A DESCRIPTIVE LIST

OF

ANTHROPOMETRIC APPARATUS,

CONSISTING OF

INSTRUMENTS FOR MEASURING AND TESTING THE CHIEF PHYSICAL CHARACTERISTICS OF THE HUMAN BODY.

DESIGNED UNDER THE DIRECTION OF MR FRANCIS GALTON,

AND MANUFACTURED AND SOLD BY

THE CAMBRIDGE SCIENTIFIC INSTRUMENT COMPANY,
ST TIBB'S ROW, CAMBRIDGE, ENGLAND.

1887

Anthropometric Apparatus. Instruments for measuring and testing the chief physical characteristics of the human body, on the same general principles as those exhibited and employed by Mr Francis Galton at the recent Health Exhibition in London, but with considerable improvements made in concert with him.

The use of periodical measurements is two-fold, personal and statistical. The one shows the progress of the individual; the other, that of portions of the nation, or of the nation as a whole.

Personal use. Periodical measurements afford a sure test of the normal physical development of the child or youth. They draw attention to faults in rearing, to be diligently sought for and remedied lest the future efficiency of the child when it grows to manhood or womanhood be compromised. There are hundreds of thousands of cases in which eye-sight has been heedlessly injured beyond repair by pure neglect; of lopsided growth, and of stunted chest capacity, which measurement would have manifested in their earlier stages, and which could have been checked if attended to in time. The necessity of periodical measurement is thoroughly recognised by those who have studied the subject of health, but it has not yet obtained that hold in England on popular opinion which it deserves, and which it will hereafter undoubtedly exercise. It seems strange that it should be neglected at any school or university in England. It is widely recognised in those of the United States.

Statistical use. Anthropometric records, when treated statistically, show the efficiency of the nation as a whole and in its several parts, and the direction in which it is changing, whether for better or worse. They enable us to compare the influences upon bodily development of different occupations, residences, schools, races, &c. There is great scientific need for a more systematic registration of physical measurements to afford a sufficiently wide basis for general inferences. Their value is indisputable, the cost of making them is trifling, and the facility of registration in any permanent institution is obvious.

The use of preserving even the minor personal data is considerable, such as those of the colour of the Eyes and Hair, which appear from the large collection of statistics published by the American War Office in 1875, under the direction of Dr. Baxter, to be associated with a marked tendency to various forms of disease or to immunity from them. If then, even the colour of the eyes and hair is a proper subject for anthropometric record, much more may we feel assured that the more obviously important personal data deserve measurement and registration.

The following list indicates the uses of the instruments thus completed or in course of construction, and the characteristics they are intended to test, while further on is a more detailed statement as to the method of using them.

Standard tints, in glass, for colour of eyes.
Head measurement, its maximum length, breadth, and height.
Height standing; height above chair when sitting.
Span of arms.
Breathing capacity.
Weight.
Strength of hand in squeezing; of arm as in drawing a bow.
Appreciation of slight differences between weights.
Eyesight, its keenness.
„ appreciation of colours.
„ judgement as regards squareness and angular divisions.
„ „ „ divisions of a line into fractional parts.
Hearing, its keenness, by distance of hearing a standard test-sound.
„ appreciation of pitch.
„ highest audible note.
Reaction time to sound and sight.

Standard Tints for the Colour of Eyes.

At the Health Exhibition Mr Francis Galton used three artificial glass eyes as standards for comparison. The colours were Blue, Brown, and an intermediate colour Grey-Brown; in the standards now made, these same colours have been kept to as nearly as possible. The following points have been considered in the design: permanence of the colours: identity of colour in all the instruments issued: portability and convenience of use. The colour is given by a piece of tinted glass: behind this is placed a piece of paper on which is printed a black spot to represent the pupil of the eye and radial lines to represent the markings on the iris. A circular piece of paper with a hole in the middle is placed on the coloured glass. This gives the size of the iris and represents the white of the eye. Above this again is a piece of clear glass to keep all clean and free from dust. The three standard tints are mounted in a convenient brass frame. £1 1 0

Head Measurement.

Horizontal Head Spanner. This is used for measuring the maximum horizontal length of the head from the forehead to the back, and also the maximum horizontal width across the head in a direction at right angles to this. Two pieces of wood are arranged to slide one against the other in a longitudinal direction, and a pair of slender steel rods are fixed to the ends of each piece of wood, projecting at right angles to them. Each pair of rods is in a plane at right angles to the direction of motion of the slide. In using the spanner, the slide is moved so that each pair of rods just touches the opposite surfaces of the head and the spanner is moved about until the maximum dimension in the required

direction is obtained. The reason why the rods are in pairs and not single, is to give an extension of surface, the rods passing through the hair like the teeth of a comb. The result is read off either in inches and tenths, or in millimetres, from a scale engraved on one of the pieces of wood. £3 0 0

Vertical Head Spanner. The third dimension required is the maximum height of the upper surface of the head above the plane passing through the holes in the ears and through the lowest part of the orbital cavity of the eyes. The Company hope soon to issue a satisfactory instrument after making some further experiments.

Height.

Height Standing. This instrument is best fixed against the wall. A piece of wood with a scale in inches and tenths, or in millimetres, is fixed in a vertical position. A horizontal arm projects from a block which slides on the vertical scale. This arm is hinged so that it can move upwards but is prevented from moving downwards by a stop. The person to be measured stands with his heels on the ground and the sliding block is then moved up or down till the head touches but does not raise the horizontal arm; the height is then read off directly from the scale. The thickness of the heel of the shoe is then measured by means of a small scale and subtracted from the former reading.

Height Sitting. The same instrument is used for this purpose by the addition of a low stool, the height of which is subtracted from the reading on the scale. In this measurement it is important that the feet should rest on the floor at a point near the legs of the stool; thus raising the knees above the level of the top of the stool itself. If this were not done uncertainties would be introduced into the measurement. Price complete including the scale for finding thickness of heels and stool for measuring the height sitting. £3 10 0

Span of Arms.

The instrument is the same as that used at the Health Exhibition and consists of two long wooden staves sliding one against the other; a piece of wood is fixed at the outer ends of each, forming a plate in a plane at right angles to the direction of the slide. The instrument is held, and the inner surface of the plates are pressed with the finger tips so as to make them slide apart as far as possible, the rod being supported by the thumb and little finger of each hand. The sliding staves should pass in front of the body across the chest. ... £1 0 0

Breathing Capacity.

The Spirometer used for this purpose is similar to that used at the Health Exhibition and measures the maximum volume of air that can be expelled from the lungs by one expiration. It consists of a cylindrical vessel of known capacity, supported with its mouth downwards in another vessel containing water. A tube passes through the water and is connected by an indiarubber tube to a glass mouth piece. After drawing as much air as possible into the lungs the person to be tested places his mouth to the glass mouth-piece and expels the air through the

tube into the inverted vessel dipping into the water. The vessel is raised and the height to which it moves is a measure of the volume of air expelled, which can be read off at once from a scale in either cubic centimetres or in cubic inches. The vessel is accurately counter-weighted, and thus remains in the position in which it is left. The water should be changed daily. £4 0 0

Strength of Hand and Arm.

In the Dynamometers used for this purpose, the force is measured by the extension of a spring. We have the advantage of Messrs G. Salter and Co.'s experience in their manufacture of spring balances, as they are kind enough to supply the springs and indicating apparatus, as well as to put the instrument in adjustment.

Hand Dynamometer. The object of this instrument is to measure the strength of each hand, in respect to the force that can be exerted in squeezing an object of the most suitable size between the fingers and the palm. It is an improvement on the form used at the Health Exhibition. An arrangement is made by means of which the distance between the two pieces to which the pressure is applied can be varied and thus the strength of the hand when acting in its most advantageous position can be measured. In the results given by the original pattern of instrument, the size of the hand was an important factor as well as the strength. After the experiment is over, the maximum force is read off directly from a divided dial either in lbs. or in kilograms, as may be desired. There are two hands, one indicating the force at any moment, and the other the maximum force during the experiment. This latter hand must be set at zero before the experiment begins. £3 10 0

Arm Dynamometer. This measures the strength of the arm when exerted in the same way as by an archer when drawing a bow. The distance between the handles can be made to vary for the reasons given in the description of the Hand Dynamometer, and the arrangement for indicating the maximum force is the same. To measure the strength of the right arm, the person to be measured stands up and stretches his left arm out horizontally to the left in the same plane as his chest and grasps one handle of the Dynamometer in his left hand. The right hand grasping the other handle should be brought under the chin with the knuckles outwards. It must not touch the chest. The fore-arm should be horizontal and the elbow sharply bent. The adjustment by means of the strap is to allow the handles to be put at such a distance apart as to make the above described position possible. The strength of the left arm should then be measured in the same way. £3 10 0

Keenness of Eyesight.

This is measured by the maximum distance at which test type can be read. At the Health Exhibition a piece of an easily procured edition of the New Testament in small type was adopted; but Mr F. Galton thought that a series of figures set at random would give a more accurate test, as the effect of memory

would be thus eliminated and the instrument could be used by persons not knowing English. These figures were set up and have been stereotyped, in order that all instruments issued should be identical in this respect. The type used known as "brilliant" is as follows:—

1234567890

The person to be tested places his eye near a hole in a diaphragm through which he sees a number of pieces cut from the standard page of printing. They stand in a series at gradually increasing distances. He then notes the furthest of the test pieces that he can read. The large number engraved above each test piece signifies its distance from the eye; these distances are given either in inches or in centimetres as desired, and the eye is assumed to be half an inch from the aperture in the one case, and two centimetres in the other. A small box attached to the instrument contains extra test-pieces to replace the others when they become soiled; also a frame containing one of these for the purpose of testing abnormally good sight, by placing it at a distance beyond the ordinary range of the instrument. Clear daylight is required for this test. £2 10 0

Appreciation of Colours.

The ordinary test with coloured wools is employed. The samples of wool are wound on black wooden reels and enclosed in a glass tube in order keep them free from dust. The person to be tested is required to place pegs in holes opposite the four shades of green; the attendant then turns the tube by means of a handle and exposes letters attached to each reel. When the colour vision of the person tested is normal, each peg will be found opposite one of the letters G. R. E. N. The whole apparatus is contained in a box which should be kept shut to prevent the colours fading. The relative position of the reels in the glass tubes should be changed occasionally as otherwise the holes opposite the Greens will become enlarged, or otherwise marked by frequent use, giving a clue to their position. Clear daylight is required for the test. £2 10 0

Judgment of the Eye as regards Squareness and Angular Divisions.

The instrument consists of a disc of ebonite with a radial line engraved on one face. A brass bar is arranged to turn about the centre of the disc, so that the bar and the engraved line can be set at any angle. The person to be tested rotates the disc and alters the angle between the radial line and the brass bar, until he thinks the angles are right angles. A divided arc is fixed on the back of the instrument, by looking at which, the error in degrees and half degrees in estimating squareness can be read at once. The same divided arc can be used for reading the error in judging angles of 45^0 and 60^0. ... ... £2 10 0

Judgment of the Eye in estimating the Divisions of a Line.

A strip of ebonite ten inches long has a small sliding strip of brass on it. This sliding piece carries a thread which forms a white line on the ebonite. The person

to be tested moves this sliding piece until he thinks that the line divides the ebonite strip into two equal parts. On looking at the back of the instrument, he at once sees any error from a scale on the brass sliding piece itself. This scale is divided into tenths of an inch, so that the error is given in a percentage of the whole length. The scale can be also used for estimating the judgment of the eye in dividing the strip of ebonite into thirds and quarters of its whole length. £0 18 0

Keenness of Hearing.

It is proposed to use an instrument which will make a certain sound of definite intensity. The results obtained however will no doubt be rough owing to the difficulty of obtaining silence, and the inherent difficulties of the case, but it is hoped that the instrument will be of use for Anthropometric purposes as well as to aurists. Further experiments are however necessary before this instrument is ready for issue.

Appreciation of difference in Musical Pitch.

The sound is produced by a closed organ pipe, and the pitch is varied by changing its length. An automatic arrangement has been adopted by which the sound is continued during one second, then there is silence during another second, then the sound is reproduced during a third second. During the interval of silence the length of the organ pipe admits of being varied by a known amount.

The instrument is used as follows:—A scale is adjusted to fix the amount of movement that can be given to the sliding plug in the organ pipe. This will allow two notes to be sounded differing by any number of hundredths of a semitone. When the scale is at zero the note sounded is Ut_4 (1024 single vibrations per second) and when at 100 it is Si_3 (966·5 single vibrations per second), that is, each division on the scale corresponds to a change of 0·575 complete vibrations per second. It is best to begin with an interval that can be easily appreciated. With the left hand a lever is raised and as soon as it touches the upper stop it is released; this operation charges the bellows with air and also starts the oscillating apparatus which opens the air passage at the intervals of time before stated. Shortly after the release of the lever the first sound is given; during the interval of silence a milled head can be turned with the right hand until the movement of the plug is stopped by the scale and the sound is either made sharper or flatter, or it need not be altered at all. If the person to be tested can, after several trials, distinguish between the notes either by saying they differ or by knowing which is the sharper, the interval between the two notes is reduced, until the limit of appreciation is found. Care has been taken to keep the air pressure constant during each experiment. ... ... From £12 0 0

Hearing highest audible Note.

This instrument consists of a whistle of very small bore with an arrangement for varying its length by an adjustable plug. It is sounded by squeezing air out of a small indiarubber bag. The whistle always makes two sounds at the same time, the

high musical note best described as a very shrill squeak and the noise made by the air leaving the mouth of the whistle. To apply the test the whistle is sounded and the length shortened until a point is reached when the squeak becomes inaudible. With a little practice this can be easily done; the length of the whistle is then measured by inserting a wedge-shaped ivory scale between a flange fixed to the plug itself and a flange on the whistle: the numbers engraved on the scale giving the length of the whistle in millimetres. The following table gives the number of vibrations per second of a column of air of different lengths, at a temperature of 15° C.

Length of Column of air in millimetres.	Number of complete vibrations per second by calculation.	Number of complete vibrations per second by experiment.
1·0	85,000	
1·2	70,830	
1·4	60,710	
1·5	56,670	
1·6	53,130	
1·8	47,220	
2·0	42,500	
2·5	34,000	
3·0	28,330	
3·5	24,290	
4·0	21,250	
5·0	17,000	
6·0	14,170	
7·0	12,140	
8·0	10,630	
9·0	9,440	
10·0	8,500	

The numbers in the second column are found by the following formula $n = \frac{\nu}{4\lambda}$.

n = no. of vibrations per second.

ν = velocity of sound taken at 340 metres per second.

λ = wave length.

The figures in the next column will be inserted when the experiments are completed. Care is taken to make all the whistles as nearly identical as possible.

Price complete in pocket case. £1 5 0

Reaction time to Sound and Sight.

This instrument is for measuring the interval of time between a signal and the depression of a key by the person observing the signal. The person sits down and rests his hand on a slab with his finger on a key. On hearing or seeing the signal, as the case may be, he presses the key as quickly as possible. The time is measured by the distance through which a rod has fallen and its amount is read off directly from graduations on the rod itself in hundredths of a second. To use the

instrument the attendant releases the rod by turning a milled head at the top of the instrument; this is carefully arranged to make no sound. The signal sound is given after the rod has fallen a definite distance by a weight which rests on the top of the rod being caught by a diaphragm. If a sight signal is required this weight is removed and the instrument is placed so that a bright light can be seen through a small aperture; the falling of the rod closes this aperture after it has fallen a definite distance. The depression of the key releases a catch which grips the rod firmly and brings it to rest. As it is impossible to destroy the momentum of the rod suddenly, an arrangement has been devised which reduces the error from this cause to an infinitesimal amount. An arrangement can be applied by means of which an electric circuit is broken at the moment the signal is given. Also an arrangement by means of which the catch for gripping the falling rod can be released by the breaking of an electric circuit. By these means the instrument can be used to measure the reaction time from an electric signal. It can also be worked from a distance which in some cases would be useful. The maximum period of time that can be measured by this instrument is three-tenths of a second.

It is proposed to design an instrument which will be able to measure a greater interval of time than three-tenths of a second.

Appreciation of slight differences of Weight.

See "On Apparatus for testing the Delicacy of Muscular and other Senses in different Persons" by Francis Galton, F.R.S. *Journal of the Anthropological Institute*, May 1883.

The instrument consists of a box containing ten trays which can be easily removed. Each tray contains three weights, identical in size and appearance but differing in weight from each other. The three weights in each tray form a series of gradually increasing weights, and the series in each tray differ in value. The weights form a geometrical series, thus :— Wr^0, Wr^1, Wr^2, Wr^3, &c.

It follows from Weber's law, that if a person can just appreciate the differences between two consecutive weights in this series, he can then also just appreciate the difference between any other consecutive pair.

The values adopted are $W = 1{,}000$ grains and of $r = 1{\cdot}01$.

The following are the values of the weights in each tray.

Tray	No.	2	contains	weight	Wr^0,	Wr^2,	Wr^4.
,,	,,	3	,,	,,	Wr^4,	Wr^7,	Wr^{10}.
,,	,,	4	,,	,,	Wr^6,	Wr^{10},	Wr^{14}.
,,	,,	5	,,	,,	Wr^1,	Wr^9,	Wr^{11}.
,,	,,	6	,,	,,	Wr^0,	Wr^6,	Wr^{12}.
,,	,,	7	,,	,,	Wr^0,	Wr^7,	Wr^{14}.
,,	,,	8	,,	,,	Wr^2,	Wr^{10},	Wr^{18}.
,,	,,	9	,,	,,	Wr^0,	Wr^9,	Wr^{18}.
,,	,,	10	,,	,,	Wr^1,	Wr^{11},	Wr^{21}.
,,	,,	12	,,	,,	Wr^0,	Wr^{12},	Wr^{24}.

Each weight has engraved in an inconspicuous manner the index of the power of r thus in

Tray No. 2 the weights have the numbers 0, 2, 4,
Tray No. 3 they have 4, 7, 10.

Thus the number of each tray is the difference of the powers of r in two consecutive weights in that tray.

To perform the test, Tray No. 6 is removed and the person is asked to arrange the weights in their order of heaviness; if this is performed correctly, No. 5 is taken and so on until a point is reached at which the person to be tested fails to put the weights in the right order. The number of the last tray correctly arranged is a measure of the dullness of the power of appreciating weight. Each tray has engraved on it the indices of r of its weights and also its number. ... £7 10 0

The following instruments are under consideration:

STANDARDS TINTS FOR THE COLOUR OF HAIR.
" " " " " SKIN.

The descriptions are given as a general guide and are not binding as to detail.

The prices are for prompt cash on delivery in Cambridge, and foreign orders should be accompanied by remittances or references to some established mercantile house in England for payment on presentation of Invoices.

The cost of packing and carriage is in all cases charged forward.

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