foot was followed by some temporary rise.

At 4.26, barometer, 30.45 inches; blood-pressure, 80 mm. (105.5); pulse, 148; respiration, 44.

At 4.27, the penis was crushed and the intestines were manipulated.

At 4.30, barometer, 30.45 inches; blood-pressure, 70 mm. (95.5).

All abdominal organs were disturbed and the perineum was torn.

At 4.31, ether was poured on the intestines; the blood-pressure fell to 55 mm. (75.5).

At 4.32, manipulation of the intestines was continued. Blood-pressure, 60 mm. (85.5).

At 4.33, the intestines were replaced and the abdomen closed.

At 4.36, barometer, 30.45 inches; blood-pressure, 70 mm. (95.5); pulse, 192.

At 4.42, barometer, 30.45 inches; blood-pressure, 75 mm. (105.5); pulse, 198; respiration, 52.

At 4.44, barometer, 30.45 inches; blood-pressure, 80 mm. (105.5); the pressure was removed.

At 4.47, barometer, 29.45 inches; blood-pressure, 80 mm.; pulse, 204; respiration, 56.

At 4.51, the intestines were exposed; barometer, 29.45 inches; blood-pressure, 60 mm. (60) temporary.

At 4.52, barometer, 29.45 inches; blood-pressure, 80 mm. (80).

After vigorous manipulation of the intestines the blood-pressure recorded 70 (70).

At 4.55, barometer, 29.45 inches; blood-pressure, 75 mm. (75); pulse, 204; respiration, 60.

At 4.56, the pressure was increased.

At 5.06, barometer, 30.45 inches; blood-pressure, 75 mm. (100.5); pulse, 192; respiration, 54.

At 5.10, barometer, 30.45 inches; blood-pressure, 70 mm. (95.5).

At 5.12, the cartilages of the ear were crushed.

At 5.13, barometer, 30.45 inches; blood-pressure, 60 mm. (85.5).

At 5.14, the intestines were manipulated; blood-pressure, 60 mm. (85.5).

Manipulation of the intestines was continued.

At 5.17, the blood-pressure remained steadily at 60 mm. (85.5).

At 5.18, barometer, 30.45 inches; blood-pressure, 60 mm. (85.5); pulse, 180; respiration, 54. The intestines were manipulated until the end of the experiment.

At 5.19, the pressure was removed and the blood-pressure remained steady at 60 mm. during the escape of air.

At 5.23, barometer, 25.45 inches; blood-pressure, 60 mm. (60); pulse, 196.

At 5.25, the pressure was raised.

At 5.30, barometer, 30.45 inches; blood-pressure, 60 mm. (85.5); pulse, 192; respiration, 52.

At 5.35, barometer, 30.45 inches; blood-pressure, 50 mm. (75.5); pulse, 196; respiration, 148.

At 5.37, the pressure was removed.

At 5.39, barometer, 29.45 inches; blood-pressure, 45 mm. (45); pulse, 200; respiration, 76.

The dog was killed. Under pressure the arterial tension and the pulse were slower than under normal atmosphere. The respiration was also slowed and strengthened under pressure. The animal was under continuous dissection and manipulation.

Experiment 223.

Resuscitation.

Dog; poor condition; weight, fourteen kilos. Ether anesthesia.

Initial blood-pressure, 130 mm.; pulse, 148. The cord was severed on a level with the second cervical vertebra, producing a fall in the blood-pressure to the abscissa line. The heart ceased action for fifteen seconds, then resumed. The blood-pressure rose to 135 mm., after which it fell to 80 mm., later declining to 65 mm.

On injecting ten minims of tincture of digitalis into the jugular vein, the pressure rose to 120 mm., afterwards falling to 80 mm.

A repetition of the injection produced a rise to 100 mm., followed in a few minutes by a fall to 80 mm.

On injecting ten minims of 1 to 1000 adrenalin solution, the blood-pressure rose to 225 mm., then fell in one minute to 35 mm.

The animal was then killed.

Experiment 224.

Resuscitation.

Dog; weight, eleven kilos. Ether anesthesia.

Initial blood-pressure, 140 mm. Clamping the trachea caused a rise in the blood-pressure to 150 mm., then a gradual fall to the abscissa line. Through the window in the thorax the heart was observed until every part of it was quiescent. At the expiration of a minute, the clamp was removed, artificial respiration was begun, and a continuous infusion of 1 to 50,000 of adrenalin into the jugular vein was made. The blood-pressure rose to 180 mm., then rapidly fell to 30 mm. On resuming the rhythmic pressure of the heart, the blood-pressure rose to 70 mm. On resumption of the rhythmic pressure, the heart beat very slowly, with a feeble and irregular contraction. Ten minims of adrenalin, 1 to 1000, were injected into the muscle and a like amount into the cavity of the heart. The heart's action increased, but after two minutes, irregular twitchings were substituted for the rhythmic contractions. The heart then passed into delirium cordis.

Time, thirty-five minutes.

Experiment 225.

Resuscitation.

Dog; fair condition; weight, sixteen kilos. Ether anesthesia.

Initial blood-pressure, 120 mm.

At 10.45, the trachea was clamped. A sharp decline in the blood-pressure of 20 mm. followed.

At 10.50, the animal was apparently dead. There were no respirations and no heart beats.

At 10.59, blood-pressure, 30 mm.

At 11.00, artificial respiration, rhythmic pressure upon the heart through the window in the chest, and a continuous infusion of adrenalin, 1 to 50,000, into the jugular vein were begun. The blood-pressure steadily rose to 40 mm., when the heart resumed beating, after which the blood-pressure rose sharply to 125 mm.

At 11.03, blood-pressure, 65 mm.; pulse, 120. The animal attempted normal breathing. The window in the thorax was closed. Shallow respirations continued a short time, then appeared to be normal.

The animal was killed.

Experiment 226.

Resuscitation.

Mongrel dog; weight, nine kilos. Ether anesthesia. The trachea was clamped. Through a window in the thorax the heart was observed until there was not even a slight twitching of the auricles. Five minutes later, artificial respiration, rhythmic pressure upon the heart through the window, and adrenalin were supplied. The blood-pressure rose from 20 mm. to 70 mm., the heart began to beat, but resuscitation failed. At autopsy a clot in the heart was found.

Experiment 227.

Resuscitation.

Mongrel dog; fair condition; weight, nine kilos. In this case the heart was quiescent for six minutes. Pulsations were re-established and the blood-pressure rose to 80 mm., but independent strong contractions and a maintenance of the blood-pressure could not be obtained.

Experiment 228.

Resuscitation.

Mongrel dog; fair condition; weight, eight kilos.
The trachea was clamped. Eight minutes after the last beat of the heart artificial respiration, rhythmic pressure upon the thorax, and adrenalin were given.
Respirations and the heart's action were restored.
The animal was killed.

Experiment 229.

Resuscitation.

Mongrel dog; poor condition, weight, six kilos.
The trachea was clamped. Ten minutes after the last beat of the heart the clamp was removed, and

artificial respiration and pressure upon the thorax were begun. The heart executed some contractions, but the animal could not be resuscitated. At autopsy clots were found in the ventricles.

Experiment 230.

Resuscitation.

Mongrel dog; good condition; weight, ten kilos. Ether anesthesia.

Initial blood-pressure was 115 mm. The animal was asphyxiated by clamping the trachea. The blood-pressure at the end of four minutes stood at 5 mm.

After a lapse of ten minutes from the last beat of the heart the clamp was removed, artificial respirations were begun, normal saline infusion was injected into the jugular vein, and rhythmic pressure upon the thorax and abdomen was made. All of these measures were continued for four minutes, the blood-pressure at no time rising above 25 mm. The heart did not beat during nor at the end of this time. The blood-pressure fell to 8 mm.

Adrenalin, 1 to 50,000, was substituted for the salt solution, and the remainder of the technique was repeated in as nearly the same manner as possible. The blood-pressure gradually rose, and after two minutes the heart evidenced irregular and slow contractions. The blood-pressure reached 80 mm., length of stroke, 28 mm., showing an over-stimulation of the vagal terminals in the heart.

One-fiftieth of a grain of atropin was then administered. Length of stroke, 12.

Two minutes later the adrenalin was discontinued. The blood-pressure had risen to 160 mm.

Eleven minutes later the blood-pressure was 150 mm., and seven minutes later had fallen to 50. The strokes were 50 mm. long and the heart's action was arrhythmic.

The blood-pressure gradually fell to 10 mm., and the animal died.

Experiment 231.

Resuscitation.

Mongrel dog; good condition; weight, nine kilos. Initial blood-pressure, 125 mm. While clamping the trachea, the blood-pressure gradually rose to 200 mm., but fell two minutes later to the abscissa line. At the end of four minutes the heart, as observed through a window in the thorax and on the tracing, was completely arrested. After a lapse of five minutes artificial respiration and rhythmic pressure over the abdomen was begun. It was observed that the blood in the carotid cannula changed to a red color. Adrenalin in 1 to 50,000 was infused into the jugular vein from a height of four feet. The flow at first was rapid, then was gradually slowed. The blood-pressure slowly rose until it reached 80 mm., when slight contractions of the auricular appendages were noted. These extended to the ventricles and varied in rate of from 60 to 80 per minute. This was followed by a short quiescent period, after which weak, slow, and regular contractions were observed. The blood-pressure continued to rise, and the infusion of adrenalin was gradually diminished. The heart resumed a normal action and the blood-pressure rose to 170 mm., where it remained for five minutes, after which it gradually fell to 110 mm. The respirations were re-established and the animal was then killed.

Experiment 232.

Resuscitation.

Mongrel dog; good condition; weight, nine kilos. Initial blood-pressure, 115 mm. The trachea was clamped, and a window made in the thorax.

At the end of five minutes, the entire heart's action was arrested, and the blood-pressure was at the abscissa line.

Four minutes later artificial respiration was begun, rhythmic pressure was made directly upon the heart, and 1 to 50,000 solution of adrenalin was infused into the jugular vein. Fibular contractions were soon noted, and later weak rhythmic contractions which soon became stronger. The blood-pressure rose to 100 mm.

Respirations were re-established. The animal was then killed.

Experiment 233.

Resuscitation.

Dog; good condition; weight, ten kilos. Ether anesthesia.

Initial blood-pressure, 125 mm. The trachea was clamped, and a window was made in the chest wall through which the heart could be observed.

At the end of three minutes cardiac action had ceased. There were no contractions of the auricles, nor could any be observed in the large venous trunks near the heart.

Five minutes after cessation of heart's action artificial respiration was begun, and through a needle attached to a rubber tube 1 to 50,000 solution of adrenalin was injected directly into the left ventricle from a height of six feet. The heart became greatly distended and pale. The adrenalin was allowed to flow for two minutes. No effect upon the heart was noted, and but a slight rise in blood-pressure followed. The heart was then gently manipulated; no contractions followed. More vigorous pressure upon the heart emptied it, but nothing more than fibular contractions were obtained. The animal could not be resuscitated.

Experiment 234.

Resuscitation.

Mongrel dog; good condition; eleven kilos. Ether anesthesia.

Initial blood-pressure, 128 mm. The trachea was clamped and a window in the thorax was made through which the heart was observed until no further contractions were noted.

After three minutes a solution of from 1 to 50,000 adrenalin was infused from a height of five feet, by means of a needle, into the left ventricle. The ventricle filled, the heart became paler, but beyond a few fibular contractions, no effects were noted. Artificial respirations were maintained during the experiment.

Experiment 235.

Resuscitation.

Mongrel dog; good condition; weight, twelve kilos. Ether anesthesia.

Preliminary blood-pressure, 125 mm. The trachea was clamped, after which the blood-pressure rose to 180 mm., then gradually fell to the abscissa line. The last heart-beat was noted three minutes after clamping the trachea. After the animal had remained apparently dead for fifteen minutes the clamp was removed from the trachea, rhythmic pressure upon the thorax over the heart was begun, adrenalin, 1 to 50,000, was infused into the jugular vein from a height of three feet, and artificial respiration was supplied. The blood-pressure gradually rose, and at the end of two minutes the heart began to beat. The pulsations were at first weak and slow, then more rapid and stronger. The adrenalin was quickly infused at first, and when the blood-pressure had risen to 40 mm. the rate of flow was gradually diminished.

The total amount used was 200 c.c. The heart did not begin to beat until the blood-pressure had risen to 75 mm. The blood-pressure rose to 190 mm. The respirations were at first extremely shallow, slow, and of the abdominal type, gradually increasing in rapidity and strength until they became normal.

At the end of three minutes the blood-pressure stood at 190 mm. Natural respirations were re-established, and the eye reflexes were present. The blood-pressure then gradually fell to 135 mm., where it remained for half an hour. The animal began to struggle and required anesthesia.

After normal respiration and circulation were established, the animal was killed.

Experiment 236.

Resuscitation.

Mongrel dog; weight, nine kilos.

The animal was allowed to remain thirty minutes after the last beat of the heart, after which resuscitation was attempted. After ten minutes of the technique employed in the previous cases, rhythmic contractions of the auricles were noted, but resuscitation was not accomplished.

Experiment 237.

Adrenalin. Normal Animal.

Male mongrel dog; fair condition; weight, ten kilos. Ether anesthesia. Thirty mg. of morphin sulphate were subcutaneously given.

Initial blood-pressure, 120 mm.; stroke, 20 mm. Thirty c.c. of solution of adrenalin, 1 to 1000, were injected into the femoral vein. The blood-pressure sharply rose to 200 mm., the heart became much slowed, and the excursions increased in length to 100 mm. An injection of .5 mg. of atropin into the femoral vein decreased the stroke to 12 mm., and increased the heart-rate.

Ten c.c. of 1 to 1000 solution of adrenalin were injected into the femoral vein. The blood-pressure sharply rose to 210 mm.; stroke, 16 mm.; pulse but slightly increased. An injection of .5 mg. of atropin was followed by an irregular and arrhythmic heart. The blood-pressure gradually fell to the normal, which fall continued until the blood-pressure stood at 20 mm. This was followed by a gradual rise in the blood-pressure to 130 mm., at which height it remained for forty-five minutes. The length of stroke was 18 mm. The animal was killed. Time, one hour and thirty minutes.

Experiment 238.

Resuscitation.

Dog; good physical condition; weight, ten kilos. Ether anesthesia. Asphyxia was produced by clamping the trachea. The minute both the respiration and heart ceased, saline solution with strychnin was rapidly infused. No effect was noted. After a lapse of thirty-six seconds, artificial respiration, with rhythmic pressure on the thorax and abdomen, was vigorously begun. A slight rise in the blood-pressure was noted, then the heart slowly resumed action, and the blood-pressure rose.

Experiment 239.

Resuscitation.

Dog; old and in poor physical condition; weight, thirteen kilos. During the administration of the anesthetic the heart suddenly failed. The respiration ceased almost simultaneously. The animal was immediately inverted head down, then feet down, and artificial respiration was supplied, but resuscitation failed.

Experiment 240.

Resuscitation.

Mongrel dog; weight, eight kilos. Ether anesthesia. The blood-pressure and the respiration were both overcome by connecting the trachea with a rubber tube four feet long, at the end of which a funnel was inserted through which water was poured, rapidly filling the trachea. The blood-pressure dropped almost immediately to the abscissa line. After one minute and fifteen seconds the dog was inverted, thus emptying the trachea. Artificial respirations and pressure upon the chest were begun. The blood-pressure rapidly rose; respirations were resumed after fifteen minutes. The animal was accidentally killed in allowing the $MgSO_4$ to enter the circulation.

Experiment 241.

Resuscitation.

Dog; good condition; weight, sixteen pounds. Ether anesthesia. The animal was reduced to asphyxia by clamping the trachea. Both the respiratory and cardiac action ceased in five and three-fourths minutes. Artificial respiration was then begun. After fifty-six seconds the animal was inverted feet down, then head down in rapid alternation, each time pressure being applied over the thorax and abdomen. On account of the change in the dog's position it was not possible to determine how much effect was exerted upon the blood-pressure. The animal was then placed in a horizontal position, artificial respiration maintained, and hot saline solution rapidly given. The blood-pressure rose 8 mm. The heart did not beat again.

Experiment 242.

Resuscitation.

Dog; fair condition; weight, twenty-four pounds. Abdominal aorta was clamped just below the diaphragm. This experiment was intended to give evidence as to whether or not ether produced a vasomotor paralysis. The anesthetic was pushed until the respirations failed. The blood-pressure began to decline similar to that in the preceding experiment. The animal was inverted head downward. Artificial respirations and rhythmic pressure upon the thorax were begun. After five minutes respirations were resumed and the blood-pressure was largely regained. The anesthetic was again crowded after the abdominal aorta was unclamped. Both respiration and circulation failed in much the same way as during the first administration. The anesthetic was continued until both the respiration and the heart ceased. The animal was inverted first feet downward, then head downward, in rapid succession, and artificial respiration supplied. Saline solution was hastily given. Rhythmic pressure was continued, but the heart did not beat again.

Experiment 243.

Resuscitation from Ether Collapse.

Spaniel; good condition; weight, seven kilos. Ether anesthesia. The anesthetic was not well taken. The ether was then pushed until the respirations gradually failed, and the blood-pressure showed a marked decline. The animal was inverted head downward. Rhythmic pressure was made upon the thorax. The heart beat stronger, the blood-pressure rose, and natural respirations were resumed. After the animal had made a good recovery the anesthetic was again crowded until both respiration and circulation failed. Suspension, head downward, with artificial respiration was of no avail.

Experiment 244.

Resuscitation.

Dog; good condition; weight, ten kilos. Ether anesthesia. The animal was reduced to asphyxia by cramping the trachea. In two minutes both the blood-pressure and the respirations began to fail. The former ceased in four minutes; the latter in six and one-half. After a lapse of twenty seconds saline infusion, artificial respiration, rhythmic pressure upon the abdomen, and thorax synchronous with the artificial respiratory movements were administered. The blood-pressure was slightly raised and maintained, the length of the stroke depending on the depth and force of the pressure. After ten seconds, the heart began to beat slowly and feebly, then stronger and faster, until it resumed its normal rate. The blood-pressure during this time rose, and after twenty minutes natural respiration was resumed.

Experiment 245.

Resuscitation from Ether Collapse.

Dog; good condition; seven kilos. The anesthetic was crowded until the respirations ceased. Artificial respirations were begun. The blood-pressure in the mean time was falling. Saline infusion was rapidly infused into the jugular vein. The animal was inclined head up, then head down, in rapid succession. The heart did not beat again.

Experiment 246.

Resuscitation.

Dog; good condition; weight, twenty pounds. Ether was given until the dog was under complete anesthesia, when chloroform was substituted. The trachea was clamped. After four minutes respiration and circulation began to fail, and at the expiration of seven and a half minutes had entirely ceased. Normal saline solution flowing in a large stream from a height of eleven feet was infused into the jugular vein. The blood-pressure rose 9 mm. The dog was inclined head downward, and pressure was applied over the thorax, then head upward, with pressure, artificial respiration having been supplied. These changes were made as rapidly as possible. The animal was then held by the hind legs and rhythmic pressure made upon the thorax. A few heart-beats were noted. The animal was not resuscitated.

Experiment 247.

Asphyxia. Resuscitation.

Female dog; good physical condition. weight, twelve pounds. The trachea was clamped. Two and a half minutes later the blood-pressure began to fall, and the respirations became slower and more shallow. Nine minutes after clamping the trachea respirations failed and the heart stopped beating. At the expiration of forty-eight seconds intravenous saline solution was given and continued until 800 c.c. were administered. The saline solution at one time was given at 70° C. The heart's action was not resumed.

Experiment 248.

Resuscitation.

Female dog; weight, nineteen kilos. The animal was reduced to asphyxia by clamping the trachea. After thirty-five seconds saline solution, artificial respiration, and rhythmic pressure upon the heart were simultaneously begun. In forty seconds the heart began to beat, at first slowly, then more rapidly, and finally normally. The blood-pressure, in the meantime, rose to the normal.

Experiment 249.

Resuscitation.

Dog; good condition; weight, ten kilos. The animal was reduced to asphyxia by clamping the trachea. After the heart had ceased beating for fifty seconds the animal was inclined head up and head down alternately, after which artificial respiration and saline solution, together with rhythmic pressure upon the heart, was ineffectual. The blood-pressure could be raised about ten millimetres by this procedure. With each pressure upon the thorax over the heart a pulse-wave was created. Large doses of strychnin were given. No effect followed.

Experiment 250.

Resuscitation.

Dog; bad condition, greatly emaciated; weight, six kilos. There was a purulent ophthalmia, and a severe rhinitis. The animal was reduced to asphyxia by clamping the trachea. Death followed almost immediately. On attempting to resuscitate by saline infusion and rhythmic pressure upon the heart, together with artificial respiration, a distinct pulse-wave and a pressure of nine millimetres was created. The heart did not beat again.

Experiment 251.

Resuscitation.

Mongrel dog; weight, nine kilos. Ether anesthesia; blood-pressure cannula in the carotid artery; cannula for infusion of adrenalin in the jugular vein.

At 4.16, the trachea was clamped.

At 4.19, both respiration and heart action had ceased; blood-pressure had fallen to abscissa; animal was apparently dead.

At 4.29, the clamp was removed from the trachea; artificial respiration, rhythmic pressure upon the thorax over the heart, and infusion of 1 to 50,000 adrenalin solution into the jugular vein was begun.

At 4.31, there was a slight attempt at breathing; the blood-pressure was rising.

At 4.32, the blood-pressure was rising more rapidly; respiratory action was more pronounced.

At 4.32.30, distinct heart-beats were recorded on the drum.

At 4.33.30, blood-pressure had risen to the normal; rhythmic pressure upon the heart and adrenalin infusion was discontinued; respirations becoming more frequent.

At 4.35, artificial respiration was discontinued; the blood-pressure, which had risen higher than the normal, had now fallen to the normal; the corneal reflex had returned.

At 5.10, the animal was doing well.

At 5.35, the forelegs were voluntarily moved; the animal was sighing.

At 6.10, the sighing increased to whining; there was incontinence of urine; one-fourth grain of morphin was administered.

At 6.20, pulse, 120; respiration, 38.

At 6.40, the eye closed when a lighted match was held before it.

At 7.48, pulse, 114; respiration, 14; the animal began to struggle; reflexes normal.

At 7.58, pulse, 108; respiration, 14.

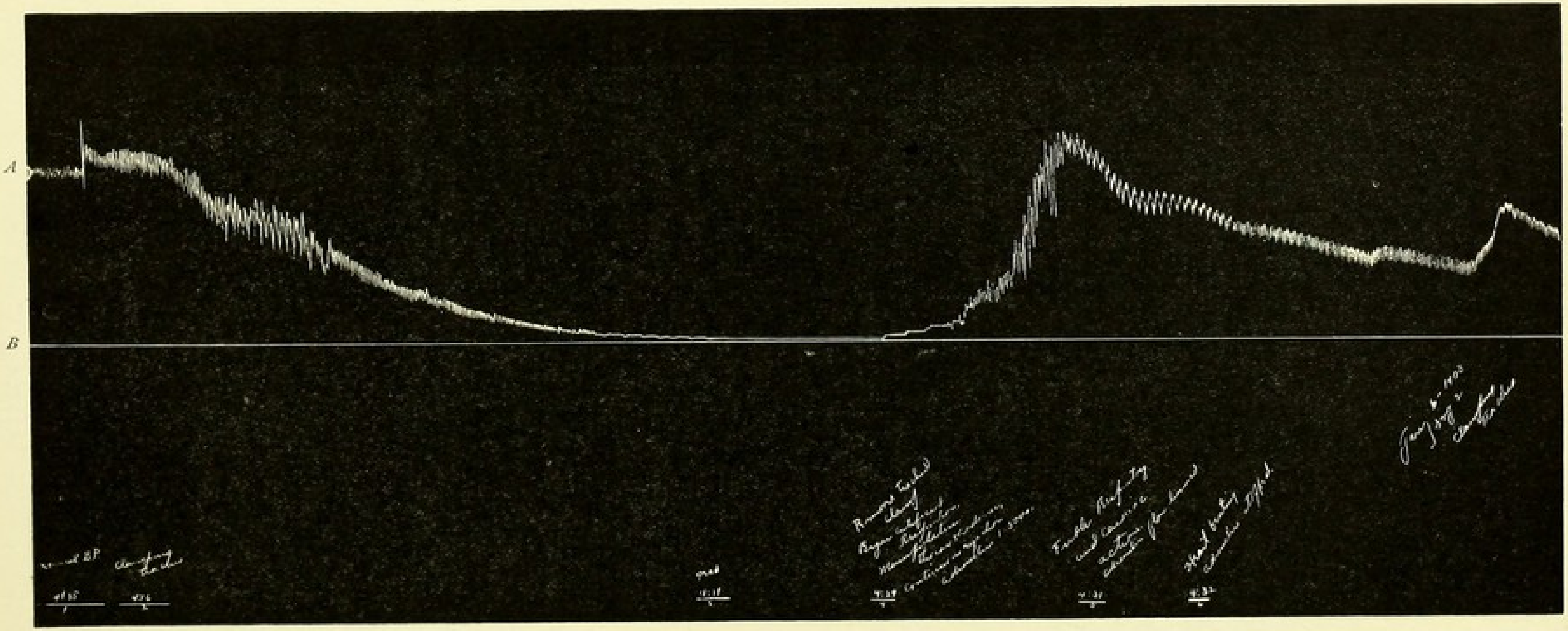


FIG. 46.—EXP. 251.—*A*, carotid pressure; *B*, abscissa. The animal was suffocated. Eleven minutes after the last heart-beat artificial respiration, rhythmic pressure upon the thorax over the heart, and the infusion of adrenalin was begun. Resuscitation was prompt, as indicated by the rising blood-pressure curve on the right. The animal made a complete recovery and was kept for several days. The drum was stopped for a considerable time during the apparent death of the animal.

At 8.15, pulse, 104; respiration, 20; the animal tried to rise.
At 8.45, pulse, 100; respiration, 20.
At 9.30, pulse, 105; respiration, 24.
At 10.00, the animal barked.
At 10.10, the dog assumed a struggling gait; hind legs not so active as the fore.
At 11.00, dog sleeping; pulse, 122; respiration, 18.
At 12.00, pulse, 120; respiration, 20.
At 12.10, dog restless.
At 12.30, the periods of restlessness were less frequent.
At 1.00, the dog was quiet.
At 1.25, dog quiet and sleeping.
At 2.00, the dog had to be restrained.
At 2.20, pulse, 122; respiration, 22.
At 2.55, the dog was doing well.
At 3.40, the dog was quiet.
At 5.00, pulse, 140; respiration, 32; dog, restless; one-fifth grain of morphin was administered.
At 6.15, pulse, 136; respiration, 16; quiet.
At 7.15, pulse, 136; respiration, 16; quiet.

From this time on the animal was kept under sufficient morphin to remain quiet; the reflexes were normal; locomotion was re-established; milk was given; on the second day the animal was killed.

SUMMARY OF EXPERIMENTAL DATA.

Alcohol.

The immediate effect of intravenous administration only was observed. The first effect usually noted was a decline in the blood-pressure. In the majority of such instances a compensatory rise followed; in a number of instances no change in the blood-pressure was noted; in but few was there a rise. The average length of the stroke of the manometer (height of pulse-wave) was increased. There was no evidence that the heart beat more forcibly. In animals reduced to varying degrees of surgical shock, the usual effect of an average dose of alcohol was the production of a further depression; in smaller doses but little effect was noted, while in larger doses a more marked decline often occurred. In a few instances the administration of a considerable dose in deep shock was followed by almost immediate death. In a number of experiments the decline in the blood-pressure was as prompt and as marked as in the administration of the amyl nitrite and nitroglycerin. In no instance, in the normal animal, did death immediately follow the largest dose of alcohol; the more profound the shock the more marked was the depressing effect of alcohol. In a number of experiments alcohol was given prior to procedures intended to produce shock. It is not certain that it rendered the animal more susceptible. It is quite certain that the susceptibility was not diminished.

Nitroglycerin and Amyl Nitrite.

The immediate effect of nitroglycerin and amyl nitrite upon the pulse was an increase in its volume and a decrease in frequency. The immediate effect upon the respiration varied. At times there was a slight increase, more frequently a slowing of respiration. The immediate effect upon the blood-pressure in almost every instance was a fall. The decline was usually rapid. There were but few exceptions, and in these there was usually no effect. A rise was rarely observed. In the latter it was but temporary and was usually followed by a fall. The descent in the blood-pressure was gradual and rather rapid, the ascent, more gradual. Compensation usually took place in a few minutes, the rising curve being more gradual than the falling. The portion of the curve representing the deepest part of the decline was rounded. Compensation in the majority of experiments was complete. In those experiments in which the later blood-pressure was not equal to that before the administration of nitroglycerin it was usually lower. On repeating the doses the effects each time were almost as marked as the preceding, even when the repetitions were at short intervals. On administering repeated doses, each in turn being twice as large, the effects were proportionately increased. Most of the animals tolerated very large repeated doses; excessive doses produced convulsions and respiratory failure. The blood became darker before the animal died.

During the convulsion the blood-pressure rose and fell with the muscular spasms. In the experiments in which the animal was in deep shock and the blood-pressure was gradually falling, there was no evidence to show any decrease in the rapidity of the decline. On the contrary, as nearly as could be estimated, nitroglycerin distinctly increased the rapidity of the decline. The effect of nitrite of amyl was in every respect similar to that of nitroglycerin. In many instances the heart beat irregularly after the injection. On the whole, nitroglycerin and amyl nitrite increased shock.

Digitalis.

In these experiments the fluid extract, the tincture, and digitalin were used. In the normal animal therapeutic doses of digitalis, intravenously administered, caused a rise in the blood-pressure. The rise began after a latent period of half a minute to several minutes and gradually increased until the maximum was reached. The maximum was well sustained for a considerable time. The pressure finally assumed about its previous level. During the ascent, the continuation, and the descent the curve was usually even; the length of the pulse-wave was usually increased; the heart's action was considerably increased in force and appreciably diminished in frequency. When given in larger doses, or when smaller doses were repeated beyond therapeutic limits, the blood-pressure rose higher and more abruptly. The heart at first beat with greatly increased force and diminished frequency. The intermissions which were sometimes noted were usually the first symptoms of a cardiac break-down. The latter was manifested by slow, powerful beats, followed by a varying number of rapid, weaker contractions, making an irregular blood-pressure curve. If the over-stimulation fell short of a fatal break-down, the intervals of alteration between the slow, powerful contraction and the rapid, weaker ones increased, later only intermissions appearing; finally the normal rhythm was re-established. In the experiments in which the over-stimulation reached the fatal break-down, the alterations became more marked and the heart suddenly stopped. The force of the contractions in some instances was so much increased as to raise the thoracic wall and even shake the entire animal. In the experiments in which both vagi and accelerantes had been previously severed, the effects were not so marked. In careful measurements of twenty-eight experiments on single doses, the mean rise in the blood-pressure was 8 mm. In animals reduced to varying degrees of surgical shock, digitalis usually caused a rise in blood-pressure. When the animal was reduced to such a degree of shock that burning the paw or stimulating the sciatic nerve caused no rise in the blood-pressure, digitalis caused a slight, if any, rise. The highest rise was 10 mm.

When over-stimulation was obtained by administering too large a single dose or by repeating smaller doses the heart became extremely irregular or the animal died suddenly from cardiac failure. In some instances convulsions occurred.

The respiration when at all affected was either impaired or arrested. Death in the digitalis experiments, even in those in which the dosage was only therapeutic, was usually more sudden than in the controls. Although the data does not permit positive statements, it seemed, on the average, that cases of shock treated by digitalis did not live as long as the controls. It may certainly be stated that they did not live longer than the controls. In the experiments in which the medulla was cocainized and those in which the cord was severed just below the medulla, digitalis caused a distinct rise in the blood-pressure. When the heart had entirely ceased, digitalis introduced by intravenous infusion or by direct injection into the chambers of the walls of the heart did not produce any appreciable effect. The animals showed considerable idiosyncrasy in their reaction to digitalis.

Strychnin.

In the majority of instances, in the normal animal, when sufficient amount of strychnin was given to cause an increased excitability of the spinal cord, as indicated by heightened reflexes and an increased muscular tone, a rise in blood-pressure was noted. In smaller doses, occasionally, a slight immediate fall, a slight immediate rise, or later irregularities were noted, but on making forty-eight careful measurements of the effects, it was found that no noteworthy changes occurred.

The stage of increased excitability above mentioned represented the border-land between the dosage without effect upon the blood-pressure and that of maximum effect. When more was given after this stage had been reached, convulsions appeared, and the blood-pressure rose abruptly, and high, sometimes even more than doubling the normal. The curve during the convulsions was exceedingly irregular, and continued for some time above the normal, exhibiting a secondary rise if later convulsions occurred. The simultaneous appearance of the rise in the blood-pressure and the increased tendon reflexes occurred in those cases in which very small doses were given at repeated intervals, and in the cases in which this effect was obtained in a single dose.

In a series of experiments in which convulsions were prevented by physiologic doses of curare, and in which convulsive doses of strychnin were given, the blood-pressure rose as high as in the experiments in which convulsions occurred.

In another series, in which both vagi and accelerantes were severed, curare given, and varying doses of strychnin administered, the general effect upon the blood-pressure did not differ materially from the effects of corresponding doses upon the normal animal. In the curarized animal and in the animal having both vagi and both accelerantes severed the rise following the physiologic dose of strychnin continued from a half to one and one-half hours. Repetition of the dose caused a second rise, in some instances as high as the first, though usually not so high, and it did not continue more than half as long. On administering the third dose (physiologic,) the blood-pressure generally rose, though not so high, and continued for a shorter period, usually but a few minutes. On repeating the dose, a period was soon reached in which no further effect was noted. After each dose, when the effect had worn off, the blood-pressure fell to a lower level than it was before the injection was given, until finally it reached the level, usually between 20 and 30 mm., which was not altered by an additional dosage. If during the time of maximum rise, following a physiologic dose, an equal or greater dose was given, a temporary rise of from 5 to 10 mm., continuing but a few seconds, was noted. Burning the paw and electrically stimulating the sciatic nerve, so long as the repeated doses of strychnin caused a rise in the blood-pressure, were followed by a rise of about the same height, though of less duration, as that in the normal animal.

When strychnin no longer produced a rise, no effect was noted on burning the paw or on electrically stimulating the sciatic nerve. The length of the pulse-wave was markedly increased during the rise of the blood-pressure: in some instances, it was increased fivefold. As the blood-pressure declined, the length of the pulse-wave diminished and finally disappeared.

During the maximum stimulation the blood-pressure curve was usually even, but as the strychnin effect diminished, the curve became irregular; between the end of the maximum curve and the beginning of the final break-down, the curve was quite irregular. After the inauguration of the final break-down, the curve became more irregular. When this stage was reached, it was usually not possible to distinguish between the terminal curve in the strychnin experiments and the terminal curve in the shock experiments. Small doses of strychnin seemed to improve respiration. Larger doses were frequently followed by respiratory failure. After the blood-pressure had reached the stage of terminal helplessness, the administration of saline solution caused a rise, which continued for some time during the flow. On cessation of the saline infusion, the blood-pressure fell to the previous level, and if the infusion continued beyond a certain limited period of time, the blood-pressure fell to or near its former level during the infusion. The administration of adrenalin, after the final strychnin break-down had occurred, was followed by a rise in proportion to the amount given,—in one instance as high as 260 mm. Bandaging and other means of external pressure produced a rise of blood-pressure. Digitalis administered in the terminal break-down in the strychnin experiments produced slight, if any, rise in the blood-pressure.

In the animals in which both vagi and both accelerantes had been severed, no change in the pulse-rate was noted. In animals in which varying degrees of shock had been produced, strychnin caused a rise in the blood-pressure proportional to the degree of shock. In the cases in which but slight shock existed, the rise and its continuation were correspondingly less. On repeating the injections, usually no rise occurred. In the cases in which shock was developed to nearly the fatal degree, only a slight rise occurred, lasting but a few minutes, after which no amount of strychnin produced a rise. In any degree of shock, after the administration of a therapeutic dose of strychnin, the animals passed into deeper shock.

In the experiments in which the animals were bled until the blood-pressure had fallen to the level of the final break-down from excessive doses of strychnin, the administration of the therapeutic doses of strychnin caused a marked rise in the blood-pressure. In the experiments in which the medulla was cocainized and therapeutic doses of strychnin were given, causing convulsions, but a temporary slight rise in the blood-pressure occurred. This rise was noted only during the convulsions.

In another series in which both the medulla and the *spinal cord* were cocainized and an excessive dose of strychnin given, convulsions did not occur and no rise in blood-pressure was noted.

Adrenalin in the foregoing caused a rise in the blood-pressure proportional to the dose—a rise as high as 260 mm. Hg.

Saline Infusion.

SUMMARY OF EXPERIMENTAL DATA.—In every observation upon animals in shock, saline infusion caused a rise in the blood-pressure. The rise was usually gradual. The difference between the systolic and diastolic pressure was increased. The rise was sustained, proportional to the degree of shock. In the cases of moderate shock the gain in pressure was fairly well sustained. In the cases in which shock was so deep that stimulating the sciatic nerve, burning the paw, and administering physiologic doses of strychnin caused no rise in the pressure, the rise on infusing saline solution was not so marked and not so well sustained. The deeper the shock, the longer the pulse-wave became during saline infusion. In the cases of deepest shock, the rise in the blood-pressure was not sustained beyond a certain time, even during the infusion. In this class of cases the systolic pressure rose much higher than the diastolic. In some instances in the most extreme cases the systolic rose, but the diastolic remained unchanged. In a greater number of observations when the marked difference between the rise of the systolic and the diastolic pressures occurred there were neither Traube-Hering nor other undulations of vasomotor origin observed. In cases in which the blood-pressure had fallen to or near the abscissa line from asphyxia, on the administration of saline infusion there was also a marked divergence in the rise in the systolic and the diastolic pressures, but Traube and other vasomotor undulations usually appeared upon the blood-pressure tracing. Blood-counts and hemoglobin estimations showed that the blood was not much diluted by the saline. The solution escaped from the vessels at a rate fairly proportional to the rate of infusion, mainly through the channels of normal absorption of water. The fluid accumulated in the walls and the lumen of the stomach, the intestines, and the abdominal cavity,—in the respiratory tract, the thoracic cavity, and the subcutaneous tissue.

When the infusion approximately equalled 320 c.c. per kilo, the amount of fluid accumulated in the splanchnic area caused embarrassment, even failure, of respiration, by mechanically fixing the diaphragm and the movable ribs.

Adrenalin.

Historical Account.—The marked action of suprarenal extract upon the vascular system has, since first announced By Oliver and Schaffer, been corroborated from many sources. There has arisen from these different investigations a conclusion which accredits the extract of the suprarenal gland as being the most powerful vasoconstrictor, as well as the most active cardiac stimulant known. Abel, in 1897, announced his discovery of the active principle of suprarenal extract, and termed it Epinephrin. O. V. Furth, soon after, denied this, stating that epinephrin consisted in part of certain impurities, and it could not therefore be viewed as the principal ingredient of suprarenal extract. Furth then claimed that he had successfully isolated the real active principle,—viz., suprarenin. Takamine next, in 1901, proclaimed the blood-raising principle to be the ingredient which he had succeeded in isolating, and which he termed adrenalin. It is this substance which has since almost universally been recognized as the active principle of the extract of the suprarenal gland, and which since its discovery has been most extensively applied on both an experimental and clinical basis. The effects of the suprarenal extract are essentially those of adrenalin, so that, in the further consideration of this subject, their action can be practically assumed to be homologous.

As already stated, the most prominent, if not characteristic effect of adrenalin, is evidenced in a certain phenomena attendant on the vascular system. Most distinct of these is the rise in blood-pressure which was first demonstrated by Oliver and Schaffer. These investigators state that after the intravenous injection of suprarenal extract there invariably occurred a rise in the blood-pressure, never a fall, even temporarily at the commencement of the injection, although a period of latency between the injection and the commencement of the rise of the blood-pressure in the artery, which in the dog averaged twenty seconds, constantly occurred. This rise was observed to have been usually very rapid, although in many cases a rapid rise for a few millimetres was followed by a more gradual rise, or even in a few instances by a slight decline. An even more rapid rise than the first then instantly followed. The maximum of the height was not maintained, as a gradual decline soon occurred, the normal level being again regained after a somewhat variable time,—this being partly dependent on the animal employed, and partly on the amount and the potency of the extract. The longest time that the action of the extract on the blood-pressure was prolonged was found to be four minutes in the case of a dog (weight, twenty kilos; dose, .19 gramme) and six minutes in the case of a rabbit (dose, .96 gramme). With the continuous flow of the extract into the vein, however, the pressure was kept up as long as the flow was continued, and for the usual time after it had been discontinued.

Almost simultaneously with the experiments of Oliver and Schaffer appeared those of Ssymonowicz and Cybulioz, who, in an attempt to determine the function of the suprarenal gland, report a series of thirteen experiments on dogs and one on a cat, in which this gland was either first excised or remained *in situ,* and a watery or alcoholic extract of this gland was then injected intravenously. The action thus obtained was evidenced in a slowing of the pulse, a rise in the blood-pressure, and a decrease in the respiratory movements. The period of latency between the time of the injection and the beginning of the rise in the blood-pressure varied from five to twenty-one seconds. The height to which the blood-pressure rose in the arteries was very great, in a few cases passing much beyond 300 mm. Hg. In one experiment this occurred twice. The time in which it reached its maximum varied from thirty to sixty seconds after the intravenous injection. Large variations from fifteen to one hundred and fifty seconds were, however, not infrequent. The duration of these appearances, as well as the fall in the blood-pressure to its former level, were dependent, so far as could be determined, upon the amount administered and its concentration. Gottlieb, in his experiments on rabbits, found that the intravenous injection of suprarenal extract caused the blood-pressure to suddenly rise after a period of latency of sixty seconds. It reached its maximum from five to eight seconds after, remaining there two or three minutes, then gradually falling in the next ten or fifteen seconds to its former level. In instances in which the blood-pressure had been artificially reduced a much longer duration of this effect (about thirty minutes) was noted. After the blood-pressure had fallen to its former level the experiment could be repeated several times with the same result. In this manner the blood-pressure could be kept above the normal by the repeated injections of the extract for a longer time.

Langlois, injecting suprarenal extract from a frog intravenously into a dog, obtained a rise of blood-pressure from 11 to 14 mm. and an increase in the rhythm of the pulse from 27 to 19 in ten seconds. The duration of this action was noted to last for forty-four seconds. On again repeating this procedure, after saline had caused no effect, a rise from 12 to 15 cm. in the pressure and a decrease in the pulse of from 26 to 18 were obtained.

The duration of this action was sixty-five seconds. In later reports of experiments similar to this, a proportional rise in the blood-pressure was obtained.

Vardier, in his experiments on rabbits, reports that after the intravenous injection of suprarenal extract, in accordance with the reports of most observers, the arterial pressure rose considerably,—*i.e.,* from 10 or 13 to 22 or 25 cm. Hg. This rise, however, only persisted for two or three minutes, falling again to its former level. Similar and identical observations are furthermore reported by Radziejewski, Frenkel, Telich, Reichert, and others.

Miles and Muhlberg, after causing a vasomoter collapse in rabbits by the administration of ether, noted that an intravenous injection of adrenalin was followed by an immediate and powerful rise of the blood-pressure, which persisted about five minutes. This rise is stated to have been higher than the original pressure before the ether poisoning. About one minute later the pressure gradually sank to the level recorded before the injection was given, but not below this level. The action of adrenalin on the cardiac organ appears next to that on the arterial system as being the most remarkable. Observations, however, are at variance. Oliver and Schaffer reported an argumentation in the cardiac beats. Ssymonowicz, on the other hand, states that the effects noted on the heart were a slowing of its action with an increase in its contraction, which usually appeared soon after the beginning of a rise in the blood-pressure, and which reached its maximum shortly before that in the rise of the blood-pressure. The heart's action then slowly but gradually increased again, and with a return of the blood-pressure to the normal the pulse also resumed its former or a greater frequency. The degree of decrease in the cardiac action was not always in fixed ratio to the height of the blood-pressure, or the quantity of the extract injected, although in general the greatest decrease was consistent with the greatest height in the blood-pressure after repeated injections; as already noted, the rise in the blood-pressure was always less, but the slowing of the cardiac action became greater.

Gottlieb next in his experiments reports that simultaneously with a rise in the blood-pressure a slowing of the pulse was noted, which at the maximum of the blood-pressure changed to an acceleration.

Cyon obtained similar results in rabbits and dogs. It was observed by him that simultaneously with the rise in the blood-pressure there occurred a marked slowing of the heart-beats, whose action was stronger. This slowing of the heart immediately ceased, and the blood-pressure reached its maximum, it then being replaced by a distinct acceleration; the amplitude of the pulse wave at this time was decreased. The acceleration of the pulse not only persisted during the period of high blood-pressure, but also for some time afterwards, and when not interrupted by experimental insults usually persisted to the end of the experiment. In dogs a transient beginning or slowing of the pulse was very seldom observed. The blood-pressure usually rose very rapidly, and from the beginning of this rise the pulse was already accelerated. In these animals also, the acceleration of the heart-beat was of longer duration than the rise of blood-pressure, and often persisted for ten or twenty minutes with a normal blood-pressure. The rise in the blood-pressure and the acceleration of cardiac contractions were in all cases much more noticeable in dogs than in rabbits. Barger, in his observations on rabbits, found that upon the heart suprarenal extract first caused a distinct slowing in rhythm and an increased force of contraction. The slowing was very marked, there being a decrease of from five to three beats per second. Subsequently the cardiac action became arrhythmic, the pulse being still slowed, after which the return to the normal occurred.

Radziejewski also states that with the rise in blood-pressure a slowing of the pulse occurred, which, at the maximum of the blood-pressure, was followed by acceleration.

The exact effect of suprarenal extracts and adrenalin upon the vascular system—the heart and vessels—is still a subject of controversy; while some authorities assume the effect to be central, others hold that this action is wholly peripheral. Oliver and Schaffer stated that suprarenal extract affected peripheral parts of the vasomotor system, basing their conclusions on the fact that the rise in the blood-pressure occurs equally after the dissection of the cord, as well as after the section of the nerve leading to the limbs. A direct effect on the muscular tissues of the heart and vessels is said to occur. Cybulski and Ssymonowicz, on the other hand, assumed that the vascular system is affected through the medium of the central nervous system, the vasomotor centres of the medulla and of the spinal cord being said to be stimulated. Simultaneously with the stimulation of these centres a stimulation of the vagus centre is also stated to occur, the slowing of the cardiac contractions resulting therefrom. Biedl inclines to the opinion that action of suprarenal extract is on the peripheral parts. In the extirpation of the medulla in mammalia, as well as after the extirpation of the whole spinal cord, he succeeded in raising the blood-pressure by means of this drug from 90 to 160 mm. Hg., and to keep the animals alive for over half an hour. Death after destruction of large pieces of the spinal cord is stated to occur from the loss of vascular tone, the blood thereby accumulating in the relaxed veins, so that the heart is rendered anemic. The immediate intravenous injection of suprarenal extract, however, served to raise the blood-pressure, which had fallen to zero, to 160 mm. Hg., and by repeated injections this could be held for some time from 90 to 140 mm. Hg. This rise in the blood-pressure is concluded to be produced not by the direct stimulation of the vasomotor centre, but by the tonic influence on the muscles of the vessels and the heart. Velich also found that after the total destruction of the spinal cord a transient rise in the blood-pressure could still be produced. In paralysis of the vasomotor centre, as by large doses of chloral hydrate and curare, the same effect of suprarenal extract was also noted.

Gottlieb gives a somewhat more complicated explanation. He assumes that in the first instance the action of suprarenal extract is exerted on the peripheral portion of the heart and vessels; the rise in the blood-pressure is, however, stated to be in part dependent on the strengthened cardiac activity. He observed that in his experiments, after the paralysis of the vasomotor centres with chloral hydrate, a distinct rise in the blood-pressure of from 20 to 30 mm. Hg. to 70 to 80 mm. Hg. constantly occurred. The rise in the blood-pressure is therefore concluded to be due to the peripheral effect on the heart and blood-vessels. To differentiate whether the heart or the vessels play the most important factor in the rise in the pressure, chloral hydrate was administered to the point at which the vessels were dilated *ad maximum,* and the minimal blood-pressure of 10 to 20 mm. Hg. was totally supported by the force of the heart.

In this condition, a constriction of the vessels is assumed not to be probable, the large pulsatory oscillations, which the cardiac activity still produces in the totally relaxed vessels, grow less with the continued administration of chloral hydrate, and the pulse is slowed. Intravenous injection of suprarenal extract raises the blood-pressure in this condition very markedly, as from 15 to 70 mm. Hg. A Roys oncometer applied upon the kidney during this rise of blood-pressure gives no indication of constriction of the vessels, while in animals but slightly chloralized this still occurs. The increase in the cardiac force, however, is apparent, in that the small pulse greatly increases in volume. This seems to indicate that the increase in the cardiac action is the most important factor in the rise of the blood-pressure. The exact portion of the cardiac organ which is directly affected is, from further experiments, stated to be the contained intracardiac ganglia, and not the muscular tissue itself.

Cyon, in adopting the view that the effect of suprarenal extract is exerted on the central nervous organs, denies that the experiment of extirpation or destruction of the spinal cord can bring the proof to the contrary. He bases this denial on the fact that the blood-pressure, as has been shown, does not occur momentarily, but in a measurable period of time. The result of this experiment is furthermore said to be misleading in that the operative interference often causes a passing irritation of the vasomotors. To definitely decide this question or controversy, section of the splanchnics should be performed. In experiments in which the blood-pressure has been raised by means of suprarenal extract from 180 to 210 mm., the severing of the splanchnics, after quickly opening the abdominal cavity, produced a fall of from 196 to 15 mm., within eight seconds. The animal did not recover. The result of this experiment is held to conclusively prove that the stimulation of the vasomotor centre occupies an important part in the rise of the blood-pressure.

Velich makes the assertion that the effect of suprarenal extract on the vascular system is both central and peripheral; that the constrictor centres of the spinal cord must be effected is concluded from the fact that larger doses of the extract are required when the cord is excised than when it remains intact; that the loss of blood is not the cause of essential increase of dosage was shown in certain experiments, in which after a profuse hemorrhage but a small dose was sufficient to produce the rise in pressure. The constricting centres of the cord must, therefore, to some extent be involved in the action of the suprarenal extract upon the vascular system. Peripherally either the vessels themselves or the vasoconstrictor nerve apparatus is affected.

That on the heart, at least, the action of suprarenal extract is not exerted by the intravention of the central nervous system is indicated in the experiments in which the resuscitating powers of this substance have been demonstrated. Hedson in perfusing this extract through the coronary arteries of the isolated cat's heart found that a strong tonic influence was exerted upon its contractions, and that this effect lasted a few hours.

Gottlieb observed that after chloral hydrate had been administered to the extent that stoppage of the heart was produced, so that its contractions were no longer apparent to the eye, injection of suprarenal extract resuscitated this organ. This resuscitation could be accomplished after the heart had ceased beating five minutes, providing that this remedy was assisted by the compression of the thorax on the systole of the heart. After injection of the extract, but a few compressions of the thorax, even one to five minutes after the last spontaneous pulse-beat, were sufficient to again re-establish the cardiac contractions, which so rapidly increased in frequency that the blood-pressure in a remarkably short time, from one-half to one minute after the heart-beats had been re-established, registered fifty to sixty mm. Hg. In seventeen such attempts the resuscitation of the heart failed but in two instances, and in these it had been too powerfully depressed by too long chloralization, —from two to three hours. The distinct effect of the extract on the heart has also been demonstrated by Cleghorn in perfusing a solution of suprarenal extract through the coronary arteries of the isolated dog heart; the apex answered almost immediately to the presence of the extract, the pulse wave being often more than double the height of the normal, while the rhythm was slightly quickened. No alteration in the tonus was noticed unless the perfusion was carried on for some time, when a gradual rise took place, until the apex ran into fibrillar contractions. Provided the first dose was of short duration, about two minutes, and not too strong, the effect gradually wore off, and the heart did not respond to a second dose in so marked a manner, nor so readily as in the first. A strong dose of the extract, about ten per cent. saline extract, would, as a rule, cause the apex to fibrillate after giving four or five enormous contractions.

Adrenalin.

SUMMARY OF EXPERIMENTAL DATA.—In the normal animal in every degree of *shock* and *collapse,* when the medulla was cocainized, when in addition the spinal cord was cocainized, when the cord was severed, and when in addition the medulla was destroyed, when the splanchnic nerves were severed, when the heart, the respiration, and the vasomotor action were arrested by 2300 volts of an alternating current, when the animal was decapitated, and when it was apparently dead as long as fifteen minutes, adrenalin administered intravenously caused a rise in the blood-pressure. In all of the foregoing conditions the blood-pressure could be raised even higher than the normal. The latent period, approximately twenty seconds, and the duration of the effect, nearly two minutes, was about the same in all. The heart was at first slowed, and later was increased in frequency. The force of the heart-beats was increased. The blood-vessels were contracted. In larger doses the heart was extremely slowed, exhibiting marked inhibitory phenomena. Atropin in most instances relieved the inhibition. The effect of the atropin soon wore off, after which the inhibition reappeared, but later it disappeared.

On observing exposed blood-vessels during the active phase of a physiologic dose of adrenalin, their contraction could be plainly seen, and there was diminished hemorrhage on cutting the muscles and skin. On palpating the heart and the blood-vessels a hard resistance was noted. On injecting adrenalin into the heart muscle, marked pallor and local contractions immediately followed. The rhythm of the heart was lost. On injecting adrenalin directly into the chambers of the heart, a break-down from over-stimulation followed. Its effect upon the walls of the blood-vessels continued for some time after death, at least after what is conventionally called death.

On a beheaded animal the effect was obtained continuously for ten and one-half hours. Clinically, it was given continuously for eight hours in a patient dying of shock. By the combined effect of artificial respiration, rhythmic pressure upon the thorax over the heart, and intravenous infusion of adrenalin in normal salt solution, a human heart which had stopped beating for nine minutes was made to beat thirty-two minutes.

Morphin.

Summary of Experimental Data.—In a large series of experiments in this and other researches mixed anesthesia of morphin and ether was used. Morphin alone, or morphin combined with ether, prevents, to a considerable degree, the animal's susceptibility to shock. There can be but little doubt that morphin and ether, combined, form an anesthetic under which more extensive operations and procedures over a longer period of time are possible than by means of ether or chloroform anesthesia alone. Chloroform anesthesia alone is decidedly more depressing. Ether alone, though less depressing than chloroform, does not permit of so much dissecting and experimenting as ether and morphin compined.

On the Mixed Effect of Certain Drugs.

Summary of Experimental Data.—Digitalis and strychnin supplement each other very well. Digitalis supplements strychnin, which has no specific action upon the heart, but heightens the excitability of the medulla and of the spinal cord. It not only heightens the excitability, but also stimulates the centres. In both these drugs the steady rise following their administration is usually well sustained, indicating that in most of their phases of action they supplement each other. In nitroglycerin, in every experiment in which an effect was noted, there was a fall in the blood-pressure, whether given after or simultaneously with strychnin and digitalis. In some instances compensation was only partial, in others it was complete. Aside from the cases in which a slight rise occurred at the moment of injection, the action of alcohol indicated it to be a progressive depressant. One might be able to so adjust the dosage of strychnin, digitalis, alcohol, and nitroglycerin that they might neutralize each other in their immediate effect upon the blood-pressure. The experimental data show that the treatment of shock by the most commonly employed stimulation—namely, strychnin, brandy, digitalis, and nitroglycerin—produced systemic confusion in the animal.

Preliminary Resection or Cocainization of the Stellate Ganglia as a Means of preventing Shock.

SUMMARY OF EXPERIMENTAL DATA.—The experiments upon the dead animals, as well as the living, showed that the position of the ganglion in the upper part of the thorax, at the base of the first intercostal space, is so inaccessible and is surrounded by such important structures, whether approached from the neck or through the thorax, that exposure and direct application of cocain necessitated so much dissection that it amounted to a capital operation in itself, causing very marked shock before the means of prevention could be applied. In the neck dissection, it was not only deep, but dangerous. Approaching the ganglia through the thorax exposed the animal to the peculiar dangers of intrathoracic procedures. On the other hand the injection of the ganglia by means of a needle was attended by the danger of wounding important vessels and by the difficulty of accurately reaching the ganglia; that is to say, the procedure is as uncertain as it is difficult, and when successful did not prevent shock.

On the Effect of Pressure upon the Circulation. Summaries.

(*b*) *Atmospheric Pressure.*—Observations upon the effect of variations in the atmospheric pressure upon the blood-pressure were made by placing animals in an iron cylinder. These observations may be grouped under the following heads, comprising a series of normal animals and of animals in shock and in collapse.

First.—On the effect of an increased general atmospheric pressure.

Second.—On the effect of a diminished general atmospheric pressure.

Third.—On the effect of inhaling air under increased pressure while the remainder of the body was under normal pressure.

Fourth.—On the effect of breathing air at the normal pressure while the remainder of the body was subjected to increased pressure.

First.—On the effect of an increased general atmospheric pressure.

On increasing the atmospheric pressure in the tube, the blood-pressure rose proportionately to the increase; the proportion of increase was about equal in all the exposed vessels of the body; *e.g.*, the carotid artery, jugular vein, femoral artery and vein, including both the central and the peripheral pressures. In a series of experiments, records of the changes in the pressure in the abdomen, in the thorax, in the skull, in the deep tissues of the extremities, in the various arteries, in the left ventricle, and in the tube itself were made. It was found that the changes in the arterial pressure most nearly parallel the changes in the tube. Next in order was the intra-abdominal, then the intrathoracic, then the intracranial; that is to say, the arterial pressure rose the most, the intracranial the least. The intracranial circulation was therefore increased. The above was noted in the normal animal and in every degree of shock. It should be particularly noted that the various portions of the vascular systems were quite evenly affected, excepting as certain vessels were protected; *e.g.*, the brain and the thorax. The animals reduced to profound shock and placed in an atmosphere of increased pressure lived longer than the controls. On removing the animal in profound shock from the increased pressure in the tube, death usually occurred earlier than the estimated time of living in the tube. The same was true of animals bled to the danger-point. Intestines that were livid from manipulation and exposure prior to the application of the pressure in the tube became markedly paler under the pressure, and on the removal of the pressure they assumed their previous color. The heart-rate was slightly lessened on increasing the atmospheric pressure. The length of stroke was slightly diminished as the pressure rose. On releasing the pressure, the pulse-rate, the length of stroke, and the blood-pressure resumed their former status. The respirations were slightly affected. To test the influence of increased atmospheric pressure upon the rate of absorption of fluids, normal saline was injected into the peritoneal cavity and under the skin, in measured quantities. The rate of absorption under pressure did not seem to vary from the controls. Autopsy showed nothing abnormal. In no instance were there any air-bubbles in the blood. There was no hemorrhage and no congestion.

Second.—On the effect of diminished atmospheric pressure.

The general trend of the pressures was on parallel lines, and the reverse of the preceding. The intracranial pressure did not fall as low as the intra-abdominal. The autopsies did not reveal any characteristic changes.

Third.—On the effect of inhaling air under an increased pressure while the remainder of the body was under normal pressure.

The immediate effect, within certain limits, of increased pressure was to diminish the height of the pulse-wave. When the pressure was raised sufficiently to produce pressure against the smaller vessels in the walls of the alveoli, higher than the pressure within these blood-vessels, the entire circulation was blocked; the blood-pressure fell abruptly to the abscissa, and the heart stopped. The effect upon the circulation was directly proportional to the increase in the pressure of the air the animal inhaled. At the autopsies air-bubbles were found in the blood, in the heart, and in the smaller arteries of the mesentery, as well as in the spinal cord. The latter were most strikingly demonstrated by placing the mesentery upon an incandescent bulb, thus showing the air bubbles in strong relief.

Fourth.—On the effect of breathing air at the normal pressure while the remainder of the body was subjected to an increased atmospheric pressure.

This was accomplished by making a communication between the tracheal tube and the outside air while the animal was in the pneumatic cylinder. Increasing the pressure upon the surface of the animal by increasing the atmospheric pressure in the pneumatic tube was followed by a rise in the blood-pressure. The length of the strokes on the writing style (height of the pulse wave) increased in a direct ratio with the increase of the pressure in the tube. The rise of the systolic pressure almost paralleled the pressure in the tube. The diastolic pressure rose but little. The difference between the systolic and the diastolic pressures (or extremes of the pulse-wave) was in some experiments as much as 50 mm., but allowance must be made for the inertia of the mercury. The respiration in every instance promptly became labored and failed early. The heart became increasingly slowed; *i.e.*, the rate of the heart-beat bore an inverse ratio, and the increase in the length of the pulse-wave a direct ratio, to the increase in the atmospheric pressure. When the pressure was continued beyond a certain point, the animal died. Life continued one minute or more, according to the height of the pressure in the tube; the heart beat slower and slower, finally stopping suddenly in diastole. Animals reduced to such a degree of shock that the length of the excursion of the writing style (pulse-wave) was reduced to a minimum, indicating that but little blood reached the heart. When animals in such a degree of shock were subjected to this experiment, the amount of blood that reached the heart was increased in proportion to the increase in the pressure in the tube, and the almost imperceptible pulse-wave became proportionately larger. The systolic pressure was more markedly increased than the diastolic. The animals died of cardiac and respiratory break-down, as in those previously described. Immediate autopsy showed the heart and pulmonary vessels to be markedly distended.

On the Effect of Increased Atmospheric Pressure upon Absorption.

In another series of experiments in which saline solution was injected into the subcutaneous tissues of the abdomen, part of the animals were placed in the atmospheric pressure for a given time, the remainder were left outside for a like period of time, as controls. In another series a given quantity of saline solution was injected into the peritoneal cavity; some of the dogs were placed under pressure and some were left outside as controls. In still another series the spinal cord was severed, and injection of normal saline was made into the peritoneal cavity. Some of the dogs were placed under pressure and some were left outside as controls.

It was intended in these experiments to determine whether or not the external pressure caused any change in the rapidity of the absorption of normal saline when injected into the subcutaneous tissues or into the peritoneal cavity, and whether or not the absorption would be as rapid under pressure, in the cases in which the cord was severed. Later, in looking over these experiments, it was found that the different animals in the controls, as well as those in the experiments, gave such widely different results that the whole matter was left in doubt. It would seem, however, that the injection into the subcutaneous tissues was absorbed more rapidly in the control dogs than in those under pressure. As to the peritoneal cavity and spinal cord series, no definite conclusions could be drawn from the data obtained.

On the Effect of alternately and simultaneously varying the Pressure of the Inspired Air and the Pressure upon the Remainder of the Body.

Summary of Experimental Data.—When the pressure of the inspired air was raised higher than the pressure upon the remainder of the body, the pulse-wave became shorter; when the pressure upon the remainder of the body was raised higher than that of the air inhaled, the pulse-wave became longer. It was not possible in cases of shock to so adjust the two pressures that the mean blood-pressure could be raised and evenly sustained. Either the increase in the pressure in the inspired air interfered with the pulmonary circulation or the increase in the pressure upon the remainder of the body caused an excess of blood in the heart and the pulmonary vessels. In the pneumatic chamber in Lakeside Hospital a number of observations concerning the previous experiments were made. Although designed for clinical tests it was, on account of the difficulties of compression and depression, found impracticable.

Mechanical Pressure.

Experimental Data.—Compressing the paw with the hand caused a slight rise in the blood-pressure; bandaging the extremities, a proportionately greater rise; pressure upon the abdomen caused a rise in proportion to the force and area of compression, but in the cases in which the extremities were not bandaged, a compensatory fall followed; compressing a vein caused a temporary fall; compressing an artery caused a rise which was early followed by a partial or a complete compensation; any localized pressure upon a vascularized tissue caused a temporary rise, which was sustained by applying an even pressure upon the area supplied by the vessels compressed; bandaging from the toes upward caused and maintained a rise in the blood-pressure. The height of the rise was directly proportional to the area compressed, and within certain limits the force of the compression. Pressure upon the thorax embarrassed the respiration. If considerable pressure was exerted upon the abdomen near the diaphragm, the respirations became embarrassed. Removal of the external pressure was followed by a fall in the blood-pressure. The fall in many instances was less than the rise. In most instances it was equal to the rise, and in a few greater than the rise. There were no evidences of unfavorable side effects.

The Pneumatic Rubber Suit.

As previously stated, the pneumatic chamber at Lakeside Hospital proved to be impracticable. After numerous experiments, a pneumatic suit (Fig. 47) was constructed of a double layer of specially made rubber, which, when inflated, exerts a uniform pressure upon the surface, constituting an artificial peripheral resistance. It is so constructed that one or more limbs or the abdomen may separately or in any combination be subjected to pressure by inflation by means of a bicycle-pump. The air-valves are so adjusted that the rate of decompression may be completely con-

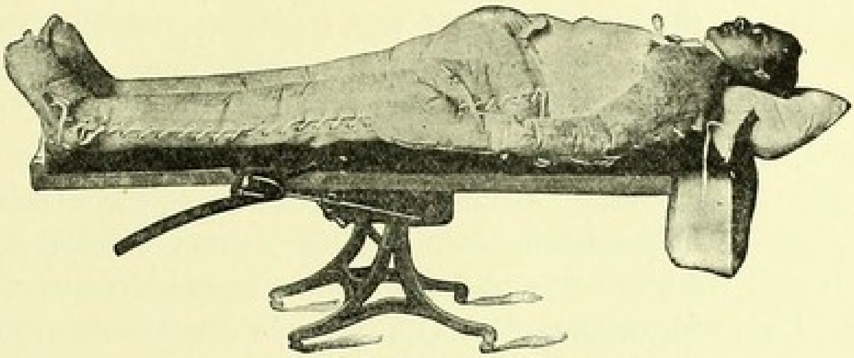


FIG. 47.—Pneumatic rubber-suit.

trolled. The effect of the suit upon the blood-pressure may be checked by means of a sphygmomanometer. The general blood-pressure may be varied at will within a range of 25 to 75 mm. of mercury. The rise has been sustained as long as twelve hours. In the late stage of fatal acute infections, there was but little benefit, although the blood-pressure could be raised. In operations upon the head and neck which are likely to be attended by dangerous shock and collapse, the pneumatic suit is put on the patient prior to the operation. The circulation of the patient is considered, and a certain level is decided upon at which the blood-pressure shall be maintained. An experienced assistant is detailed to watch the blood-pressure by means of the sphygmomanometer. If the pressure falls to the lowest level of estimated safety, the pneumatic suit is gradually inflated. By inflation and deflation the blood-pressure may, within certain limits, in the heaviest operations, be maintained at a given level. At the close of the operation, and so long as necessary, the blood-pressure is watched, and deflation gradually made. In a laryngectomy with extensive resection of the lymphatic bearing tissue of the neck moderate shock developed. The blood-pressure was raised by means of the rubber suit, which soon sprung a leak; note the fall in pressure in Fig. 72. The influence of the pneumatic suit upon the blood-pressure was strikingly demonstrated in a pulseless case in which the blood-pressure was raised to 110 mm. Having reached this register, the suit broke, it being under a considerable pressure, and the blood-pressure fell from 110 mm. to the pulseless condition below 40 mm., the patient becoming unconscious. In another case, during an extensive operation for cancer of the tongue and of the glands of the neck, the blood-pressure fell from 140 mm. to 112 mm., and the normal blood-pressure was restored by inflating the suit. After the operation, deflation was gradually made during several hours. The patient's circulation was thought to be satisfactory. There was a considerable oozing in the back part of the floor of the mouth which became troublesome. The head and shoulders were elevated, syncope immediately occurred. (See Fig. 94.) The rubber suit was at once inflated and the syncope as rapidly disappeared. A back-rest was then arranged and the patient was placed in a semi-sitting posture without ill effect. The oozing ceased, and later the patient was placed in a horizontal posture and the suit slowly deflated. In the falling of the blood-pressure, occurring towards the fatal issue of acute infection, the application of the pneumatic suit was of little or no benefit. In operations upon the head or neck in which the sitting or the reclining posture is desired, by means of the pneumatic suit, the bulk of the blood may be kept circulating in the thorax, neck, and head. This posture is of marked importance in such cases as removal of the gasserian ganglion, etc., in which venous hemorrhage is most troublesome. The recovery of the blood-pressure on inflating the pneumatic suit is often striking. The effects may be readily noted in the superficial circulation of the face. If continued for some time, especially after the condition of the patient has improved, the pressure may become annoying.

On the Resuscitation of Animals apparently Dead.

(*a*) *Preliminary Statement.*—Research heretofore has been directed principally towards the resuscitation of the isolated heart. The restoration of the function of the vasomotor and other centres, while of equal importance in resuscitating the entire animal, has received but scant attention. The present research was directed towards the resuscitation of the entire animal.

First. By mechanical, therapeutic, and electric stimulation of the heart, in conjunction with artificial respiration.

Secondly. By alternating the posture, head down and head up, in rapid succession, alone and in conjunction with the preceding.

Thirdly. Artificial respiration, rhythmic pressure upon the thorax over the heart, and intravenous administration of adrenalin.

(*b*) *Brief Statement of Previous Research.*—Arnaud bled a rabbit until its heart ceased beating. After the lapse of ten minutes, warm defibrinated blood was injected into the aorta towards the heart. Regular contractions, which continued for some time, almost immediately appeared. The blood-pressure was not restored.

Hedon and Giles, as stated by Langendorff, repeated this experiment on the heart of an executed criminal about one hour after his execution. There was then no response to irritations. But on injecting warm arterial blood into the coronary arteries, distinct rhythmical pulsations of the auricles and right ventricles appeared. An identical result is reported by these observers to have been obtained in a dog. In neither the man nor the dog was the circulation restored.

Langendorff, in similar experiments, found that an apparently dead heart would resume energetic and frequent contractions by the infusion of arterial blood. It is said that these attempts were always attended with success, providing that the heart was not in rigor. In one case a cat could not be resuscitated by the usual means from a chloroform death. Two hours after the removal of the heart from the body it resumed contractions on the injection of warm arterial blood.

In a recent communication (1902) Kuliabio presents the most complete treatise on this subject which has yet appeared. With the injection of Locke's fluid, which contains the same mineral ingredients as the blood and 0.4 per cent. dextrose, and which has been shown to greatly prolong the duration of action of the isolated mammalian heart, the isolated rabbit's heart, after it had ceased beating for ten, fifteen, and twenty minutes, resumed pulsation. In another experiment, the action of the heart had been interrupted for twenty, twenty-one, and twenty-five minutes respectively, and again resumed contractions. After this it was covered with snow for two minutes. The heart-beats then ceased. With the removal of the snow they reappeared, being now even stronger although less frequent than before. Subsequent to this, the heart was allowed to remain in a cold atmosphere over night. Upon renewing the circulation with Locke's fluid, the following morning, the contractions immediately reappeared around the region of the inferior vena cava, and later they also extended over the auricles.

In another experiment, a rabbit's heart which had lain on ice for eighteen hours was also subjected to this artificial circulation. Within half a minute forcible rhythmical contractions in the region of both vena cavæ appeared, which soon extended over the auricles. After about half an hour, strong rhythmic contractions of the right ventricle also appeared. The left ventricle remained quiescent. The pulsations of the heart were during this time (three hours) irregular, in that after six or eight weaker contractions a stronger one followed. Four and one-half hours after the beginning of the experiment the contractions ceased, and neither electrical nor mechanical stimulations were effective.

The longest period of cessation of cardiac action after which the heart again resumed its function, is stated, in the case of the cat's heart, to be twenty-four hours. It was during this time placed in a refrigerator. A rabbit's heart similarly exposed for forty-four hours, again resumed its contraction for a period of over three hours.

While these experiments have all been practised in the isolated heart, resuscitation of this organ *in situ* is reported to have been accomplished by Watson, after its cessation from chloroform narcosis. In a series of experiments on dogs to determine the feasibility of puncturing the heart or cardiocentesis, in death from chloroform, it is stated that out of sixty experiments the heart failed to resume its action in only two instances. The average time which elapsed in these experiments between the cessation of the heart's action and the introduction of the instrument was one minute and twenty seconds, the longest period being two minutes. In but two of these sixty experiments was the circulation re-established.

In the remaining experiments, the action of the heart aroused by the puncture persisted but a few minutes. Prior to my own experiments, Professor George N.

Stewart made experiments upon resuscitation by the use of adrenalin in Locke's solution infused into the aorta. Respiratory action and some feeble heart-beats were noted, but the animals did not recover.

On Resuscitation.

SUMMARY OF EXPERIMENTAL DATA.—When asphyxia caused failure of the heart and respiration, vigorous artificial respiration usually restored their function when administered within a few seconds. It was effective in an inverse ratio to the time that had elapsed; it was rarely effective after forty seconds. By the addition of saline infusion a larger proportion of animals could be resuscitated after the lapse of a little longer time.

Rhythmic pressure upon the heart, either through the thorax by pressure upon the ribs over the heart or direct pressure within the thorax, was also an aid. The effect of the traumatism to the heart by the direct method partially counterbalanced the benefit from this measure. Nitroglycerin, alcohol, and digitalis were useless; rapidly alternating the posture, head up, then head down, was not effective. Suspending the animal head down and making rhythmic pressure upon the heart was an effective method. This method gave the brain the advantage of gravity; it provided a moderate artificial circulation as well as respiration. It could be promptly applied. The addition of saline infusion increased the effectiveness of the method.

Animals apparently dead for periods up to fifteen minutes were resuscitated by the combined effect of artificial respiration, rhythmic pressure upon the heart, and the infusion of adrenalin. When the blood-pressure had risen to thirty or more mm. Hg. the heart began to beat and the blood-pressure was rapidly restored. The return of respiration was signalled by a short, almost imperceptible movement of the diaphragm, the respiratory action becoming gradually stronger and more frequent. The conjunctival reflex returned early. Some of the experiments failed on account of too great elevation of the adrenalin bottle; some on account of an overdose of adrenalin; several were only partially successful, owing to too great dilution of the adrenalin. In the experiments in which 10 minims of adrenalin in 1 to 1000 concentration were injected an overstimulation occurred. Adrenalin, when injected directly into the chamber or into the wall of the heart, caused fibrillar contractions, after which the heart could not be resuscitated. After final cessation of the heart, by employing manual compression of the heart and infusing adrenalin, the blood-pressure could be raised even higher than the normal. Respiration in some instances was partially restored.

In some of the animals considerable bruising of the spleen was noted. In the recovery experiment the animal showed restoration of all its ordinary functions. In experiments in which the heart was directly observed through a window in the chest during its gradual cessation, the waves of contraction of the venous trunks were last to disappear, and earliest to reappear when resuscitation occurred. A dog that had been apparently killed by the shock of an alternating electric current of 200 volts, applied by means of large moist sponge electrodes in the anus and in the mouth, was resuscitated, at least as far as the recovery of the circulation and respiration.

Experiments in which saline infusion was substituted for adrenalin, and which were unsuccessful, were promptly successful on adding adrenalin.

In a patient with crushed skull admitted to Lakeside Hospital, and whose heart had ceased beating for nine minutes, resuscitation of the heart for thirty-one minutes by this method was made. During the operation for the elevation of the depressor bone the patient moved his head.

On the Effect of an Increased Heart Action upon the Blood-Pressure.

SUMMARY OF EXPERIMENTAL DATA.—Severing the vagi caused an increase in the rate and probably in the force of the heart-beats. In normal animals a rise of 10 to 12 mm. usually occurred. In animals in shock, the deeper the shock the less the rise on severing the vagi. When the shock had reached such a degree that stimulation of the sciatic nerve, burning the paw, and physiologic doses of strychnin caused no rise in the blood-pressure, severing the vagi caused none. In recently dead animals in which the peripheral resistance was maintained by intravenous administration of adrenalin, and the cardiac action by rhythmic pressure upon the heart, an increase in the force and frequency of the compressions caused an immediate rise in the blood-pressure which could be only partially sustained; the net gain varied from 5 to 15 mm. The blood-pressure in these animals could by the administration of adrenalin and manual compression of the heart be raised much higher than the normal; without adrenalin the pressure by means of compression with the hand as forcibly and rapidly as possible and the simultaneous administration of an equal amount of saline solution sustained a pressure varying from several to 15 mm. In the experiments with an artificial circulatory apparatus, consisting of an iron cylinder through the perforations in the wall of which rubber tubes formed a double communication between an extremely elastic rubber bag in the cylinder (representing the peripheral resistance area) and a rubber bulb with competent valves on the outside (representing the heart), by altering the atmospheric pressure in the tube the peripheral resistance could be correspondingly altered. The force and frequency of the heart-beats were represented by varying the force and frequency of the compression of the bulb (heart). The arterial pressure (rubber tubing leading from the bulb) was recorded by means of a mercurial manometer. An increase in the force and frequency of the heart (compression of the rubber bulb) caused an immediate rise in the blood-pressure (rubber tube leading from the bulb). The immediate rise could only be partially sustained. The pressure could not be sustained higher than 10 mm. by the greatest possible force and frequency. The peripheral resistance remained the same. On increasing and diminishing the peripheral resistance the arterial pressure rose and fell, and paralleled precisely the pressure in the tube; variations in the force and frequency of the heart (compressions of the bulb) during the variations in the pressure (peripheral resistance) did not maintain an alteration of more than 10 mm.

Collapse.

Summary of Experimental Data.—In collapse caused by asphyxia or hemorrhage, stimulating the sciatic nerve, burning the paw, and administering physiologic doses of strychnin were attended by a rise in the blood-pressure. This occurred in cases in which the pressure had fallen as low as in the cases of shock in which such stimulation caused no change in the pressure. On raising the pressure by saline infusion in profound collapse, Traube and other vasomotor curves usually appeared. At first there were long sweeping curves, then shorter, and finally they disappeared. During the development of fatal asphyxia, vasomotor curves of increasing length appeared and continued until the blood-pressure began the decline of the final breakdown. During this final stage the strokes were at first very long, then gradually diminished until the heart stopped. The characteristics of the falling curve in approaching death in certain forms of collapse are reversed in the rising curve of restoration. Normal saline infusion was usually attended by a well-marked rise which was in most instances well sustained.

On removal of the cause of the collapse, or on the application of the means for restoring the normal blood-pressure, the circulation was, within physiologic limits, automatically continued.

On the Nature of Traumatic Shock.

Additional Experimental Data.—In all the experiments in which pure shock was produced it was found that a considerable time was required, usually half an hour or more. The extent of the rise in the blood-pressure on stimulating the sciatic nerve and burning the paw gradually diminished as the blood-pressure fell, and finally, when the stage of most profound shock was reached, usually when the blood-pressure had fallen to approximately 20 mm., stimulation of the sciatic nerve or burning the paw produced little rise in the blood-pressure. The extent of the rise in the blood-pressure following the intravenous administration of strychnin diminished with the development of shock, and when the deepest degree had been reached (that is, when the blood-pressure had fallen to approximately 20 mm. and stimulating the sciatic nerve and burning of the paw caused no rise) strychnin in the curarized animals caused no rise in the blood-pressure. In the non-curarized animals there was an irregular slight rise, which continued only during the convulsions. After each dose of strychnin, large enough to cause any effect, the animal passed into a deeper degree of shock. In the animals in which the heart was isolated from the central nervous system by severing both vagi and both accelerantes, shock was as readily induced as in the controls. The rise in the blood-pressure on stimulating the sciatic, or burning the paw, or administering strychnin corresponded fairly well to that of the normal animal; the gradual diminution and final disappearance of the effects of these were similar to those in the controls. In every degree of shock in the animals in which the vagi and the accelerantes were intact, and in those in which both had been previously severed, adrenalin caused a rise in the blood-pressure proportional to the dose. The rise following adrenalin was but slightly modified by the degree of shock. In some of the experiments of the series in which the animals were reduced to such a degree of shock that stimulation of the sciatic nerve, burning the paw, and administering a physiologic dose of strychnin did not cause any rise, the splanchnic nerves were severed and both the central and peripheral ends were stimulated by placing them in contact with the electrodes of a Dubois-Raymond coil. No change in the blood-pressure from the stimulation of the central ends was noted. In certain experiments some rise followed the stimulation of the peripheral ends. No variation in the susceptibility of the animals under curare and artificial respiration as compared with the controls was noted. In the experiments in which the medulla was cocainized by dropping the solution upon its surface, or by injections into its substance, the blood-pressure fell to 40 or 50 mm. In such experiments the usual procedures for producing shock caused but little effect. In the experiments in which collapse occurred early—*e.g.,* from over-anesthesia, from hemorrhage, from asphyxia, from too rapid administration of curare, etc.—an increased susceptibility to shock was noted. In the cases of deepest shock in which the blood-pressure was raised higher than the normal by adrenalin, the heart performed its function normally. In such cases mechanical stimulation of the laryngeal mucosa caused a reflex inhibition of the heart and respiration.

CLINICAL OBSERVATIONS ON BLOOD-PRESSURE.

The determination of the blood-pressure in the human being for the purpose of clinical study has been variously contemplated by a number of different observers. All these methods have for their basic principle the force that is required for the obliteration of the pulse, this being directly derived from the common usage of measuring the arterial tension by means of digital compression. Vierordt, in 1855, is stated to have measured more accurately the force required for the obliteration of the pulse, by means of a sphygmograph, of which he stated that absolute values, as to the tension of the arteries, could not be obtained.

N. V. Kries, in 1875, determined the capillary tension in the human being, by causing a pallor of the integument, by means of the pressure of known weights. Marey, in 1786, applied the same principle, by enclosing the entire arm in a glass cylinder, then compressing the contained air to a point sufficient to produce pallor. The blood-pressure, as determined by this method, corresponded to a point midway between the pressure of pallor and of flushing. In later investigations hydrostatic pressure was employed instead of air-pressure, as well as a mercury manometer for the registration of the oscillation of the pulse. The maximum pressure was then determined by increasing the pressure till all oscillations of the pulse ceased. According to later investigators, this method is stated to be quite faulty (Breuer, Basch, Recklinghausen).

In still later attempts Marey inserted only a finger in a cylinder; this seemingly did not insure greater efficiency.

Ray and Brown, in 1878, then measured the blood-pressure by placing a membrane, stretched over a capsule, upon the skin and applying air- or water-pressure. The capsule was connected with a water manometer. A distinct advantage is stated to be possessed by this method as the obliteration of the vessels could be accurately determined macroscopically.

Waldenburg, in 1880, again employed the method of Vierordt, rendering it somewhat more serviceable.

Among the methods which have since appeared, all of which have been variously employed by the different investigators, there are:

1881. The method of v. Basch.
1895. The method of Mosso.
1896. The method of Hurthle.
1896. The method of Riva Rocci.
1896. The method of Hoepfle.
1898. The method of Hill and Bernard.
1899. The method of Oliver.
1899. The method of Gaertner.
1903. The method of Stanton.

The sphygmomanometer of v. Basch consists of a glass tube divided into centimetres. It is expanded into a bulb at its lower extremity. This bulb is encased in a glass cylinder below which a membranous bulb is attached. The bulb and cylinder communicate by a small opening in the former, which in part contains mercury and in part water, while the glass cylinder is completely filled with water. The pressure exerted on the membrane is transmitted by the watery medium to the mercury, the degree of pressure being then indicated by the number of centimetres to which the mercury rises in the tube. To determine the amount of the blood-pressure, the instrument is applied over an artery, such as the radial, and pressure is then applied up to the point at which the disappearance of the pulse, peripheral to this point,

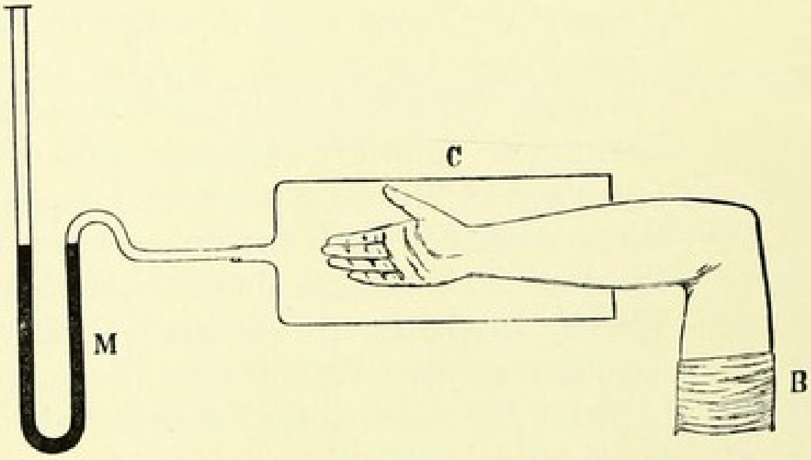


FIG. 48.—Hurthle apparatus; schematic. *B*, bandage around arm: *C*, cylinder; *M*, manometer.

occurs. Having caused the disappearance of the pulse, by this instrumental compression of the artery,

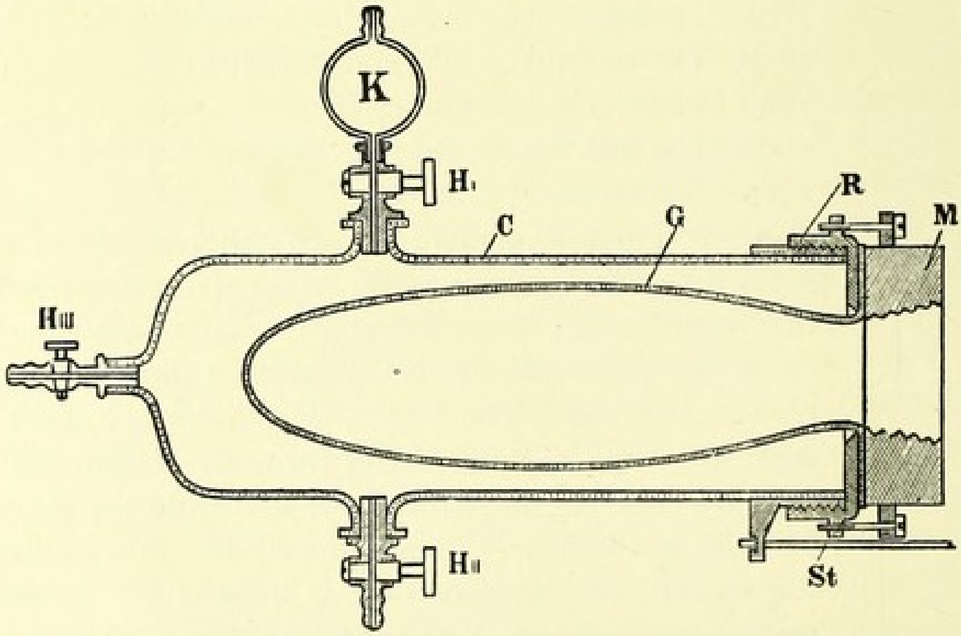


FIG. 49.—Hurthle apparatus. Glass cylinder for insertion of the arm.

the pressure is gradually diminished until the pulse again reappears, this being the point which is supposed to indicate the blood-pressure.

In Hurthle's method of determining the blood-pressure (Figs. 48, 49, and 50) the forearm is first exsanguinated by the application of a rubber band; the blood is then excluded from this part by a second

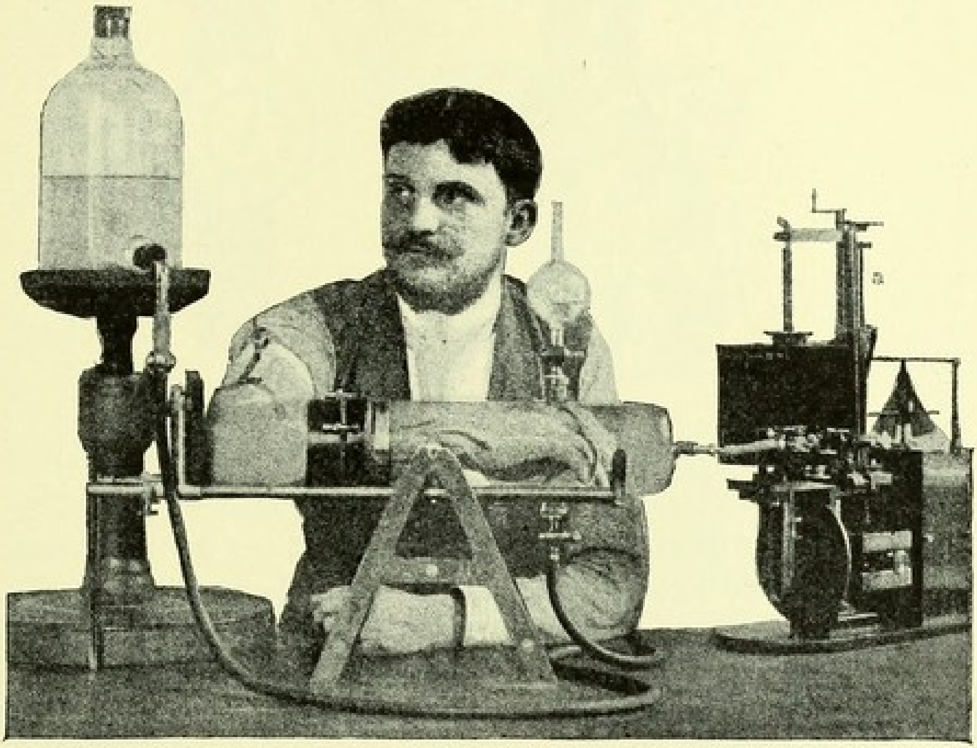


FIG. 50.—Hurthle apparatus.

bandage applied around the arm; the body of the forearm is thereby diminished, this diminution being equal to the blood and lymph which has been pressed out by this process. In this condition the forearm is placed in a glass cylinder, being encased therein in a rubber sleeve, this serving for a more complete hermetical sealing of the part. The space between the arm and cylinder is next filled with water which has been freed from all air by boiling and the bandage around the arm is removed. The pressure is now determined by means of a manometer, which is connected to the glass cylinder, and which records the values of the blood-pressure on the drum, as seen in the accompanying illustrations.

The instrument of Hoepfle (Fig. 51) consists of two cylinders, one of which is enclosed within the other;

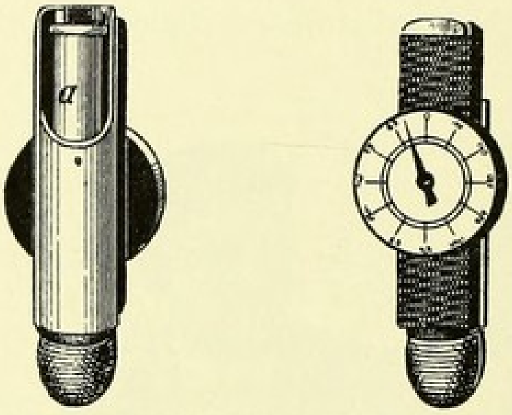


FIG. 51.—Hoepfle blood-pressure apparatus.

the internal movable cylinder (*a*) in its turn encases a spiral spring which rests upon the floor of the external cylinder. Pressure exerted on the upper surface of the external cylinder compresses the spring, the amount of this compression being measured by an indicator by means of an enclosed cog-wheel. The lower end of the instrument consists of a rubber bulb filled with glycerin. In the application of this instrument the bulb is placed over the middle of a suitable artery, such as the temporal or radial, and pressure then applied to the point at which the pulse peripheral to the point of compression disappears.

The Riva Rocci sphygmomanometer (Figs. 52 and 53), as described by Stanton, consists essentially of three parts: "A flat rubber bag or tube, about 40 cm. in length and 4 cm. in width, covered on the outer surface with canvas, to prevent expansion outward. One end of this tube is kept permanently closed by the special clamp, while the other end is pressed by a lever, worked with a screw adjustment, after the tube has been properly fitted to the upper arm of the patient. A metal tube passing through the clamp serves to connect the interior of the tube to the remainder of the

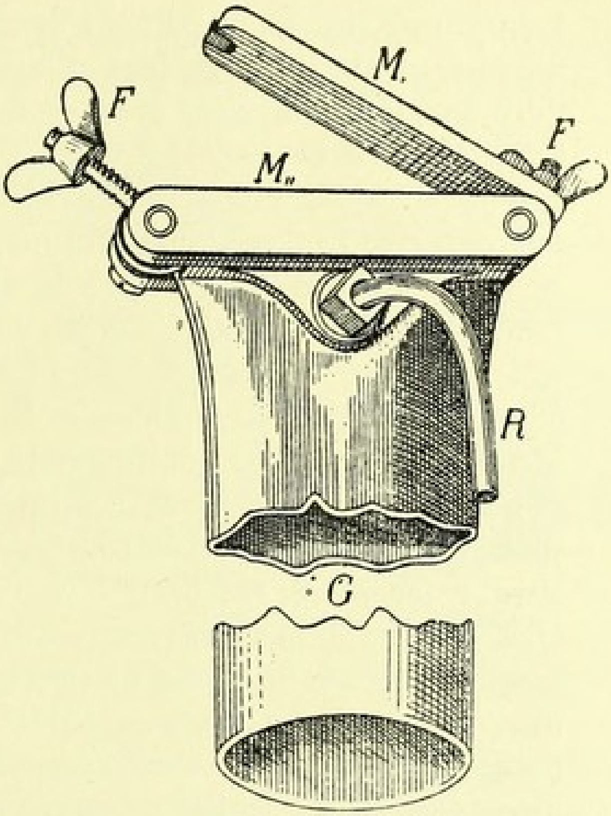


FIG. 52.—Air-tube and clamp, Riva Rocci sphygmomanometer.

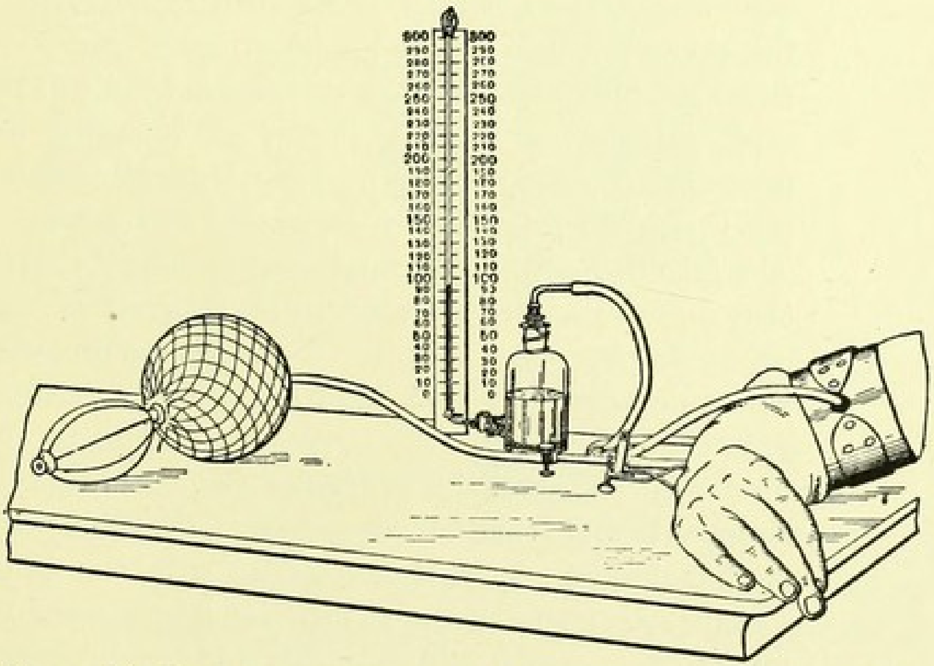


FIG. 53.—Riva Rocci sphygmomanometer with Hill-Barnard arm attachment. (From Janeway.)

apparatus. The second part is a mercury manometer, the scale of which will register at least 300 mm. The third part is the air-pipe, which in this case is a rubber syringe of the type furnished with the thermo-cautery (Cushing's modification). These three parts are connected to three limbs of a four-way glass connection. To the fourth limb is attached a short rubber tube closed with a spring clip, by means of which the air can be allowed to escape after the pressure has been determined." In the application of this instrument the rubber armlet is fitted around the arm above the elbow, the muscles being in a state of relaxation and the constriction occurring at about a level with the heart. As the air enters the armlet, it compresses the arm with a force that is measured by the height of the mercury column, and this compression is transmitted through the soft tissues to the artery. As the pressure increases, the pulse disappears. Either this point of disappearance of the pulse or the point at which the pulse reappears after compression, is read off the manometer scale as the pressure. Cushing's modification of the Riva Rocci instrument, whereby a thermo-cautery bulb for rapid inflation and a special clip for releasing the pressure are added, renders more frequent observations possible and greatly increases its usefulness.

The Hill-Barnard sphygmomanometer (Fig. 54) consists of "(1) a leather armlet, inside of which is fastened a flaccid rubber bag; (2) a force-pump provided with an escape-valve (A); and (3) a pressure-gauge graduated in millimetres of mercury. In using the instrument the method is as follows: (1) the armlet is strapped firmly around the upper arm; the rubber bag is thus brought into close contact with the skin; (2) the extra tube of the rubber bag is connected by means of a T-tube with a pump and the pressure-gauge; and (3) the pressure is raised within the rubber bag and gauged by means of a pump until the point is found where the index of the gauge exhibits

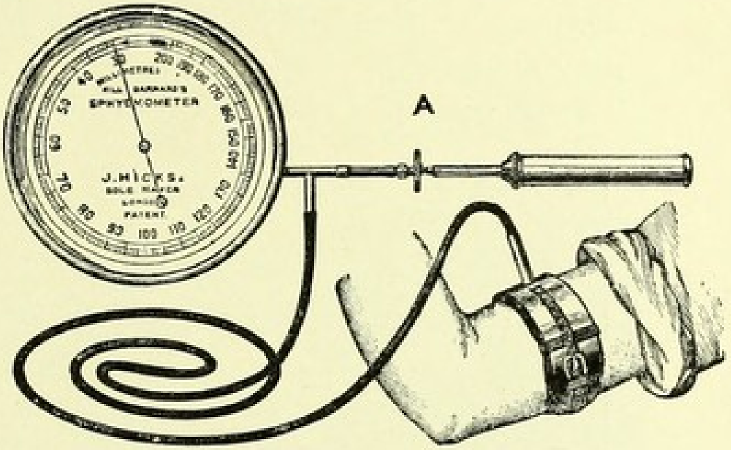


FIG. 54.—Hill-Barnard sphygmomanometer.

the maximum cardiac pulsation. This point indicates the mean arterial tension."

Oliver's hemadynamometer (Figs. 55, 56, 57, and 58) consists of two principal parts,—(1) the pad and (2)

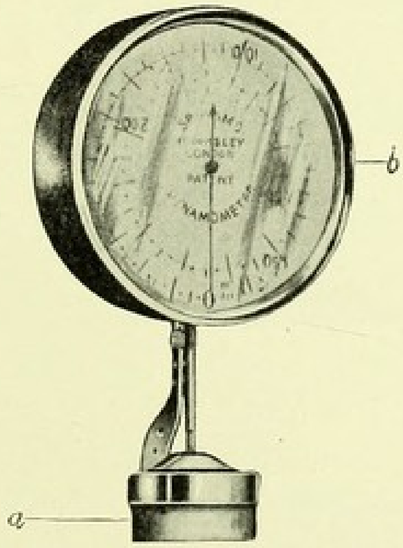


FIG. 55.—Oliver's hemadynamometer. *a*, the rubber pad; *b*, the recorder.

the recorder,—the former of which is made of thin rubber, it being small and cylindrical in shape and encircled by a metal rim. The convex lower end of the pad projects beyond the rim so that when applied over the vessel only a soft rubber is brought in contact with the skin. At its upper end a stem connects with the circular spring of a recorder. The pad is filled with fluid water, brought up to an average of specific gravity of serum (1030) by the addition of glycerin. The recorder is a circular box, two inches in diam-

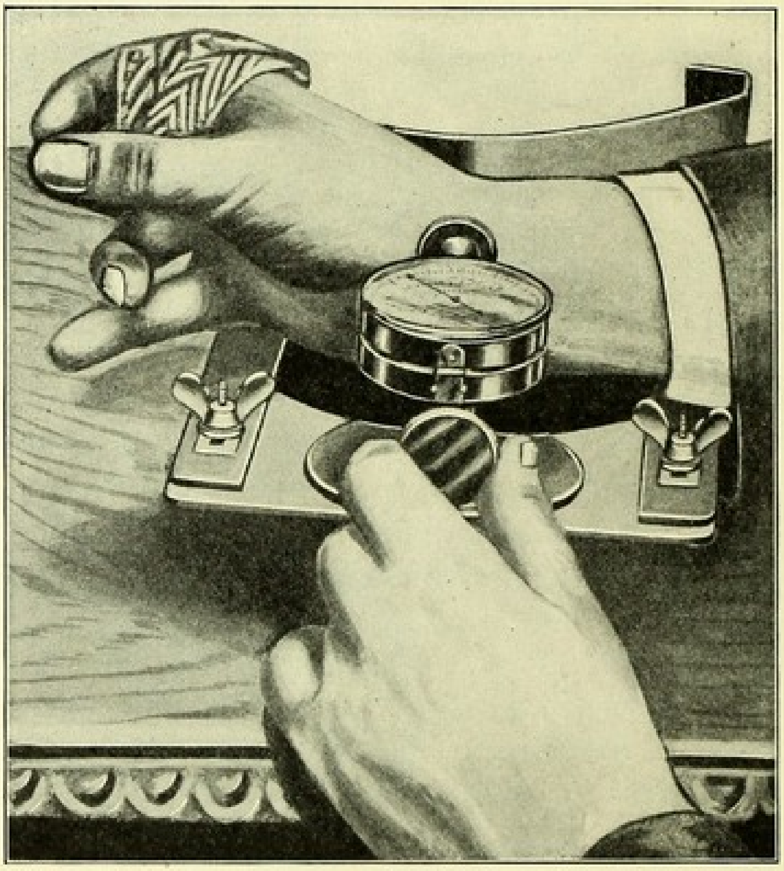


FIG. 56.—Mode of applying the hemadynamometer to the radial artery on rest with screw adjustment.

eter, containing a circular spring which receives the pulsations transmitted through the fluid pad. In the application of this instrument the pad is placed over the artery and pressure is then applied. The indicator begins to pulsate after denoting a pressure of 50 mm., and the pressure now being steadily increased, the pulsations gradually become larger until they attain the maximum excursion, from which

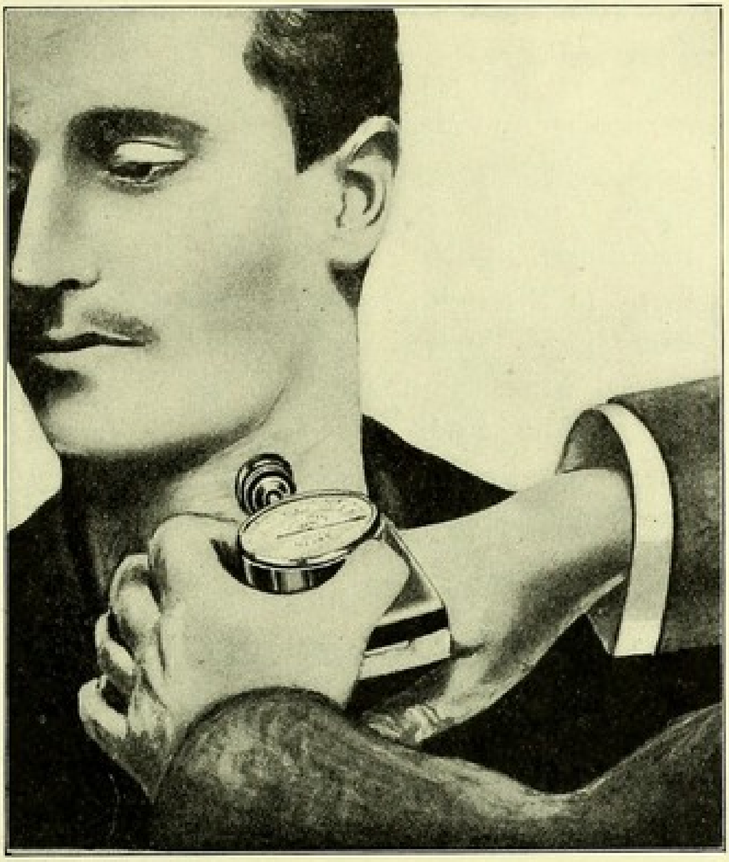


Fig. 57.—Mode of applying the hemadynamometer to the carotid artery.

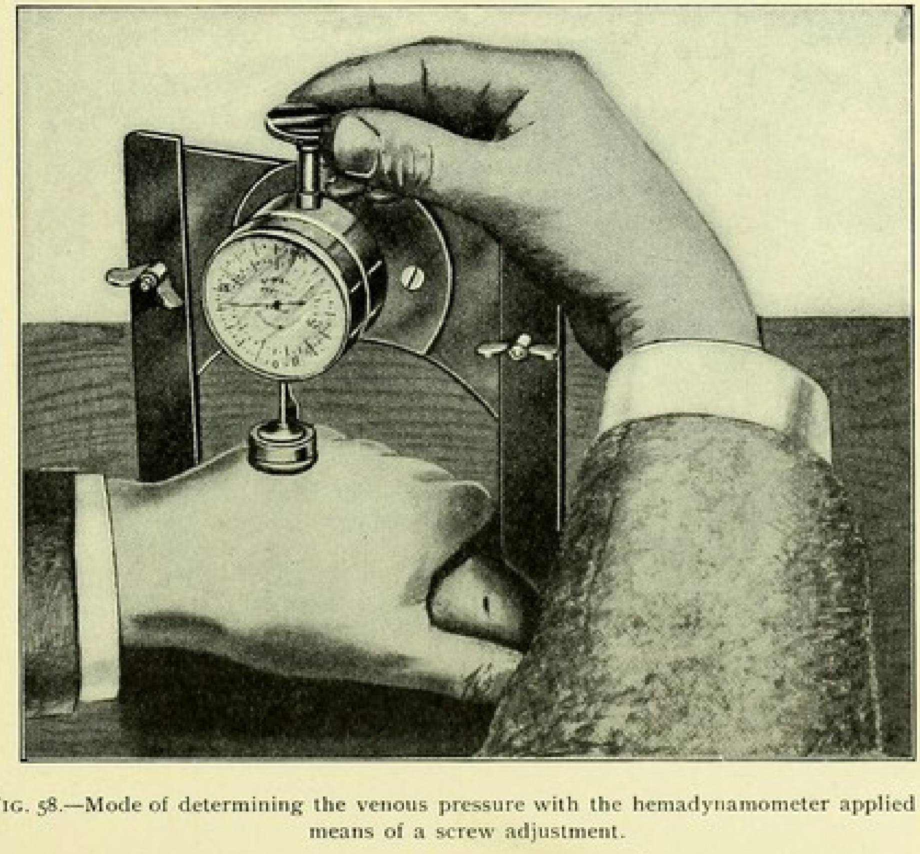


Fig. 58.—Mode of determining the venous pressure with the hemadynamometer applied by means of a screw adjustment.

point, as the pressure is carried farther, they as gradually diminish, the progressive rise and fall in the motion being perfectly equable throughout. The mean arterial blood-pressure is indicated when the maximum motion is obtained, the reading being made at the point between the two minutes of the excursion. The maximum arterial pressure is recorded when the pulsation of the artery beyond the pad is obliterated.

Gaertner's tonometer (Fig. 59) consists of a pneumatic ring about 1 cm. in height and 2½ cm. in

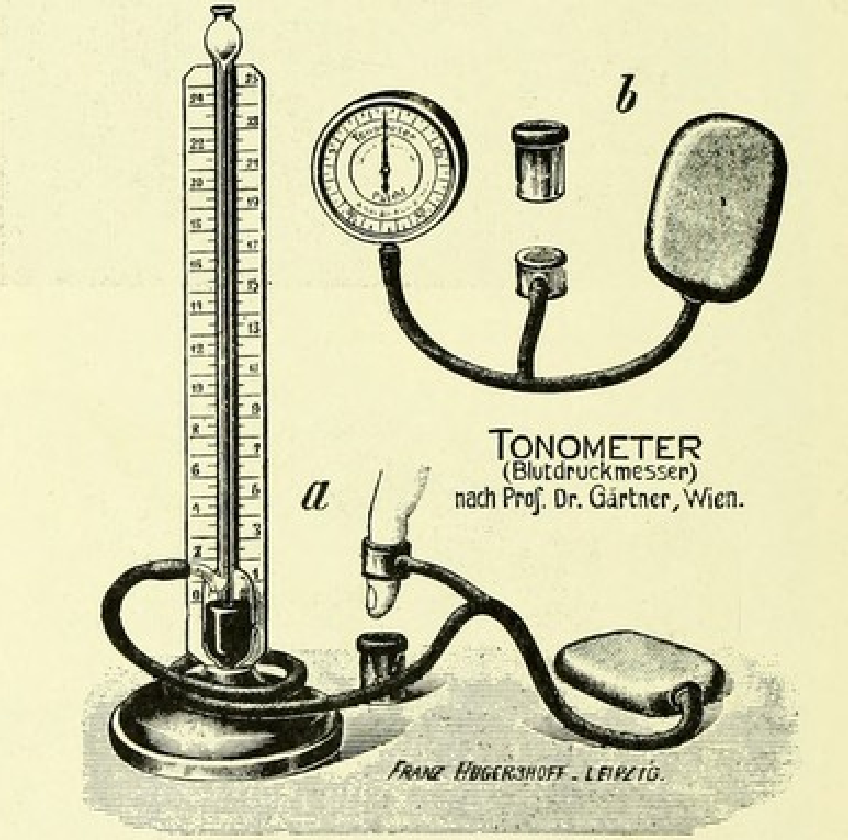


FIG. 59.—Gaertner tonometer. *a*, larger apparatus; *b*, pocket apparatus and compressor.

diameter. This ring is perforated by a metal tube which, as illustrated, is connected with both a manometer and a compressor. The blood-pressure is determined as follows: The ring is slipped over the second phalanx of the finger or over the first phalanx of the thumb after the terminal phalanx of the finger has been exsanguinated either by means of a thimble-like compressor or by a rubber ring which is rolled downward over the finger. The pneumatic ring is then

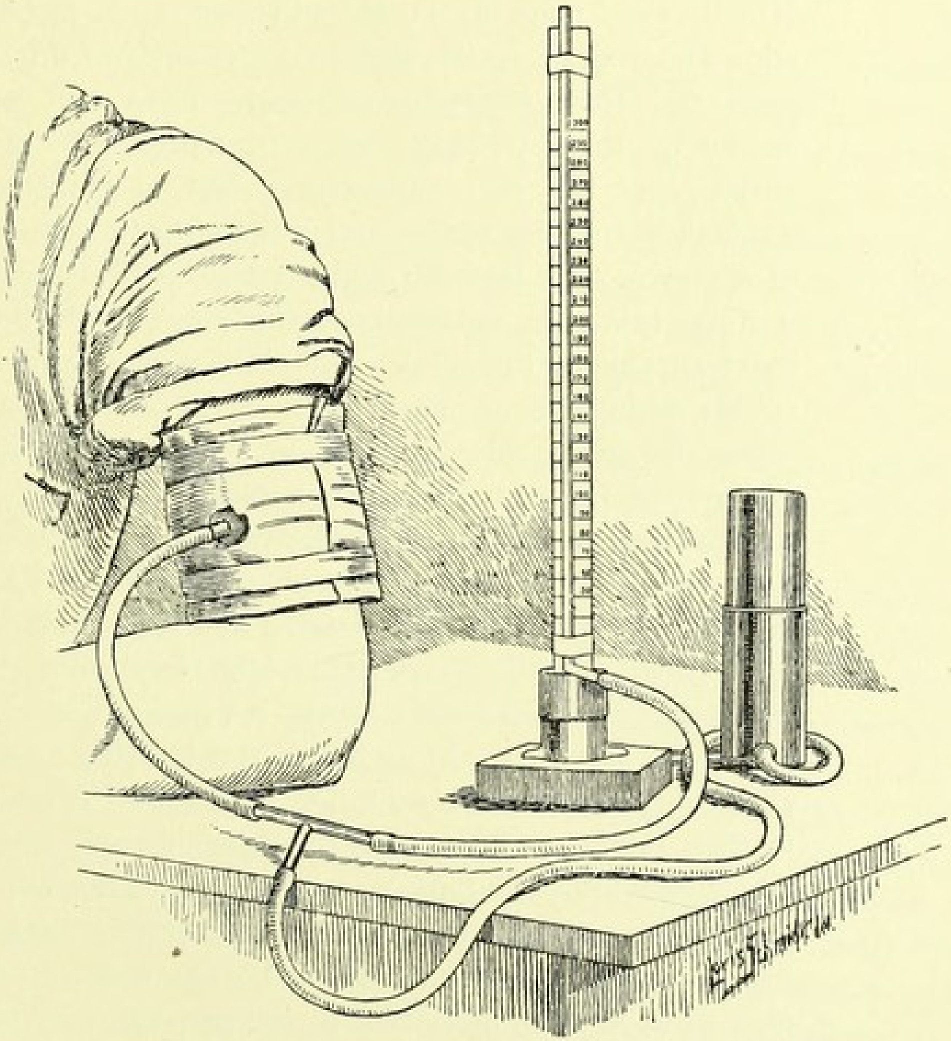


FIG. 60.—Stanton's method for the determination of blood-pressure.

filled with air at a pressure higher than that of the blood and the compressor or rubber band then removed. The compression of the pneumatic ring is now gradually reduced. At a certain moment the finger suddenly flushes, the patient at the same time feeling a distinct throb. This point indicated by the manometer is supposed to be identical with the blood-pressure.

Stanton's method (Fig. 60) consists of a rubber arm in which the widths of the compressing surface is more than twice as large as that of the Riva Rocci or the Hill-Barnard methods (three and one-fourth inches wide and sixteen inches long). This rubber cuff is prevented from expanding outward by a cuff of leather or of double-thick canvas re-enforced by tin strips. "To the centre of the rubber cuff is cemented a rubber valve-stem of the kind used on the inner tube of a bicycle tire, through which passes a glass connecting tube, its extremity being flush with the inner surface of the armlet. A piece of stiff-walled rubber tubing, about one-fourth inch in caliber, connects the glass tube in the valve-stem with one end of the horizontal limb of a glass 'T,' while a similar piece of tubing joins the other extremity of the horizontal limb to a mercury manometer. The vertical limb of the 'T' is connected by a softer tubing of the small pump." To determine the blood-pressure by this method, the rubber armlet is fitted to the arm above the elbow and air is forced through the apparatus until the pulse is no longer palpable. The air is then permitted to escape through the soft tube, which is held by the fingers until the pulse reappears, and this point is mentally noted as the systolic pressure. The pressure is now reduced a few millimetres at a time, and the pulsation in the mercury column will increase in size until a maximum is obtained, then diminished. The base line of these maximum pulsations is noted as diastolic pressure. The mean pressure is the mathematical mean of the two pressures obtained.

These various methods enumerated are in principle similar, if not identical, and may all be classified as the indirect method in which the determination of the blood is accomplished by compression of the arterial vessels in contradistinction to the direct method in which the blood-pressure is measured by the insertion of a cannula into the lumen of the vessel. The latter method has in a few instances been practised on man.

Faiver, according to Zadeck, during amputations, determined the blood-pressure in the brachial artery of a man sixty years of age, and also in the femoral of a man thirty years of age. In both a value of 120 mm. Hg. was registered. The blood-pressure in the brachial artery of a man twenty-three years of age was found to be 110 mm. Hg. Vierordt mentions a case in which during an amputation of a leg the blood-pressure was found to be 155 mm. Hg.

As will be seen later, these figures essentially agree with those obtained by the various clinical methods in the different arteries of the body.

While this direct method of inserting a cannula within the arterial lumen is undoubtedly the method of preference, it is not totally devoid of inaccuracy, for the reason that in the exposure of the artery the pressure of the surrounding tissue is frequently removed, and also from the fact that the circulation peripheral to the cannula is lost, and which, in consequence, tends to raise the blood-pressure in the artery in question. While the first of these objections, in experiments in which the superficial arteries, such as the carotid or the femoral are employed, cannot be considered as being of much consequence, the latter becomes a distinct factor of inaccuracy in the determination of normal blood-pressure. In regard to the determination of the blood-pressure by means of the various clinical methods, this objection is also valid. Recklinghausen has determined that the compression of the large artery is in itself a blood-pressure-raising measure. In the compression of the femoral artery for a period of ten seconds, he found that the blood-pressure rose 2 cm. water, and when the arm was compressed for a longer time a distinct rise of the blood-pressure gradually occurred. After one minute the rise of 10 cm. water was frequently observed, and when compression was prolonged for over one and one-half minutes, the rise continued. In one instance, after twenty minutes' compression, with Hurthle's instrument, the rise of from 140 cm. to 185 cm. was noted, and after the compression had been discontinued for several minutes the pressure still measured 155 cm. Recklinghausen, however, inclines to the view that the rise of the pressure, as produced by compression, is the result of stimulation of the vasomotor centres, and is not a peripheral or local effect.

As to the accuracy of the values obtained by clinical methods, several factors have been stated by different authors to influence these determinations. These are:

(1) The resistance offered by the arterial wall.

(2) The resistance offered by surrounding tissue.

(3) The quantity of blood contained within the arterial system.

The resistance of the arterial wall to the compressive force was measured by v. Basch on fresh carotids of horses and also on the human radial arteries, which were obtained soon after death. They noted that the lumen of these vessels was obliterated, when the external pressure exceeded the internal pressure by but a few millimetres (1–2–3 mm. Hg.). The effect that the arterial wall may have on these determinations by compression is then furthermore indicated in the experiments in which sclerotic arteries were employed, in which 5 mm. Hg. more of external pressure was required to overcome the internal pressure. Whether, however, on the living normal artery, on which the tonicity of the muscular layer of the artery is present, an excess of the external pressure is required still remains doubtful. The living arterial walls tend to constantly contract upon the contained column of blood, so that the elastic vital force is to be associated with the instrumental compression of the vessel. While it cannot be definitely said to aid this compression, it can also not be stated to offer any resistance. (See Figs. 61 and 62.)

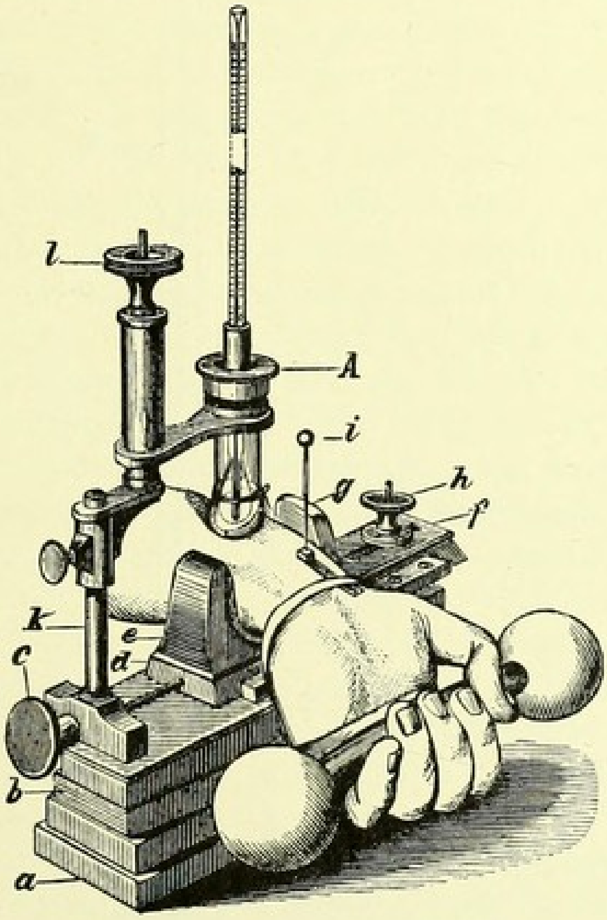


FIG. 61.—V. Basch sphygmomanometer.

The manner in which compression affects the artery is that its lumen becomes obliterated by the apposition of its opposing walls. In this apposition of the arterial walls the flattening of the artery ultimately results, whereby its lumen is transformed into a linear slit. The first part of the arterial walls to come in apposition is the middle point of what ultimately constitutes this linear slit, so that the arterial lumen first

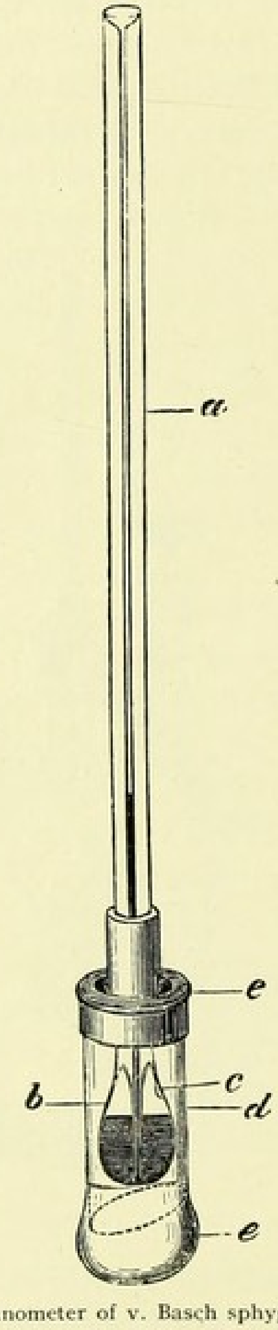


FIG. 62.—Manometer of v. Basch sphygmomanometer.

assumes an hour-glass-shaped contour. While the arterial lumen assumes the hour-glass-shaped type the current of blood is not completely interrupted, its flow still continuing through the two ends, or corners, of the vessel. The pulse may still be palpated as a barely perceptible wave.

With the obliteration of these two open ends the pulse also ceases in the peripheral parts, and it is at this moment, when all parts of the arterial walls come in contact, that, theoretically, the blood-pressure should be determined.

Of the resistance offered by the surrounding tissues of the vessel to compression, and the objections advanced as to the inaccuracy of the determinations so obtained, it has also been shown not to be a serious hinderance. Zadeck states that with the method of v. Basch the absolute values obtained in women is farther from the normal than in men, owing to the thicker panniculus adiposus. Experiments performed on human cadavers in which the internal pressure was a known quantity have led to a similar conclusion; in the latter, however, the vital elasticity of the tissues is lacking. The living tissues, moreover, contain a high percentage of fluids, so that, in accordance with hydrostatic laws, the pressure, from the compression of a part, can be assumed to be equally transmitted in all directions, with but little loss. The observations of different clinicians are in full accordance with this assumption. It is known that the blood-pressure, in distant arteries of different dimensions, such as the radial and femoral, when measured by the insertion of a cannula, show but a very slight variation, which is readily accounted for by the difference in the distance from the heart or by the difference in the size of the vessels. In measurements by instrumental compression the results obtained have been parallel.

Recklinghausen found that, in the simultaneous determination of the blood-pressure in the upper arm and thigh, with his modification of the Riva Rocci method, the pulse, as felt either at the radial artery or at the dorsal artery of the foot, disappeared either at the same time or in other instances with a very slight difference, whose extremes varied from —1 to —4 cm. He concludes that in these observations the pulse disappeared in both arteries simultaneously with the same amount of pressure, and that the difference mentioned is to be attributed to the mistakes in the determinations. The deduction reached from these experiments is that the soft parts surrounding the arterial vessel do not influence its compression, and that the greater width as compared with the forearm is of no material difference in the determination.

Gumprecht, on the other hand, had previously to this reached a deduction opposed to this. In his observations with the Riva Rocci method he states that he ascertained that the thicker parts of the body register a higher pressure than the thinner parts, and in the parts of an extremity in which much osseous tissue and but little soft tissue was present, a higher pressure was usually also obtained. In a tabulation comparing the results as obtained in the upper arm, forearm, thigh, calf, and leg this appears quite striking. This disparity in the observations of these two investigators has been fully and concisely explained by Recklinghausen, who correctly attributes the difference to the difference in the width of the cuffs, Gumprecht employing the regulation Riva Rocci cuff, while Recklinghausen used his modification of the same.

In all of the clinical methods which attempt the determination of the blood-pressure by the compression of an artery, and take as the indication for sufficient compression the disappearance of the pulse peripheral to this point, the mean arterial pressure is not obtained. As has been variously stated, the determination of the blood-pressure in this manner corresponds to the maximum blood-pressure. As we know, the blood-pressure is physiologically in a state of constant variation, as is readily denoted in a graphic presentation of a pulse-tracing. In these oscillations of the pulse there can be readily differentiated a point of minimum and a point of maximum pressure, which are, respectively, the highest and lowest points of the pulse-curve. Both have primarily a cardiac origin, representing, respectively, the ventricular contraction and relaxation. The point of maximum pressure, therefore, indicates the systolic pressure, while that of the minimum pressure is to be associated with the diastolic phase of the ventricular cycle. Midway between these two points lies that of the median blood-pressure; *i.e.*, the point which has no preponderant cardiac factor, but which represents a pressure in whose production the heart, arterial tension, and the volume of the blood are all represented in about equal proportions. In the determination of the maximum or of the minimum pressure, or both, it can be asserted that a conclusion as to the mean pressure can be derived therefrom, although the value so obtained is but relative. With the increase in the ventricular systolic action, and therefore with the increase in the maximum pressure, a simultaneous decrease in the ventricular diastole and a minimum blood-pressure may or may not occur. In instances in which such an increase in the one is not accompanied by a decrease in the other, the mid-point between high and low pressure is necessarily disturbed, and now lies at a higher position, so that the medium pressure is also increased. If, on the other hand, the decrease of the minimum pressure coexists with an increase in the maximum pressure, the medium point between the two may or may not remain stationary, according as to whether the decrease in the minimum pressure is or is not proportionate to the increase in the maximum pressure. Tshcelinoff, as cited by Masing, in fact, asserts that during exercise the maximum pressure rises simultaneously with the fall of the minimum pressure, while the medium pressure is slightly altered. He explains this by an increase in the cardiac action (increase in the maximum pressure) and a concomitant dilatation of the peripheral vascular system (decrease of the minimum pressure), so that the medium pressure remained fairly constant. Hensen, however, on the contrary, estimates that the maximum pressure is a fair indication as to the medium pressure. In compressing the abdominal aorta below the origin of the renal artery, he found that, with the record of a sphygmograph, the mean pressure rose almost proportionately with the maximum, and, discounting the slight errors which result in the determinations, he concludes that the maximum pressure can give a reliable basis for the deduction of the mean pressure.

Masing, also, in his observations, draws a positive deduction on the question. He reports the following observations in support of the statement of Hensen:

PULSE-PRESSURE AMPLITUDE IN MM. HG. OBTAINED BY THE SPHYGMOGRAPH.

	Pulse-pressure. Minimum.	Pulse-pressure. Maximum.	Amplitude.	Remarks.
I. B. K. 19 Rest . .	125	155	30	
Work . .	155	205	50	
II. E. K. 21 Rest . .	95	142	47	
	100	140	40	
	110	155	45	After work.
III. K. J. 68 Rest . .	110	150	40	
	110	145	35	
	125	150	35	
	125	160	35	After work.
IV. D. T. 73 Rest . .	110	150	40	
	110	150	40	
	100	150	50	
	110	170	60	After work.
Work . .	135	190	55	
	115	170	55	

In general there were obtained the following results:

	Pulse-pressure. Minimum.	Pulse-pressure. Maximum.	Amplitude.
I., II. Rest	113	150	37
Work	152	200	48
III., IV. Rest	111	153	42
Work	130	198	68

He concludes from this tabulation that in muscular exercise the maximum and minimum and consequently also the mean pressures are increased, all these, however, in different degrees, and that the minimum pressure is influenced the least. The oscillations of the medium pressure are often not exactly those of the maximum. On the whole, however, the alterations of the maximum pressure are shared by the mean pressure, so that the determination of one in muscular exercise gives indication as to the simultaneous alteration of the other.

Stanton, however, takes exception to the general conclusion which Hensen derives that the systolic pressure can be used as a guide to the mean pressure, and concludes that a reliable means has not yet been found to determine the mean pressure. He quotes, in this connection, also, the work of Howell and Brush, who on dogs were able to produce variation in the high and lower pressure without effecting the mean pressure, and who also showed that the mathematical mean of the systolic and diastolic pressure approximately equalled the mean pressure.

All of the methods which clinically determine the blood-pressure have been stated to have their defective qualities.

To the v. Basch method Waldenburg takes exception, stating that, among other objections, it does not measure the blood-pressure, but the arterial tension, —viz., the blood-pressure, the tension of the arterial walls, and the resistance of the overlying tissues. In that the tension of the arterial wall remains an unknown quantity, the determination of the blood-pressure is said not to be possible.

Zadeck, however, concludes that this method does not give the absolute value of the blood-pressure, but only figures which are probably greater, but which approach it the more, the thinner the overlying soft tissues are.

According to Ewald, the v. Basch method is subject to mechanical errors. In his investigations as to the accuracy of the instrument, the value of the blood-pressure is said to have been partly dependent on the size of the compressor. Employing a larger-sized compressor than that used by v. Basch the blood-pressure was found to register less.

This same objection is advanced by v. Recklinghausen, and it is to be noted that v. Basch has lately adopted the larger-sized compressor. Howell and Brush, as well as Stanton, also state that this method is prone to errors.

The Hill and Barnard instrument, as well as the Oliver's hemadynamometer, has found a limited field of application. Both these, as Stanton asserts, are based on the theory of Mosso,—viz., that the greatest oscillations occur in the arterial wall when an external pressure is applied, that just equals the mean pressure. Howell and Brush, however, have shown on dogs that the greatest vibrations occur at the time when the pressure within the artery is lowest, so that these instruments really record the diastolic pressure. Mechanically, also, according to Stanton, the Hill and Barnard instrument is faulty, in that, owing to the spring soon losing its strength, its accuracy soon becomes impaired, etc.

Riva Rocci, as cited by Hensen, states of his method, that the determinations, as obtained thereby, are but ½ mm. too high. As a proof of its accuracy he advances certain experiments on animals in which the values obtained were higher than the normal by the above-mentioned figures. In cadavers he also found that the thickness of the musculature did not influence the determinations.

V. Recklinghausen, however, asserts that this method is highly inaccurate, and advances, as a much more efficient method, a modification of the same, consisting essentially of a greater width of the cuff employed for the compression of the part. Insufficient dimensions in the area of compression is held to be the cause of the too high values which are obtained in most methods, as also in the Riva Rocci method. In a simultaneous determination with a regulation Riva Rocci cuff 5 cm. wide and one 12 cm. wide, as applied on both arms, he reports the following results. Circumference of each arm, 24½ cm.

	Broad cuff.		Riva Rocci cuff.	
Pulse returns	Right upper arm	90 to 96	Left upper arm	116
Pulse returns	Right upper arm	92 to 100	Left upper arm	114
Pulse disappears	Right upper arm	90 to 98	Left upper arm	112
Pulse returns	Right upper arm	92 to 98	Left upper arm	114
Pulse returns	Left upper arm	96 to 104	Right upper arm	118
Pulse returns	Left upper arm	94 to 104	Right upper arm	120
Pulse disappears	Left upper arm	104 to 108	Right upper arm	120
	Average	94 to 104		116

These errors in the determination are the higher, the greater the width of the part. In the correction of this error, Recklinghausen states that it becomes necessary to procure a cuff which is of sufficient width to exclude all errors the varying diameters of an extremity may have. He has found by experimentation that a length of the cuff of 10 cm. is just sufficient for an arm of 24 cm. in circumference, while one of 15 cm. length is sufficient for most all cases, and one of 32 cm. length, which includes the arm from the axilla to the middle of the forearm, gives absolute results in every case. The exact numerical width of a cuff can be ascertained by the application of several cuffs of different dimensions, the narrowest cuff, whose results correspond with those of greater width, being one which insures sufficient accuracy.

Hensen, on the other hand, gives the Riva Rocci method preference, in that he believes its subjective errors to be small. In experiments on cadavers he corroborates the results of Riva Rocci, the values obtained being but ½ mm. too high. The musculature, if relaxed, was found to cause no errors in the determination. Contracted muscles as well as edemas, however, influenced the accuracy of this method.

Stanton has lately corroborated the findings of Recklinghausen as to the disparity in the results with the narrow and the wide cuff. With the narrow cuff he obtained like readings on the arm and the forearm, but on the thigh, unless the patient was very thin, the readings were higher. With the wide cuff all of the readings were practically the same. He concludes, that it is evident that the pressure measured by this apparatus is the maximum or systolic pressure plus any possible tension due to transmission, this possible loss being, however, small. "Therefore the conclusion seems to be justified that circular compression of the arm by the Riva Rocci method gives an accurate measurement of the systolic pressure, provided the width of the compressing armlet is properly proportional to the circumference of the arm."

The Gaertner tonometer, as stated by Recklinghausen, is also inefficient, in that the area compressed is not of sufficient width, nor does the compressor adapt itself to the finger in a sufficient degree. In a compression of greater width, which was applied to the basal phalanx instead of the second phalanx, this being a pressure more in accordance with that of the arteries than that obtained farther distant, the results obtained were found to vary from those obtained by the Gaertner method.

The tabulation of these results is as follows:

Table V.

Simultaneous blood-pressure measurements on two fingers of his own person; sitting three hours after noon-day meal; warm day; slight perspiration on the forehead.

Pressure in mm. Hg. The sensation of the throb taken as the criterion.

No.	Left hand, Gaertner's ring. Index finger.	Middle finger.	Ring finger.	Small finger.	Right hand, new cuff. Index finger.	Middle finger.	Ring finger.	Small finger.	Difference.
1.			82			82			0
2.	86					86			0
3.	80					80			0
4.	100 (After new attempt)					78			+ 22
5.	90 (After new attempt)					78			+ 12
6.			76			76			0
7.	102					86			+ 16
8.			86			86			0
9.		92			94				— 2
10.			96		96				0
11.		90			92				— 2
12.		90			90				0
13.		86					86		0
14.				100	82				+ 18
15.				100	78				+ 22

More important and interesting observations were made simultaneously on the arm and the finger of the opposite member, the modified finger-cuff being employed.

Comparative blood-pressure measurements on the left upper arm and the right middle finger. Patient sitting; warm day; maximal pressure in mm. Hg.

Arm	92	92	94
Finger	82	82	86
Arm	90	94	88
Finger	88	84	86
Arm	94	96	90
Finger	90	84	

It is seen, therefore, that but a small difference was found between these two methods, but the pressure in the arteries of the fingers is generally lower than that of the brachial. It was noted that in a series of successive determinations small values were first obtained, which rapidly increased, then remained constant. The compression in itself seems, therefore, to be a blood-pressure-raising measure. Recklinghausen concludes that the accuracy of the Gaertner tonometer is but small, and the values obtained thereby are too low. A low limit of the maximal pressure can, however, be assumed to be obtained thereby.

Fraenkel also takes exception to the Gaertner tonometer, in that it alone records the maximum pressure without an indication as to the mean pressure being necessarily obtained therefrom. In aortic insufficiency, however, a high maximum pressure exists as well as a low minimum pressure without the mean pressure varying much from the normal. Another error which is attached to this method is that the pressure is measured on a small peripheral artery. Peripheral arteries, however, have a relatively strong muscularis, and when, under the influence of psychical excitement, the lumen narrows, a lower pressure than normal is obtained. Therefore it is not to be recommended, as has been suggested, that successive measurements be made on the same finger, as the vessels after the first attempt are more or less in a state of paralytic relaxation.

Stanton, in criticising the Gaertner tonometer, states that the assertion that it registers the mean pressure has been denied by a few investigators. "While it seems plausible that the flushing of the skin cannot occur until the external pressure is below that within the artery, it is likely that the apices of the pulse-waves will break through and cause the flush at a higher level than the mean pressure." In his own observations it is stated it was difficult to define exactly the point of flushing, and in many instances this occurred gradually, and the pressure at which the flush appeared seemed to be dependent on the degree at the primary pressure—a high pressure giving a lower flushing point. Cushing states that the exact level at which the flushing occurred was also hard to determine in negroes and in all cases in which artificial light was used. In many instances it was practically impossible, according to Stanton, to get two successive readings to correspond with each other, and frequently a variation of 20 mm. or more between the high and low points was found in a series of ten successive tests on the same patient.

Upon the Results obtained by Various Methods.

The normal blood-pressure, as ascertained by the various methods, shows a variation which is more or less constant. With the v. Basch method v. Basch himself states the normal pressure to be 100 to 130, with 150 still within the limits of the normal. In a later publication he, however, states that the normal pressure varies between 135 to 165 mm. Hg., but says that a pressure above, or below, this point is not necessarily pathological. Zadeck, as well as Christeller, determined the normal value as measured in the radial artery to be from 70 to 150 mm. Hg., although in the majority of cases this variation was much more limited,—viz., 100 to 130 mm. An increase or decrease from this figure is by Christeller regarded as pathological.

V. Ziemssen gives a somewhat lower value, 80 to 110 mm. Hg. He states that he had repeatedly observed the blood-pressure in man by both the manometer and the v. Basch method simultaneously on the temporal arteries of both sides and found that there was but a very slight difference between the two.

Fedener gives as the normal value 70 to 90 to 100 mm. Hg., while Eckert in healthy females, twenty to thirty years of age, obtained a median pressure of 174 mm.

Potain, with his method, gives as the normal, 15 to 19 cm. for males, and 14 to 18 cm. for females, of from twenty to twenty-five years of age. In younger individuals he obtained:

Five to seven years	8 cm.
Eight to twelve years	9 cm.
Thirteen to sixteen years	13 cm.
Eighteen to twenty years	15 cm.

After this the blood-pressure is stated to increase progressively with age, it being said to register 20 to 24 cm. in old age, this being, however, in part due to a sclerosis of the arterial walls.

Investigations as to the pressure with the Riva Rocci method are more numerous. Gumprecht gives as the general average:

Ghildren	90 to 110 mm. Hg.
Females	120 mm. Hg.
Males	140 mm. Hg.

Sahli, according to Huber, obtained a general average which was still higher, 150 to 160, while Boeri asserts that the physiological pressure, as obtained by this method, oscillated between 120 and 140, it being considered low when below 110 to 100, and high when above 160 to 170. Hochhaus, on the other hand, states that the normal pressure may oscillate between 100 and 160 mm. Hg., and Tigerstedt, as stated by Masing, gives the limits of healthy adults as 100 to 210 mm. Hg., and, as stated by Jellinek, gives a mean of 150 mm. Hg.

Hensen, in twenty-five healthy laborers from seventeen to thirty years of age, found the blood-pressure, as measured by the Riva Rocci method, to vary between 105 to 158 mm., or a mean average of 137.

In thirty healthy females of the same age it varied between 105 and 160, or a mean average of 132 mm. He states that 100 to 160 is therefore to be considered as the normal value, with 100 to 110, and 150 to 160 as the limits, outside of the pathological.
Mueller obtained almost similar values,—viz., 140 to 150 mm. Hg. He, however, holds that these are too high, as with the v. Recklinghausen modification cuff the normal registered but 105 to 115.
The difference in the results obtained by these two methods is shown by Recklinghausen in a comparative table. The blood-pressure was measured simultaneously on both arms, the regulation Riva Rocci cuff, 5 cm. wide, being attached to the arm and a cuff 12 cm. broad to the other.

	Broad Cuff.		Riva Rocci Cuff.	
Pulse returns	Right arm	90 to 96	Left arm	116
Pulse returns	Right arm	92 to 100	Left arm	114
Pulse disappears	Right arm	90 to 98	Left arm	112
Pulse returns	Right arm	92 to 98	Left arm	114
Pulse returns	Left arm	96 to 104	Right arm	118
Pulse returns	Left arm	94 to 104	Right arm	120
Pulse disappears	Left arm	104 to 108	Right arm	120
	Average	94 to 101		116

More lately Masing has estimated the median blood-pressure as determined by the Riva Rocci method in young children to be 135 to 140 mm. Hg.
With the Gaertner tonometer lower values have been obtained.
Gaertner himself estimated the normal pressure to be from 90 to 105. Weiss subsequently stated it to be 90 to 120 in males, and 80 to 100 in females.
Schule gives it as 80 to 130; in half the cases it, however, registered from 100 to 110, so that he rather assumes the latter to be the normal for adults in the sitting posture. Heim, for children, obtained a normal value of from 80 to 90, the extremes being 75 to 95. Sommerfeldt states the normal pressure to be 100 to 130 mm. Hg., and Grebner states the

normal pressure to be 100 to 120 to 135 mm. Hg., as determined in persons from eighteen to thirty-five years of age.

Jellinek, in an extensive series of observations, arrives at the conclusion that it is difficult even under physiological conditions to obtain a normal value, as great differences in this respect are to be found. In the great majority of cases, the measurements having been conducted on five hundred soldiers, the normal pressure was found to vary between 100 and 160, but figures above and below this were also found in normal persons.

Strauss, in his investigations on healthy males, all below thirty-six years of age, obtained a normal value of 90 to 100 mm. Hg., it being nearer to 90 than to 100.

Oliver in his method estimates the average arterial pressure to be 100 mm. Hg. as taken at the radial artery, with the body in the recumbent position. To this average he, however, states that a margin of 10 mm. above or below must be added. This margin embraces in the majority of healthy subjects the average physiological variations.

The blood-pressure in the normal condition, as has been determined by the various moods, shows physiological variations. Most observers have noted a higher pressure in males than in females, and the latter a higher pressure than in children. In boys he found that the pressure was higher than in girls of the corresponding age.

Oliver says that the arterial pressure is much the same in women as in men, and Hensen states that the difference between the young and adults is not very evident, it being found by him that children five to six years old may have the same pressure as adults. With increase of weight and height the blood-pressure increases; with increasing age similar observations have also been made.

A symmetrical inequality as to the pressure of the two sides of the body has also been noted by a few observers. Eckert with the v. Basch instrument found that the pressure of the left temporal artery was higher than that of the right, explaining this fact from the direct origin of the left carotid from the arcus aortæ. As stated in his table:

Age.	Body length. Cm.	Medium blood-pressure. Right temporal.	Left temporal.
2 to 2½ years	74 to 81	95	99.5
3 years	80 to 86	96	100
4 to 4½ years	81 to 89	97.5	102
5 years	79 to 105	103	105
6 to 6½ years . . .	99 to 101	107	109
7 years	105 to 107	109	111.5
8 years	104 to 116	108	115
9 years	112 to 116	115.5	117.5
10 to 11 years	119 to 130	113	116.5
12 to 13 years	124.5 to 133	112	114

Jellineck in this connection found that out of twenty soldiers the values obtained on the right and left hands were almost identical. In forty-nine cases, however, the tonometer registered higher on the right than on the left hand. This was verified by repeated observations. In eleven cases the value on the left hand was 5 cm. higher than on the right.

Diurnal variations of the blood-pressure have been frequently observed. Zadeck found that with the v. Basch instrument the blood-pressure varied during the course of the day similarly as occurs with the excretion of urea and CO_2O. Although in most cases the pressure was found to fall in the afternoon, at times it would rise from 8 to 15 mm., and occasionally higher, this rise being independent of the noon meal.

In the observations of Oliver as to the diurnal rise in the blood-pressure—both arterial and venous—throughout the day, the venous pressure was found to be both absolutely and relatively lower than the mean arterial pressure in the morning and in the earlier half of the day than in the subsequent hours and in the evening. The arterial pressure and especially the maximum arterial pressure increased as the day advanced and attained its highest point in the evening. Hensen found that these daily variations, which frequently registered 10 to 20 mm. and even 40 to 60 mm., and which under normal conditions could reach 25 mm. within an hour, were neither constant nor did they occur with regularity. The blood-pressure might be higher in the morning or inversely in the evening.

After the ingestion of food, decrease in the blood-pressure has frequently been observed. Colombo, as cited by Recklinghausen, found with the method of Mosso that the blood-pressure was highest prior to the main meal and lowest a few hours after,—*i.e.*, at the height of digestion.

Zadeck, however, noted an increase of from 10 to 20 mm. Hg., which is attributed to the increase of the blood volume from the greater diffusion into the splanchnic veins during the process of digestion.

Oliver states of the digestion that it would seem that the mere intake of solids or liquids produces at once a rise in the arterial pressure, mean and maximum, as well as in the venous pressure. He observed that in the morning before breakfast the mere taking of a glass of cold water could within five minutes raise the arterial pressure 5 mm. or more, and this effect could continue for ten or fifteen minutes. The mere ingestion of anything, it is said, appeared to stimulate the circulation immediately in a reflex manner. This view is supported by the observation that when the water was rendered more stimulating to the gastric mucous membrane containing a charge of carbonic gas or of salt, the rise in the arterial and venous pressure was further increased.

The digestive process affected the blood-pressure considerably. The maximum arterial pressure was usually raised throughout the digestion of each meal. As a rule, the mean arterial pressure was likewise increased while the venous pressure fell. The rise of the mean arterial and the fall of the venous pressure were not invariable, they being, as a rule, observed after the ordinary solid meals. However, after a meal, like that of breakfast, containing a preponderance of warm fluids, the mean arterial pressure much more commonly fell than the venous pressure rose. In this way, it is stated, breakfast tends to lower the mean arterial pressure, even though it raises the maximum arterial pressure.

Jellineck, in a tabulation of twenty cases as to the influence of the digestive process on the blood-pressure, reports the following:

No.	Age.	Before meals. Pressure mm.	Before meals. Pulse.	After meals. Pressure mm.	After meals. Pulse.
1	22	110	70	140	78
2	21	140	72	160	84
3	20	140	74	150	84
4	22	110	68	120	76
5	23	120	70	140	86
6	23	110	68	140	84
7	20	90	60	150	90
8	22	150	70	130	70
9	22	130	70	130	86
10	22	130	72	130	88
11	21	120	64	140	86
12	21	120	60	140	80
13	22	110	58	140	84
14	22	150	64	120	90
15	23	100	60	140	98
16	22	120	64	140	78
17	22	120	66	140	78
18	22	100	68	140	78
19	22	110	70	110	78
20	22	140	72	140	86

Thus, out of twenty cases, an increase in the pressure was noted in fourteen, while in four the pressure did not vary, and in two it fell. Furthermore, in forty-two cases, in which the pressure was measured six times daily for ten successive days, the highest values were nearly always obtained during digestion. Recklinghausen, in accordance with other observers, also reports that the pressure is liable to variations during the process of digestion. In his observations he found that immediately after the mid-day meal the pressure rose.

Hensen, in contradiction to these, found that the pressure during digestion did not rise according to a definite rule. Simultaneous observations on a number of individuals, the same diet having been given, showed that while in one the pressure regularly rose fifteen to twenty-five minutes after the meal, in another individual this did not occur.

According to Weiss, the pressure, as measured with the tonometer, falls after digestion. (See Fig. 63.)

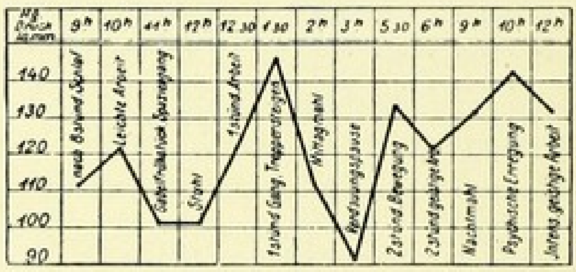


FIG. 63.—CHART I. (Weiss).—Physiological variations in the blood-pressure.

Schule, however, states that the decrease of pressure from the ingestion of food, as is asserted to occur by Weiss, could not be found. The alterations in the pressure were even absent in a case of dyspepsia. He concludes that a relation between the ingestion of food and the blood-pressure does not exist. Ingestion of fluids was furthermore found by this same observer not to influence the blood-pressure in a definite way. In a person whose pressure was 105 cm. it fell to 90 mm. ten minutes after the ingestion of 1000 cm.

water, and ten minutes later it registered 100 mm. The ingestion of fluids with regard to its influence on the blood-pressure has, however, been more especially studied by Maxinowitsch and Rieder with the v. Basch instrument. They report that all fluids increase both the pulse frequency and the pressure notably according to the quality of the liquid. Beer gave the most marked variation, probably owing to the CO_2 and the alcohol contained; then followed in their successive order wine, coffee, tea, cocoa, and water.

Oliver, in this connection, also reports some preliminary observations on the effect of alcohol, coffee, and tea. It was found that these do not all exert the same influence on the different parts of the circulatory organs. Alcohol and coffee seemed more particularly to stimulate the ventricle, while tea appeared mainly as a vasomotor stimulant.

The former raised the maximum arterial pressure, as also the venous pressure, while tea augmented the mean arterial pressure, lowered the venous pressure, and did not materially affect the maximum pressure.

Exercise.—Mosso, according to Brunton and Tunicliffe, is stated to have found that an arm, enclosed in a water plethysmograph, diminished in volume during the contraction of the flexors and increased above its normal volume immediately after the cessation of the contraction. (See Fig. 64.) Also that an increase in the amplitude of the pulsation of the whole arm took place, both during and after the contraction of the flexors. Tshcelinoff observed, with the manometer of Mosso and v. Basch, that the pressure rose in almost all instances after ascending the stairs; this rise, however, registered less with the instrument of Mosso than with that of v. Basch. Oertle also observed a considerable rise in the general pressure following muscular exercise.

Zadeck similarly found that muscular exercise increases the pressure which he assumed to be due to the increase in the cardiac action. This rise, which disappeared soon after rest had again been instituted,

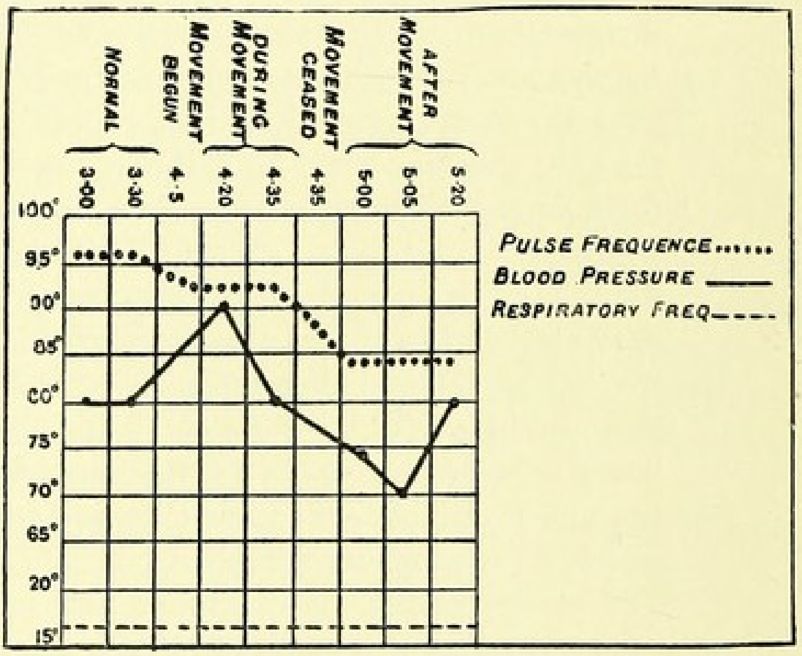


FIG. 64.—CHART II. (Brunton and Tunicliffe).—Effects of movement on blood-pressure.

registered in moderate exercise 10 to 20 mm., and in greater exertions, such as running, 30 mm. Hg.

Maxinowitsch and Riedner in an extended series of observations with the v. Basch instrument found that the greatest height in the increase of the blood-pressure from work was reached immediately after the cessation of work. This rise from the normal being 25 to 50 mm. Hg.

Brunton and Tunicliffe, employing the sphygmomanometer of Mosso with the patient in the erect posture, found that generally the effect of exercise, so gentle as to cause no increase in the respirations or in the pulse, was, that during the exercise itself the pressure first rose above the normal, but began to fall again, even during the continuance of the exercise, and continued to fall, so that at the end of the exercise it had usually again reached the normal. After the cessation of the exercise the pressure continued to fall, remaining subnormal for half an hour or longer, then gradually rising to its initial height. The discrepancy between these observations and that of other observers is attributed to the difference in the amount of exercise taken.

In case of other observers the amount of exercise taken was sufficient to increase the frequency of the pulse and respiration, while in their experiments this did not occur.

Oliver, in general, corroborates the findings of Hill, stating, however, that the rise in the pressure from the effects of the exercise is not the invariable rule. This effect, as stated, is the resultant of two factors, central and peripheral, one being the increased ventricular action, the other the dilatation of the peripheral vessels. In certain instances it was noted that the mean pressure remained without appreciable alteration, or actually fell, though there was no suspension of fatigue, and, moreover, after a certain amount of exercise, this amount apparently being subject to individual variation, a stage was reached in which the mean arterial pressure declined. It is assumed that it is not improbable that the different proportions of the central and peripheral effects of the exercise might induce some variability as regards the rise in the mean pressure, or might altogether prevent the rise, or even determine a fall.

Edgecomb and Bain, by the method of Oliver, conclude that the effect of the exercise on the blood-pressure depends on the severity of the exertion. An initial rise was found to occur in all forms of exercise. If it was mild, a fall occurred during its continuance; if severe, the fall was maintained. After the cessation of both moderate and severe exercise, a fall occurred. The venous pressure was found to be raised during all forms of exercise, and to remain raised during the subsequent arterial fall. The return to the normal, after the exercise, occurred more or less rapidly, according to the gentleness or to the severity of the exercise, and to the temperature of the atmosphere.

Masing, determining the effects of exercise by the Riva Rocci method in applying the instrument to the person in the horizontal position, and who for this purpose exercised the leg, found that in one hundred and forty attempts of this nature, with six thousand determinations of the pressure, it rose most generally immediately after the beginning of work. At times a short decline preceded the rise. The rise in the blood-pressure is attributed to the increased cardiac action, whereby more blood is thrown into the aorta. The increase in the cardiac action consists in an acceleration of its beats and in an increase in the volume of the beat. In young people the rise was found to be independent of the duration of the work; in old people, however, it frequently fell after prolonged work. Immediately after the cessation of work it declined more or less rapidly to the normal. The rise in the pressure was the greater, the greater the amount of work performed. The reason that in old age the pressure falls earlier is due to the insufficiency of the muscular tissues, its contractile substance being said to be partially lost.

Concerning the effects of exercise on the blood-pressure, Recklinghausen reports an observation in which the patient was placed in the horizontal position and then elevated a 5-kilo weight, with one hand, above the level of the chest. A gradual rise of the pressure occurred, which in one and one-half minutes registered 14 cm. Immediately after the exercise was discontinued the pressure fell 7 cm.

More lately, Schule, in his investigations with the tonometer, denies that physical exertions influence the pressure, while Weiss asserts that a rise occurs, as does Grebner, while Gaertner states that a fall is usually to be noticed.

Potain gives the influence of the exercise on the blood-pressure as variable.

In general, all moderate exercise elevates the arterial pressure, this effect being produced at the moment activity is begun. All prolonged and energetic or severe exercise, on the other hand, is said to lower the pressure.

Rest.—Zadeck, estimating the pressure of persons at rest, determined it to be lowered. In a comparative investigation after awaking and immediately after rising he found with the Basch method:

	In bed.	After rising.
A. August 7	60 to 70 (80)	72 to 74 (92).
August 8	72 to 76 (76)	76 to 82 (76).
August 12	76 to 80 (76)	80 to 84 (96).
B.	126 to 130 (73)	140 to 146 (84).
C.	94 to 100 (72)	98 to 104 (76).

As stated by Cliver, rest, mental as well as physical, has a marked influence on lowering the pressure (arterial as well as venous), this being manifestly due to a reduction in the force and in the frequency of the heart's action. Maximum and mean arterial pressure are both lowered in proportion to the reduction in the cardiac action, the former, however, to a greater degree. The fall in the venous pressure is still more pronounced than in those of the arterial, as the peripheral vessels probably shrink from the diminution of the distensile pressure of the ventricles.

Hill, in observations with the sphygmometer in sleep, found that the pressure falls very decidedly. This fall in the pressure is attributed directly to the warmth and rest in the horizontal posture, with which sleep is associated, as when lying awake in the morning the fall of pressure was as great as when sleepy at night, that is, as long as the subject remained quiet and in the recumbent position, and even in the sitting position such a fall would occur, given the conditions of warmth and rest.

Wagner also found that the pressure fell in sleep.

Psychical Influences.—Gumprecht asserts that all psychical influences, either of a joyful or sorrowful nature, markedly influence the blood-pressure. After anger it may rise 30 to 40 mm. One patient, whose pressure was measured daily and almost constantly, registered 170; after a game of cards it was found to be 202 mm. A moderate amount of laughing caused a pressure to rise from 156 to 172. A man, after receiving a traumatism, showed a blood-pressure value of 143, and, after he had related the story of his affliction, 172 mm. Recklinghausen reports an observation on his own person concerning the psychical influence on the blood-pressure. As measured on the finger, he noted in one instance a rise of 12 cm. of water in the blood-pressure at the moment when some one entered the room to whom he intended to make an explanation. Oliver, speaking of mental exercise and emotional excitement, states that the blood-pressure may be almost as powerfully affected by the activity of the nerve-centres as by muscular exercise. It is most particularly raised by any form of emotional excitement.

Hill, to indicate the result of mental excitement on the general blood-pressure, reports the following table:

EXAMPLE III.

Time.	Condition.	Position of body.	Arterial pressure.	Pulse-rate.
1.30 P.M.	Before lunch ; quiet.	Sitting.	103 to 105	64
4.30 P.M.	Engaged in discussion and excited.	Sitting.	130 to 140	84

EXAMPLE IV.

Time.	Condition.	Position of body.	Arterial pressure.	Pulse-rate.
1.30 P.M.	Before lunch ; quiet.	Sitting.	103 to 105	64
4.35 P.M.	Quiet after mild exercise.	Sitting.	103	74

EXAMPLE VII.

(To illustrate result of muscular activity.)

Time.	Condition.	Position of body.	Arterial pressure.	Pulse-rate.
11 A.M.	Reading ; quiet.	Sitting.	98	64
11.10 A.M.	After running four hundred yards fast ; panting.	Sitting.	120 to 130	100
11.20 A.M.	Resting.	Sitting.	110 to 115	100
11.30 A.M.	Resting.	Sitting.	100 to 103	96
12.30 P.M.	Resting.	Sitting.	90 to 95	80

Schule states that strong psychical excitement predisposes strongly to high-blood value in cases where the patients are not anemic or marasmic. Pain, he states, seems to lower the blood-pressure. In four cases of sciatica the pressure was observed to measure 70, 80, 90, and 100.

Strauss, speaking of psychical influences, states that high values were obtained in patients who had been in the clinic a short time, while in those who had remained for a longer period a lower value was found. Successive determinations of a relatively high tonometric value in persons in which arteriosclerosis, nephritis, or chronic lead intoxication can be excluded arouse a suspicion of a neurosis. Pain, he states, increases pressure. In four cases of trauma a rise of 20, 30, 35, and 40 was noted upon pressure upon a nerve. Even in healthy persons pinching of the integument was noted to increase the pressure. In twenty-five such observations the rise and pressure was absent but three times. In fourteen cases this rise registered over 15 mm., and in four cases 20 mm. Hg.

Hein, in his investigations with the Gaertner's tonometer concerning the psychical influence, observed that the first measurement was always 10 to 20 mm. higher than the succeeding ones measured a quarter of an hour afterwards.

In neuropathic children a higher value was constantly obtained, this being due to the momentary psychical excitement. In twenty-five observations on neuropathic children, such as those having headache, " stitch in the side," loss of appetite, vomiting, fainting, dizziness, convulsions, etc., a distinct rise in the pressure was noted. As illustrative of the degree to which psychical effects may influence the pressure, the cases of two boys are cited, one of whom, twelve years old, had pharyngitis, and the other, eleven and one-half years old, slight bronchitis. In both, the pressure, measured several times, registered 95 and 80 mm. Both boys had toothache, and before the teeth were extracted one had a pressure of 160 mm., the other, of 140 mm. A few days later the normal value was again obtained. The fear of the extraction of the teeth had raised the pressure in both of these cases.

Kapsammer, speaking on the subject, states that psychical conditions of the patient determines marked oscillations of the blood-pressure, so that the real pressure is not easily obtained. These oscillations are dependent upon the intelligence, temperament, and health of the patient. They become marked in nervous and hysterical persons, and, on the other hand, are much less or altogether absent in phlegmatic persons or in persons unconscious.

Fever.

In certain pathological conditions a marked variance in the blood-pressure has been noted, and especially so in fevers. Zadeck reported the blood-pressure in the various forms of fever, such as recurrent and intermittent fever, typhoid, and pneumonia. He found that in all cases of typhoid the rise in the blood-pressure almost constantly coincided with the height of the temperature, this being true also of the continued as well as of the remittent fevers. In pneumonia, the temperature, pulse frequency, and blood-pressure fell simultaneously in one case, the fall of the temperature, 4°, occurring with the diminution of the pulse, of from 30 to 50 beats, and a fall of the pressure, of from 30 to 40 mm. In another case the fall of 2° corresponds with a diminution of 22 in the pulse, and a fall in the pressure of 20 mm. He concluded that fever in general causes an increased blood-pressure, this being due to the increase in the temperature of the blood, as when baths are given in fever the pressure was again lowered. Exception, however, is made to such fevers as are caused by septicemia, pyemia, etc., which experimentally on dogs were found to lower the pressure.

V. Basch, from an extended number of observations, in the various diseases with fevers, states that the question where the pressure rises or falls in fevers cannot be answered by a simple yes or no, as various other factors which influence the blood-vessels are to be given consideration.

Wetzel, in a series of twenty observations on fevers, including typhoid, diphtheria, pneumonia, and acute gastritis, in which the pressure was measured by the method of v. Basch, concludes that increased temperature tends to lower the blood-pressure. It was noted that in all cases the rise in the temperature was concomitant with the fall of the pressure, and that with the return of the temperature to the normal the pressure again rose.

Arnheim, on the other hand, essentially agrees with the result which Zadeck obtained. In typhus the rise in the pressure was almost always determined,—the increase being parallel to the height of the axillary temperature, the pressure being exceptionally high in the fastigium and gradually falling during the defervescence. In recurrent fevers, a marked rise in the pressure also occurred during the paroxysm of fever. In the apyrexia the blood-pressure also fell, but not as markedly as the axillary temperature, and returned soon to the normal.

Eckert, from 28 observations on the various forms of fevers, concludes:

(1) That fever always more or less increases the pressure.

(2) That in fever of short duration the rapid rise in the temperature and a distinct crisis affect the pressure notably in that it distinctly rises with the rise of the temperature and during the crisis it falls below the normal.

(3) Continued fevers also at first cause a rise in the pressure, but if the fever continues for a longer period, a distinct fall in the pressure follows.

Hensen, discoursing on the conflicting views as to the rise or fall of pressure as found by the various observers in the termination of fevers, states that these differences are dependent on the inability to distinguish the exact condition present at the time of the determination. The normal variation which occurs spontaneously during health are complicated with the pathological conditions. Furthermore, the fever is complicated with numerous other disturbances, which, in themselves, influence the pressure. Finally, the normal pressure has been but rarely determined before the onset of the disease. In his own observations he noted that with the increase of the fever, a moderate rise of blood-pressure from 10 to 30 mm. frequently occurred. In fevers of longer duration a gradual fall in the pressure is stated to have occurred.

Schule states that in his observation, in accordance with the general acceptance, the pressure fell in fever. It fell at times to 80 and even 50 and 60 mm. In individual cases the pressure rose with the decrease in the fever. The cessation of the pathological process, as in pneumonia, etc., may also have played a part.

Potain states that typhoid fever lowers the arterial pressure. In general this fall is from 3 to 4 and 5 cm. This fall is stated to be neither proportionate to that of the temperature nor to the frequency of the pulse. In the defervescence the pressure at times falls suddenly, then during the convalescence gradually rises again to the normal. In pneumonia and pleurisy the blood-pressure is also stated to be lower, this fall being, however, not as great.

Cardiac Disease.

The blood-pressure in the various cardiac diseases has been noted by several observers. V. Basch reports the following:

No.	Sex.	Age.	Pressure.	Remarks.
1	M.	28	120	Insufficiency in mitral stenosis.
2	M.	50	115	Insufficiency in mitral stenosis.
3	M.	20	116	Insufficiency in mitral stenosis.
4	M.	40	122	Mitral stenosis.
5	F.	30	100	Insufficiency and mitral stenosis. Hydrops ascites.
6	F.	22	150	Insufficiency and mitral stenosis. Recent endocarditis. Acute rheumatism.
7	M.	53	195	Aortic insufficiency.
8	M.	52	140 to 180	Aortic insufficiency, with aneurism of the aorta.

Hensen denies the assertions of v. Basch that the blood-pressure in mitral disease is lowered, stating that in general the pressure does not vary from the normal. In a tabulation, including the various forms of cardiac disease, he reports:

I.—MITRAL INSUFFICIENCY.

MALES.

No.	Age.	Pulse.	Pressure.	Remarks.
1	16	70	120	Old mitral insufficiency after arthritic rheumatism.
2	24	76	160 to 170	Mitral insufficiency after arthritic rheumatism, three months.
3	25	68	143	Recent mitral insufficiency and polyarticular rheumatism.
4	21	80 to 100	120 to 125	Mitral insufficiency for three years. Slight incompensation.
5	22	64 to 92	130 to 135	
6	22	72	147	Recent mitral insufficiency and polyarticular rheumatism.
7	31	76	150	For ten years slight mitral insufficiency. Acute dilatation of heart.

FEMALES.

No.	Age.	Pulse.	Pressure.	Remarks.
8	21	80 to 100	130 to 145	Old mitral insufficiency.
9	15	70 to 120	110 to 140	Mitral insufficiency, one to two years' standing.
10	50		125	Old mitral insufficiency.
11	30	80 to 100	125 to 160	Mitral insufficiency, one to two years old.
12	24	80 to 100	120 to 125	Slight mitral insufficiency.

CHILDREN.

No.	Age.	Pulse.	Pressure.	Remarks.
13	15	88 to 112	80 to 113	Uncompensated mitral insufficiency.
14	11	100	123	Mitral insufficiency, four years' standing.
15	10	92	133	Mitral insufficiency, one-half year's standing after chorea.

II.—MITRAL STENOSIS.

No.	Age.	Pulse.	Pressure.	Remarks.
16	30	80 to 100	105 to 140	Mitral stenosis, ten years.
17	60		140	Old mitral stenosis.
18	16	120	127	Old mitral stenosis. Post-diphtheritic paralysis.
19	72		140	Old mitral stenosis.

III.—MITRAL INSUFFICIENCY AND STENOSIS.

MALES.

No.	Age.	Pulse.	Pressure.	Remarks.
20	40	90 to 120		Old mitral stenosis and insufficiency.
21	21	116	105 to 142	Autopsy. Severe mitral insufficiency. Uncompensated tricuspid insufficiency.
22	19	120	130	Mitral insufficiency and stenosis. Recent endocarditis.

FEMALES.

No.	Age.	Pulse.	Pressure.	Remarks.
23	60		150	Old mitral insufficiency and stenosis.
24	38	128	117	Mitral insufficiency and stenosis. Bronchitis.
25	17	88	160	Mitral insufficiency and stenosis, one to two years after articular rheumatism, with endocarditis.
26	14	88	129	Mitral insufficiency and stenosis after chorea.

In compensated mitral disease, Hensen concludes the pressure does not vary from the normal in recent cases; however, it seems that the pressure is somewhat higher.

Hochhaus, in examining thirty-six cases of cardiac neurosis, twenty males and sixteen females, found that in males the lowest pressure was 150 mm. Hg., the highest being 210 mm. Hg., it usually oscillating between 160 and 190. In females the lowest was 140 and the highest 210, generally oscillating between 150 and 170.

Weiss states that in cardiac diseases the pressure markedly varies so that the relation of the blood-pressure to the cardiac disease is of no diagnostic value. In individual cases, however, he states it may be of some value. The value of drugs in the various forms of cardiac diseases was demonstrated by this observer. Among some of his observations are the following: Female aged twenty-three; weak and very anemic; pulse scarcely palpable; very marked dyspnea; cyanosis; respiration, 72; pulse, 240 per minute. Traces of albumin in the urine; dilatation of the heart. Anemic murmurs; arteries soft, straight, and not well filled. Administration of digitalis infusion for three days; delirium cordis.

After three injections of camphor oil, the blood-pressure was as follows:

August 17, 9.45 A.M., 90 mm.

At 9.50, 100 mm.

At 9.55, 105 mm.

At 10.00, 105 mm.

At 10.10, 110 mm.

At 10.20, 105 mm.

Teaspoonful of digitalis administered every half-hour.

At 12.30 P.M., blood-pressure, 85 mm.

Four teaspoonfuls of digitalis administered.

At 5.00 P.M., blood-pressure, 95 mm.

Nine tablespoonfuls of digitalis administered.

August 18, 9.00 A.M., blood-pressure, 85 mm.; pulse, 198; respiration, 48.

At 5.00 P.M., blood-pressure, 104 mm.; pulse, 104; respiration, 36.

Digitalis continued.

August 19, 9.00 A.M., blood-pressure, 105 mm.; pulse, 66; respiration, 34.

At 5.00 P.M., blood-pressure, 110 mm.; pulse, 72; respiration, 36.

August 20, 9 A.M., blood-pressure, 50 mm.; pulse, 62; respiration, 32.

Digitalis continued.

Schule remarks that in his determinations, in cardiac affections, no positive results could be obtained.

Compensated cardiac disease, such as mitral stenosis and aortic insufficiency were found to have no influence on the blood-pressure. Potain gives a pressure in many of the cardiac diseases as lower than that of the normal individual of the same age and sex. This is, however, stated to be very variable, the pressure oscillating from 10 to 20 mm. Lower figures, as stated, indicate an insufficient compensation and render the prognosis unfavorable. It is to be recollected, however, that grave cardiac affections may have an accentuated arterial tension as a concomitant. Aortic insufficiency of all cardiac diseases lower the pressure the least.

Diseases of the kidney as stated by Hensen give a valuable determination, chronic interstitial nephritis being constantly accompanied by a high pressure as shown in the following table:

CONTRACTED KIDNEY.

No.	Age.	Pulse.	Pressure.	Remarks.
1	54	70	245	Contracted kidney. Marked arteriosclerosis.
2	44	96	195	(Secondary.) Contracted kidney. Pulse arrhythmic.
3	50	90	205	Contracted kidney. Chronic pulmonary phthisis.
4	23	112	185	Older (interstitial) nephritis. Exacerbation after diphtheria.
5	51	80	144	Autopsy. Contracted kidney. Synechia of pericardium. Cardiac hypertrophy.
6	24	80	195	Beginning uremia. Exitus two days. Autopsy.—Contracted kidney. Cardiac hypertrophy.
7	37	96	242	Contracted kidney. Moderate arteriosclerosis. Uremia.
8	60	92	200	Contracted kidney. Moderate arteriosclerosis. Beginning arteriosclerosis.

CONTRACTED KIDNEY—*Continued.*

No.	Age.	Pulse.	Pressure.	Remarks.
9	53		240	Contracted kidney. Severe arteriosclerosis. Old apoplexy.
10	55	104	185	Contracted kidney. Moderate arteriosclerosis. Old apoplexy.
11	68	72	250	Contracted kidney. Arteriosclerosis. Aortic insufficiency. Old hemiplegia.
12	63	80 to 116	175 to 218	Autopsy.—Contracted kidney. Strong arteriosclerosis. Cardiac hypertrophy.
13	63	112	195 to 235	Autopsy same as 12.
14	70	80	235	Autopsy same as 12. Moderate arteriosclerosis.
15	45	100	200 to 210	No arteriosclerosis.

CHRONIC PARENCHYMATOUS NEPHRITIS.

No.	Age.	Pulse.	Pressure.	Remarks.
16	40		135	Phthisis.
17	64		160	Chronic parenchymatous nephritis.
18	24		130 to 135	Chronic parenchymatous nephritis (large white kidney). No cardiac hypertrophy.
19	27	88	130	Moderate chronic hemorrhagic nephritis.
20	26	60	142	Acute hemorrhagic nephritis.
21	36	72	120	Chronic parenchymatous nephritis. Cachexia.
22	30	72	115	Acute hemorrhagic nephritis.
23	29	64	155	Chronic parenchymatous nephritis. Marked edema.

In reference to the blood-pressure in nephritis, Weiss states that the highest tonometric values are obtained in this affection. In the chronic nephritis of young people, he states that high determination is an important indication, as it points to the increased peripheral resistance and the hypertrophy of the left ventricle, and thickening of the arterial walls. In a recent nephritis of short duration, on the other hand, even subnormal values are found, so that the tonometric values can be used in the different diagnosis, as to the form of renal disease. A parenchymatous nephritis of short duration has not as yet a high pressure, while a chronic one with a secondary symptom has.

Arteriosclerosis.

Hensen in the consideration of arteriosclerosis on the blood-pressure divides this affection into the light, median, and strong degrees, to which he appends the following tables:

ARTERIOSCLEROSIS OF MEDIAN DEGREE.

MALES.

No.	Age.	Pulse.	Pressure.	Remarks.
1	71	76	160	
2	63	92	165	
3	69	68	160	Arthritis.
4	44	40	130	
5	52	108	175	
6	65	normal	220	
7	53	76	190	
8	46	60	158	
9	33	68	170	
10	38	normal	180	
11	50	80	179	
12	59	84	155	
13	52	76	154	
14	59	72	190	
15	57	78	165	Dilatatio cordis.

FEMALES.

No.	Age.	Pulse.	Pressure.	Remarks.
17	52	116	215	
18	57	80	121 to 160	
19	63	80	205	

ARTERIOSCLEROSIS OF HIGH DEGREE.

MALES.

No.	Age.	Pulse.	Pressure.	Remarks.
1	53	104	210	
2	60	52	172	Arthritis urica. Saturnismus.
3	71	120	185	
4	55	72	180	
5	80	normal	174	
6	70	52	145	Anemia. Emphysema.
7	59	88	210	Coronal sclerosis. Asthma cardiale.

FEMALES.

No.	Age.	Pulse.	Pressure.	Remarks.
8	80	72	185	

The general average of these tables as corrected record a figure of 157 mm., or about 20 mm. higher than the normal. Variations in the pressure in arteriosclerosis are, however, great, and are readily explained in that various portions of the vascular system may be affected. Other factors also play a rôle in this consideration. Sclerosis of the splanchnic vascular system, for instance, exhibits a tendency to raise the pressure, although the peripheral arteries may not be affected.

Weiss also found that in arteriosclerosis, the pressure is high, which he attributes to the increased cardiac action from the increased peripheral resistance and the rigid vascular walls. In some instances, however, a decrease in the pressure was noted, and this is accounted for by the weakened cardiac action as shown by the injection of camphor.

The following is illustrative:

Male, aged sixty-eight. Extreme atheroma, cardiac weakness, obstipation, pulmonary emphysema, hemorrhagic infarct.

August 7, lying down, 100 mm.

August 7, lying down, 50 mm. (cardiac weakness). Patient given three camphor injections.
After ten minutes, 75 mm.; pulse, 96.
After fifteen minutes, 82 mm.; pulse, 106.
After twenty minutes, 90 mm.; pulse, 106.

In another instance, a female fifty-five years; rigid arteries, emphysema pulmonum, dilatation of the right heart.

August 14, pressure, 100 mm.
Later, collapse. Pressure, 80 mm.
Patient given three camphor injections.
After eight minutes, pressure, 120 mm.
After fifteen minutes, pressure, 125 mm.
Gradually pressure falls to 110 mm.
August 15, collapse. Pressure, 85 mm.
Three camphor injections.
After three minutes, pressure, 120 mm.
After five minutes, pressure, 138 mm.
After seven minutes, pressure, 150 mm.
After eight minutes, pressure, 155 mm.
After nine minutes, pressure, 145 mm.
After ten minutes, pressure, 140 mm.
After twelve minutes, pressure, 138 mm.
After fourteen minutes, pressure, 120 mm.
After sixteen minutes, pressure, 130 mm.

Schule gives as the main field for tonometric determinations, arteriosclerosis and nephritis (especially the chronic). Both show the rise in the arterial pressure. In arteriosclerosis it is the most constant symptom and already present at the beginning of the affection. (Abnormally frequent increases in the blood-pressure may, however, be the primary causation of arteriosclerosis). This increase in the pressure may be present at the time in which the peripheral arteries do not show any evident thickening of the walls. Occasionally these remain unaffected for a long time, while central vessels, as those of the abdominal viscera, are already markedly affected. In arteriosclerotic subjects examined in whom the superficial arteries were plainly thickened and tortuous there was regularly found a distinct rise in the pressure as 140, 150, 160, and even 200, the latter being the highest figure determined. Tonometry is, therefore, to be considered a valuable measure in the determination of beginning arteriosclerosis.

Potain also found that arterial atheroma is constantly accompanied by an evident hypertension, but it was impossible to exactly estimate the proportion as to the degree of atheromatous alterations and the degree of elevation in the arterial pressure.

Drs. Cook and Briggs, of Johns Hopkins, made a valuable contribution to the study of the effects of stimulants upon the blood-pressure, particularly in medical cases. Dr. Cook's modification of the Riva Rocci instrument, in making the manometer in two parts, rendering it more easily carried, has added to its practicability.

Surgical Observations concerning the Blood-Pressure.

The surgical aspects concerning the rise and fall of the blood-pressure have been more especially noted by Kapsammer in the various operative procedures. With the Gaertner tonometer he noted that in the course of two laparotomies the pressure fell once from 120 to 90, and in the other instance from 170 to 50 mm. In the opening of an enormously distended sigmoid with carcinomatous stenosis a fall of from 155 to 80 occurred in one observation. Aspiration of pleuritic fluid in two instances was also accompanied by a fall in the pressure. Similarly in two marasmic persons in which large quantities of fluid were removed from the abdomen under the local anesthesia a distinct fall in the pressure occurred. In the one case, a girl thirteen years old with tuberculous peritonitis, more than 10 litres of fluid were removed, in the mean time the pressure falling from 120 to 50 mm.

Five days later the pressure registered 90 mm.

In the other instance, a cystadenoma of the ovary, 12 litres of fluid were removed. The pressure fell from 85 to 50 mm. The next day it registered 53 mm. and the woman died.

The fall in the pressure in the cases just mentioned is explained as being probably caused by the sudden relaxation of the vascular system of the splanchnic area, and therefore by a decrease in the peripheral resistance. Similar cases have been reported by Cushing.

In the surgery of the osseous system it was noted that the chiselling of the pelvic bone for a fascial sarcoma caused a fall in the pressure from 100 to 60 mm. In the resection of an elbow under local anæsthesia, however, the pressure rose from 110 to 165 mm.

Resection of the trigeminus caused a rise in the pressure from 120 to 160 when the nerve was stretched, and in another instance a rise from about 100 to 170 mm.

Cushing has reported most original and interesting observations along this line. Some of his charts are here reproduced. With the Riva Rocci method he found that the moment the Gasserian ganglion was evulsed a rapid fall of the blood-pressure occurred, and when pressure was applied, the blood-pressure rose and the pulse-rate fell. (See Fig. 65.)

In a case of stretching the sciatic nerve a rise in the pressure was noted, while in a breast operation, in which no important sensory nerve-trunks were handled or divided, no appreciable effect on the pressure was observed. In amputations in which the nerve-trunks supplying the operative field were cocainized. No noteworthy change in blood-pressure was noted.

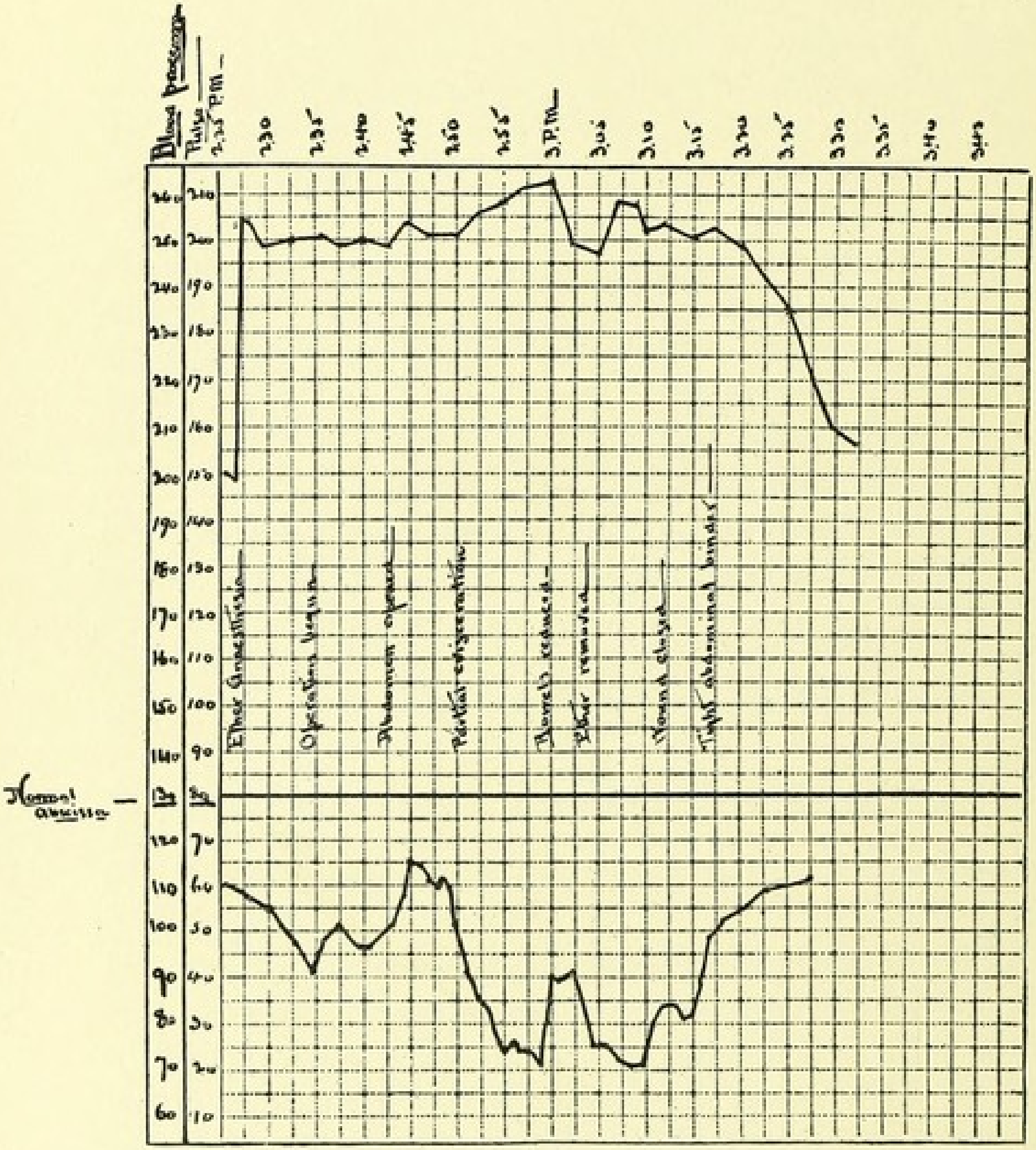


FIG. 65.—CHART III. (Cushing).—Chart showing the alterations in the pulse and blood-pressure during an abdominal operation for tubercular peritonitis in a feeble child.

In a typical Halstead operation for carcinoma of the breast no noteworthy changes occurred. (See Fig. 66.)

In a case of tubercular peritonitis in which the viscera were exposed and handled, the blood-pressure fell.

He has strikingly shown the value of blood-pressure determinations in the diagnosis of pressure upon the brain, and its value in making the prognosis in such

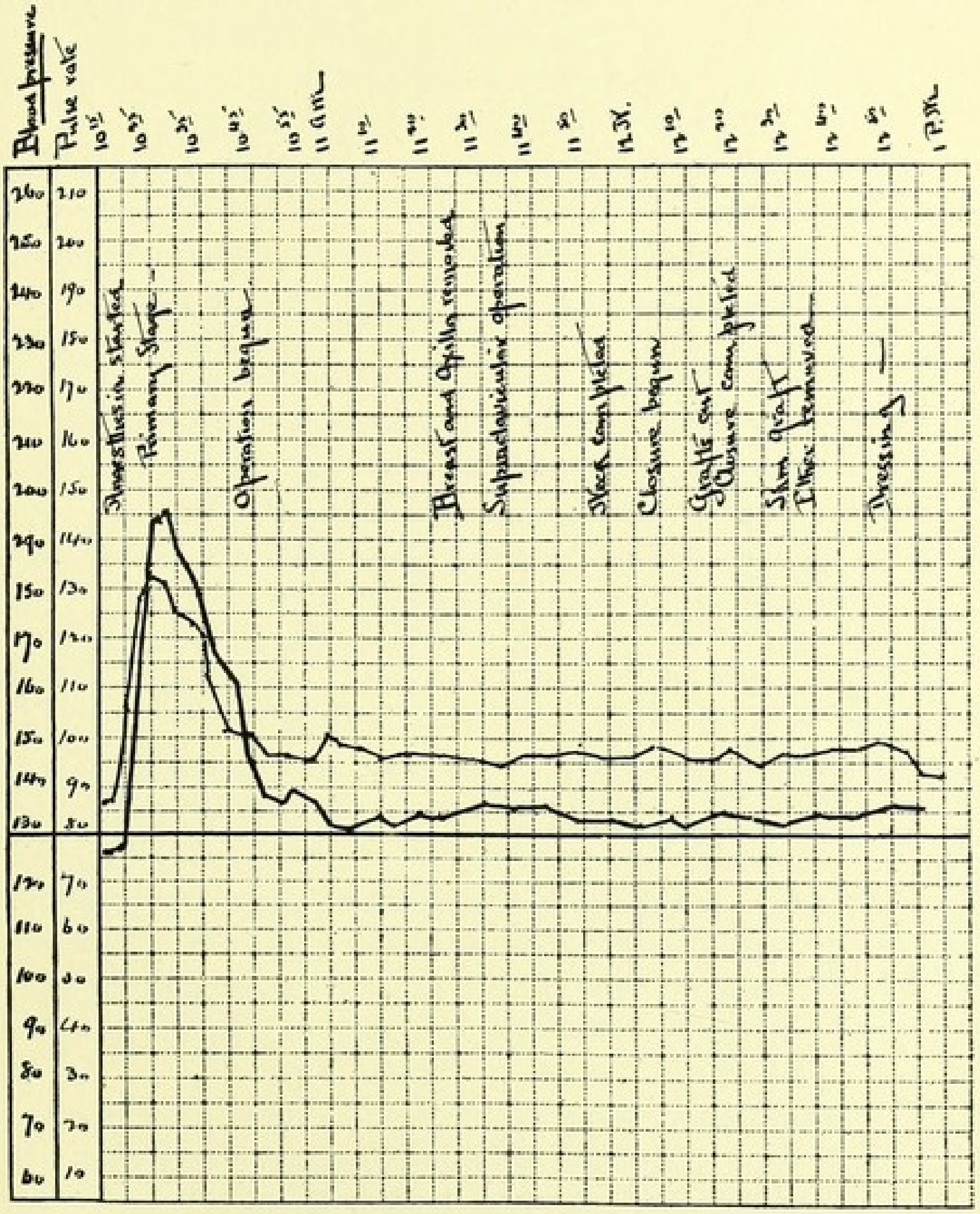


FIG. 66.—CHART IV. (Cushing).—Chart showing pulse-rate and blood-pressure curves taken during a Halstead operation for carcinoma of breast.

cerebral condition. His researches and writings gave a very great impetus to the blood-pressure work in this country.

The influence of narcosis on the blood-pressure has been more fully determined by Kapsammer in observations in eighty patients. In general it was found that the blood-pressure fell in narcosis, this being observed in seventy-five cases. This fall measured in most instances 10 to 40 mm. In some cases, however, 60 to 70 mm., and once even 120 mm.

A distinct relation between the height of the blood-pressure before the administration of the anesthetics and the difficulty in narcosis could not be determined. Patients whose pressure registered 100 mm. before the anesthetic were just as hard to anesthetize as those with 180 mm. During the narcosis, however, the oscillations were in direct accordance with the course of the same. A rise in the pressure regularly occurred when the patient came out from under the influence of the anesthetic and also in vomiting and coughing. This rise generally averaged 20 to 30 mm.

ON THE HUMAN BLOOD-PRESSURE.

Remarks.—In the first part of the series of observations upon the human blood-pressure the Gaertner tonometer was used, when Dr. Harvey Cushing, to whom most of the interest in blood-pressure work in this country is due, brought the Riva Rocci instrument to my attention. The latter instrument, especially with Cushing's modification, proved itself decidedly more practical.

In estimating the clinical value of blood-pressure determinations, consideration must be given to the following questions: Is there a normal standard of blood-pressure in the same species? How great are the individual variations? Are there variations of consequence in the same individual? Are the causes of the individual variations such as will likely interfere with correct determinations? Have we the means of making accurate determinations of the human blood-pressure? Are the variations in clinical cases of importance?

On 100 dogs accurate arterial pressure under full anesthesia was recorded. The minimum pressure was 80; the maximum pressure, 170; the medium pressure, 125. The weight of the animals and their blood-pressure bore no relation to each other. It was impossible to estimate the blood-pressure of a given animal. Often a small cur showed a higher pressure than a Newfoundland, or a fox terrier higher than a bull dog. In continuous observations upon the blood-pressure of the same animal marked variations were noted. This was true in the animals in which ether anesthesia, morphin anesthesia, or curare was administered. It was not possible by the closest observation to predict the changes at any moment. These normal changes in pressure varied from a few to 20 mm. Hg. In some instances the changes were abrupt; in others they were gradual.

The duration of the changes varied. These variations, which have been proved to be mainly vasomotor, were prominent in the normal animal. After the blood-pressure had been reduced very considerably, the changes were less marked. The nearer the fatal point was reached in the fall of the blood-pressure, the less marked were the changes; but when the blood-pressure had fallen to such a degree that the vasomotor changes were not so marked, the effect of respiratory action upon the blood-pressure curve was increased. In some extreme instances in these low blood-pressures the variation during each respiratory action was more than half that of the entire blood-pressure.

The difference between the systolic and the diastolic pressure in normal animals varied greatly. In the development of shock the difference between the systolic and the diastolic pressure was diminished; that is to say, there was a decrease in the height of the pulse-wave. In asphyxia, in reflex inhibition, in the administration of saline infusion, in cerebral compression, the pulse-wave was increased in length. The most marked difference between the systolic and diastolic pressures occurred in the experiments in which saline infusion was rapidly administered after the animals had been reduced to a profound degree of shock or collapse. In making the blood-pressure determinations on normal individuals by means of the Riva Rocci and Gaertner instruments, very marked individual differences were noted. These differences not only appeared in different ages and psychic states, but also in subjects of the same age and under virtually the same conditions. To determine more accurately these differences, observations were made on the inmates of the Protestant Orphan Asylum, in which the conditions were as nearly equal as could be obtained. Here individual variations were still marked. Similar results were obtained in blood-pressure determinations upon the aged. In making repeated determinations in the same individual, it was found that the physical state, such as exercise, the ingestion of food, sleep, fatigue, etc., all caused variations. The psychic state caused in some instances a variation of 40 or more mm. Hg. Fear, anxiety, self-consciousness, all caused a rise in the blood-pressure. While experimenting upon the pneumatic rubber suit it was very difficult to find any one not under an anesthetic who did not exhibit a marked rise in the blood-pressure while the suit was being applied, and before any pneumatic pressure had been exerted. These psychic changes were so marked that our observations on any except the anesthetized were not regarded as accurate. In following the blood-pressure under full anesthesia, when non-operative procedures were in progress, considerable change was noted. Normal subjects, even in a quiet horizontal posture, without apparent cause showed variations, although usually slight. By giving close attention, the variation in pressure occurring with each respiratory excursion could be occasionally noted.

The accuracy of the various instruments thus far devised is only relative. This is particularly true in the determination of the diastolic pressure. The coefficient or error is diminished with the increase in skill and experience in the use of the instrument.

A STUDY OF THE CHANGES IN THE BLOOD-PRESSURE DURING SURGICAL OPERATIONS.

Operations on the Head.

TREPHINING.—Incising the scalp caused no notable change in the blood-pressure. Separating the periosteum over considerable area of bone by means of a periosteotome caused a slight irregularity. Cutting through the bone by means of a mallet and a chisel caused some irregularity, although no marked net change was noted. Irritation of the dura mater caused a fall with considerable irregularity. (See Fig. 67.) In an operation for securing hemorrhage from a branch of the meningeal, considerable manipulation was necessary. In order to control the hemorrhage during the removal of more skull, gauze was packed between the skull and dura some distance beyond the margin of the bone; this caused a very considerable fall in the blood-pressure. Exploring the brain by means of a slender probe for a tumor caused no appreciable change. (See Fig. 68.) A similar observation was made in exploring both lobes of the cerebellum in like manner for a tumor. The incision of the dura mater with a sharp knife caused no appreciable change. Sponging with pressure caused the most marked fall.

In operations for the removal of the Gasserian ganglion, the blood-pressure and the pulse showed marked variations without any considerable net change until the skull was opened. (See Figs. 69 and 70.)

In both cases in which these observations were made the common carotid artery was closed and the hemorrhage up to the point of making the intracranial

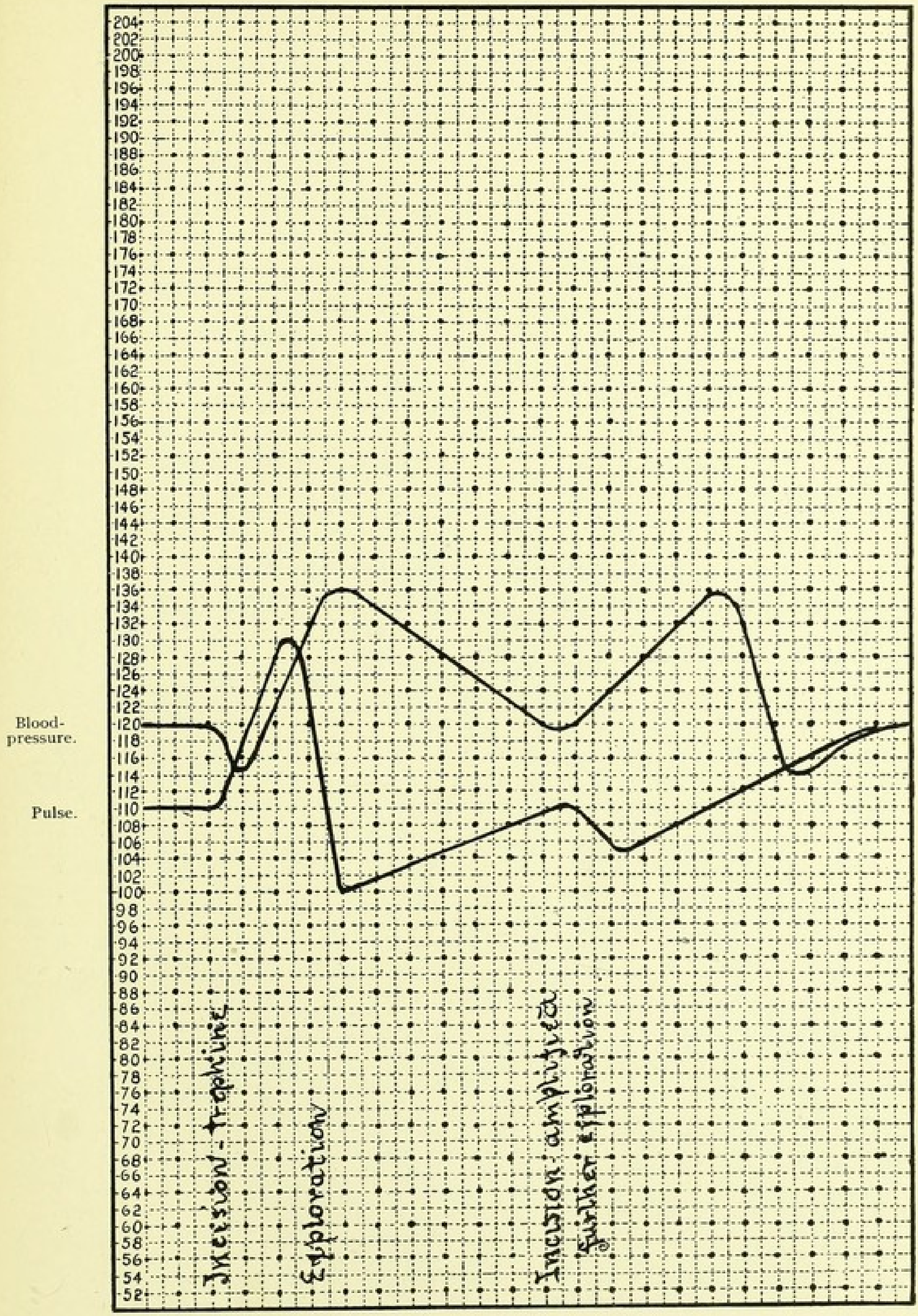


FIG. 67.—CHART V.—Operation upon the cranium. Note the irregular curve during the exploration of the dura mater for an extradural abscess. Note the rise in the blood-pressure and the fall in the pulse during the exploration which involved some pressure.

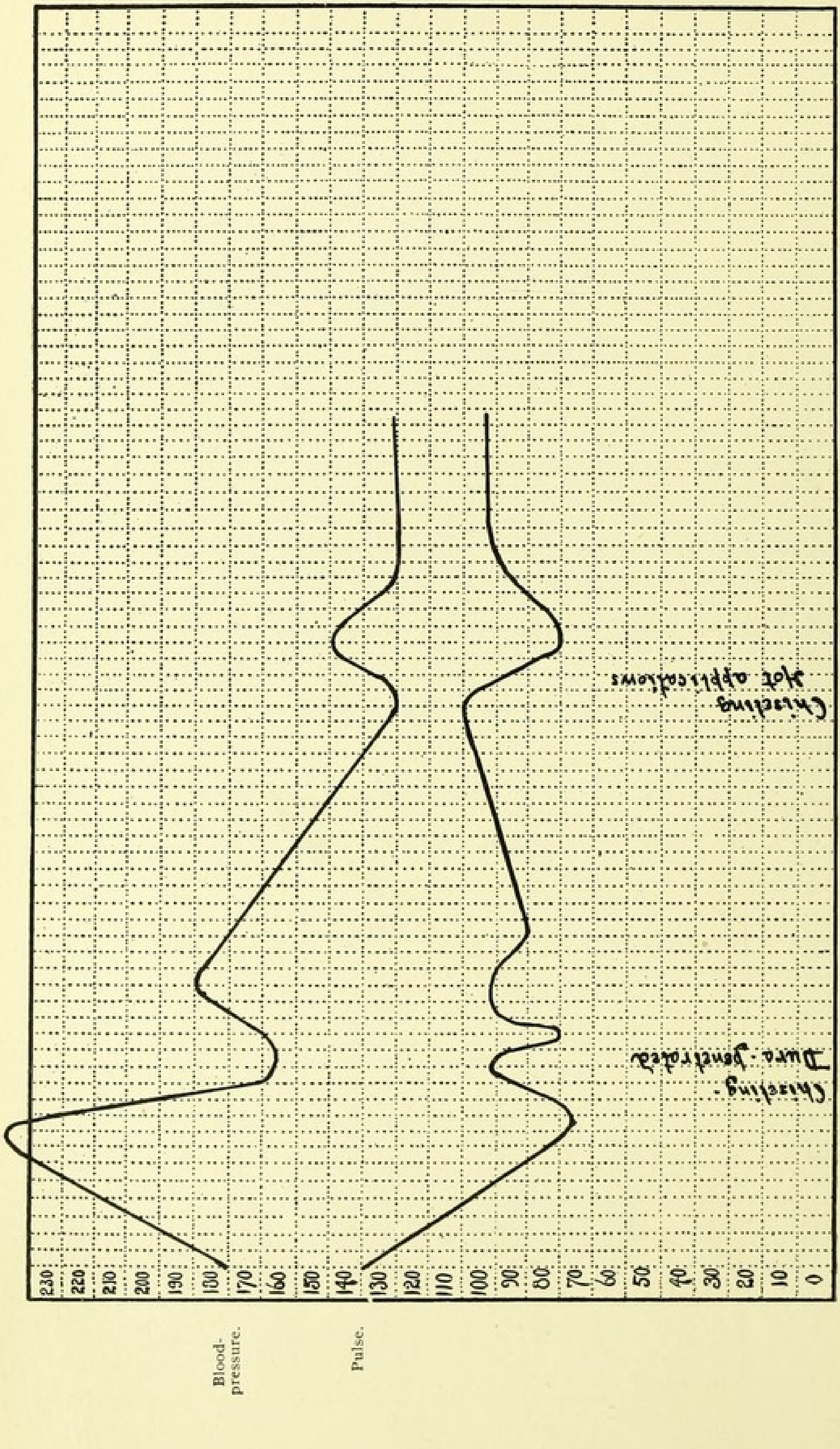


FIG. 68.—CHART VI.—Showing phases of an operation on the brain.

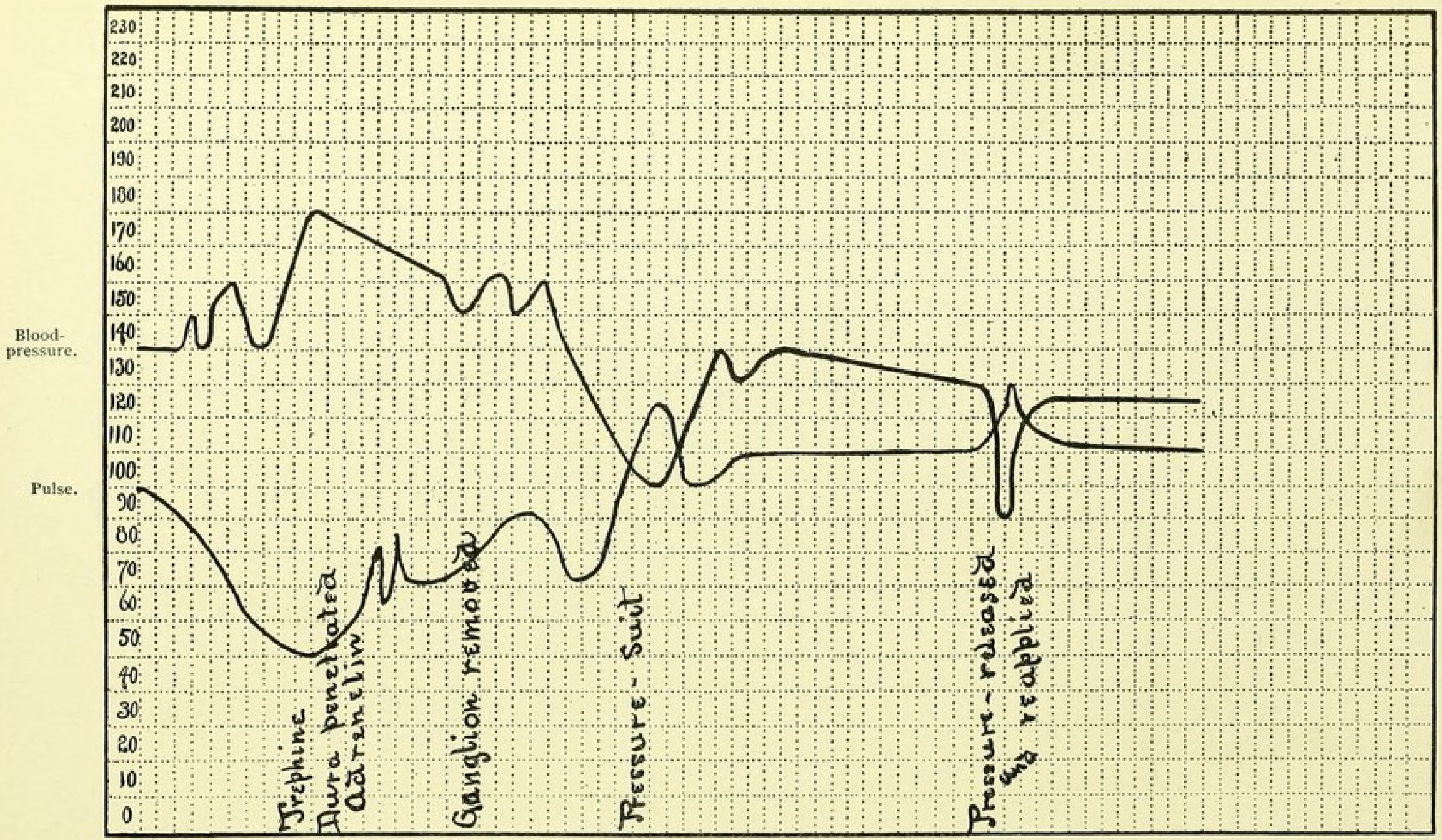


FIG. 69.—CHART VII.—Excision of the Gasserian ganglion. Note the rise in the blood-pressure and the fall in the pulse-rate while the ganglion was being extracted. On the completion of the operation the blood-pressure fell to 100 mm., having lost 40 mm. during the operation. The patient during the operation was in a semisitting posture to minimize the venous hemorrhage. The rubber suit was then inflated until the blood-pressure again reached 140 mm., the level before operation. After two hours the pressure in the pneumatic suit was released. The blood-pressure immediately fell 40 mm. The pneumatic suit was then inflated until the blood-pressure rose to 124 mm. and there maintained until the shock disappeared.

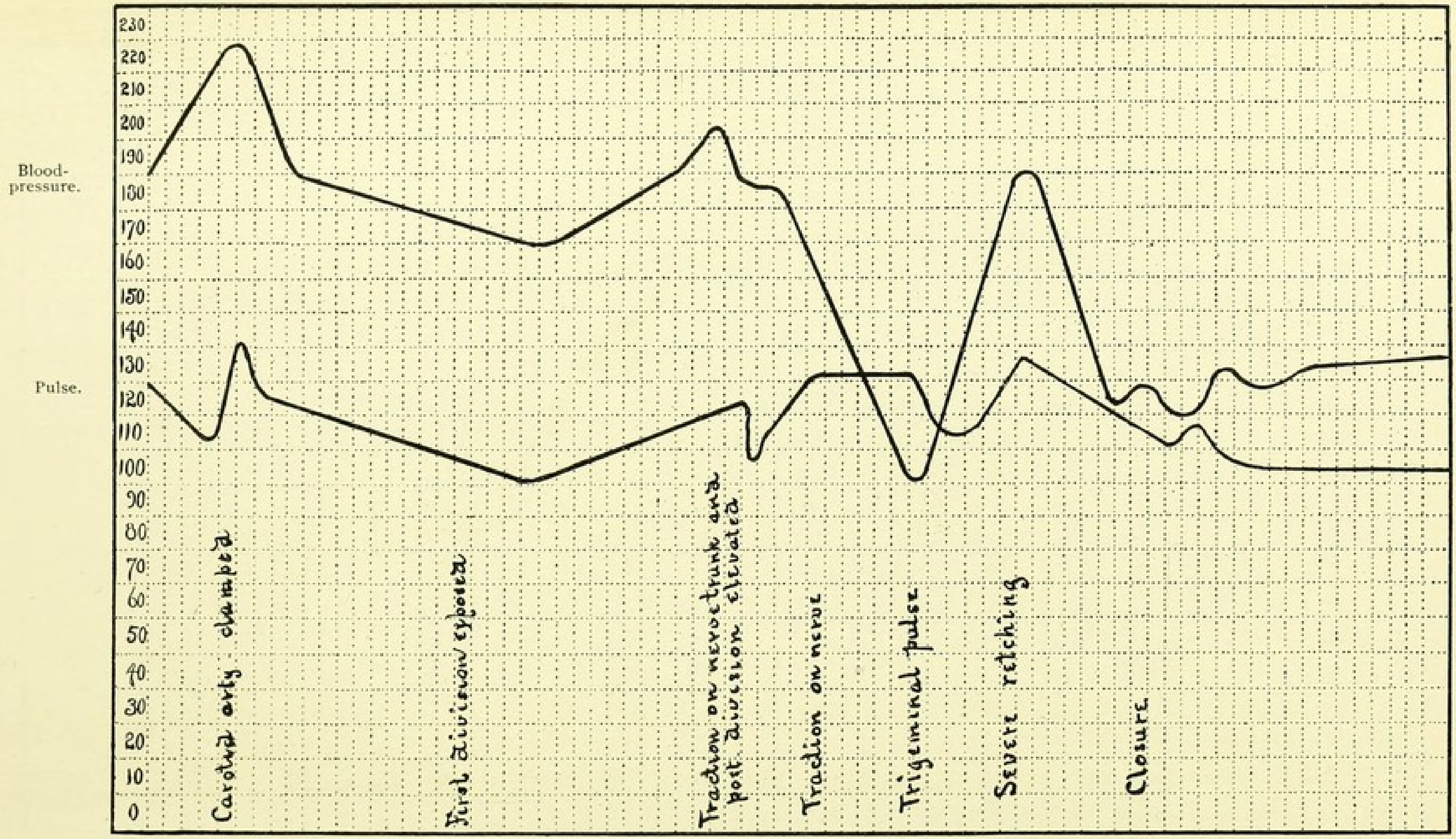


FIG. 70.—CHART VIII.—Excision of the Gasserian ganglion. In this case care was taken to minimize the traumatism of the brain. In the former operation there was considerable tamponing to control oozing. In this one the patient was placed even more nearly upright and the common carotid artery was closed by means of a special clamp as a preliminary measure. There was a relatively small amount of hemorrhage and the shock was light.

dissection was practically nil. Elevating the dura caused an irregular fall in the pressure and an increase in the pulse-rate. Separating with considerable gentleness the branches and the body of the ganglion caused no marked change. Elevating the temporosphenoidal lobe in order to give room for the exposure and removal of the ganglion caused a marked rise in the blood-pressure and an almost corresponding fall in the pulse-rate. These phenomena were strikingly shown in several of Cushing's cases. During this part of the operation, there was some oozing; against this adrenalin tampons were used. A considerable rise in blood-pressure in one case followed, due probably to absorption of adrenalin. In both cases the posterior root was entirely exposed in a clear field, so that the effect of evulsion might be noted. It was found in each case that when the root was entirely isolated and in clear view, the weight of the ganglion was sufficient to sever it. The most rapid fall in the blood-pressure in the cerebral group occurred in a case in which there was a rapid hemorrhage from the meningeal artery, which was controlled by gauze packing. The combined effect of the hemorrhage, the irritation of the dura mater, and the pressure of the brain caused a rapid fall. The amount of shock in operations upon the head was proportionate to the manipulation, the pressure upon the brain, the hemorrhage, and the duration of the operation.

Operations in the Mouth.

In bloodless excision of the tongue, and in operations on the floor of the mouth, there was but little change in the blood-pressure or the pulse.

Operations on the Neck.

TRACHEOTOMY.—Asphyxia caused a very marked rise in the blood-pressure and slowing of the pulse-rate. In one case the unusual opportunity presented itself of making observations upon the blood-pressure just before and during the development of asphyxia. (See Fig. 71.) The blood-pressure rose abruptly from 150 mm. to 220 mm. Hg. Immediately upon opening the trachea and producing artificial respiration, the blood-pressure fell to 140 mm. and the pulse became more rapid than normal. The character of the pulse, both as to quality and rate, underwent as rapid changes as the blood-pressure.

Tracheotomy under cocaine in the absence of asphyxia is attended by no special changes in the blood-pressure.

In laryngeal operations the mucosa and the superior laryngeal nerves were cocainized; under these conditions, opening the box of the larynx, explorations of the interior of the larynx, and even laryngectomy, caused no marked change in the blood-pressure. (See Figs. 72 and 73.) In one instance, while dissecting out glands lying close to it, the superior laryngeal nerve was subjected to traction. This was attended by an immediate fall in blood-pressure and a marked slowing of the heart. Both were due to reflex inhibition from mechanical stimulation. (See Fig. 74.) In one instance, a papilloma which filled the entire box of the larynx and extended up to and over the entire under surface of the epiglottis was removed without any marked change in the blood-pressure.

In operations for the removal of tumors of the neck shock was proportional to the loss of blood, to the mechanical insult to the tissues, to the manipulation of certain nerve-trunks, and to the duration of the operation. In removing tumors of the parotid, it was found in two instances that while dissecting them out of their bed, in the deep angle behind the jaw, a marked and sudden fall in the blood-pressure and in the pulse-rate occurred. (See Fig. 75.) As

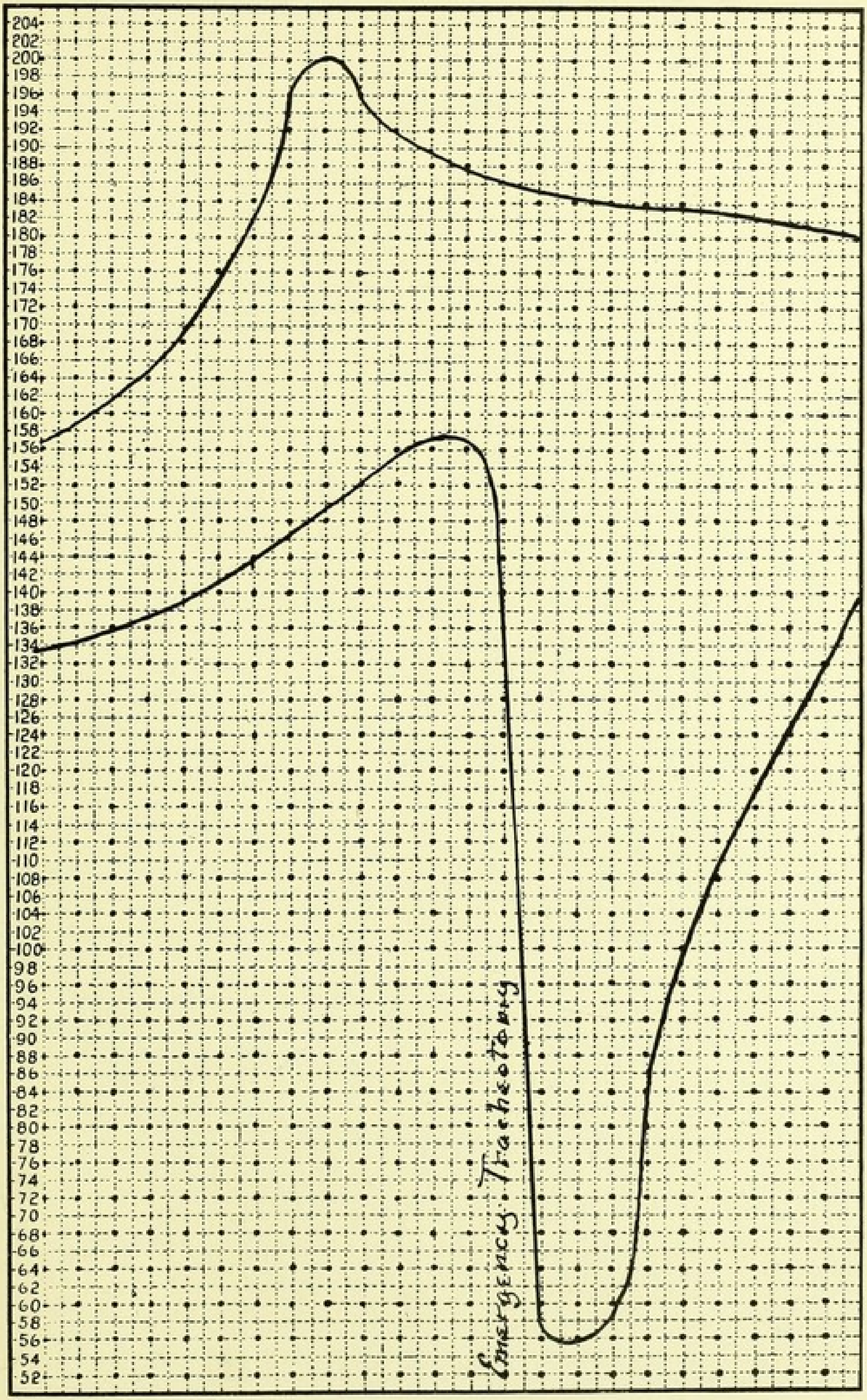


FIG. 71.—CHART IX.—Case of extreme asphyxia. Note the fall in the pulse-rate and the rise in the blood-pressure. Note the rapid recovery after tracheotomy.

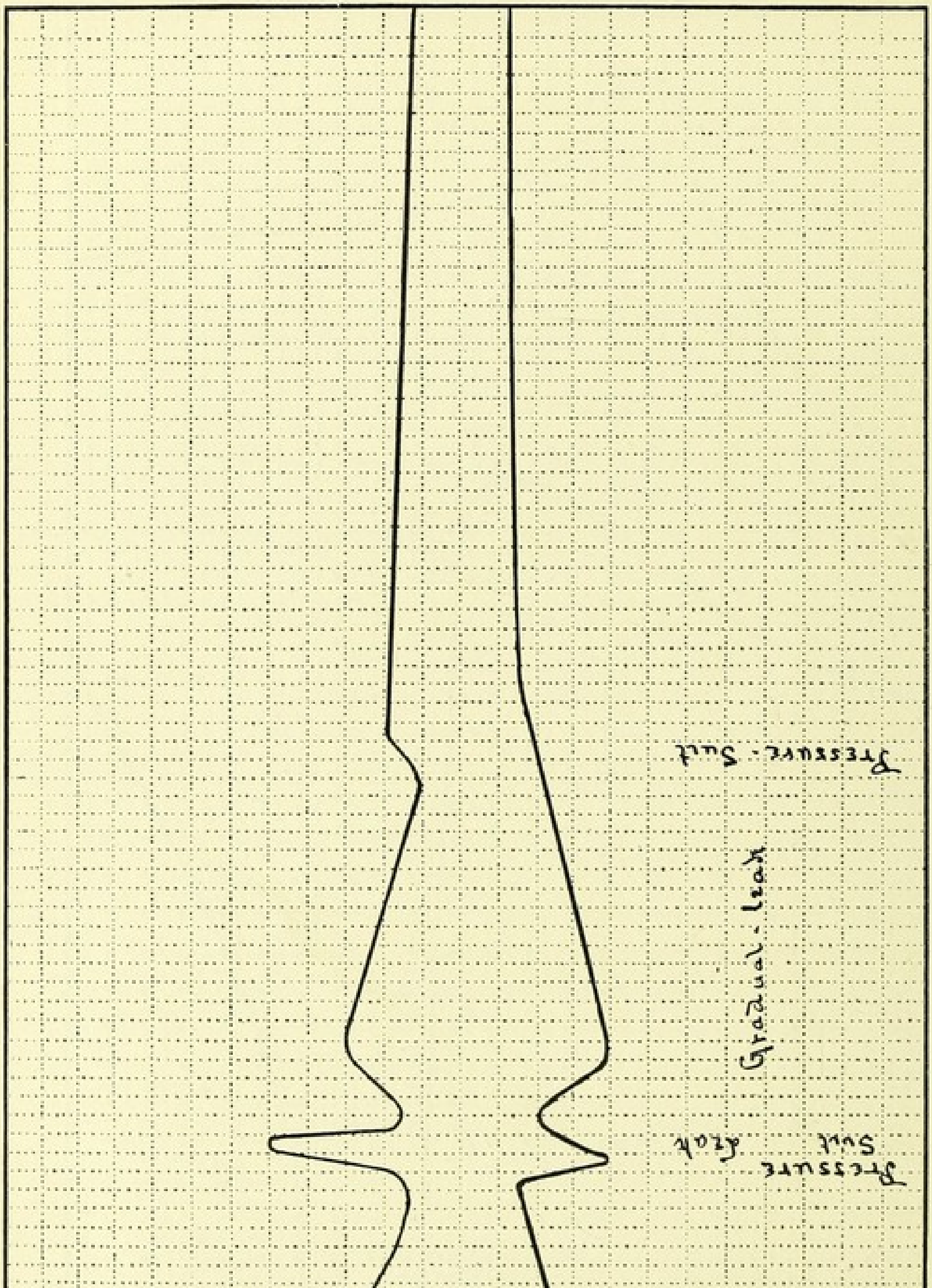


FIG. 72.—CHART X.—Moderate shock. Note the effect of the pneumatic suit upon the blood-pressure. This tracing was taken in the experimental stage of the development of the pneumatic suit. The rubber was not strong enough, giving the opportunity of studying the effect of inflation as well as of leakage upon the blood-pressure.

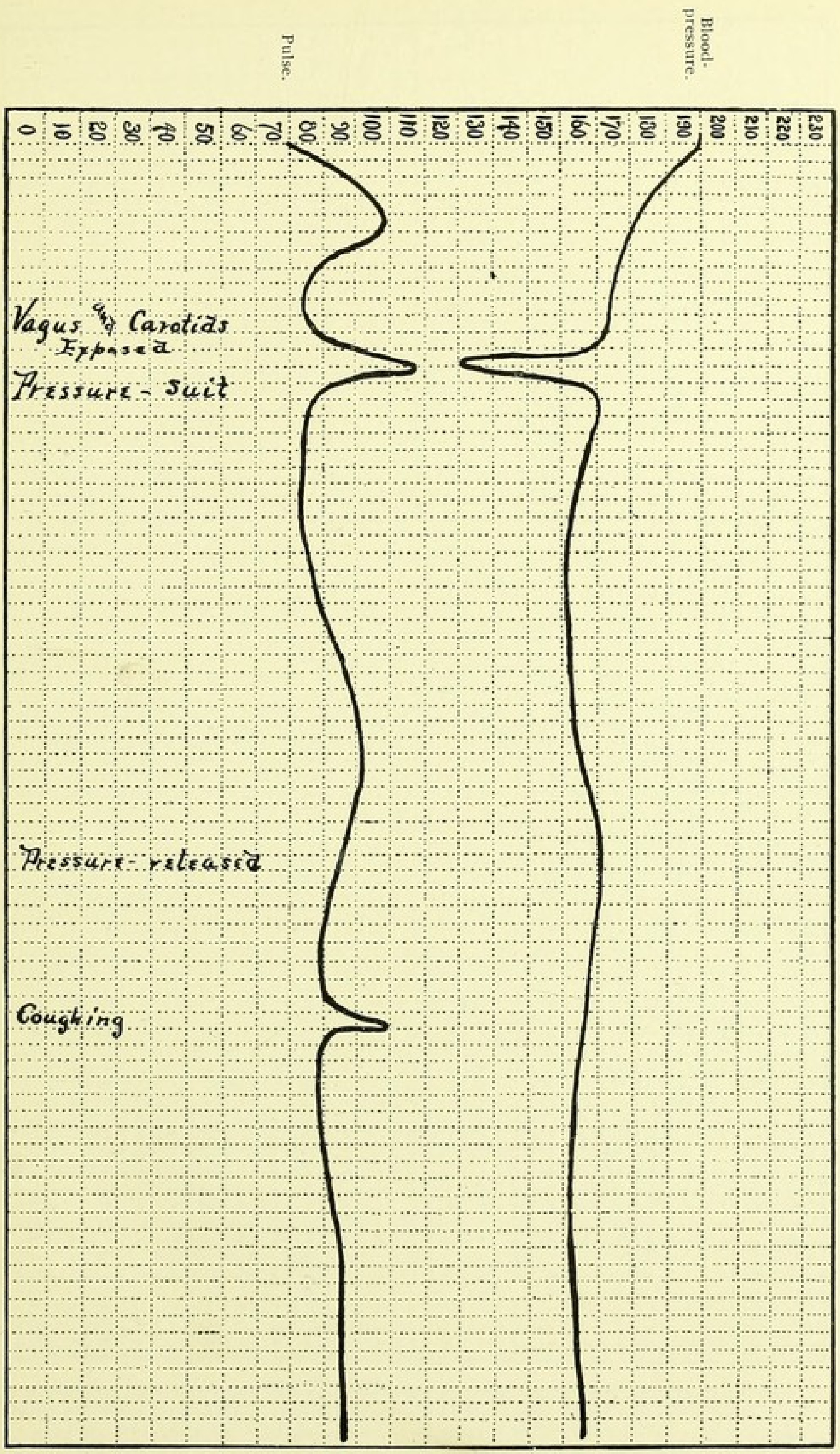


FIG. 73.—CHART XI.—Note the rapid rise and even maintenance of the blood-pressure on inflating the rubber suit after the marked fall in the pressure during deep dissection of the neck.

Blood-pressure.

Pulse.

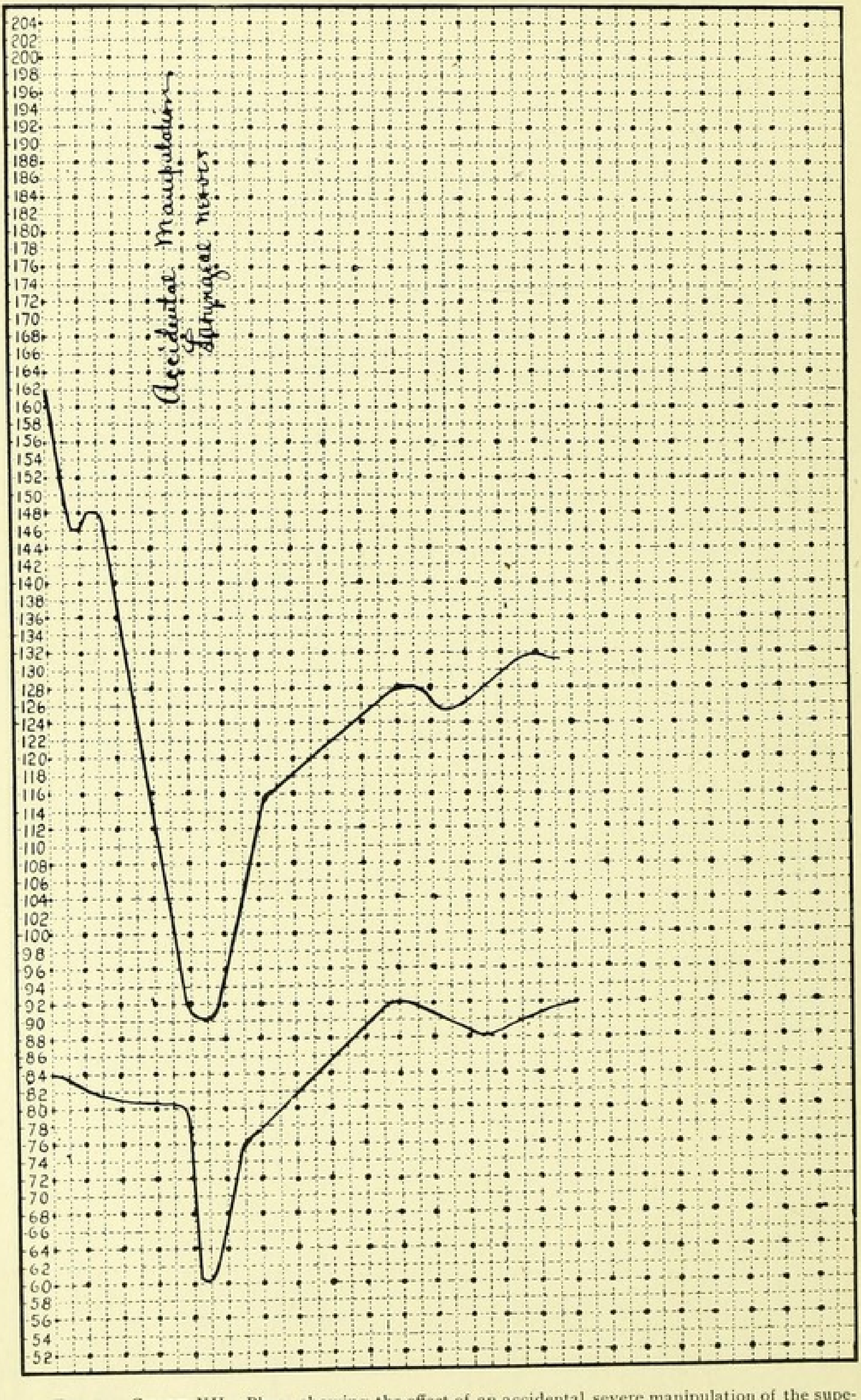


Fig. 74.—Chart XII.—Phase showing the effect of an accidental severe manipulation of the superior laryngeal nerve in a laryngectomy. Note the marked fall in the pulse-rate and in the blood-pressure. The nerve was then identified, cocainized, and severed, after which the pulse and pressure ran an even course, the pneumatic suit supporting the circulation.

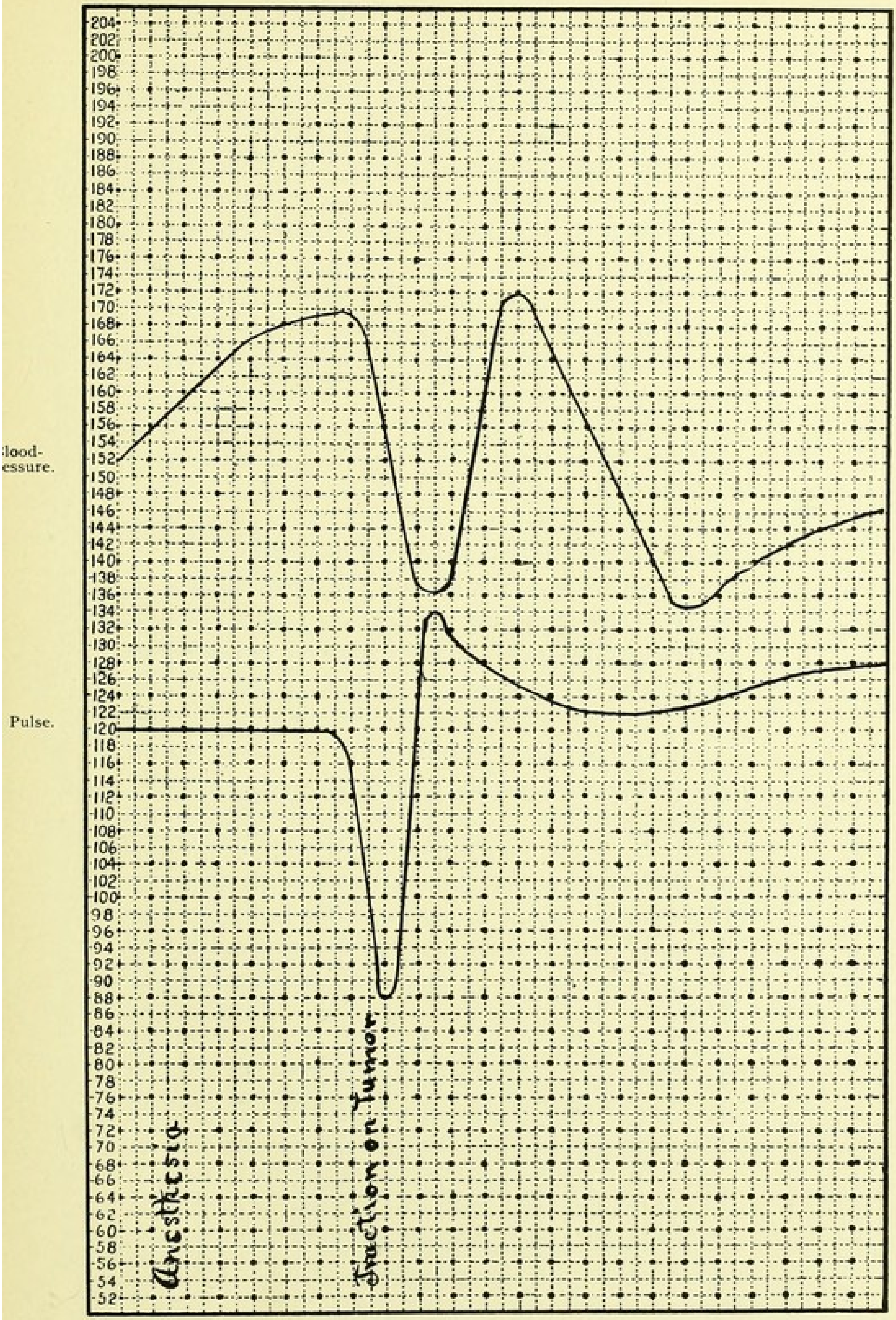


FIG. 75.—CHART XIII.—Removal of tumor of the parotid. Note the fall in the pulse-rate and the blood-pressure during traction upon the territory traversed by the superior laryngeal nerve. After the striking evidence of inhibition through mechanic stimulation of this nerve, a more gentle dissection was made and cocain used, after which no further inhibition was noted.

soon as the change was noted, the area was packed with cocain. After this, by more careful manipulation, and from the effects of the cocain, the tumors were removed without producing further depression. Excision of such muscles as the sternomastoid caused no marked change. Quick division of the vagus caused no effect upon the blood-pressure or pulse, but rough manipulation and traction caused a considerable fall. Observations were made upon eleven sections of the vagus. Dissections involving exposure and manipulation of the sympathetic nerve-trunks caused an increase in the pulse-rate. Resection of the trachea and of the esophagus caused no marked change. There were no immediate effects following temporary or permanent closure of the carotid artery.

Observations upon the blood-pressure during the removal of five branchiogenic carcinomata, in which all the structures above mentioned were removed *en bloc,* gave the opportunity for making the observations. In removal of branchial cysts but little change in the blood-pressure was noticed. In operations for the removal of tubercular glands the amount of shock was proportional to the vitality of the patient, the duration of the operation, the amount of loss of blood, and the amount of mechanical irritation.

In a case of sarcoma projecting from the thorax into the lower portion of the neck, exhibiting a misleading amount of mobility, removal was attempted. (See Fig. 76.) It was not discovered, until the dissection had proceeded so far that hemorrhage underneath and behind the tumor could not be controlled, that it should have been regarded as an inoperable case. In pushing this dissection to its conclusion the clavicle was resected, the pleural cavity opened, and the brachial plexus partially removed. In this operation a rapid decline in the blood-pressure was noted. In the manipulation for dislodging the tumor from its deep bed,

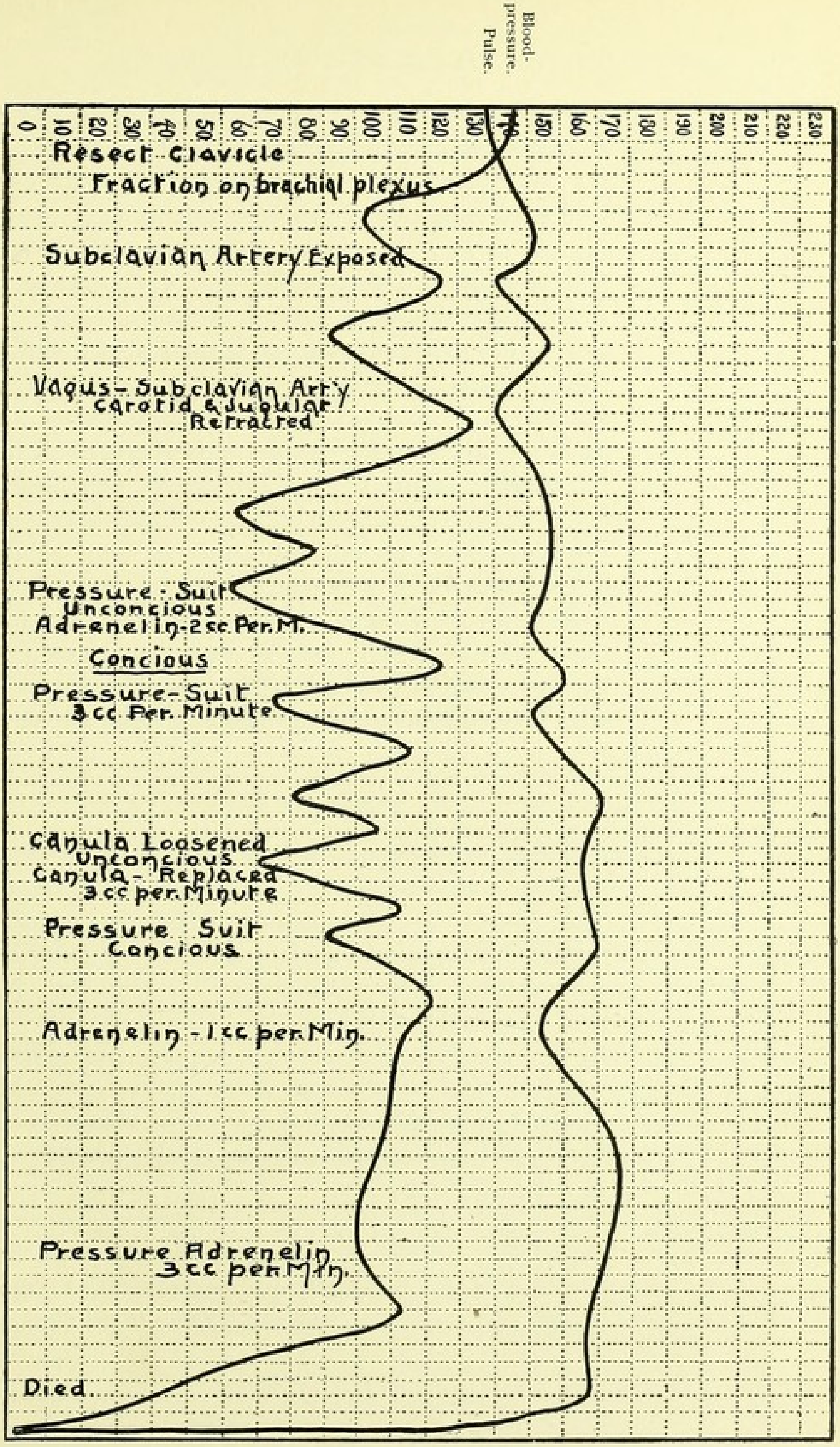


Fig. 76.—Chart XIV.—Excision of a large tumor of the neck and the upper thorax. There was much hemorrhage and extensive dissection involving the complete removal of the brachial plexus clavicle and penetration of the pleural cavity. The pneumatic suit was placed upon the patient prior to beginning the operation, and after the blood-pressure had fallen to 55 mm. and the pulse had become scacely perceptible, the suit was inflated. The pulse became stronger as the pressure rose, and the most difficult part of the operation was then performed. Completion of the operation during life without the support of the rubber suit could scarcely have been possible. After the completion of the operation a 1 to 25,000 solution of adrenalin chlorid at the rate of 3 c.c. per minute was administered. Note the well-sustained blood-pressure,

the brachial plexus was roughly manipulated, several trunks severed, and great hemorrhage incurred. During this time the blood-pressure fell rapidly to 68 mm. The pneumatic rubber suit was then inflated, bringing the pressure to 110 mm., at which point it was maintained during the remainder of the operation.

In the removal of large tumors, in which hemorrhage was controlled by closing the carotid artery with a special clamp, in which a preliminary injection of atropin to protect against reflex inhibition of the heart was given, in which sharp dissection and gentle retraction instead of blunt dissection was largely made, and in which when branches of the vagus were involved inhibitory impulses were prevented by the use of cocaine, a comparatively small amount of shock was encountered. In all these serious operations the rubber suit was put on before beginning, and, as occasion demanded, the blood-pressure was supported so as to be maintained at a certain level.

Thorax.

Excision of the breast for carcinoma in middle-aged subjects was attended by only moderate changes. The blood-pressure sometimes showed a decline towards the close of the operation and the pulse became proportionately accelerated. In an elderly patient a marked fall was noted. (See Fig. 77.)

In the complete dissection of the axilla, particularly when the large blood-vessels and the nerve-trunks are involved in the dissection, the principal change in the blood-pressure was noted, the net result of which was an irregular decline.

Dissection with a sharp knife, with minimum traction, caused the least change. Rough sponging, blunt dissection, and strong retraction caused the most marked change. Resection of ribs caused but slight change,

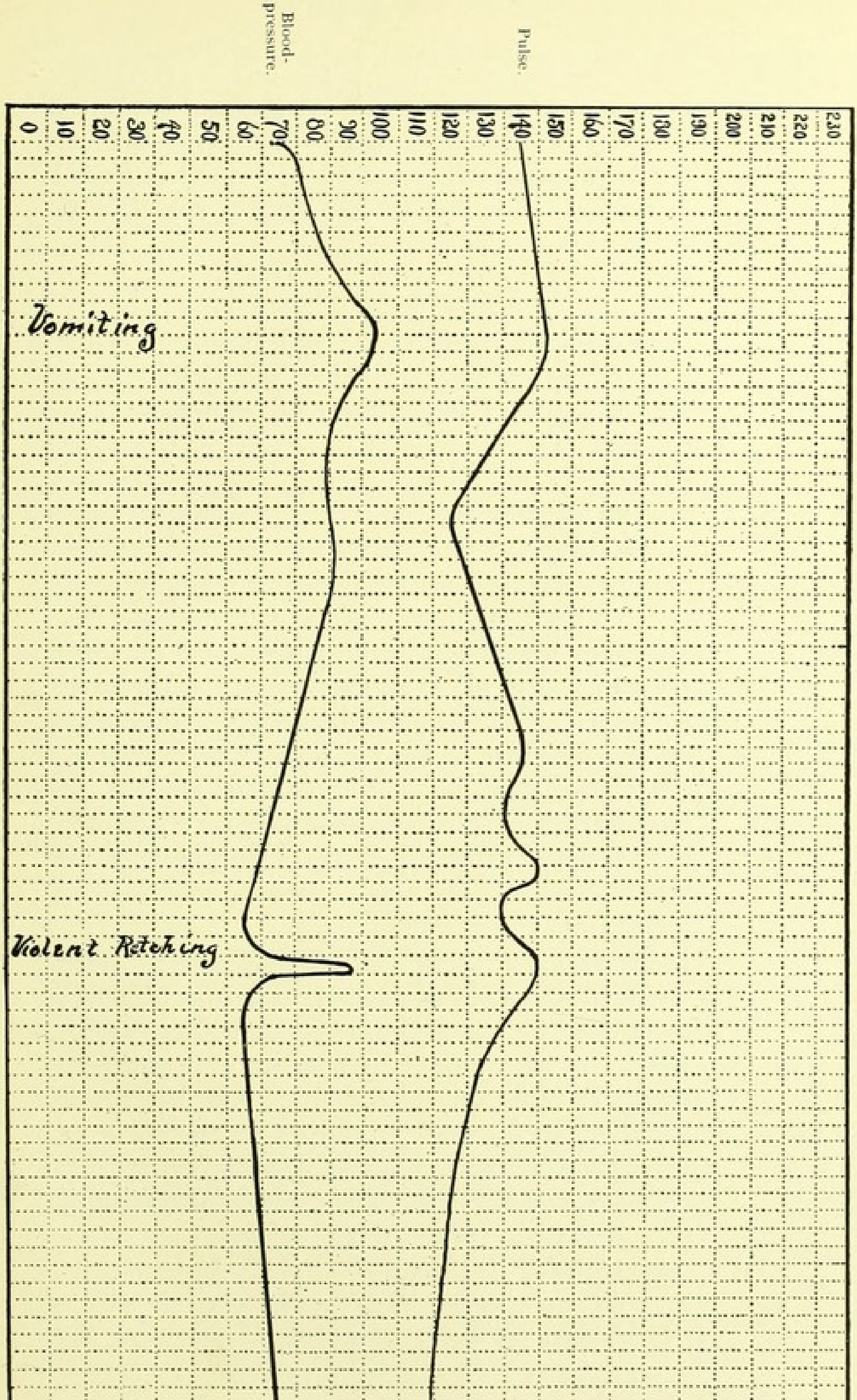


FIG. 77.—CHART XV.—Amputation of a breast.

though opening the pleural cavity caused a marked change. In operation for empyema, the opening of the cavity and the discharge of the pus were attended by a rapid fall in the blood-pressure and an increase in the pulse-rate. (See Fig. 78.)

Abdomen.

Observations were made during pylorectomy, partial gastrectomy, gastroenterostomy, enteroenterostomy, choledochotomy, cholecystotomy, cholecystectomy, appendectomy, resection of the cecum, and resection of the large and the small intestines. It was found that the amount of shock was directly proportional to the amount of traumatism inflicted upon the peritoneum. The mucous membrane of the hollow viscera did not seem to be capable of producing shock. Exposure to the air, manipulation, and sponging caused a fall in the blood-pressure and a rise in the pulse-rate. This was noted in packing the abdominal cavity with gauze. (See Fig. 79.) Flushing out the cavity also caused a decline in the blood-pressure. A most marked effect was noted during the exploration of the abdominal cavity in the development of the field of operation, separating adhesions, and bringing tumors into the wound.

In operations involving only a small segment of the intestine, although considerable time was occupied, there was little change in the pressure after the first effect had worn off. This was true only when the remainder of the peritoneal cavity was kept free from irritation, as, for example, during the application of the sutures in an anastomosis, but slight change in the blood-pressure was noted. The same is true in appendectomy. During the technique of the appendectomy but little change was noted. In operations, such as the dissection of gangrenous bowel in strangulated hernia, the extensive washing and

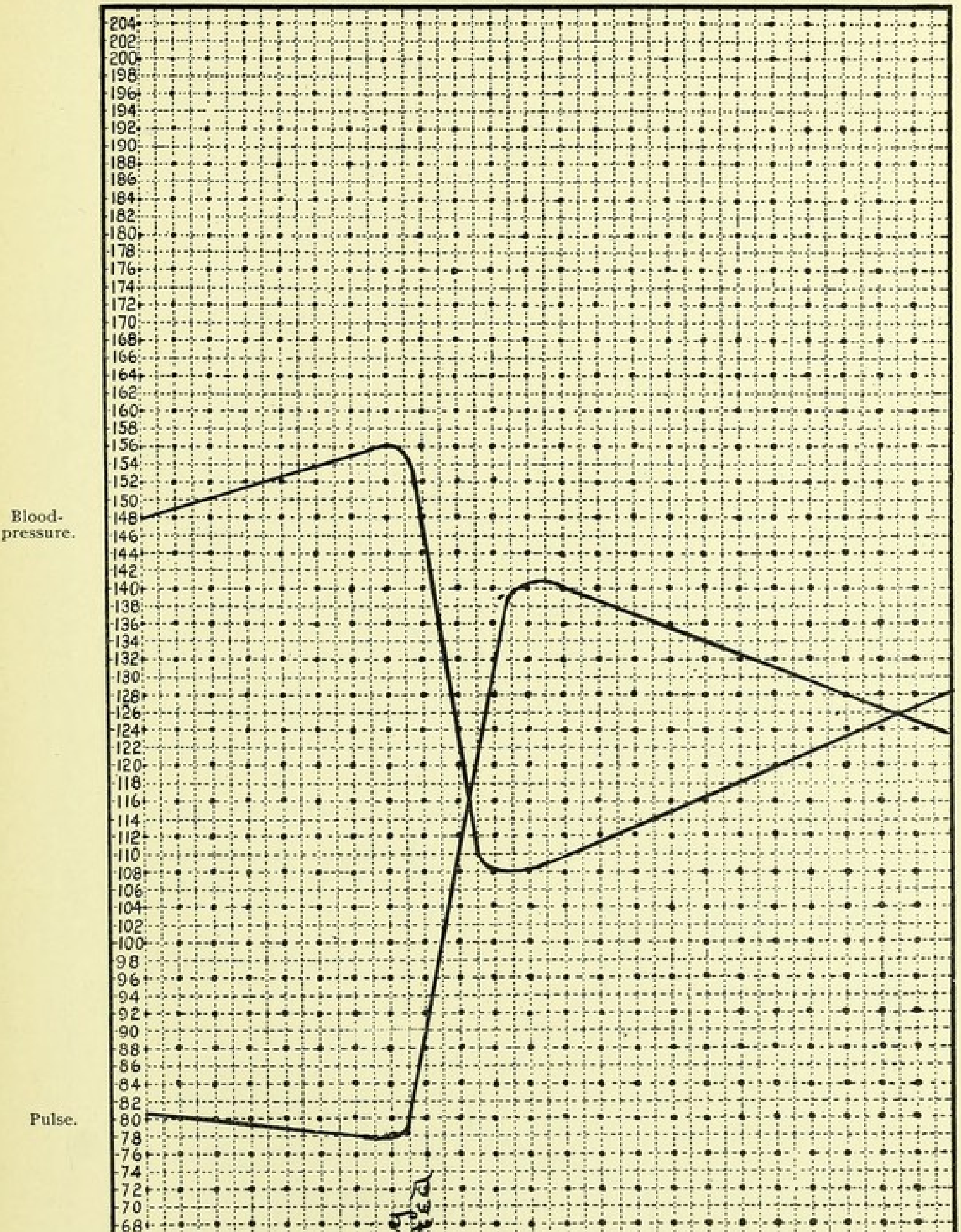


FIG. 78.—CHART XVI.—Operation for empyema. Note the simultaneous increase in the pulse-rate and the fall in the blood-pressure.

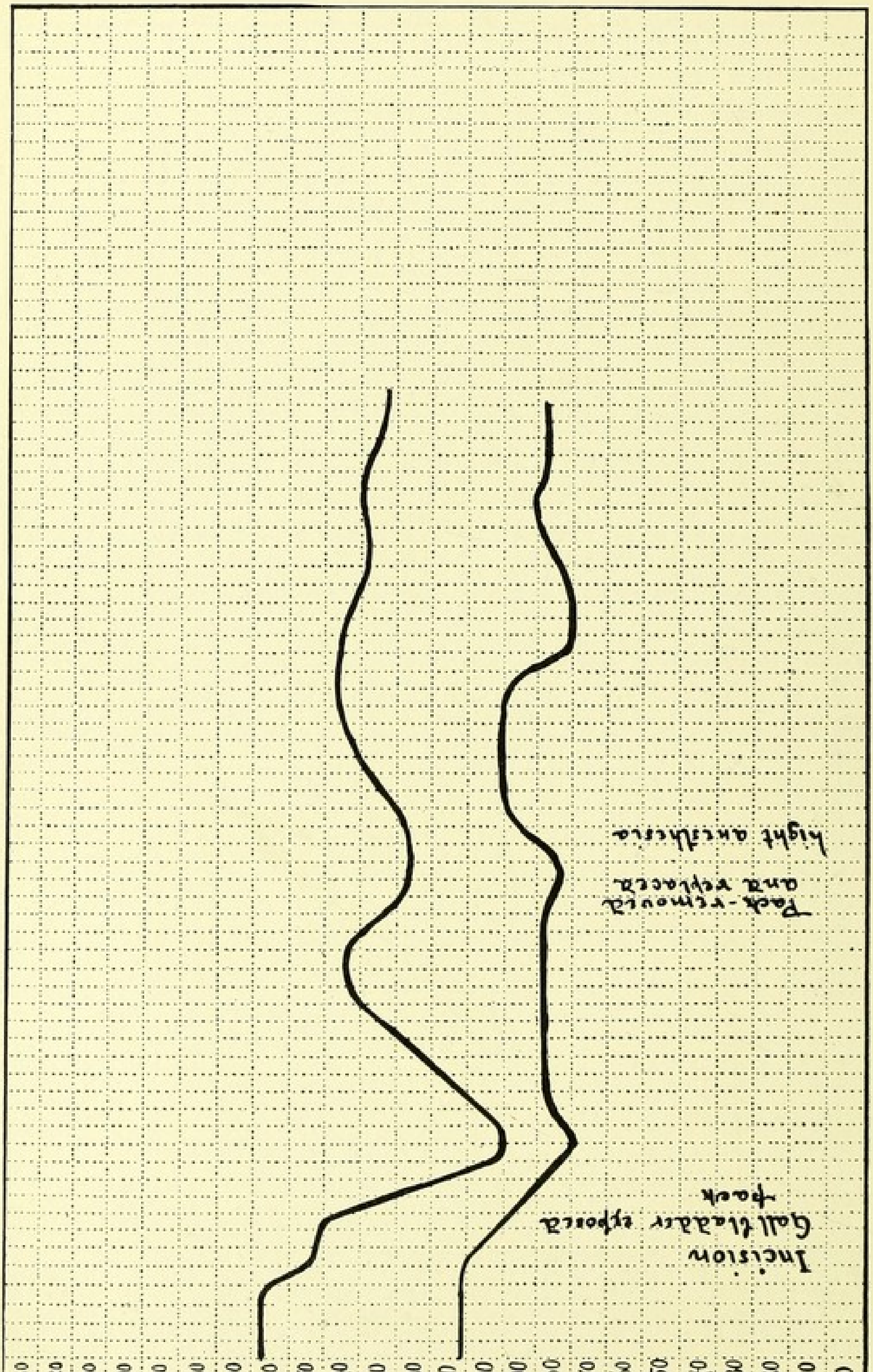


FIG. 79.—CHART XVII.—Operation for gall-stones. Note the marked fall in blood-pressure during the considerable manipulation incident to exploration of the biliary tract and "packing off" the gall-bladder. Note the fall during the removal of the soiled pack and replacing it with fresh gauze. Experimental evidence supports the clinical data.

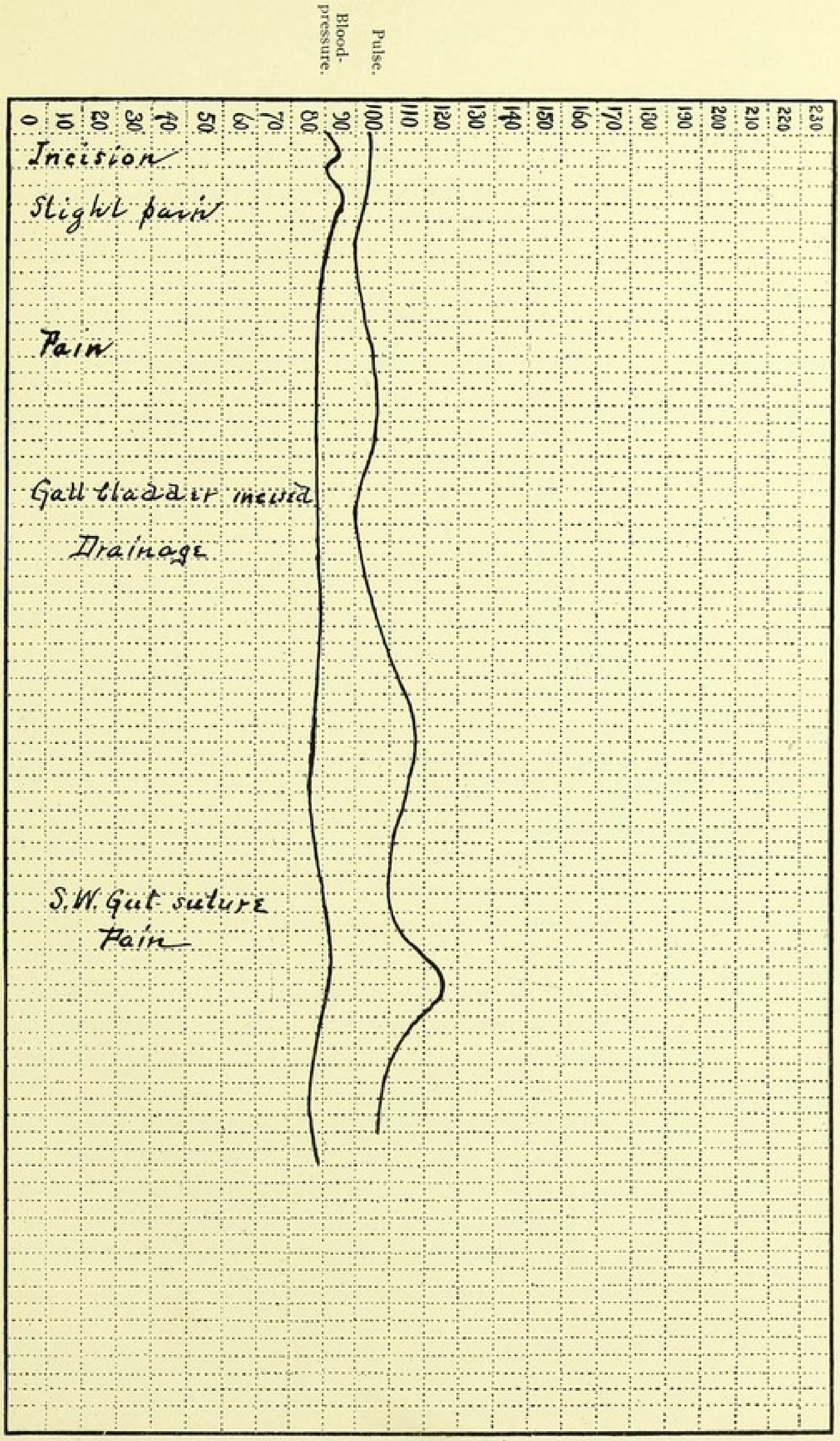


FIG. 80.—CHART XVIII.—Operation in the course of typhoid fever upon the gall-bladder under cocain. Note the slight change in the pulse-rate and the blood-pressure. The manipulations were as few and as gentle as possible.

sponging of the field to remove infection was attended by a considerable decline in the blood-pressure. The manipulation which caused the changes in the blood-pressure in almost every instance caused an increase in the respiration.

The Doctors Mayo, of Rochester, Minnesota, from their extensive clinic, made observations upon twenty-five cases of gall-stone operations in which the increase in the respiration and in the pulse-rate was noted. (See Fig. 80.) The pulse and the respiration were increased during the manipulation, particularly while removing common duct-stones, and in exploration of the field. Observations upon the respirations and the pulse in my own cases of gall-stone operations corroborated these results. (See Fig. 81.) The most striking effects were noted in the operations in the upper portion of the peritoneal cavity near the diaphragm. The lower portion of the abdominal cavity showed less reaction. In all the abdominal operations above mentioned the net tendency of the changes was towards incline. In some instancs temporary rise appeared, but this usually gave way to greater decline. In the female genital organs observations were made during operations for resection of the ovaries, the removal of ovarian tumors, excision of the tubes for pyosalpinx, myomectomy, hysterectomy, both abdominal and vaginal, dilating and curetting the uterus, and plastic operations upon the vagina and peritoneum. In almost every instance the immediate effect of manipulation of these organs was a rise in the blood-pressure. (See Fig. 82.) This rise usually continued during the period of manipulation, and was proportional to the traumatism administered. The most marked rise was noted in the case of large fibroid tumors, in which considerable difficulty, owing to impaction and adhesion, was experienced in raising the tumor from its bed.

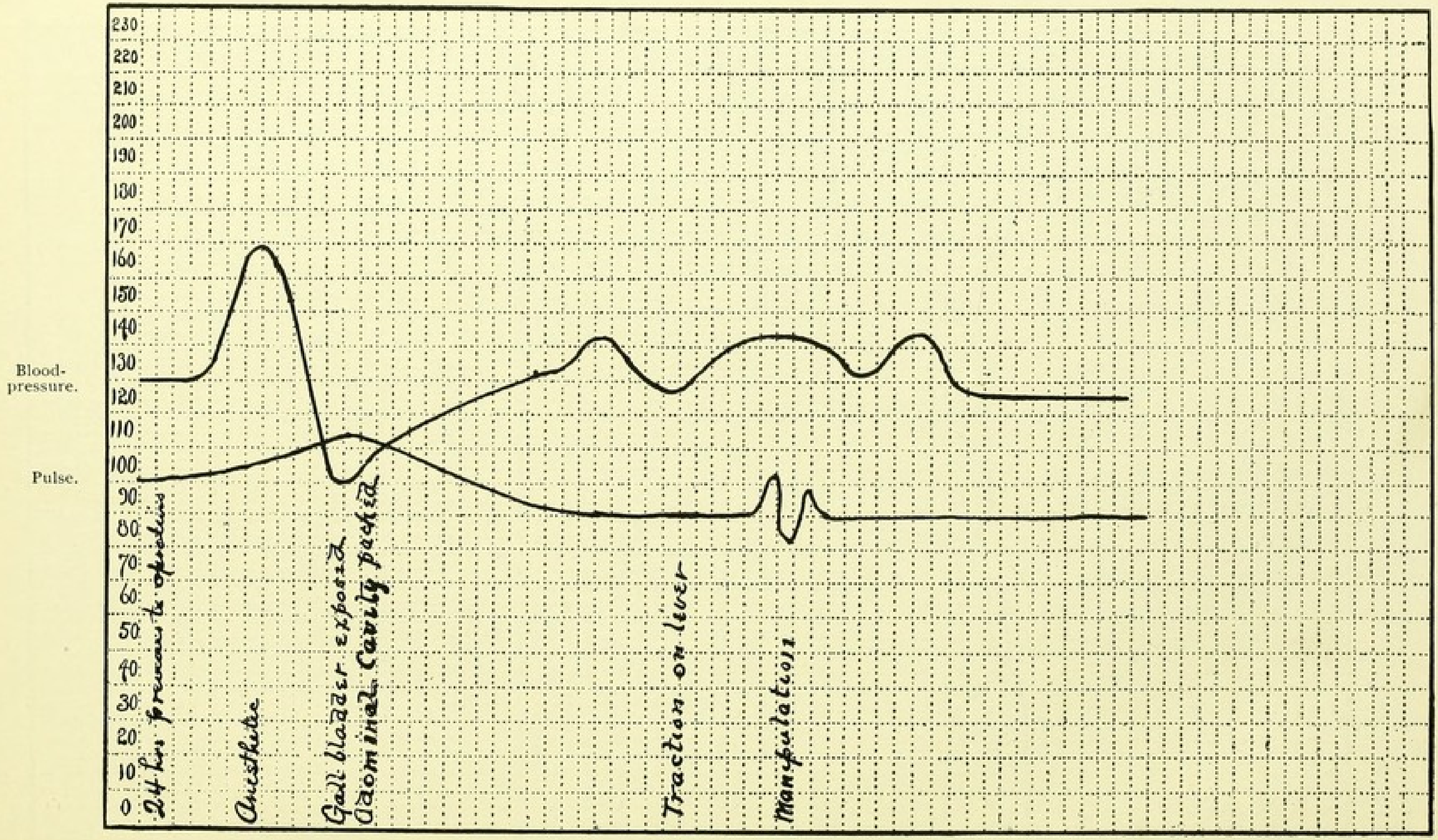


FIG. 81.—CHART XIX.—Operation upon the gall-bladder. Note the marked psychical rise of the blood-pressure during the first stages of anesthesia, then the fall in the pressure during manipulation of the peritoneum. After the gall-bladder was well "packed off" and the exploration and development of the field completed, note the recovery of the blood-pressure. Both the experimental and the clinical evidence point to the importance of minimum manipulation.

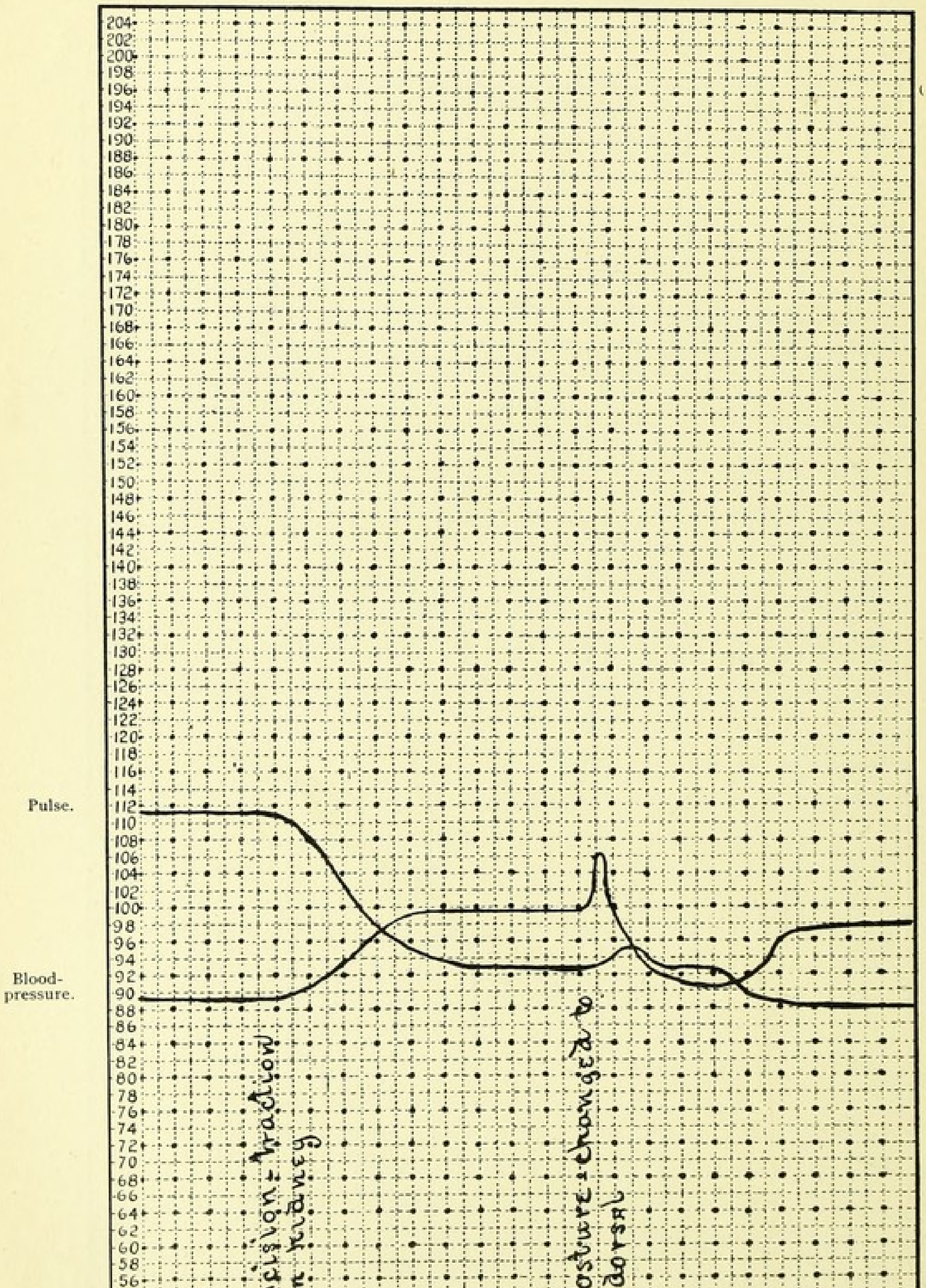


FIG. 82.—CHART XX.—Phases of the removal of an ovarian cyst. Note the rise in the blood-pressure, supporting experimental evidence formerly published.

Similar results were noted in the different operations upon the perineum and vagina. Divulsion of the sphincter ani caused a very marked rise in the blood-pressure and some increase in the pulse-rate. (See Fig. 83.) The respirations were markedly increased in depth and rhythm. During the manipulation of the sigmoid, respiration was always increased, particularly its inspiratory phase. This also occurred in dilating the cervix.

Genito-Urinary System.

Blood-pressure determinations were made during nephrectomy, nephrotomy, nephrorrhaphy, and suturing of the ureter. (See Fig. 84.) During the removal of large inflamed carcinoma of the kidney the blood-pressure fell rapidly. In nephrorrhaphy and incising the kidney the slight effects were noted.

Testicles.

In dissecting a firmly adhering sac of a scrotal hernia, marked fall in the blood-pressure was noted. (See Figs. 85 and 86.) In excising the thickened hydrocele sac, the same was noted. (See Fig. 87.) In all manipulations, when any effect was noted, it was a fall. In amputation of the penis in an elderly subject the fall was marked. (See Fig. 88.) During careful dissection of the enlarged veins of a varicocele no effect was noted.

Spinal Column.

Blood-pressure determinations in two laminectomies under cocain anesthesia were made. Incising the skin, fascia muscles, and the bones caused no appreciable change in the pressure. On exposing and exploring the membranes of the cord a marked fall in the blood-pressure occurred. (See Fig. 89.)

In one case the exploration extended from the fifth

Blood-pressure.

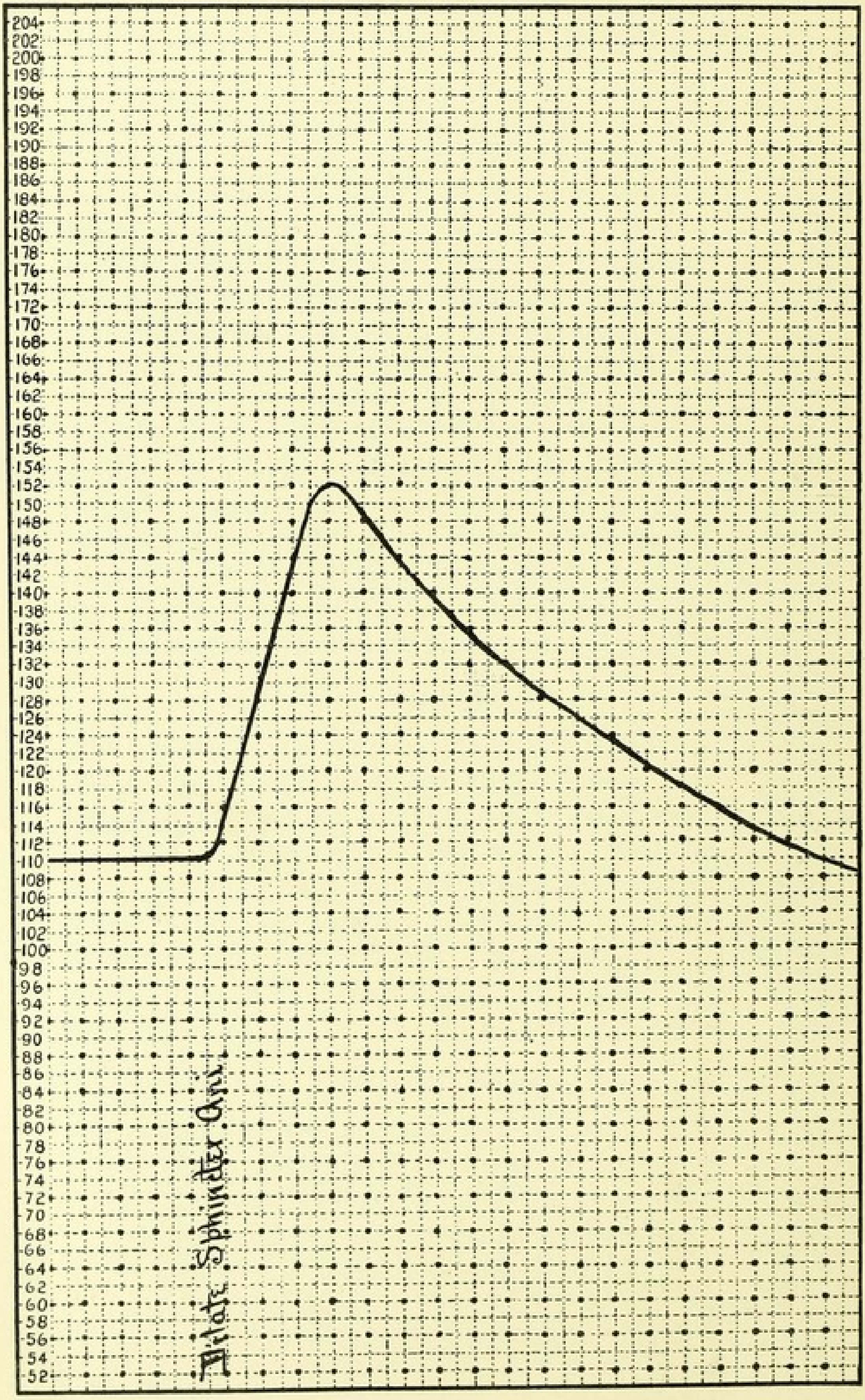


FIG. 83.—CHART XXI.—Divulsion of sphincter ani. Note the marked rise in the blood-pressure, corroborating general clinical observation and supporting former experimental evidence.

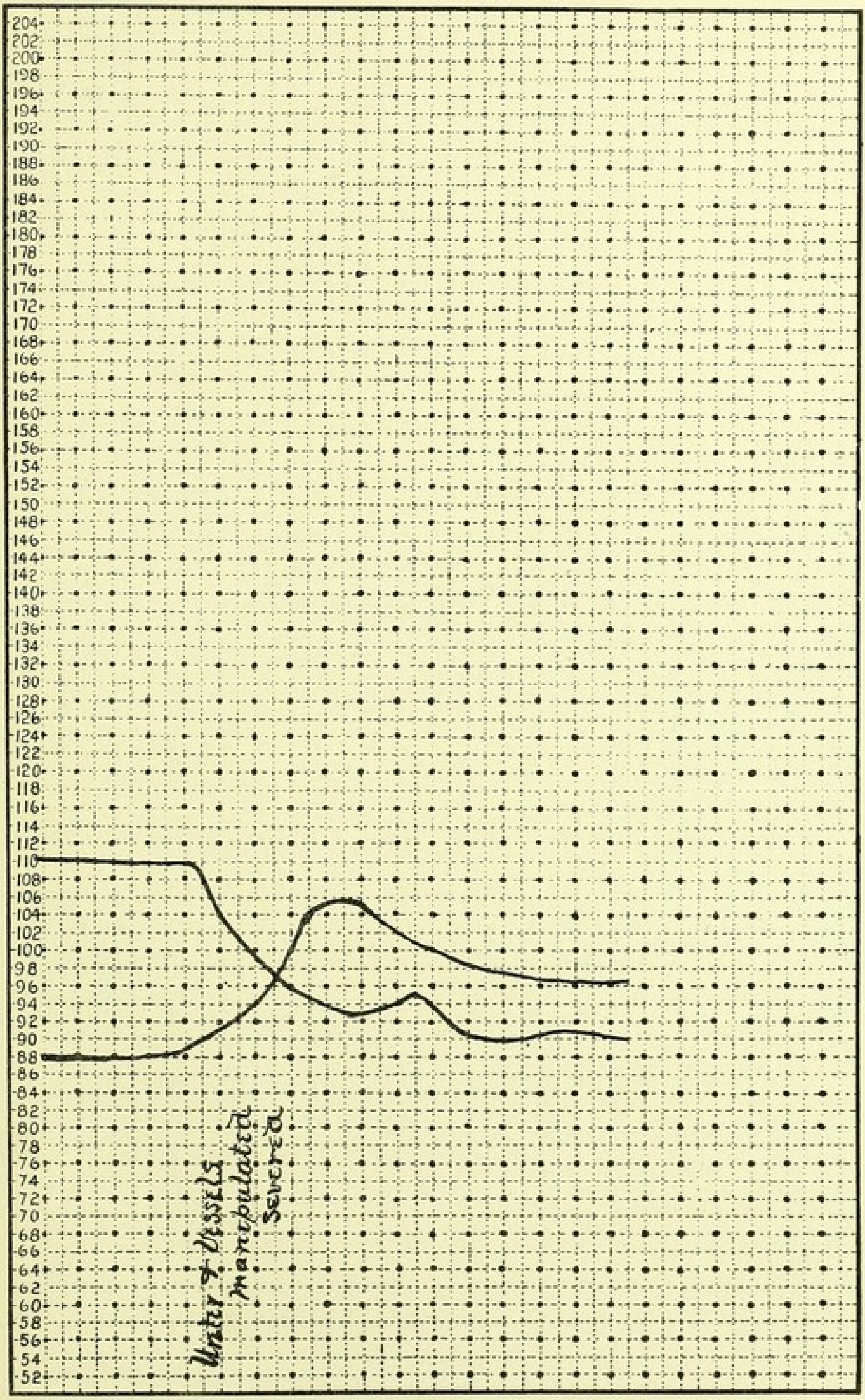


FIG. 84.—CHART XXII.—Phase of nephrectomy. Note the simultaneous increase in pulse-rate and the decline in the blood-pressure.

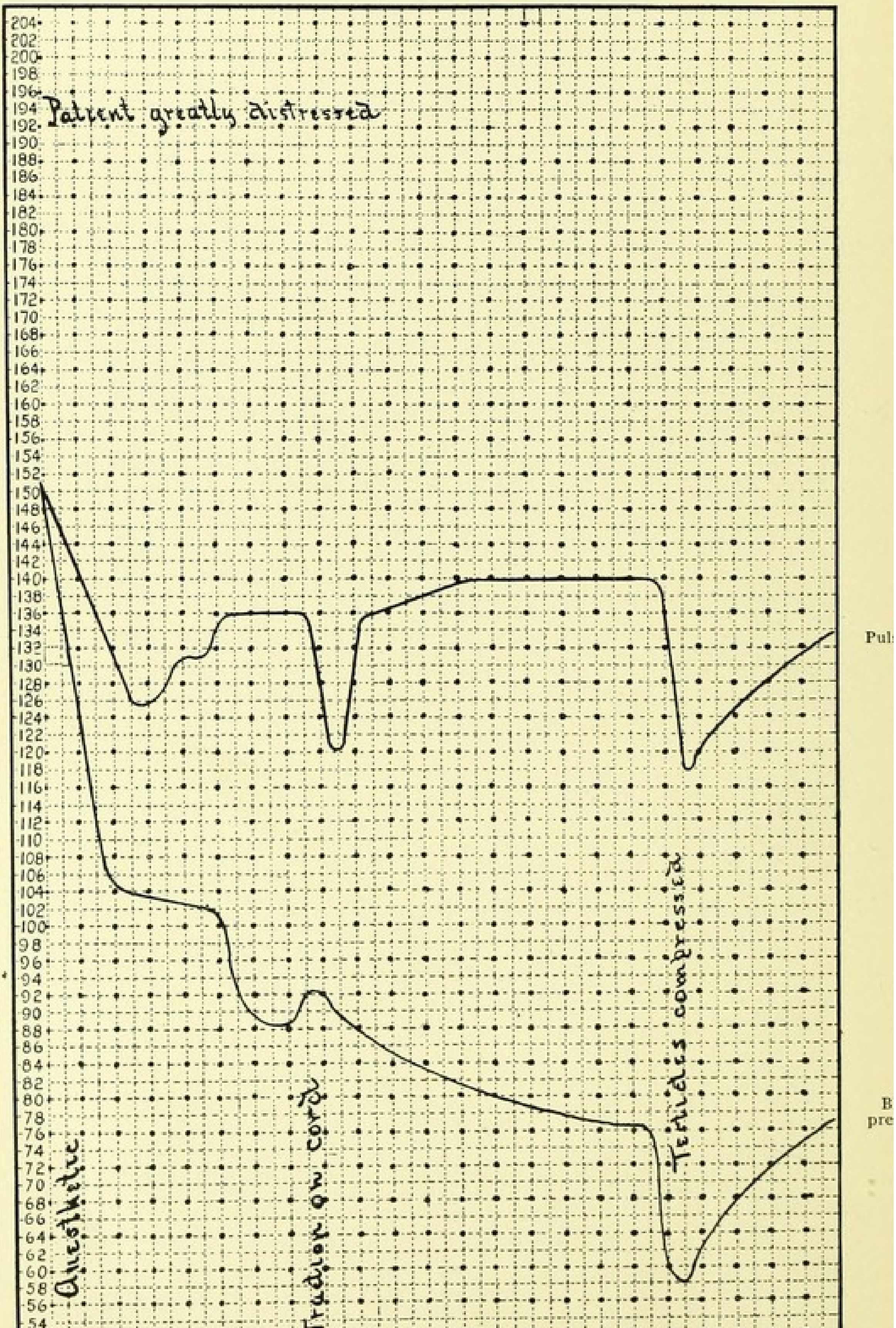


FIG. 85.—CHART XXIII.—Phases of operation upon the testicles.

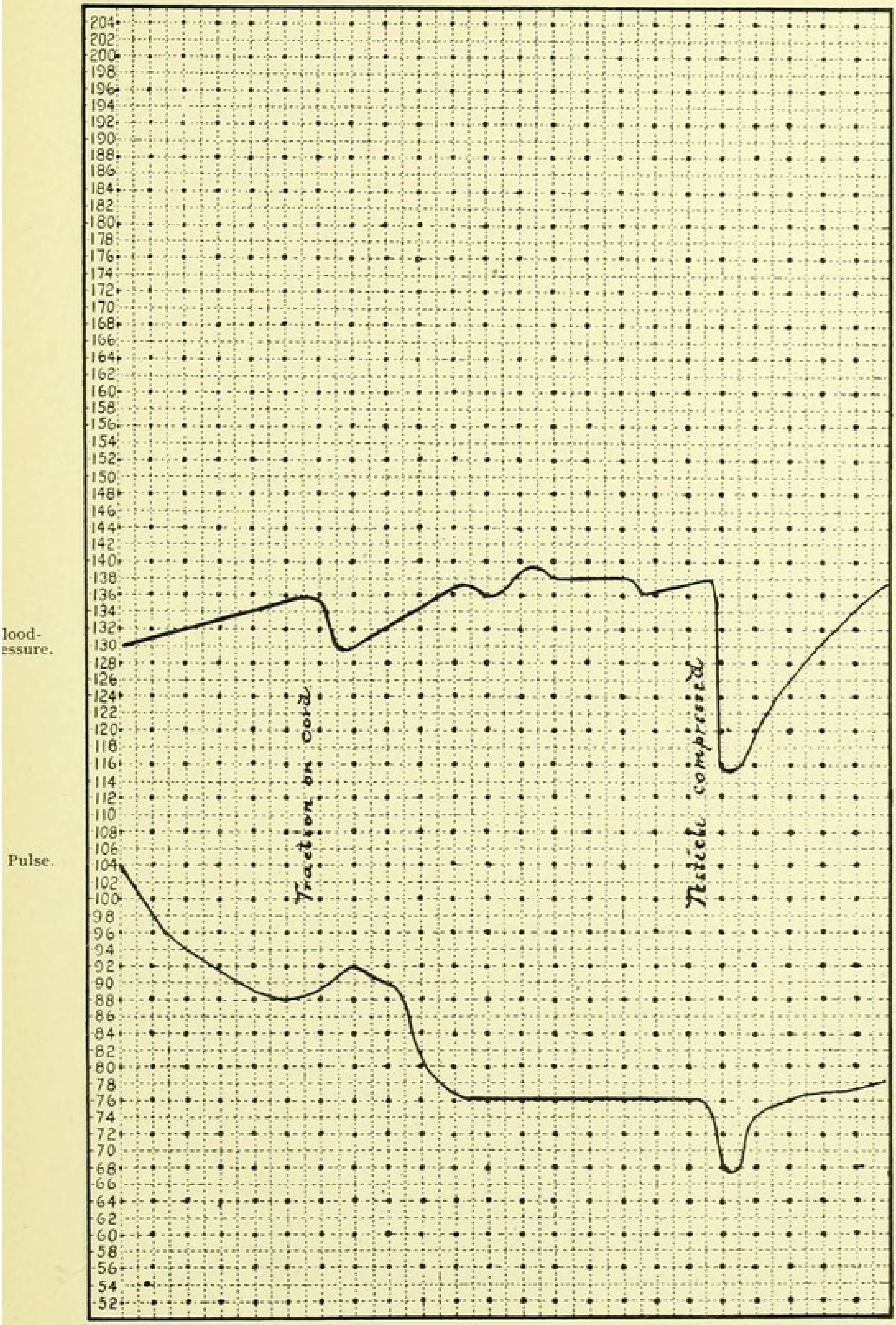


FIG. 86.—CHART XXIV.—Phases of operation on the testicles.

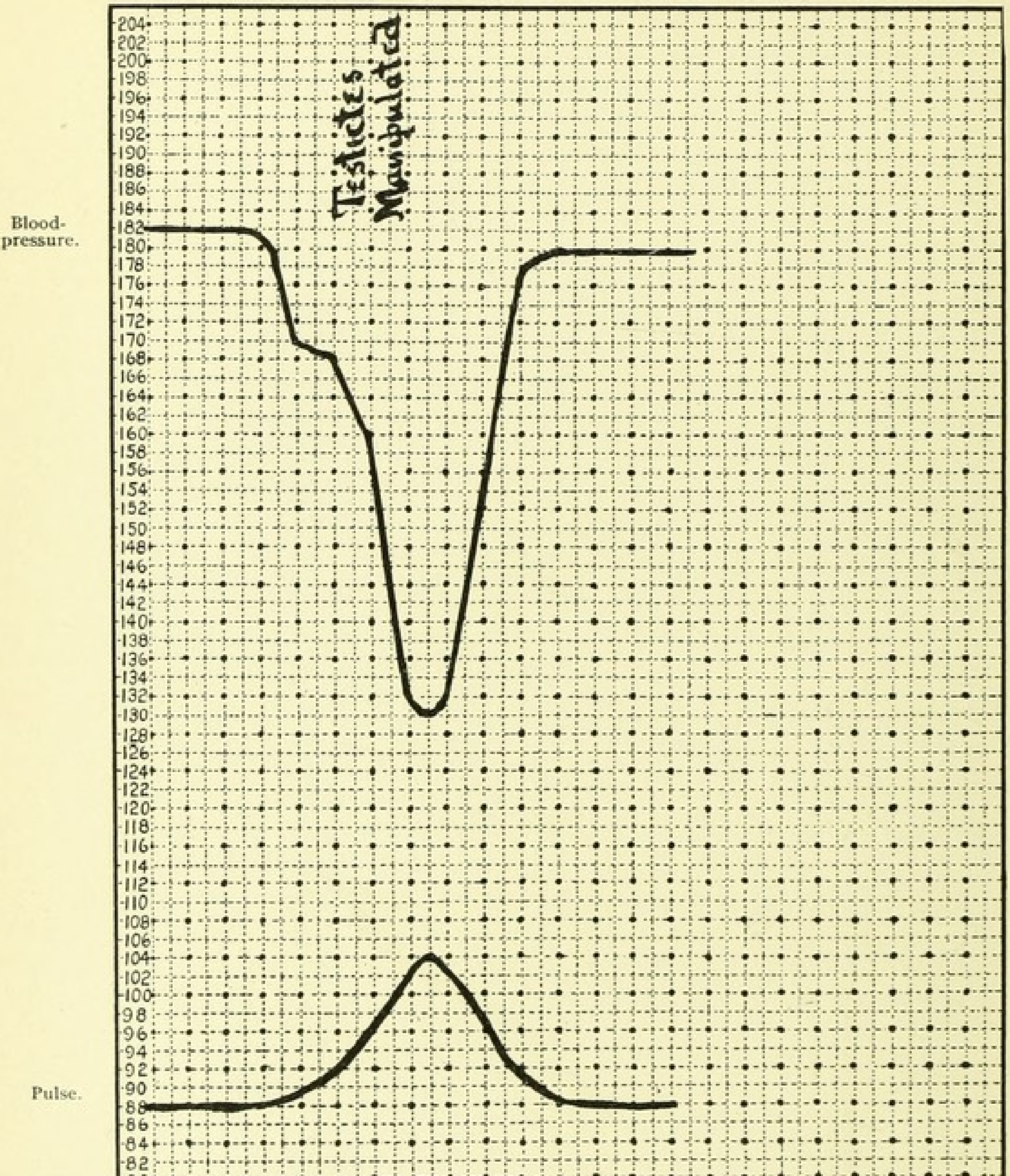


FIG. 87.—CHART XXV.—Phase of operation for neglected and inflamed hydrocele. Note the marked fall in the blood-pressure and a simultaneous increase in the frequency of the heart. The latter would tend to overcome the fall in the blood-pressure. The marked fall in the blood-pressure despite the increase in the frequency of the heart-beat supports the experimental evidence that the fall in the blood-pressure in traumatism of the testicle is due to a vasodilation through vasomotor influence.

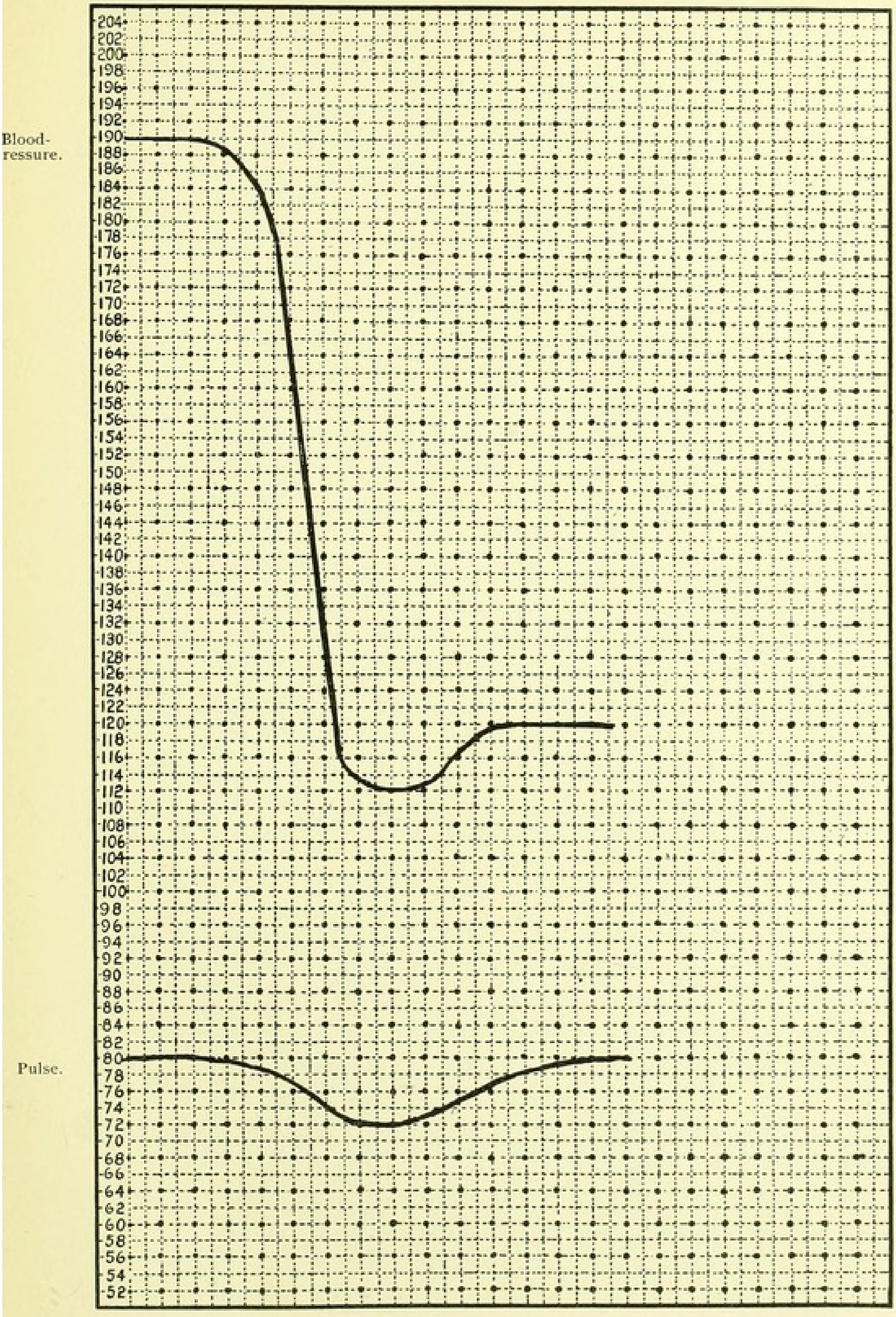


FIG. 88.—CHART XXVI.—Phase of an amputation of the penis for carcinoma in an elderly subject. Note the striking fall in blood-pressure during the actual amputation. The fall was but temporary. The high initial pressure is commonly found in aged subjects.

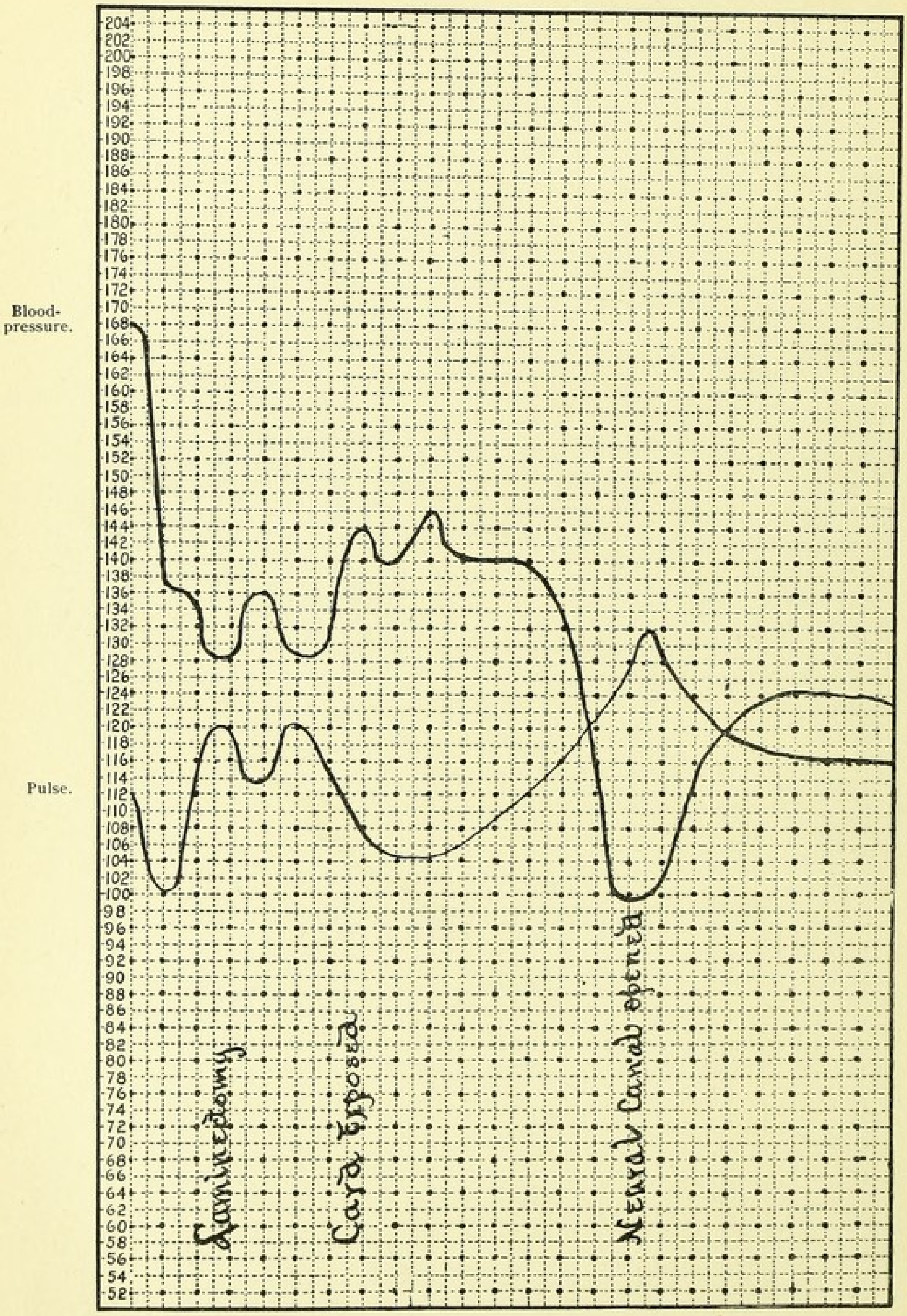


FIG. 89.—CHART XXVII.—Exploration of the spinal cord for a tumor. The initial blood-pressure was high owing to the influence of anxiety and fear. Note the marked fall in the blood-pressure and the increase in the pulse-rate when the dura was opened and there was free escape of cerebrospinal fluid; considerable manipulation was made. A compensatory rise immediately followed.

cervical to the axis. It was found that the deep tissues of the back over the middle line have but few sensory nerves. No cocain was required in the division of the deepest fascia, the separation of the deepest muscles, the division of the spinous processes and the laminæ, and in exploration of the dura mater, with the exception of the points of exit of the sensory nerve-roots.

The slightest contact with the sensory nerve-root caused an intolerable electric pain. There was quite a tendency to compensation in the blood-pressure following the fall upon opening the canal and making mechanical contact with the dura.

Hernia.

In operations for inguinal hernia no effect was noted, except in those in which there were adhesions of the sac to the spermatic cord, necessitating considerable manipulation. (See Fig. 90.) In such cases a fall in pressure was noted. This fall was probably due to the excitation of the characteristic depressor nerve mechanism of the part. In operation for ventral hernia no special changes in the blood-pressure were noted, except in the cases requiring considerable peritoneal manipulation.

Extremities.

Stretching the sciatic nerve caused a marked and irregular rise in blood-pressure (see Fig. 91) and an increase in the pulse-rate. Operating on the soft parts caused an irregularity in the pressure, more particularly a rise. Some of the cases of most profound shock were caused by heavy injuries of the limbs; *e.g.*, railway accidents. In an amputation of a shoulder-joint, in which the trunks of the brachial plexus were cocainized, thereby "blocking" the afferent impulses, no material change in the blood-pressure was

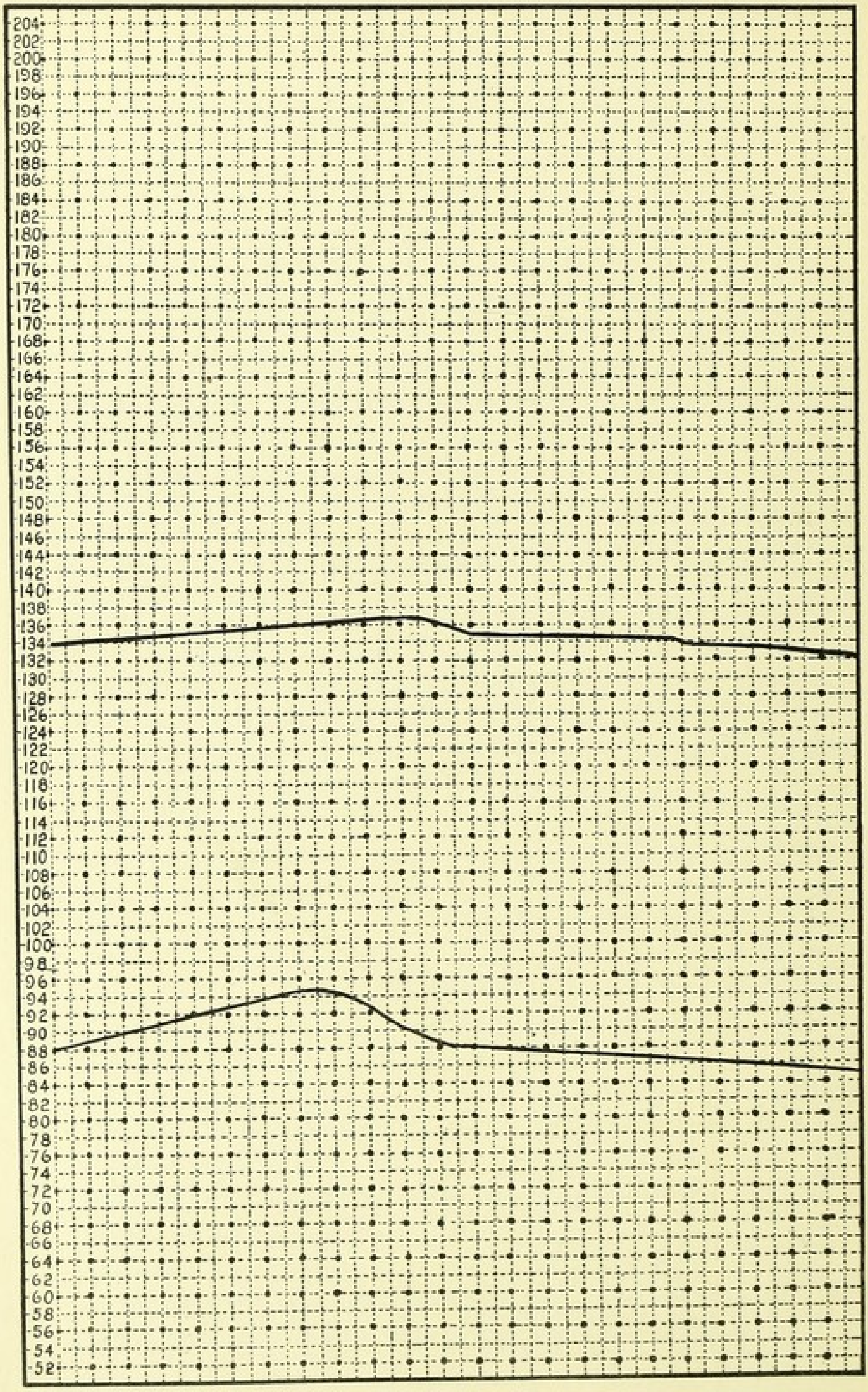


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FIG. 90.—CHART XXVIII.—Herniotomy (Bassini).

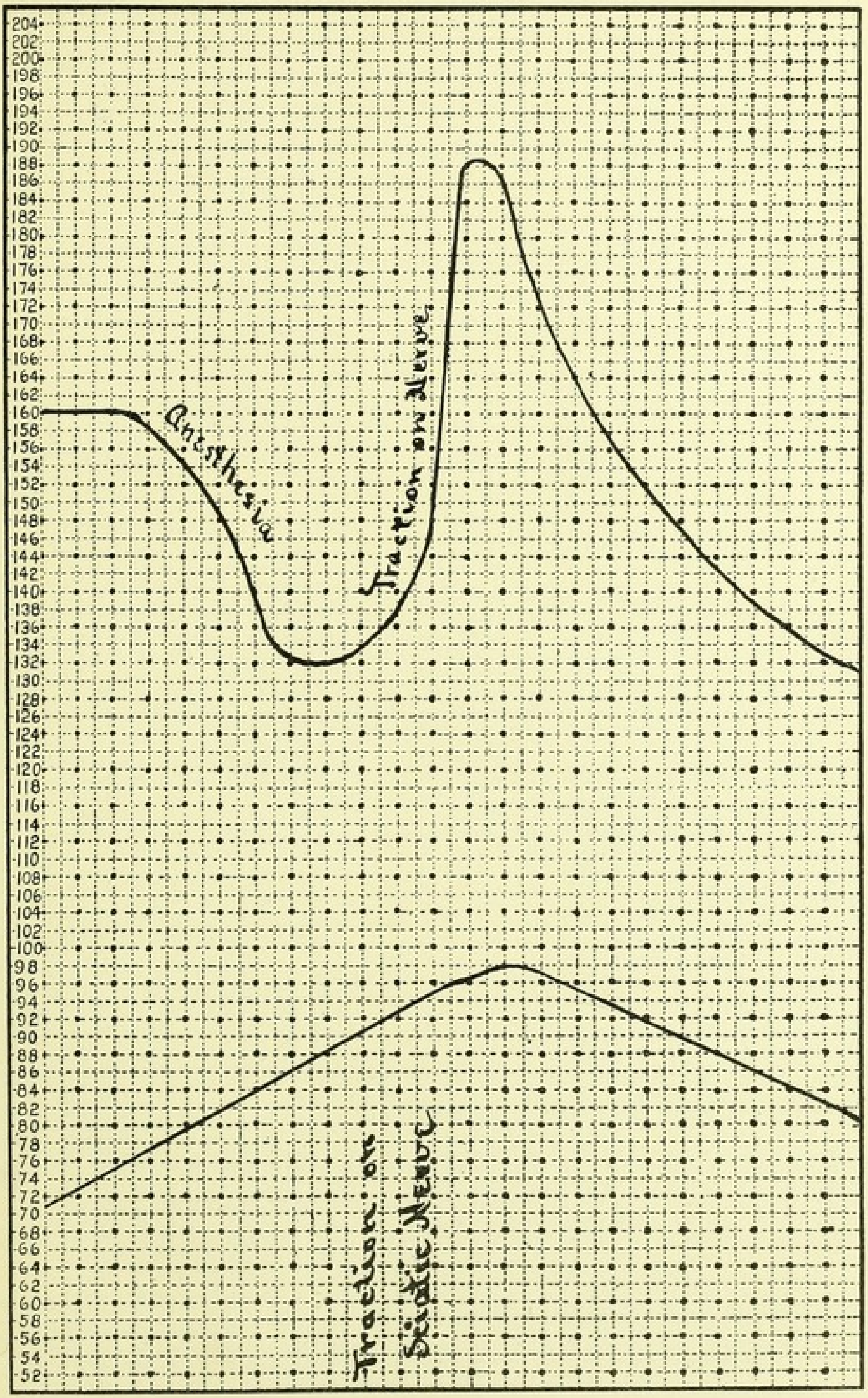

FIG. 91.—CHART XXIX.—Stretching the sciatic nerve for intractible neuralgia. Note the anesthetic fall (chloroform) then the abrupt rise from 132 mm. to 188 mm. The pulse-rate during the same period rose from 70 to 98. The decline after the stretching was almost as rapid as the rise.

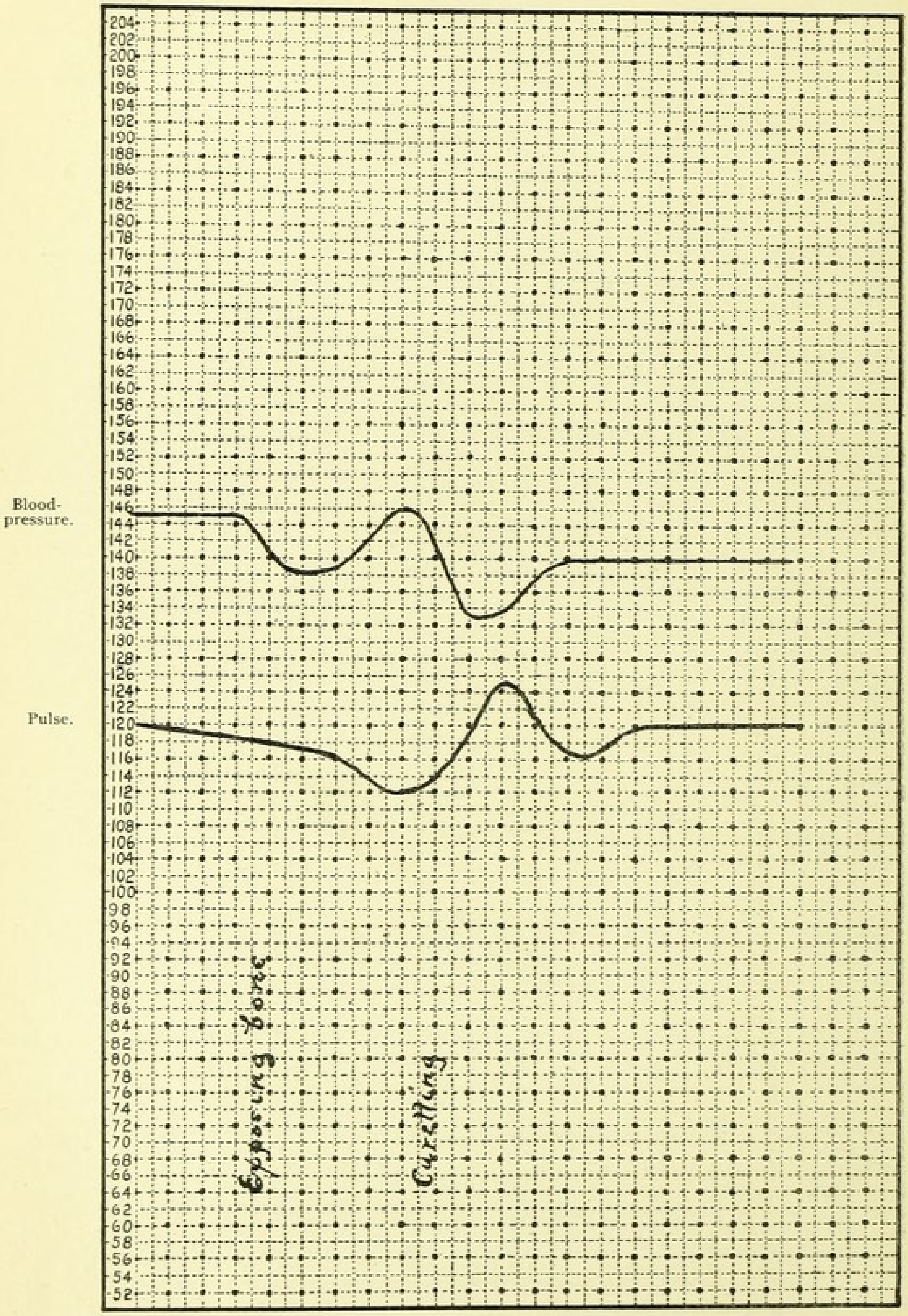

FIG. 92.—CHART XXX.—Operation for removing necrosed bone. Although the operation was extensive, the net alteration in the blood-pressure and the pulse was not marked.

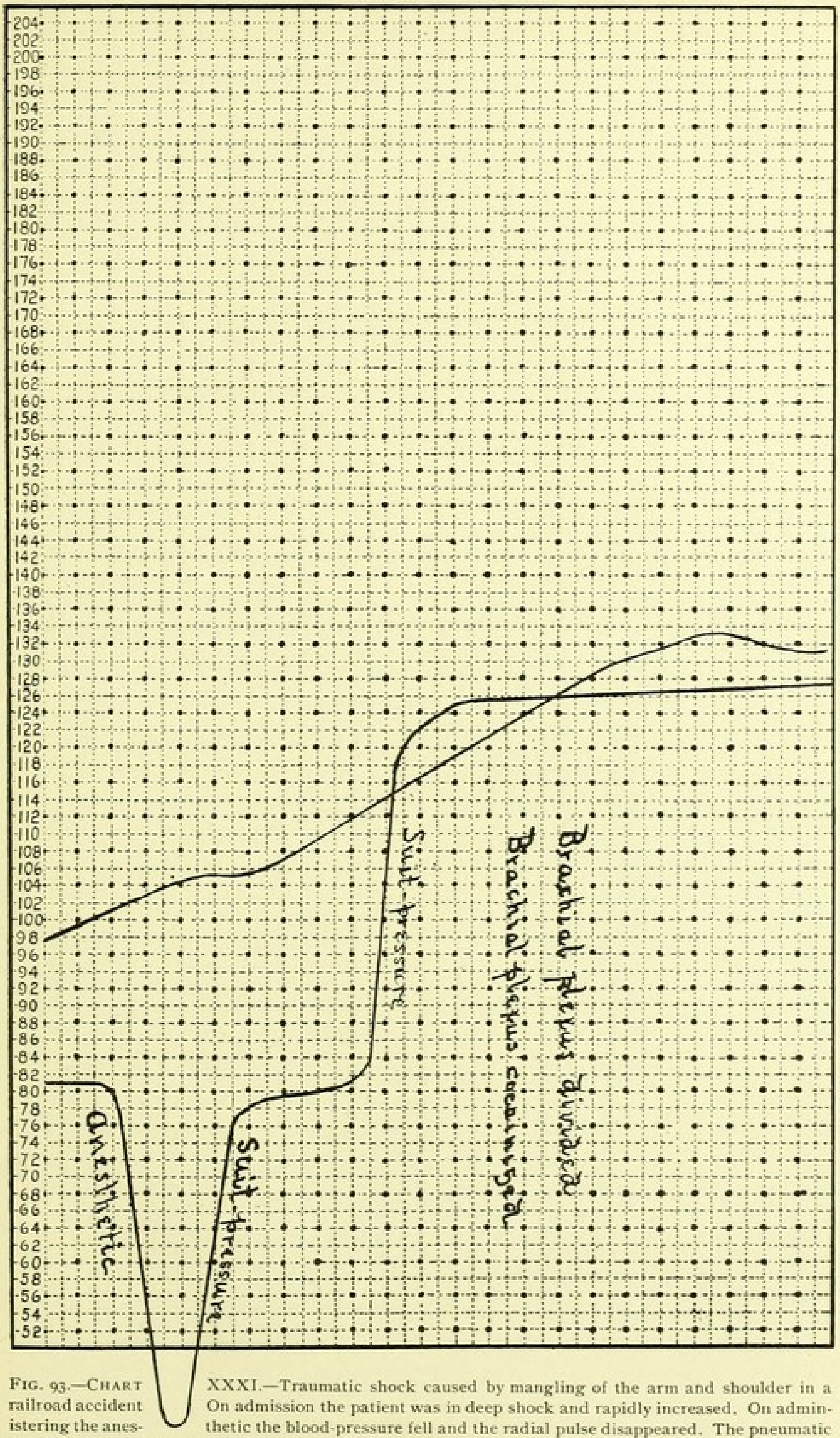

FIG. 93.—CHART XXXI.—Traumatic shock caused by mangling of the arm and shoulder in a railroad accident On admission the patient was in deep shock and rapidly increased. On administering the anesthetic the blood-pressure fell and the radial pulse disappeared. The pneumatic suit was hastily put on and inflated. Note the rapid rise in the pressure. The brachial plexus was exposed, cocainized, then divided. Note the even blood-pressure tracing during the amputation owing to the "blocking" of the brachial plexus and the support of the circulation by means of the pneumatic suit. The patient recovered.

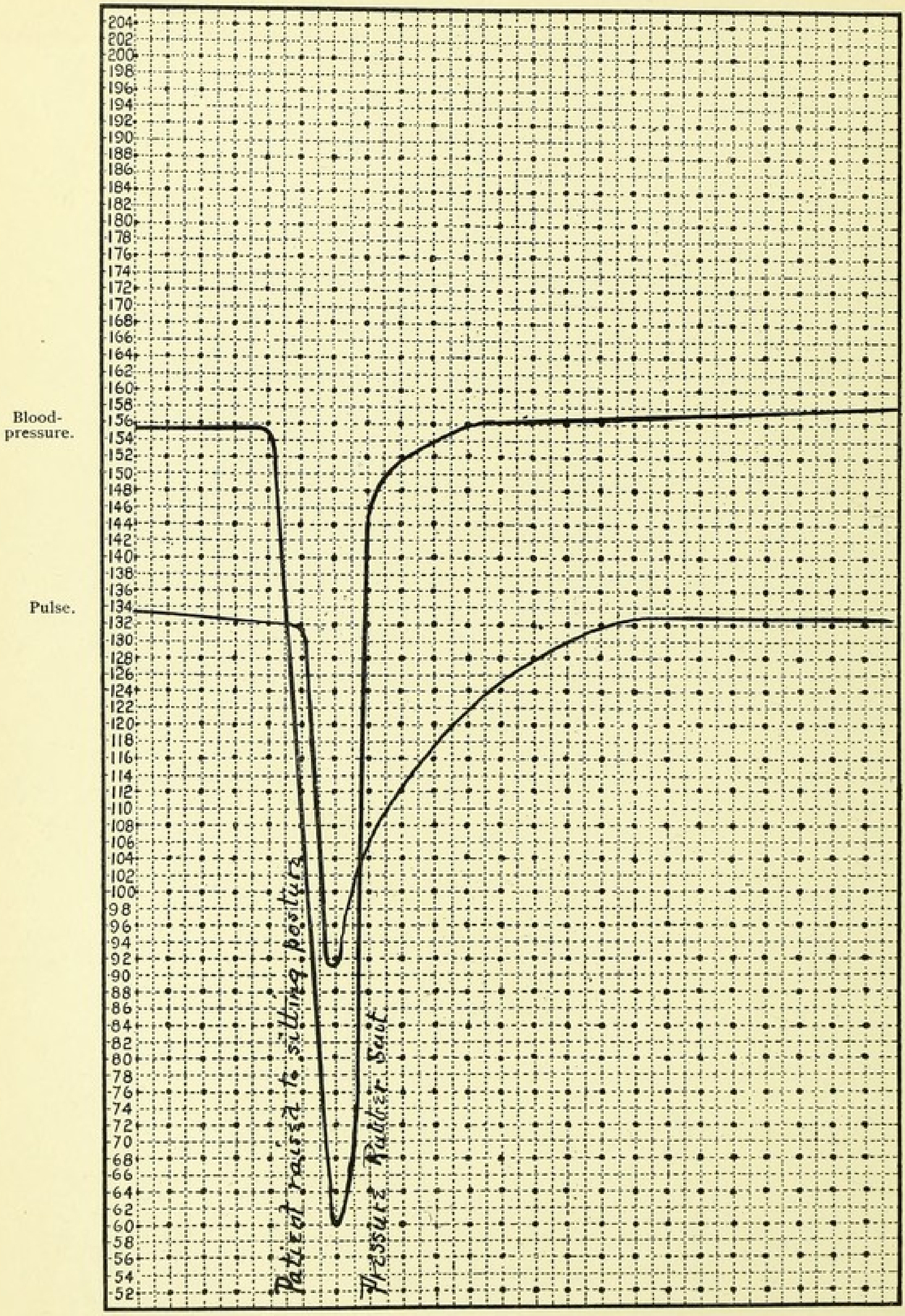

FIG. 94.—CHART XXXII.—Curve of blood-pressure and pulse in a case of collapse (fainting) after an operation. The operation consisted in a removal of all the glands and the jugular vein on one side of the neck, and the superior cervical on the other side, together with an excision of the tongue for carcinoma. The pneumatic suit had been used during the operation, but had been gradually deflated on returning the patient to bed. Owing to oozing in the back part of the mouth, the patient was propped up in bed. He immediately fainted. The pneumatic suit was promptly inflated, bringing back consciousness very promptly without changing his posture. The suit was then allowed to remain several hours and gradually deflated. An assistant took rapid observations before, during, and after the faint.

noted. In operations upon bone the blood-pressure showed comparatively small variation. (See Fig. 92.) The most marked variation was noted during procedures upon the periosteum.

Operations under Cocain.

In abdominal operations under cocain (see figure) not so much alteration in the blood-pressure was noted as in operations under general anesthesia. This was noted in an operation for typhoid perforation in a boy of twelve years; in a case of cholecystectomy for gall-stones in a woman of seventy; in two cholecystotomies in young adults (see Figs. 80 and 90) during typhoid; in a gastrostomy with exploration of the esophagus; in colostomy, and in other laparotomies. If there was momentary pain or fear, the blood-pressure usually rose irregularly. The less amount of shock in these operations under cocain was probably due to several factors. There was no depressing effect of a general anesthetic; the operation did not necessitate much manipulation; and the same precaution against the cause of pain—minimum manipulation—was just as effective against shock. In the instances in which either pain or fear caused a rise in the blood-pressure a later decline was noted. Operations upon the area supplied by nerve-trunks subjected to cocain "block" produced no shock. (See Fig. 93.) Intrathoracico-scapular amputations in which the brachial plexus was "blocked" by cocain caused no shock. Collapse in laryngeal and other neck operations may be avoided by the proper use of cocain.

Summary.—The estimations of the blood-pressure by means of a sphygmomanometer were certainly more accurate than the palpation of the radial pulse by the untrained anesthetizer or the inexperienced interne. During important operations, and in the after-care of certain cases, blood-pressure determinations were frequently of vital importance. In five cases of typhoid perforations suggestive changes were noted. In one the blood-pressure rose from 90 to 130 mm. in six hours. In a case of a child that was admitted as a perforation the blood-pressure was 102 mm.; following the operation for closure of the perforation the general peritonitis disappeared. The pressure then fell to 80 mm. A second perforation occurred on the eighth day. The blood-pressure then rose from 82 to 110 mm. In another case of perforation the blood-pressure was 165 mm. The fifth case registered a pressure of 210 mm. In view of the great variation in individuals, a single observation is of but little diagnostic importance, but repeated observations may have some value. In 115 cases of typhoid the maximum pressure was 138 mm.; the minimum 70 mm. In the first week the mean pressure was 115 mm.; during the second week, 106; the third, 104 mm.; the fourth, 96 mm.; the fifth, 98 mm. As opposed to the effect of typhoid toxins, acute infective inflammation causes a rise in the blood-pressure. In 23 cases of peritonitis in the height of the attack the minimum pressure noted was 145 mm.; the maximum, 210 mm. The average was 162 mm. Blood-

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NOTE.—In a personal communication, Dr. Briggs, of Johns Hopkins, referred to a case of typhoid perforation in which the two hundred or more previous blood-pressure determinations had well established the typical typhoid curve, and which suddenly rose from about 110 mm. Hg. to 144 mm., but on careful examination no other symptom of perforation was found. Four hours later typical symptoms of perforation appeared. At operation a perforation was found.

In another case in which there was sudden onset of symptoms of perforation—pain, tenderness, muscle spasm, leucocytosis, distention, drawn features, etc.—no change in blood-pressure was noted. The exploration did not reveal either perforation or peritonitis.

These two cases under the direct notice of a skilled observer seem to me to be of great importance. They corroborate my own previous observations and present even greater value than any of my own. The negative evidence in the second case seems quite as important as the positive in the first.

pressure determinations in acute infective inflammations show a rise. These determinations are of but little value in making a prognosis. In the later stages, in the unfavorable cases a rapid fall indicates impending dissolution, but at this stage other symptoms indicate even more clearly the fatal termination. As a means of diagnosis of infection in superficial parts, other symptoms are so much more marked and reliable that blood-pressure determinations may be dismissed as not adding to our means of diagnosis. The blood-pressure of individuals varies within a wide range; for a number of causes blood-pressure in the same individual varies greatly. It is particularly difficult to eliminate the psychical factor. It is frequently difficult to interpret the blood-pressure readings when their indications are most needed. The methods of determining the pressure thus far devised are only relatively accurate. In surgical practice blood-pressure determinations have added a new resource of a fair amount of practical value. The observations during surgical operations correspond very closely with those previously published as observed in experiments on animals.

Argument.

In *shock* the essential phenomenon is a diminution of the blood-pressure. Since there are no demonstrable lesions in the fatal cases, and no later effects in those that recover, we will assume exhaustion, rather than structural lesions, to be the cause of this fall. It must then be an exhaustion of the cardiac muscle, of the cardiac centres, of the blood-vessels, or of the vaso motor centres.

Is it due to exhaustion of the cardiac mechanism? The heart as an organ is noted for the large amount of labor it may perform without fatigue. In shock, on account of the diminished blood-pressure, there is even less work for the heart muscle to do than in the normal state. In a series of experiments, after the animal had been reduced to a degree of shock presumably fatal, the blood-pressure was, by special means, raised much higher than the normal. The heart then performed its normal function. There was, then, no material fatigue of the heart muscle.

Is it due to exhaustion of the cardio-inhibitory centre? In experiments in which animals had been reduced to a degree of shock presumably fatal the blood-pressure was by special means raised to the normal. Then on manipulation of the laryngeal mucosa a normal reflex inhibition of the heart was induced. The cardio-inhibitory centre and its peripheral nerve mechanism were, therefore, not exhausted. That the cardio-accelerator mechanism remains active in every degree of shock is constantly evidenced by the increasing rapidity of the heart until the inauguration of the phenomena of death. In a series of experiments the heart was isolated from the nervous system by severing both vagi and both accelerantes. Shock in such animals was as readily produced as in the controls. We may then exclude the heart and its nerve mechanism as factors in the primary causation of shock and look to the loss of peripheral resistance as the essential factor. The loss of peripheral resistance may be due to (*a*) an exhaustion of the peripheral nerve vascular mechanism, the anatomical periphery, or (*b*) an exhaustion of the vasomotor centres.

In a series of experiments in which both vagi and both accelerantes had been severed, a physiologic dose of curare given, and artificial respiration maintained, the animals were reduced to such a degree of shock that the vasomotor centre gave the usual physiologic proof of exhaustion. Varying doses of adrenalin were then given. The blood-pressure rose proportionally to the dose, even much higher than the normal. The same was also noted in the experiments in which the medulla and the cord were cocainized or destroyed after such a degree of shock had been produced. Fatigue of the blood-vessels may then be excluded. That the vasomotor centres become exhausted in complete shock is indicated by the absence of any rise in the blood-pressure on electrical stimulation of the sciatic nerve, or burning the paw, by giving a physiologic dose of strychnin, or by deepest asphyxia, all of which cause stimulation of the normal vasomotor centres. Cocainizing the vasomotor centres, or decapitation, causes a fall in the blood-pressure to about the same level as that of profound shock. We may then conclude that shock is an exhaustion or break-down of the vasomotor centres. From this stand-point, then, let us consider the vasomotor stimulants, such as strychnin.

In forty-eight experiments it was found that strychnin in therapeutic doses did not, on the average, cause a rise in the blood-pressure. In another series in which the dose was gradually increased until the convulsive stage was reached a remarkable rise occurred. Was this rise due to the muscular contractions in the convulsions? No; since an equal or greater rise occurred when convulsions were prevented by preliminary injections of curare. Was the rise partly due to a simultaneous stimulation of the heart? No; since strychnin caused an equal rise in the blood-pressure in animals, in which both vagi and both accelerantes had been previously severed and a paralyzing dose of curare given; neither was an increased action noted on making direct observations on the heart, nor by noting the endocardial pressure. It was, therefore, a pure vasomotor stimulant. A brilliant stimulant, indeed, sometimes doubling the normal blood-pressure and lasting from thirty minutes to several hours. Each succeeding physiologic dose caused less effect, and after from two to four doses no appreciable effect was noted. The blood-pressure in the mean time had fallen, and at last had reached the same level as in most profound shock. It was at this stage not possible by reactions, such as electric stimulation of the sciatic nerve, burning of the paw, by deepest asphyxia, nor by a study of the terminal tracings, to distinguish between these animals and the animals in profound traumatic shock. The vasomotor centre in each was exhausted. It was, in effect, shock produced by strychnin. The effect upon the function of the vasomotor centres seemed to be alike, whether the stimulation was mechanical and external, as in injuries or operations, or internal, as from strychnin.

Conversely, in a series of experiments in which strychnin was given in various degrees of shock, in such dosage as to cause a stimulation, the effect was proportional to the degree of shock; that is, when but little shock was present a marked effect from strychnin was obtained; when most profound there was no effect. In the intervening degrees, the effects were proportional, but after giving strychnin in physiologic doses the animals not yet in complete shock always passed into shock of a deeper degree. Later in the research it was found that the most convenient and certain method of producing shock for experimental purposes was by the administration of physiologic doses of strychnin. It then follows that treatment of shock by vasomotor stimulants in the form of drugs is on precisely the same basis as treatment by burning the animal or crushing its paws, or by subjecting it to injury or operation. It would seem to be as reasonable to treat strychnin shock by administering traumatism as traumatic shock by strychnin.

What has been said of strychnin may be assumed to apply equally well in the case of other stimulants of the vasomotor centre. Turning, then, to cardiac stimulants, we must first consider how much influence an increase in the force and frequency of the heart-beats have upon the blood-pressure. Even in normal animals, when the peripheral resistance is at its best, an increase in the force and frequency of the heart-beats has but a limited power of increasing the blood-pressure. In a series of experiments in which the vasomotor centre was reduced to varying degrees of exhaustion, and the vagi severed, thereby increasing the force and frequency of the heart-beats, the rise in the blood-pressure sustained an inverse ratio to the degree of exhaustion; and in the case in which the vasomotor centre was entirely exhausted the blood-pressure was not raised by any increase in the force and frequency of the heart-beats. In the decapitated animal the blood-pressure, unassisted except by artificial respiration and the elasticity of the vessels, falls to about 10 to 15 mm. This represents even more than the cardiac factor in the maintenance of the blood-pressure. An artificial circulatory apparatus was arranged so that the peripheral resistance was represented by the atmospheric pressure in a cylinder which contained an elastic bag filled with water and communicating by means of tubing with an artificial heart on the outside. In this rough way the force and frequency of the heart-beats and the peripheral resistance could be increased or diminished at will. It was not possible by any increase in the force and frequency of the artificial heart-beats to raise and maintain the mean artificial blood-pressure more than 10 mm. The velocity of the circulation was, of course, much increased. On the other hand, any change in the peripheral resistance was attended by an equal change in the blood-pressure. From the stand-point of physics, as well as physiology, it would seem that the peripheral resistance (vasomotor action) fixes the gauge for the height of the blood-pressure, while the heart supplies the force necessary for circulating the blood.

This would leave but a limited range of possibilities for heart stimulants. In another series of experiments cardiac stimulants were tested. It was found that as the peripheral resistance was lowered, the effect upon the blood-pressure was diminished, and when complete exhaustion of the vasomotor centre existed the cardiac stimulants had but slight influence upon the blood-pressure. Other drugs which are, in practice, generally included in the class of stimulants, such as alcohol, nitroglycerin, and amyl nitrite, were studied at length. No justification could be found for classifying these drugs as stimulants. In the case of alcohol, in not a single instance was there a sustained improvement in the blood-pressure or in the respiration. On the contrary, the most constant and most marked effect upon the blood-pressure was a decline. The rapidity and the extent of the decline were proportional to the depth of the shock and the dosage of alcohol. In all the experiments upon nitroglycerin, when any effect was noted, it was an immediate fall in the blood-pressure. This occurred in every degree of shock. A compensatory rise equal to the fall in most instances followed. The rising curve was usually more gradual than the falling. Most of the animals showed a marked degree of toleration. On the whole, nitroglycerin acted unfavorably in shock. As in digitalis and alcohol, when considerable dosage had been given, the final break-down of the circulation was more sudden than in the control animals.

If the foregoing be true, it is obvious that in true shock the use of stimulants acting upon the vasomotor, the cardiac, and other centres of the medulla are, on the whole, either inert or harmful. In considering other methods of controlling the blood-pressure, normal saline solution demands consideration. Normal saline administered intravenously or subcutaneously is a purely mechanical aid to the circulation, which temporarily increases the blood-pressure. The solution in any considerable quantity is not retained in the blood-vessels, but is eliminated at a rate proportional to the rate of administration through the same tissues that normally absorb water, mainly the alimentary tract. That the blood does not tolerate much dilution with normal saline was shown also by repeated observations upon the number of corpuscles and the amount of hemoglobin during its administration. The accumulation of saline solution in the walls, and in the lumen of the stomach and of the intestines, in the peritoneal cavity, and in the liver, after approximately 320 c.c. per kilo had been given, caused so much additional distention as to progressively hinder and finally prevent the excursions of the diaphragm and the movable ribs, causing death from respiratory failure. In the cases of pure shock—that is, in cases in which the vasomotor centres have been exhausted and no blood had been lost—the rise in the blood-pressure, even during its administration, if prolonged, was not sustained on account of the absence of the peripheral resistance and the elimination of the solution. Saline solution has a limited range of usefulness. It is obvious, then, that to increase and sustain the blood-pressure, when the vasomotor centre is exhausted, it is necessary to create a peripheral resistance either by a drug acting upon the blood-vessels themselves or by mechanical pressure. Adrenalin in the normal animal, or in any degree of shock, caused a marked and, in sufficient dosage, an enormous rise in the blood-pressure. This rise occurred when the vasomotor centres were proved to have been exhausted, when they were cocainized, and when they were destroyed. It occurred when, in addition, both vagi and both accelerantes had been severed and the animal was under the influence of curare. In larger doses a marked inhibitory action upon the heart was noted. This was immediately relieved by the injection of atropin. It was finally found that the most effective method of administration was by a continuous intravenous infusion in salt solution, varying in strength from 1 to 50,000 or 100,000. After the experimental research seemed to have shown that adrenalin and salt solution thus administered could maintain the circulation with the heart isolated from the nervous system by section of both vagi and both accelerantes, with the vasomotor centre exhausted (complete shock), and with the muscular system paralyzed with curare, it followed that if these observations were correct a decapitated animal must be kept alive during a certain period of time. An ordinary laboratory dog was decapitated. Adrenalin and saline solution were immediately and continuously administered. It was found that the blood-pressure could be controlled at will. The beheaded animal lived ten and one-half hours, and finally died of air emboli produced by the artificial respiration. On beheading animals, the primary fall in the blood-pressure was approximately the same as in profound shock.

But one clinical application of adrenalin when the vasomotor centre was exhausted has been made. In this instance a patient who was dying was kept alive for ten hours by the continuous administration of adrenalin and the application of external pressure. It is to be remembered that, owing to rapid oxidation in the tissues, adrenalin is more effective when given intravenously, and, since it is even more rapidly oxidized in the blood, it should be given continuously. It is found to be most conveniently given in saline solution from a burette, the rate of flow being controlled by a screw-cock attached to the rubber tube The circulatory phenomena should be under continuous observation. Great caution must be exercised in the administration of adrenalin. Its practicality has not yet been established.

The therapeutic support of the blood-pressure in theory and in practice is at present unsatisfactory.

In considering external pressure as a means of supplying a peripheral resistance, it is well to bear in mind that when the vasomotor centre is becoming exhausted, the blood-accumulates in the veins, especially in the larger venous trunks. The condition may be described as an intravenous hemorrhage. Pressure applied uniformly upon the skin from the periphery towards the centre over an area containing such intravenous hemorrhage causes the blood to flow towards the heart, just as the normal vascular tone does. After numerous experiments, from water-baths to pneumatic chambers, in which it was attempted to devise a method of supplying an artificial peripheral resistance, a rubber pneumatic suit was found to be the most practical. The suit is made of a double layer of specially constructed rubber, and when inflated gives a uniform pressure upon the surface producing an artificial peripheral resistance. The inflation is accomplished by means of a bicycle-pump, and may be varied at will. Regardless of the posture of the patient, a considerable portion of the blood may be delivered to the right heart, preventing thereby, to a certain degree the continuance or development of cerebral anemia. By means of this suit the blood-pressure may be, within a range of 25 to 60 mm. mercury, placed under the operator's control. The pneumatic suit has been employed in many clinical cases, and the effects studied by means of the Riva Rocci sphygmomanometer.

Collapse.

For the present purpose the term "*collapse*" is applied to the cases of the more sudden fall of the blood-pressure from hemorrhage, from injuries of the vasomotor centre, or from cardiac failure. These conditions represent suspension of function rather than exhaustion of centres. There being no exhaustion, stimulants may be of value. As an illustration, if one animal is subjected to such a degree of shock (exhaustion of the vasomotor centre) as to produce a sufficient accumulation of blood in the veins (intravenous hemorrhage) to cause a decline in the blood-pressure to 25 mm., and if another animal is subjected to an extravascular or ordinary hemorrhage, until the blood-pressure has been reduced an equal degree, it might be impossible, on the symptoms alone, to make a differential diagnosis. Yet, in the one case, stimulants could have no effect because the vasomotor centres are exhausted, and in the other the effect might be marked because the centres are not exhausted. In the animal with the exhausted vasomotor centres (or shock) saline solution could be of little assistance, but in the animal subjected to ordinary hemorrhage, and having normal vasomotor centres, saline infusion might be of marked benefit. In collapse, mechanic, thermic, electric, or therapeutic stimulants, such as bruising, burning, application of electrodes, the administration of saline infusion or change of posture may be beneficial.

After having considered the means of controlling the blood-pressure in cases in which there is exhaustion of the vasomotor centres (shock), and in cases in which there has been a temporary suspension of the function of the heart or of the vasomotor centres (collapse), it remains to consider the control of the blood-pressure in cases in which the vasomotor, respiratory, and cardiac centres, and the heart itself have all ceased to show any functional activity,—that is to say, when the animal is apparently dead. In a series of experiments, observations were made upon the use of electricity; upon needling the heart; upon massaging the heart; upon making rhythmical pressure upon the thorax over the heart; upon the injection of strychnin, adrenalin, digitalis, and other drugs into the chambers of the heart and into the heart muscle; upon artificial respiration; upon the administration of salt solution intravenously; upon rapidly alternating the posture of the animal, head up and head down,—all of these methods were employed singly and in various combinations, but in no instance did we find it possible to resuscitate the animal after more than fifty-eight seconds after the last rhythmic contraction of the heart.

The most favorable results were obtained by combinations of rhythmic pressure upon the thorax over the heart, artificial respiration, and intravenous saline infusion. Unless the heart and the vasomotor centre resumed action, the blood-pressure could be raised and sustained to but a very limited degree. During the experiments upon the decapitated dog it was observed that adrenalin acted upon the blood-vessels after the circulation had ceased. It was then planned to kill the animals by asphyxia, give artificial respiration, make rhythmic pressure upon the thorax over the heart, and at the same time administer adrenalin in saline solution into the jugular vein. By this means adrenalin might, through the feeble artificial circulation, be brought into contact with the walls of the blood-vessels, causing their contraction, thereby increasing the blood-pressure, which in turn might re-establish the coronary circulation, which in turn might re-establish the action of the heart. By this method animals apparently dead for various periods up to fifteen minutes were restored to conscious life again. The circulation and the respiration in dogs electrocuted by a shock of 2300 volts of an alternating current were re-established.

Final Summary.—In many instances the control of the blood-pressure is the control of life itself. Surgical *shock* is an exhaustion of the vasomotor centres. Neither the heart muscle nor the cardiac centres, nor the respiratory centre, are other than secondarily involved. *Collapse* is due to a suspension of the function of the cardiac or of the vasomotor mechanism, or to hemorrhage. In *shock* therapeutic doses of strychnin are inert. Physiologic doses are dangerous or fatal. If not fatal, increased exhaustion follows. There is no practical distinction to be made between external stimulation of this centre, as in injuries and operation, and internal stimulation by vasomotor stimulants, as, for example, strychnin. Each in sufficient amount produces shock, and each with equal logic might be used to treat the shock produced by the other. Stimulants of the vasomotor centre are contraindicated. In *shock* cardiac stimulants have but a limited range of possible usefulness, and may be injurious. In *collapse* stimulants may be useful because the centres are not exhausted.

Saline infusion in *shock* has a limited range of usefulness; in *collapse* it may be effective. The blood tolerates but a limited dilution with saline solution. Elimination takes place through the channels of absorption. Its accumulation in the splanchnic area may be sufficient to fix the diaphragm and the movable ribs, causing death by respiratory failure. Saline infusion in *shock* raises but cannot sustain the blood-pressure.

Adrenalin acts upon the heart and the blood-vessels. It raises the blood-pressure in the normal animal; in every degree of shock; when the medulla is cocainized, and in the decapitated animal. It is rapidly oxidized by the solid tissue and by the blood. Its effects are fleeting; it should be given continuously. By this means the circulation of a decapitated dog was maintained ten and one-half hours. In excessive dosage there is a marked stimulation of the cardio-inhibitory mechanism. Due caution must be exercised. Its clinical value still remains unproved.

The pneumatic rubber suit provides an artificial peripheral resistance without injurious side effects, and gives a control over the blood-pressure within a range of from 25 to 60 mm. mercury. By the combined use of artificial respiration, rhythmic pressure upon the thorax over the heart, and the infusion of adrenalin, animals which were apparently dead as long as fifteen minutes were resuscitated.

By the same method, with the addition of the rubber suit, a patient who, from fatal injury of his brain, had been conventionally dead for nine minutes was partially resuscitated for thirty-two minutes, during which a strong heart-beat was noted and he was able to move his head.

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