INSTRUCTIONS FOR ASSEMBLING AND OPERATING

The BENEDICT-ROTH METABOLISM APPARATUS

WARREN E. COLLINS INC.
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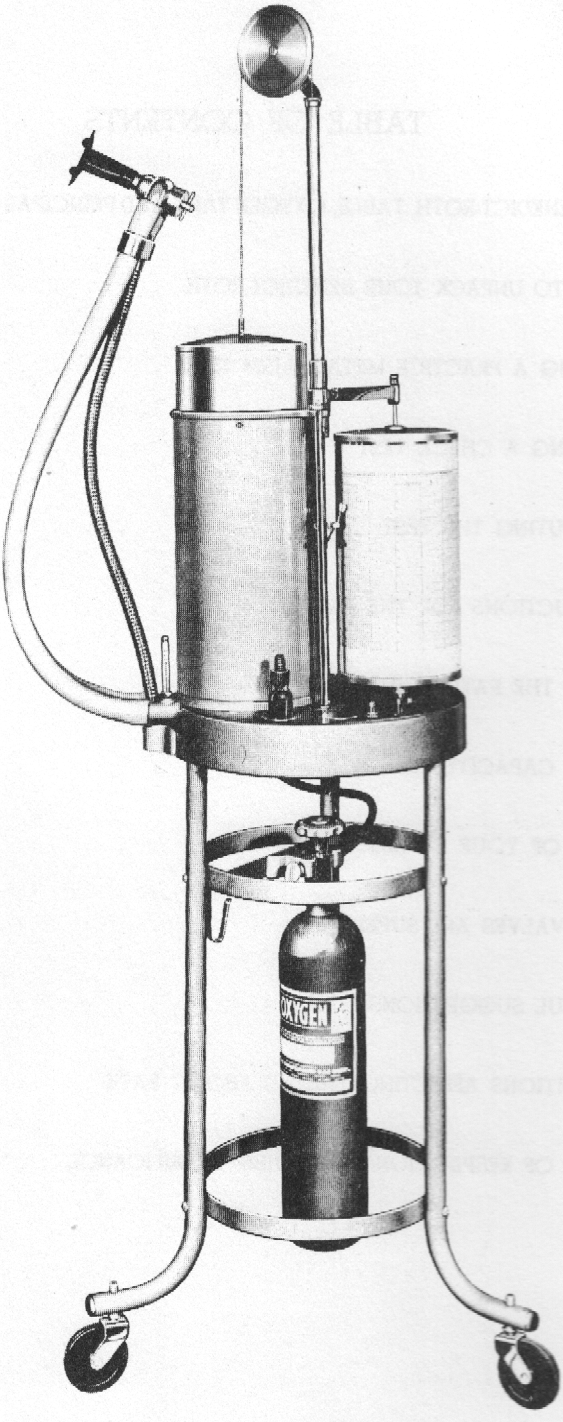


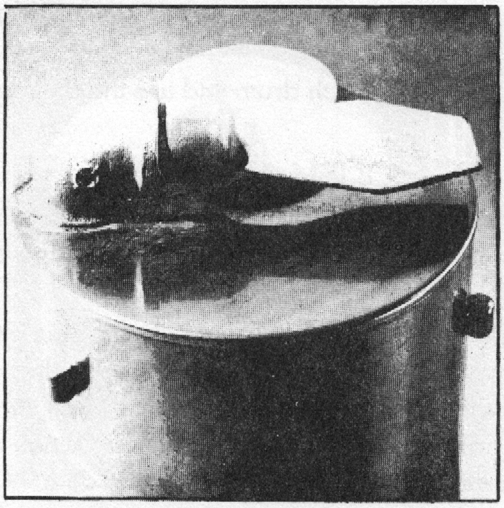
THE BENEDICT-ROTH, TABLE, OXYGEN TANK AND PRINCIPAL PARTS

HOW TO UNPACK YOUR BENEDICT-ROTH AND GET IT READY FOR USE

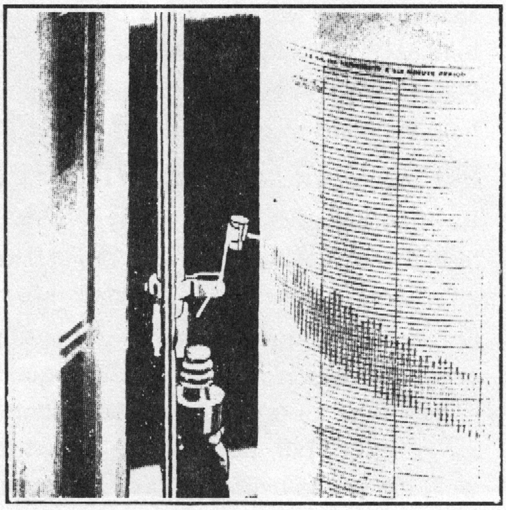
The Benedict-Roth Metabolism Apparatus comes complete in one fiber-board carton, the table in another and the oxygen in a third carton. All are packed so that they may be opened quickly and easily. The metabolism apparatus with all small accessories are packed in the carton which has a cardboard handle. Open the top and remove the small parts from the upper partition. Then grasp both partitions where they come together in the center of the box and lift them both out. Then remove the large inside carton which holds the machine in place. Now grasp the apparatus securely by the top of the kymograph support and the flexible arm which supports the breathing tubes and lift the machine out of the carton together with the wooden base to which it is attached. To remove the wooden base unscrew the wing nut located underneath and lift the apparatus from the base. To fasten the apparatus securely to the table, slide the threaded stud that is attached to the base of the metabolism apparatus through the hole located in the top of the table and replace the wing nut securely. Before attempting to remove the apparatus proper, unpack the small parts and check them with this list. You will find 3 rubber mouthpieces . . .; 1 nose-clip . . .; 1 bottle of ink . . .; 1 extra pen . . .; 1 roll of kymograph paper . . .; 1 box of stickers . . .; 1 leak tester . . .; 1 carton of soda lime . . .; 1 pen wire . . .; 1 barometer . . . (if ordered); 1 vital capacity mouthpiece with short rubber tubing for vital capacity readings . . .; 1 cloth cover . . .
Remove the wrapping and lift the corrugated paper from around the oxygen bell, then lift out the oxygen bell. The compensator-chain may be disconnected from the bell by raising the little outside cap, and sliding the last bead out of the slotted knob.

FILLING SODA LIME CONTAINER

Lift out the folded paper on top of the soda lime container and packing at the sides. The soda lime container may be lifted out by the elbow to which the valve is attached. Re-



SODA LIME CONTAINER



PEN AND COUNTERWEIGHT

move the large rubber stopper and fill the container with the complete amount of soda lime received with the machine. If you will squeeze the top of the carton into a point, the lime will pour out easily without spilling. Replace the rubber stopper and put the container into the apparatus exactly the way you removed it. It will fall into place with a few turns.

Remove the string which secures the graphic record pen and also the counterweight and other moving parts.

Place the kymograph drum on the clock spindle; the top knob will lift up to accommodate the height of the drum.

Raise the telescoping pulley rod as high as it will go and slide the round headed stud into the slot to fix the pulley in place. Now the pulley chain may be attached to the bell. Place the outside cap on the chain first, then slip the bead into the slotted knob and drop the outside cap over this knob. This prevents the chain from becoming detached. Attach the rubber breathing tubes to the two openings at the base of the machine and place the bottle of ink in its holder and the leak tester around the ink bottle. Now the apparatus is ready to be filled with water.

FILLING WITH WATER

Raise the oxygen bell 3 or 4 inches and pour the water down the side of the bell. This will prevent spilling and will not allow the water to get into the inside of the apparatus. The water seal will take 5 pints of water to fill it to within 3 inches of the top. Ordinary tap water is quite satisfactory and should be used unless it is "hard" in which case distilled water would be preferable.

Fill the graphic pen with 5 or 6 drops of ink and use the cleaning wire to prime it for writing the first time. Moisten the wire with ink and insert it into the point of the pen, move it back and forth once or twice and you will find the ink flowing freely. The ink should not be washed out of the pen and it will always write easily without priming as long as it is kept filled with ink.

Place a sheet of kymograph chart paper on the kymograph drum and use the stickers to hold the chart in place.

PRELIMINARY WORK WITH THE METABOLISM APPARATUS

Now the Benedict-Roth is ready to go to work, but before making any actual metabolism tests it is advisable to make some trial tests so that you may get accustomed to the best procedure of handling it and know how each part functions.

Obviously, the prime purpose of the apparatus is to measure accurately the amount of oxygen a person consumes. Consequently, the first thing to determine is whether the apparatus is air-tight. The construction of a Benedict-Roth is such that air leaks almost never occur; but, nevertheless, a test for tightness is a prime requisite and since this will help you to become more familiar with the apparatus, now is the time to do it — before you use it on anyone.

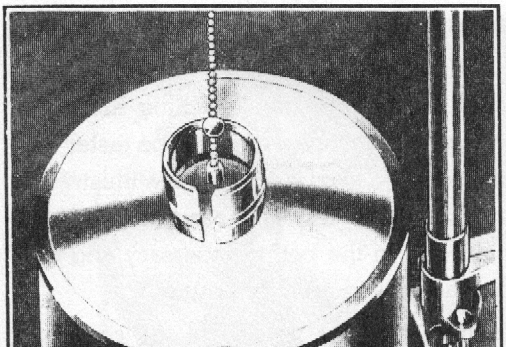
TESTING FOR TIGHTNESS

Turn the free-breathing valve so that its handle is at right angles to the breathing tubes. Raise the oxygen bell (by lifting gently on the chain) 5 or 6 inches. Turn the valve in its opposite position (with handle in line with flexible arm). Be sure oxygen inlet valve is closed. Place the leak tester weight on top of the oxygen bell and set pen against kymograph chart. After 2 or 3 minutes, observe if the pen is in the same position vertically. If it has changed its position more than 2 mm. vertically, run the chart a complete revolution (15 minutes) and see if the pen does not finally come back on its original tracing.

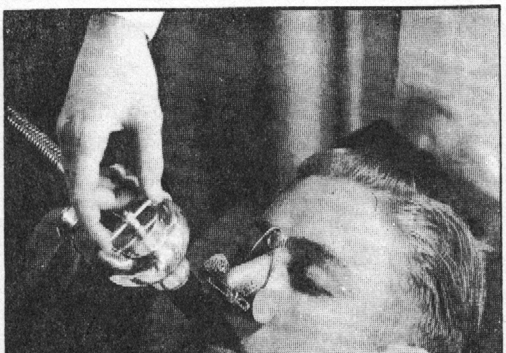
In case you find that there is a slight leak as shown on the kymograph chart, examine the rubber tubing connections.where they join the apparatus and the two-way valve and make sure that they are tight. After you have examined all connections and made sure that everything is quite secure, make the leak test once more and the apparatus should be air-tight. If there is any doubt leave the apparatus standing under test over night. If the bell is not at its lowest position in the morning the apparatus is air-tight beyond a question of doubt.

SEE FOR YOURSELF HOW EASY IT BREATHES

It is advisable for you to know how the machine operates and how it feels to be breathing into it. Admit a little oxygen until the bell is half filled. Take the outlet of the free-breathing valve in your mouth, hold your nose with your fingers and breathe in and out for a minute or two. Notice how easily the apparatus breathes. Observe that each time you exhale, the oxygen bell rises and with each inhalation it falls. At the same time, the pen is recording your respirations and, later on, these are going to be the basis of the metabolism test.



TESTING FOR LEAKAGE



MOUTHPIECE — NOSECLIP — VALVE

MAKING A PRACTICE METABOLISM TEST

By this time you should be sufficiently familiar with the Benedict-Roth to proceed with your first metabolism test, but it should be a "make-believe" test on your assistant, or a friend — anyone who will cooperate for the purpose of giving you real, practical experience in the procedure. In this case, the pseudo-patient does not have to conform to the basal conditions that prevail in a bona fide test (explained later) and consequently this test can be made in the middle of the afternoon or any time convenient to both parties. Prepare the apparatus by putting on a fresh chart, sterilize a rubber mouthpiece and fill the pen with ink. Then have the "patient" lie down on a couch or bed and make her comfortable with one or two pillows.Turn the two-way valve handle so that the patient will breathe room air when first connected to the apparatus. Admit oxygen into the apparatus until the pen comes within 2 inches of the bottom of the paper, on the first vertical time line. Now adjust the flexible arm so that the rubber mouthpiece comes near her mouth and explain that the mouthpiece should be inserted so that the flange is between the gums and the lips and the two tabs between the upper and lower teeth. Apply noseclip so that the sponge rubber pads are well down on the nostrils, press them together firmly but gently and adjust the thumb-screw to hold the noseclip in this position. Ask your patient to try to exhale slightly through her nose. If she can do this, the noseclip is not tight enough and should be readjusted until this is impossible. Also ask the patient if the noseclip is uncomfortable before proceeding with the test. Now the "patient" is breathing room air through the slot in the free-breathing valve. Turn the valve handle in its opposite position. This connects the patient to the breathing circuit of the machine so that from now on the oxygen bell should be moving up and down with each exhalation and inhalation, and the pen similarly. At any convenient time, set the clock in motion by moving its starting lever. Allow the test to run about 3 minutes and as the pen crosses the 3rd time line, place the leak tester weight on top of the bell and leave it there until the pen crosses the next time line; then remove it and allow the test to continue another 3 or 4 minutes.

In case there is a slight leak around the noseclip, mouthpiece or breathing tube connections, this added weight on top of the bell will cause the oxygen to escape faster and you will notice that the patient's respirations will assume a steeper angle (see illustration on page 15). If leakage shows on your tracing, stop the test and readjust noseclip, mouthpiece and tubing connections. Put more oxygen in the bell if necessary and proceed with the test. Be sure to make the test for leakage again after 3 minutes.

Seven or 8 minutes is long enough for a metabolism test on a Benedict-Roth, so to end the test turn the free-breathing valve back to the room air connection (this will keep the oxygen from escaping and allow you to use it for the second or check test). Shut off the clock, remove mouthpiece and noseclip.

At the start of the test, make a note of the thermometer reading and again at the end of the test. If there is any difference in the readings, take an average of the two. Also take a barometer reading.

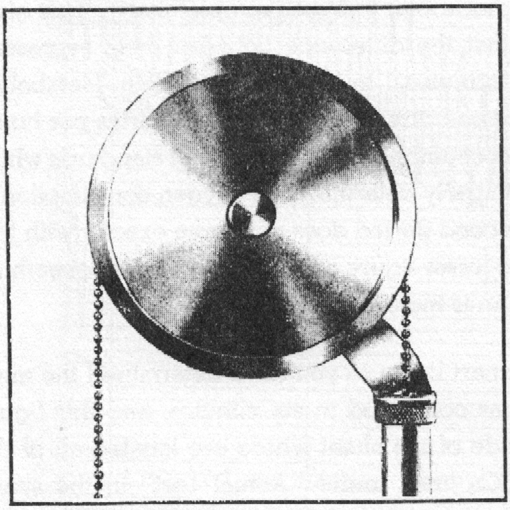
RUNNING A CHECK TEST

No matter how satisfactory this first test may appear, it is always a sign of good technique to check it with a second test just to verify the first result. This is very important and cannot be over-emphasized particularly when you start on real patients because one metabolism test without the verification of a second check test cannot possibly have unquestionable proof of accuracy. For your own satisfaction and protection, as well as for the patient's best interests, two periods should always be run on every patient.

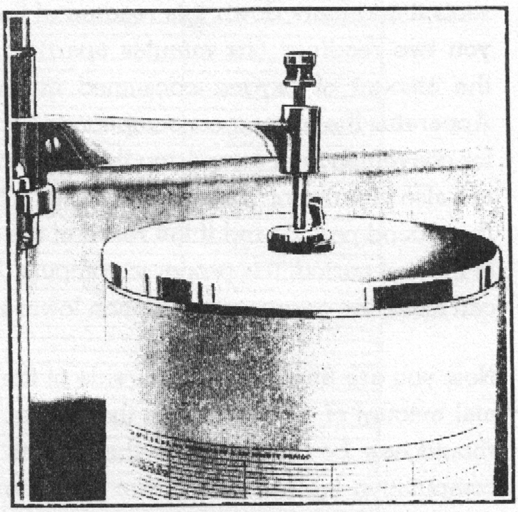
ADVANTAGE OF LARGE KYMOGRAPH DRUM

No other metabolism apparatus can do this so conveniently as the Benedict-Roth because it alone has a large enough kymograph drum to accommodate even 3 periods on the same sheet of paper. So, after waiting 3 or 4 minutes after the end of the first period, prepare to run the second period. Proceed as before, but use the same sheet of paper, only start the test 2 or 3 minutes away from the beginning of the first period, so that the second period will not run into it. (See sample chart.) Don't forget to test for tightness by putting the test weight on top of the bell and don't forget to read the thermometer and barometer sometime during the period.

It may very well be that you will want to repeat all this several times and perhaps on several different "patients" on different days. That is a matter which you will have to decide for yourself depending upon whether the machine still feels "strange" or familiar to you. Once you have mastered the little technical details of making the patient comfortable, filling the apparatus with oxygen, applying the mouthpiece and noseclip, etc., you should feel confident to proceed with regular patients.



CHAIN-COMPENSATION



LARGE KYMOGRAPH

COMPUTING THE TEST

After you have obtained several good-looking records, that is, records which by their very appearance of regularity and similarity indicate that they show a reliable oxygen consumption, this would be a good time to determine what the metabolic rate is and thereby become familiar with the computation tables.

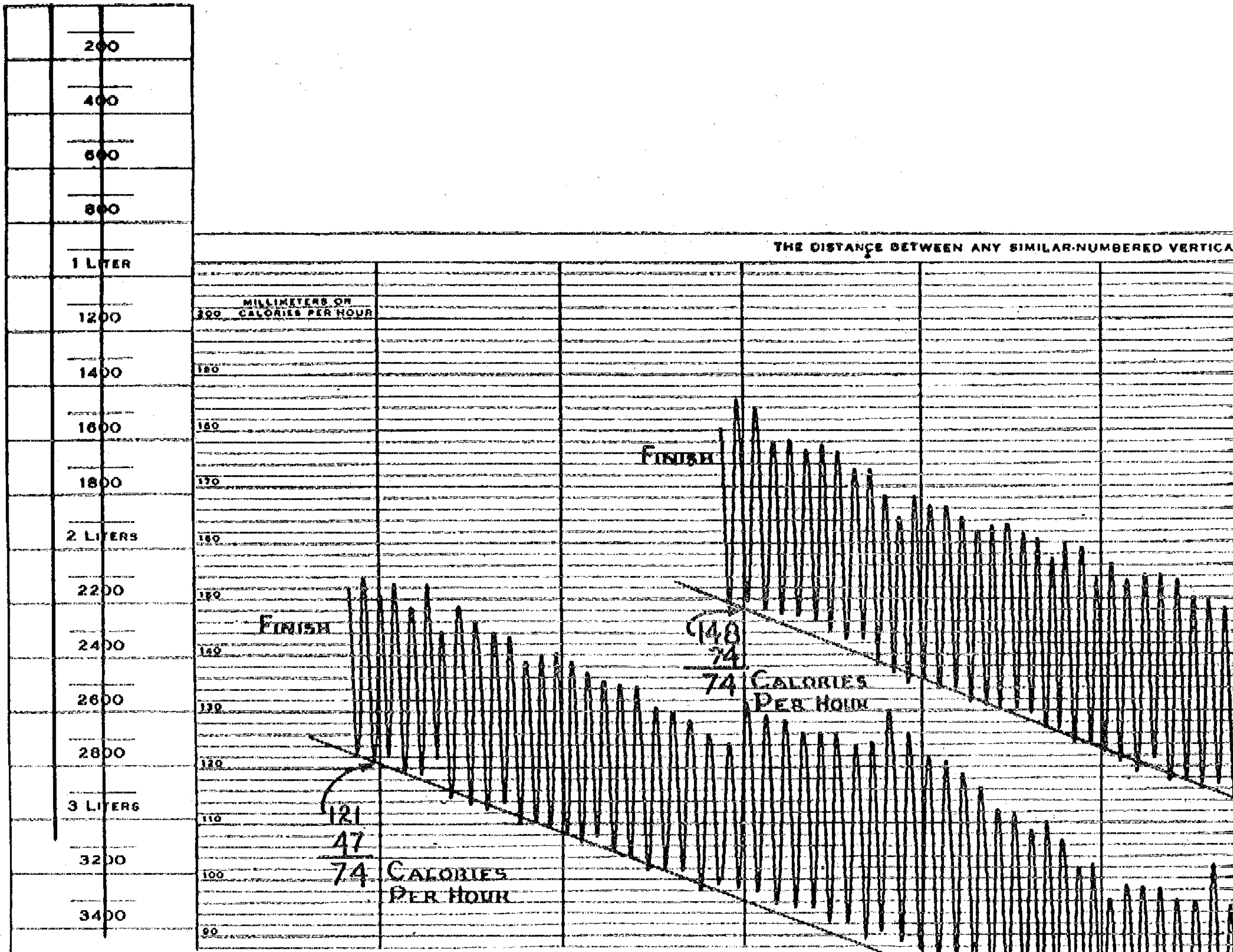
DRAWING THE O_2 LINE

Fundamentally, the purpose of the metabolism test is to measure the amount of oxygen which a patient consumes so that you may compare it with the normal amount which the patient should consume. The slope which the graphic record assumes on the chart becomes the index of the oxygen consumption. Consequently, remove the chart from the drum and lay it flat on a desk. Using a ruler, place it underneath the first period in such a way that you can draw a pencil line through a majority, or an average of the lower points. This line is called the O_2 line because it indicates the slope of the graph and the oxygen consumption. Similarly draw another line through the lower points of the second record. A good test will show these two lines to be parallel or practically so.

OBTAINING OXYGEN CONSUMPTION

Now notice where this O_2 line intersects the last time line of the graph and note the graduation which it intersects and mark down its value. Observe that this time line has a number at the bottom of it, and go back towards the beginning of this test period to the similar-numbered vertical time line, notice where the O_2 slope line intersects it and mark down this reading of the horizontal line (see sample chart). This gives you two readings (six minutes apart) so that the difference between them represents the amount of oxygen consumed in six minutes. In the Benedict-Roth Metabolism Apparatus the oxygen consumption is expressed directly in terms of "calories per hour" for convenience in comparing this oxygen consumption with the normal standards which are also in terms of "calories per hour". Similarly determine the oxygen consumption of the second period, and if the result of the second period does not agree exactly with that of the first period, it is proper to compute the lesser figure on the basis that almost nothing can make the oxygen consumption lower than is indicated on the chart.

Now you are through with this side of the chart because you have determined the minimal amount of oxygen which the patient has consumed in six minutes, and this figure should now be transposed to the reverse side of the sheet where are located all of the computation tables. Jot it down opposite "O_2 line" under "Actual Test" in the space reserved for computations.

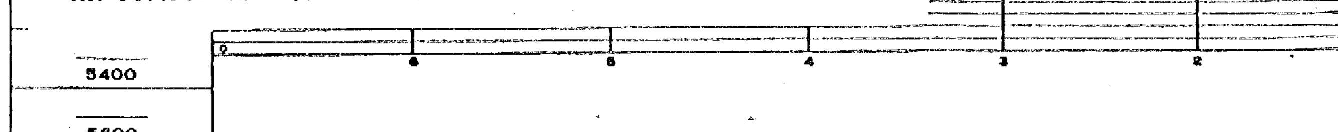


EXPLANATION

Run the test for 8 minutes and repeat after a few minutes rest with a second period to check the first. Selecting the best 6 minute section of each record draw a line through the bottom peaks. The slope of this line indicates the rate of oxygen consumption (in terms of calories per hour) which is easily read from the 6 minute lines which it intersects.

The beginning of these periods may frequently be irregular for a minute or two until the patient settles down to the new condition of breathing into the apparatus and should, therefore, be disregarded when locating the oxygen slope line. Whenever the two periods do not check exactly it is better to compute the lower result than to average them.

The computations of this record are illustrated in detail on the reverse side of this sheet.



VITAL CAPACITY CHART

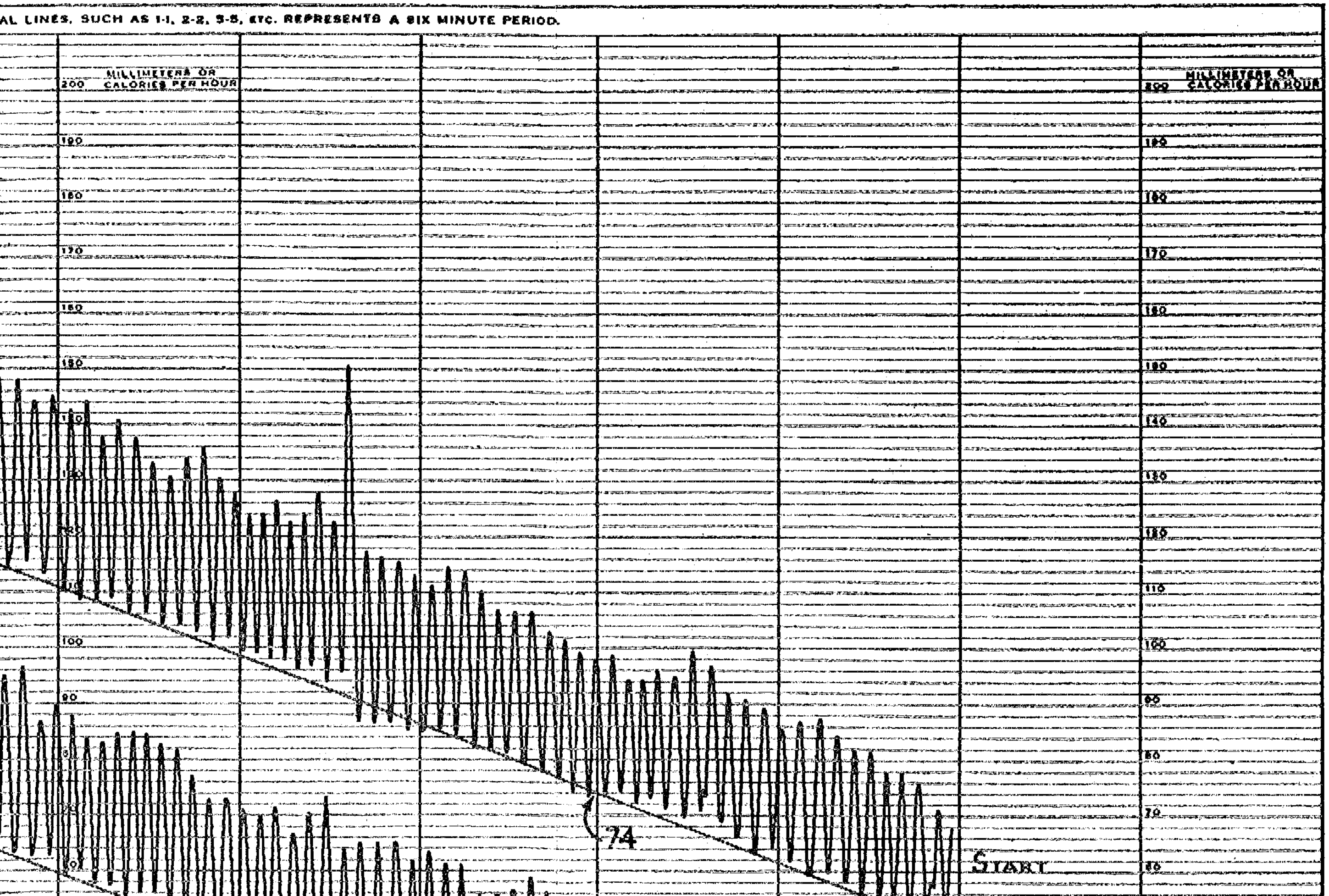

AL LINES, SUCH AS 1-1, 2-2, 3-3, ETC. REPRESENTS A SIX MINUTE PERIOD.
MILLIMETERS OR CALORIES PER HOUR
MILLIMETERS OR CALORIES PER HOUR
74
47
START
1ST PERIOD
START
2ND PERIOD

TABLE "C"

CORRECTION FOR TEMPERATURE AND PRESSURE

Temperature in degrees Centigrade

mm	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
600	.735	.732	.728	.725	.721	.718	.715	.712	.708	.704	.701	.697	.693	.689	.685	.681	.677	.673	.669	.665	.661
605	.742	.739	.735	.731	.727	.724	.721	.718	.714	.710	.707	.703	.699	.695	.691	.687	.683	.679	.675	.671	.667
610	.748	.745	.741	.737	.733	.730	.727	.724	.720	.716	.713	.709	.705	.701	.697	.693	.689	.685	.680	.676	.672
615	.754	.751	.747	.744	.740	.737	.734	.730	.726	.722	.719	.715	.711	.707	.703	.699	.695	.691	.686	.682	.678
620	.760	.757	.753	.750	.746	.743	.740	.737	.733	.729	.725	.721	.717	.713	.709	.705	.701	.696	.692	.688	.684
625	.767	.764	.760	.756	.752	.749	.746	.743	.739	.735	.731	.727	.723	.719	.715	.711	.707	.702	.698	.694	.690
630	.773	.770	.766	.762	.758	.755	.752	.749	.745	.741	.737	.733	.729	.725	.721	.717	.713	.708	.704	.700	.696
635	.779	.776	.772	.768	.764	.761	.758	.755	.751	.747	.743	.739	.735	.731	.727	.723	.719	.714	.710	.706	.702
640	.785	.782	.778	.774	.770	.767	.764	.761	.757	.753	.749	.745	.741	.737	.733	.729	.725	.720	.716	.711	.707
645	.792	.788	.784	.781	.777	.773	.770	.767	.763	.759	.755	.751	.747	.743	.739	.735	.731	.726	.722	.717	.713
650	.798	.794	.791	.787	.784	.780	.777	.773	.769	.765	.761	.757	.752	.748	.744	.740	.736	.732	.727	.723	.719
655	.804	.800	.797	.793	.790	.786	.783	.779	.775	.771	.767	.763	.758	.754	.750	.746	.742	.738	.733	.729	.724
660	.810	.806	.803	.799	.796	.792	.789	.785	.781	.777	.773	.769	.764	.760	.756	.752	.748	.744	.739	.735	.730
665	.816	.812	.809	.805	.802	.798	.795	.791	.787	.783	.779	.775	.770	.766	.762	.758	.754	.749	.745	.741	.736
670	.822	.819	.816	.812	.809	.805	.801	.797	.793	.789	.785	.781	.776	.772	.768	.764	.760	.755	.751	.746	.742
675	.828	.825	.821	.818	.815	.811	.807	.803	.799	.795	.791	.787	.782	.778	.774	.770	.765	.761	.757	.752	.748
680	.834	.831	.827	.824	.821	.817	.813	.809	.805	.801	.797	.793	.788	.784	.780	.776	.771	.767	.763	.758	.754
685	.841	.837	.833	.830	.827	.823	.819	.815	.811	.807	.803	.799	.794	.790	.786	.782	.777	.773	.769	.764	.760
690	.848	.844	.841	.837	.833	.829	.825	.821	.817	.813	.809	.805	.800	.796	.792	.788	.783	.779	.775	.770	.765
695	.854	.850	.847	.843	.839	.835	.831	.827	.823	.819	.815	.811	.806	.802	.798	.794	.789	.785	.780	.776	.771
700	.860	.856	.853	.849	.845	.841	.837	.833	.829	.825	.821	.817	.812	.808	.804	.800	.795	.791	.786	.781	.777
705	.866	.862	.859	.855	.851	.847	.843	.839	.835	.831	.827	.823	.818	.814	.810	.806	.801	.796	.792	.787	.783
710	.872	.868	.865	.861	.857	.853	.849	.845	.841	.837	.833	.829	.824	.820	.816	.812	.807	.802	.798	.793	.788
715	.878	.874	.871	.867	.863	.859	.855	.851	.847	.843	.839	.835	.830	.826	.822	.818	.813	.808	.804	.799	.794
720	.885	.881	.877	.873	.869	.865	.861	.857	.853	.849	.845	.841	.836	.832	.828	.824	.819	.814	.810	.805	.800
725	.891	.887	.883	.879	.876	.872	.867	.863	.859	.855	.851	.847	.842	.838	.834	.830	.825	.820	.816	.811	.806
730	.897	.894	.890	.886	.882	.878	.874	.869	.865	.861	.857	.853	.848	.844	.840	.836	.831	.826	.822	.817	.812
735	.904	.900	.896	.892	.888	.884	.880	.875	.871	.867	.863	.859	.854	.850	.846	.842	.837	.832	.827	.822	.817
740	.910	.906	.902	.898	.894	.890	.886	.881	.877	.873	.869	.865	.860	.856	.852	.848	.843	.838	.833	.828	.823
745	.916	.912	.908	.904	.900	.896	.892	.887	.883	.879	.875	.871	.866	.862	.857	.853	.848	.844	.839	.834	.829
750	.922	.918	.914	.910	.906	.902	.898	.893	.889	.885	.881	.877	.872	.868	.863	.859	.854	.849	.845	.840	.835
755	.928	.924	.920	.916	.912	.908	.904	.899	.895	.891	.887	.883	.878	.874	.869	.865	.860	.855	.851	.846	.841
760	.934	.930	.926	.922	.918	.914	.910	.905	.901	.897	.893	.889	.884	.880	.875	.871	.866	.861	.857	.852	.847
765	.941	.936	.932	.928	.924	.920	.916	.911	.907	.903	.899	.895	.890	.886	.881	.877	.872	.867	.863	.857	.852
770	.947	.943	.939	.935	.930	.926	.922	.917	.913	.909	.905	.901	.896	.892	.887	.883	.878	.873	.869	.863	.858
775	.954	.949	.945	.941	.936	.932	.928	.923	.919	.915	.911	.907	.902	.898	.893	.889	.884	.879	.875	.869	.864
780	.960	.956	.952	.948	.943	.939	.935	.930	.926	.921	.917	.913	.908	.904	.899	.895	.890	.885	.880	.875	.870

TABLE "B"

THE DUBOIS NORMAL STANDARDS

as Modified by

BOOTHBY AND SANDIFORD

(From The Mayo Clinic) Prelim. Report: Am. J. Physiol. 1929, 90,291

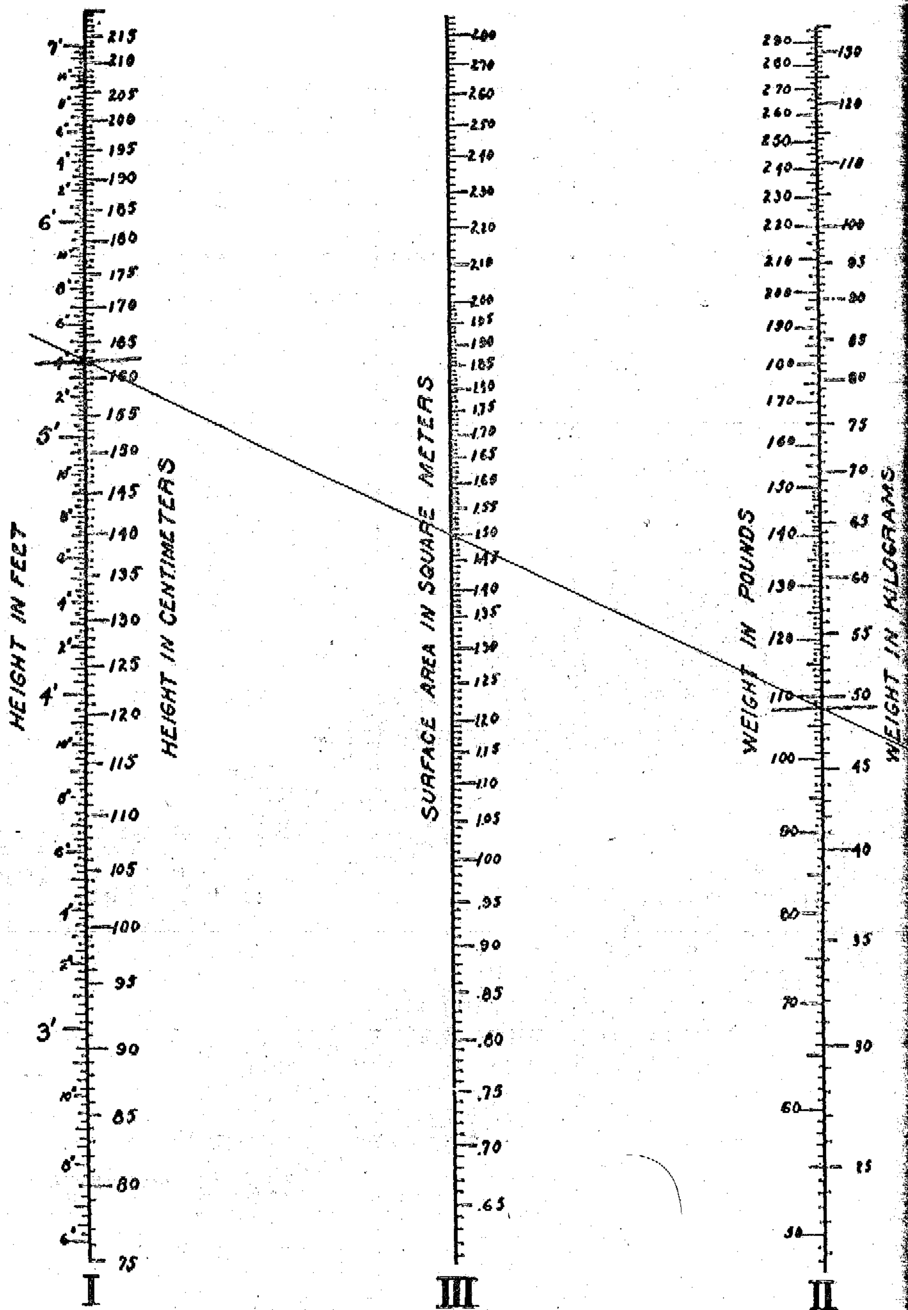
CALORIES PER SQUARE METER PER HOUR

Age	Males	Females	Age	Males	Females
5	(53.0)	(51.6)	20-24	41.0	36.9
6	52.7	50.7	25-29	40.3	36.6
7	52.0	49.3			
8	51.2	48.1	30-34	39.8	36.2
9	50.4	46.9	35-39	39.2	35.8
10	49.5	45.8	40-44	38.3	35.3
11	48.6	44.6	45-49	37.8	35.0
12	47.8	43.4			
13	47.1	42.0	50-54	37.2	34.5
14	46.2	41.0	55-59	36.6	34.1
15	45.3	39.6	60-64	36.0	33.8
16	44.7	38.5	65-69	35.3	33.4
17	43.7	37.4			
18	42.9	37.3	70-74	(34.8)	(32.8)
19	42.1	37.2	75-79	(34.2)	(32.3)

TABLE "A"

DUBOIS BODY SURFACE CHART

(As prepared by Boothby and Sandiford of the Mayo Clinic)



THIS CHART FOR USE WITH BENEDICT-ROTH RECORDING METABOLISM APPARATUS, MADE BY WAR

DIRECTIONS

With the computation tables on this sheet it is possible to compute the Basal Metabolic Rate of any patient from 5 to 80 years of age according to the DuBois method, as modified by Boothby and Sandiford of the Mayo Clinic.

To determine the NORMAL use Table A and draw a line through the patient's height found in column I and through the weight in column II. Using a straight edge (ruler) draw a line between these two points and read the BODY SURFACE AREA where this line intersects column III. Transfer this body surface figure opposite "Column III" in the space for computations. Then refer to table B and using the patient's age (nearest birthday) and sex read the calories per square meter per hour. Transfer this figure beside "Table B" in space for computations. Multiply III x B which will give the total NORMAL CALORIES PER HOUR—the exact normal for a person of this height, weight, age and sex.

To determine the ACTUAL TEST, transfer the difference in height of the 6 minute test period (from kymograph tracing on the reverse side) to the space provided for it opposite O line. Next record the temperature of the oxygen bell (from the thermometer) and the prevailing barometric pressure in millimeters. Using table C draw a circle around both the temperature and the barometer readings and at the intersection of these two columns you will find the correction factor. Transfer this figure opposite "Table C" in space for computations. Multiply O line by table C which will give the total ACTUAL TEST CALORIES PER HOUR.

Now you have the NORMAL oxygen consumption determined from the tables and the ACTUAL oxygen consumption as found by the TEST both in terms of calories per hour.

To find the BASAL METABOLIC RATE from these two figures (i.e. the relation of one to the other in terms of per cent) simply subtract the smaller figure from the larger, then divide the difference ALWAYS by the normal. This will give you a decimal fraction which when multiplied by 100, or by moving the decimal point two figures to the right, gives the Basal Metabolic Rate in per cent. To determine whether this per cent is plus or minus, simply note whether the ACTUAL TEST is greater or less than the NORMAL. If greater than the Normal the result is plus and if less than the Normal the result is minus.

REN E. COLLINS, Inc., 220 Wood Road, Braintree, Mass. 02184

COMPUTATIONS AND DATA

Name *Miss N.W.* Date *March 12, 1962*

Address *16 Wilson Road, Boston*

Age *49* Yrs. *4* Mo. Height *5' 4"* Weight *108 lbs*

Temperature *20* Barometer *750*

NORMAL		ACTUAL TEST	
Column III =	*1.50*	O_2 Line =	*74*
Table B =	*35*	Table C =	*.902*
	75		*148*
	45		*6660*
III × B =	*52.5*	O_2 Line × C =	*66.748*

Subtract smaller from larger; Divide difference by normal

66.75
52.50
14.25

52.5) 1425 = .2714
1050
3750
3675
750
525
2250

BASAL METABOLIC RATE IS *+27 %*

ADD HERE ANY OTHER DATA OF INTEREST SUCH AS

Pulse *72 - 70*

Body Temperature *98.0*

Blood Pressure *110 - 80*

COMPUTING THE TEST

After you have obtained several good-looking records, that is, records which by their very appearance of regularity and similarity indicate that they show a reliable oxygen consumption, this would be a good time to determine what the metabolic rate is and thereby become familiar with the computation tables.

DRAWING THE O_2 LINE

Fundamentally, the purpose of the metabolism test is to measure the amount of oxygen which a patient consumes so that you may compare it with the normal amount which the patient should consume. The slope which the graphic record assumes on the chart becomes the index of the oxygen consumption. Consequently, remove the chart from the drum and lay it flat on a desk. Using a ruler, place it underneath the first period in such a way that you can draw a pencil line through a majority, or an average of the lower points. This line is called the O_2 line because it indicates the slope of the graph and the oxygen consumption. Similarly draw another line through the lower points of the second record. A good test will show these two lines to be parallel or practically so.

OBTAINING OXYGEN CONSUMPTION

Now notice where this O_2 line intersects the last time line of the graph and note the graduation which it intersects and mark down its value. Observe that this time line has a number at the bottom of it, and go back towards the beginning of this test period to the similar-numbered vertical time line, notice where the O_2 slope line intersects it and mark down this reading of the horizontal line (see sample chart). This gives you two readings (six minutes apart) so that the difference between them represents the amount of oxygen consumed in six minutes. In the Benedict-Roth Metabolism Apparatus the oxygen consumption is expressed directly in terms of "calories per hour" for convenience in comparing this oxygen consumption with the normal standards which are also in terms of "calories per hour". Similarly determine the oxygen consumption of the second period, and if the result of the second period does not agree exactly with that of the first period, it is proper to compute the lesser figure on the basis that almost nothing can make the oxygen consumption lower than is indicated on the chart.

Now you are through with this side of the chart because you have determined the minimal amount of oxygen which the patient has consumed in six minutes, and this figure should now be transposed to the reverse side of the sheet where are located all of the computation tables. Jot it down opposite "O_2 line" under "Actual Test" in the space reserved for computations.

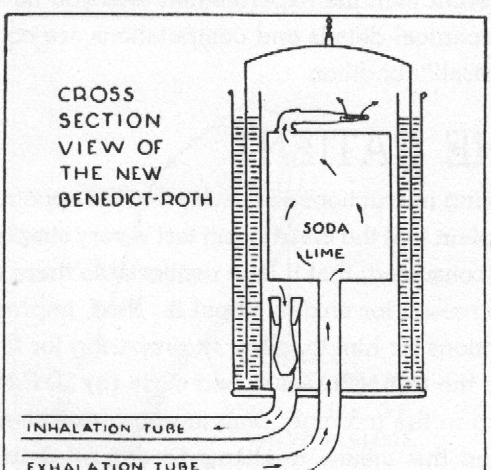
CORRECTIONS FOR TEMPERATURE AND BAROMETER

At this point you should recall a little of your high school or college Physics and bear in mind, first, that this volume of oxygen consumed was at a comfortable temperature and at the barometric pressure prevailing during the test; and second, in order to compare one volume of any gas (the actual test) with another volume of gas (the NORMAL) they must be at the same temperature and the same barometric pressure. Because O°C. and 760 mm. have been universally accepted as the standard temperature and pressure at which volumes of gases are compared and because the normal standards were originally worked out on this basis, consequently it is necessary to correct the oxygen consumption for temperature and pressure.

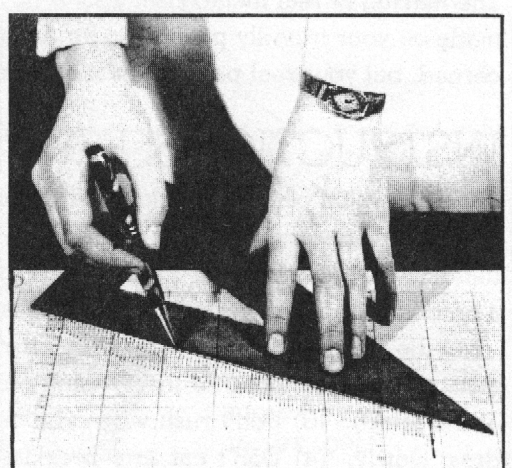
Fortunately, this is even easier to do than it is to explain, so that if you will refer to Table "C," mark a circle around the temperature corresponding to the reading of the thermometer during the test, and mark another circle around the nearest barometer reading. The intersection of the horizontal figures (opposite the barometer reading) with the vertical figures (underneath the temperature reading) gives the decimal number by which the O_2 line figure should be multiplied in order to correct the oxygen consumption to O°C. and 760 mm. This new corrected figure should always be less than that of the O_2 line. In other words, the purpose of all this is to get the oxygen consumption down to that amount which would have been consumed if we were able to make metabolism tests at O°C. and 760 mm.

OBTAINING NORMAL OXYGEN CONSUMPTION

So much for the actual test, and now we must determine whether the patient consumed more, or less, or just the right amount of oxygen; and how much more or less in terms of per cent. To do this you must realize that any person of a known height and weight, and age and sex should consume a definite amount of oxygen. Many years of research



DIRECTION OF RESPIRATIONS



DRAWING SLOPE LINE

by Benedict, Roth, Aub, DuBois, Dryer, Boothby and others have made these tables of normal oxygen consumptions available, and Tables B and C on the reverse side of the Benedict-Roth kymogragh chart are generally considered as reliable as our present knowledge of metabolimetry makes possible. Refer to Table C, locate the height and weight on it and draw a line between them which will intersect the middle column at a figure which represents the body surface in square meters. Transpose this result opposite "Column III" under NORMAL.

Next refer to Table B, locate patient's age (using nearest birthday) and find the factor under the proper sex. Transpose this figure opposite Table B under NORMAL. This represents Calories per hour per square meter of body surface so that if you multiply these two figures you will obtain the NORMAL amount of oxygen which this patient **should** consume.

HOW TO GET THE BASAL METABOLIC RATE

Now you have the normal oxygen consumption for this patient and the ACTUAL oxygen consumption from the test. To determine the B.M.R. in per cent subtract the smaller from the larger and always divide this difference by the NORMAL. This will give a decimal fraction which when multiplied by 100 gives the B.M.R. in per cent. If the ACTUAL is larger than the NORMAL the result will be plus, if less it will be minus.

Further reference to the sample chart in this book will show the computations in detail, and you should study it until you understand it thoroughly. Observe carefully that the computations involve only two simple multiplications, one subtraction and one simple division.

MAKING REAL METABOLISM TESTS

The making of real metabolism tests is no different than the experimental tests you have made on your friendly patient, so far as the technical details and computations are concerned, but your real patients must be in a "basal" condition.

INSTRUCTIONS FOR THE PATIENT

This means that patients should have the following instructions on the day that the appointment for the metabolism test is made. First, explain that the metabolism test is very simple, that it simply measures the amount of oxygen consumed, that it is so comfortable there is a tendency to fall asleep, and that there is no reason for anxiety about it. Next, impress upon the patient that there are special instructions for him to follow in preparing for the test. (1) Eat a light dinner the evening before the test. (2) Get to bed early (by 10 P.M. at the latest). (3) Don't rush when you get up in the morning, omit morning exercises, dress slowly. (4) Don't eat **any** breakfast and this means **nothing to eat or drink** whatsoever except water. (5) Come to the office (or wherever the test is to be made) with as little exertion as possible.

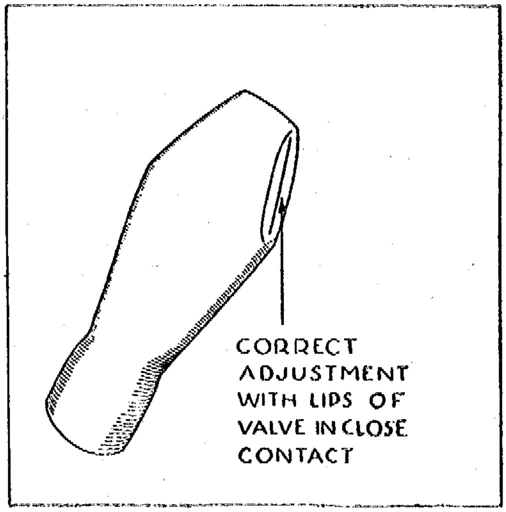
AFTER THE PATIENT ARRIVES

When the patient arrives, greet him cheerfully, ask him if he is sure he did not have breakfast this morning, and show him to the place where he is to lie during the metabolism test. Regardless whether metabolism tests are made in the hospital or in the office, the surroundings should be as quiet and as free from disturbing noises as possible. In the hospital this requirement is usually easily attained; but in the office it might be desirable to use an ante-room, or set off a space with a folding screen.

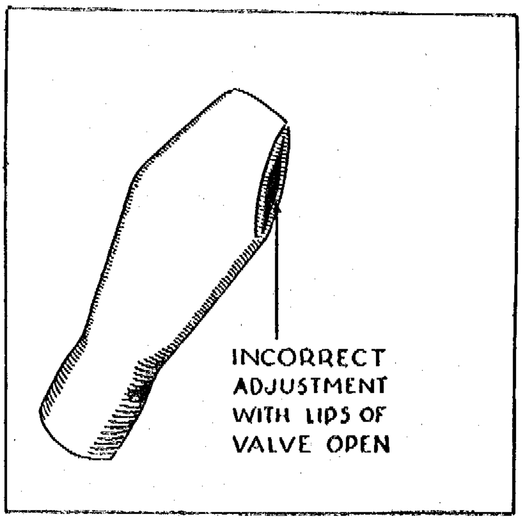
Always have the metabolism room comfortably warm, have a few blankets handy and two or three pillows. Be sure that all tight clothing, girdles, belts, collars, etc., are loosened and have patient remove shoes. After the patient has rested for one-half hour you are ready to proceed with the metabolism test. Be sure you have attached a sterile rubber mouthpiece to the machine, that there is a fresh chart on the kymograph drum, and that the pen is filled with ink and ready to write.

Fill the apparatus with oxygen; make the patient comfortable by adjusting pillows the way he likes them, show patient how the rubber mouthpiece fits the mouth (frequently they prefer to put the mouthpiece in their own mouths without assistance); and apply noseclip properly. Now turn the free-breathing valve so that the patient is breathing into the apparatus; start the clock and continue as you did in your experimental tests.

Don't forget — (1) After the test has run 3 minutes, place the leak tester weight on the bell for 1 minute; then take it off and continue for 3 minutes more. (2) Don't forget to note the temperature and barometer during the test. (3) Don't forget to run a second period for "check" purposes.



CORRECT



INCORRECT

After the test take the patient's height (in stocking feet) and weight (make allowance for clothes). Either before or after the test it is advisable to take febrile temperature, pulse rate and blood pressure. As a very nice little courtesy, offer your patient a cup of coffee, or bouillon, with crackers after the test.

The computation of these real metabolism tests will be identical in every respect with the experimental tests you have made and the sample chart.

VITAL CAPACITY READINGS

It is now a simple matter to obtain accurate vital capacity readings on your Benedict-Roth Metabolism Apparatus. At the left hand end of each kymograph sheet is a vital capacity chart divided into liters and tenths of liters.

To make a test, first open the two-way breathing valve at the mouthpiece assembly so that it is connected to the apparatus — not room air. Raise the flexible arm with breathing tubes and valve to its highest point so that when standing in front of the apparatus the open end of the free-breathing valve is pointing directly at you.

Now connect one end of the short rubber tubing which comes with the apparatus to the open end of the two-way valve and insert the vital capacity mouthpiece into the other end. Be sure the spirometer bell is down at its lowest point. Fill the pen with ink and turn the kymograph chart so that the writing point of the pen is inside the limits of the vital capacity chart. Be sure to lift the kymograph drum from the clock whenever changing its position. Forced movement of the clock mechanism either way may be harmful.

With the patient standing, have him take a full breath, filling the lungs to the utmost, close off the nostrils with the thumb and forefinger and exhale into the apparatus. The pen will make a straight line downward as the bell rises to the height of the exhalation. After the exhalation peak has been reached, the bell will sink and the pen return to its starting point. Two or three readings should be taken.

To determine the patient's normal, it is recommended that Dr. West's formula be used. This is determined by multiplying the body surface in square meters by 2500 cubic centimeters for men and by 2000 cubic centimeters for women. Table A on the reverse side of the kymograph chart enables you to obtain the body surface area easily.

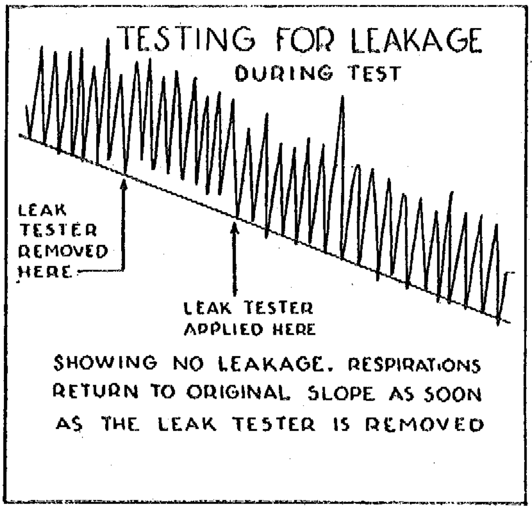
CARE OF YOUR BENEDICT-ROTH

Good metabolism tests are dependent upon (1) good care of the apparatus and (2) a sympathetic technician to operate it intelligently.

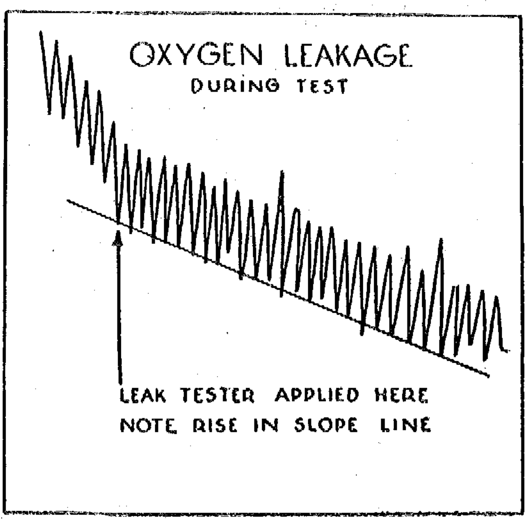
The Benedict-Roth itself requires little care. Keep it dusted and "shined up". After the day's tests raise the spirometer bell above the water seal and disconnect the breathing tubes. This will allow the apparatus to air out and will prevent moisture of condensation from collecting in the machine. Whenever you change soda lime (usually after 50–70 individual test periods, or 25–35 patients) wipe out the inside of the chamber clean and dry. Also examine the respiratory valves, especially the one underneath the soda lime can, and see that they are in good condition. Notice that the lips of the valves should just barely come together but not gap open perceptibly at the two lateral slits. Once a month the rubber breathing tubes should be removed completely and scrubbed inside and out with soapsuds and a long-handled brush, then rinsed with scalding water and hung up to dry. Similarly the 2-way breathing valve should be rinsed with scalding water, but do not allow it to stand in water — just allow the hot water to run through it. Rubber mouthpieces should be sterilized by boiling for 3 minutes and wrapped in a napkin or paper towel until just before placing it in the patient's mouth. The noseclip should be scrubbed occasionally.

Just as a matter of information, there is no danger of transmission of bacterial infection from one patient to another by breathing into the apparatus. This is because the soda lime acts as an efficient scrubber, and the inhalations do not pass through the same breathing tube that the exhalations pass through. Of course, if you should have a case of an offensive character, you should take extra precautions to "air" the apparatus and give the breathing tubes an immediate bath and scrubbing before the next patient.

As time progresses you will appreciate more and more the advantages of the routine and regular care of your Benedict-Roth. It gives you an opportunity to check up on the condition of the whole machine — to see that the flutter valves are in good order, that the inside of the spirometer is free from excess moisture, etc.



NO LEAKAGE



SHOWING LEAKAGE

CARE OF SODA LIME

The purpose of the soda lime is to absorb the carbon dioxide from the expired air. One filling will last from 50 to 70 8-minute tests or 25 to 35 patients assuming 2 test periods for each patient. When refilling the container with fresh soda lime, fill it to within only one inch of the top of the can so that the rubber stopper will not press against it.

It is advisable to keep a record of the number of tests run on each change of soda lime, and if ever you should do a metabolism test in which the respirations at the end are faster and 2 or 3 times deeper than at the beginning, this is an indication that the soda lime is "used up" and should be changed before the next test.

Soda lime not only absorbs the patient's CO_2 but it also collects a certain amount of moisture from the exhaled air which decreases its efficiency. About once a week, remove the soda lime and place it in a shallow dish lined with towels. Place on a radiator or some warm place to dry for several hours. This not only removes excess moisture but presents fresh surfaces of contact to the exhaled air as well as preventing caking of the lime thereby making it last much longer.

INEFFICIENT SODA LIME

When the soda lime is no longer removing the CO_2 from the patient's exhaled air, it will show on the kymograph chart. Inefficient soda lime will produce respirations that are increasingly deeper and closer together. As it is very easy to recognize this condition you will find that this method of determining the efficiency of your soda lime is not only reliable but will allow you to obtain its maximum efficiency.

LOCATING LEAKS

On page 7, instructions were given for testing for leaks by placing the leak tester weight on top of the bell. Reference to the illustrations [page 15] shows what happens in your record first when there is no leak and second when there is. In the first case, the weight simply displaces the record to a higher level which is parallel to the rest of the record. In the second case, the weight causes the oxygen to escape faster at the source of the leak with the result that the record ascends more rapidly. Usually the leak occurs around the mouth or nose and further adjustment of the mouthpiece or noseclip will remedy it.

CARE OF THE PEN

We have found that it is no longer necessary to clean the pen after you are through using the apparatus for the day. In fact, better results have been obtained by leaving the pen full of ink even though you may not run another test for a week or so. In case the pen ever does clog, wash it thoroughly, then use a fine wire to clean out the writing point.

TESTING VENTILATION

At the time you are changing the soda lime, you should check the breathing qualities of the apparatus to see that the valves are functioning properly. Remove the breathing tubes from the free-breathing valve and exhale and inhale into each of them separately. You should be able to exhale very freely and inhale only with difficulty through one, and you should be able to inhale very freely and not exhale through the other. If these conditions do not prevail, it will be necessary to have new valves, but this should not occur before two years.

TIMING THE KYMOGRAPH

At regular intervals, the kymograph should be checked for time. Inasmuch as the drum is supposed to make one complete revolution in 15 minutes, start it going with the pen on one time line and see if it takes 15 minutes to return to the starting point. A difference of a few seconds is of negligible consequence.

CARE OF THE FLUTTER VALVES

Once the valves are adjusted properly, they require practically no attention at all. Fortunately, both inlet and outlet valves are located inside the circuit so that there can be no external leaks as might happen if you used a motor-blower. Just make sure that the lips of the valves just barely come together at the lateral slits and do not gap. This can be regulated by merely drawing the valve stem more or less over the metal holder until the proper adjustment is made. When properly adjusted, flutter valves will be absolutely noiseless and will not stick.

WHY VALVES ARE SUPERIOR

There is one flutter valve located at the beginning of the inhalation tube and another at the end of the exhalation tube on top of the soda lime container. Their purpose is to gently guide each respiration so that the inhalations are drawn from the pure oxygen in the bell and the exhalations will pass up through the soda lime to remove CO_2. In a properly designed and counterbalanced metabolism apparatus such as the Benedict-Roth, flutter valves provide natural, comfortable respirations and a motor-blower is not only unnecessary but would actually be a hindrance. Motor-blowers set up a positive and negative pressure which require effort on the part of the patient each time he breathes. Anything that requires effort on the part of the patient will raise his metabolic rate. Motor-blowers are noisy, vibrate and can cause both internal or external leakage as well as present electrical difficulties.

Flutter valves have none of the above objections and are silent and dependable at all times. Valves cannot leak, vibrate and do not require electric current to operate.

Like the Tissot Gasometer, which is still regarded as the most accurate apparatus for determining oxygen consumption, the Benedict-Roth uses silent, efficient flutter valves to gently guide each inhalation and exhalation.

HELPFUL SUGGESTIONS

WET SODA LIME

If the soda lime becomes damp or wet from the moisture in the patient's exhaled air or from water spilled inside the apparatus, pour the soda lime into a shallow pan and allow it to dry thoroughly.

WATER IN BASE OF APPARATUS

Condensation of the patient's breath will collect in the exhalation tube and the bottom of the apparatus. After every two or three tests or after you are through using the machine for the day, disconnect the exhalation tube where it joins the base of the machine and let it dry out. Also, remove the soda lime container and wipe out the inside of the apparatus with a dry cloth or sponge.

DIFFICULT BREATHING

Should your patient complain of difficulty in breathing, it is probably the result of one of two things. Either the soda lime is wet and packed down or the lips of a flutter valve have become stuck together. Occasionally, there may be some obstruction in the breathing tubes and it is a good idea to examine them also and to make the test for ventilation (see page 17) too.

OXYGEN BELL RUBBING

If the oxygen bell rubs against the side of the outside cylinder, it means that the apparatus is not level. This may be corrected. Even if the bell does rub, it will do no harm unless it makes a noise which irritates your patient.

FAST OR SLOW CLOCK

If the clock movement is turning the kymograph cylinder at too fast a rate, it will give you a low oxygen consumption reading. If, on the other hand, the clock is slow, it will give you a higher oxygen consumption than you should normally get.

HIGH READINGS

Tests that seem too high may be due to leaks around the noseclip or mouthpiece, an open oxygen petcock or a slow clock.

LOW READINGS

When unusually low readings occur, it is usually the result of oxygen leaking in through the oxygen petcock, inefficient soda lime or a fast clock movement.

SQUEAK IN COUNTERWEIGHT

Sometimes the two parallel rods which guide the fiber cross member at the bottom of the counterweight become bent and rub against the fiber. These rods can either be bent with the fingers or the nut loosened at the top and the rod turned until it no longer binds against the fiber cross bar.

BASAL CONDITION

It is obvious that, to obtain a true basal metabolic rate, your patient must be in a basal state, i.e., he must be at rest and relaxed and without nourishment. Under these conditions, we may consider the body machine as "running idle"—living on itself at minimal requirements to sustain its physiological processes. Mental relaxation is also important. Chilliness will raise the rate and the patient should be kept warm, especially the feet. Sedatives, especially narcotics, in ordinary doses lower the rate while tea or coffee usually increase it within the first hour after taking. The usual therapeutic doses of strychnine have no effect, nor does alcohol except for a slight rise in some cases. Thyroid and suprarenal extracts are, perhaps, the only drugs which increase the metabolic rate more than 10 per cent.

CONDITIONS AFFECTING THE METABOLIC RATE

It is now recognized that many conditions other than true hyper or hypothyroidism cause variations in the metabolic rate. The following list gives the most common conditions which influence the metabolism test and show an increased or decreased metabolic rate.

Increased Metabolic Rate in:

Hyperthyroidism
Exophthalmic Goiter
Thyroiditis
Adenoma with Hyperthyroidism (Toxic Adenoma)
Hyperpituitarism, Acromegaly, Gigantism
Leukemia: Lymphatic and myelogenous
Anemia, when severe
Malignancy, in about 30 per cent of cases
Hodgkin's Disease
Diabetes, when moderate
Acidosis, when severe
Arterial Hypertension
Fever: 7 per cent increase for each degree F. of rise of body temperature (DuBois)
Convalescence from wasting diseases, and rapid growth

Decreased Metabolic Rate in:

Hypothyroidism
Post-Thyroidectomy
Myxedema
Cretinism
Thyrogenous Obesity
Hypopituitarism
Hypophyseal Obesity
Hypo-adrenalism
Addison's Disease in about 15 per cent of cases
Undernutrition, Starvation
Epilepsy
Arterial Hypotension
Nephrosis

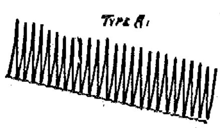
Normal Metabolic Rate in:

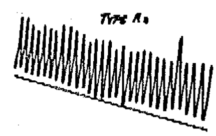
Obesity
Endogenous Obesity
Goiter (without abnormal thyroid function) Colloid Goiter
Adenoma, without Hyperthyroidism
Heart Disease per se
Nephritis, without Hypertension
Pregnancy, in most cases
Menstruation (slight increase in the premenstrual period)

TYPES OF RESPIRATIONS AND THEIR SIGNIFICANCE

Not only does the Benedict-Roth give an accurate determination of the Basal Metabolic Rate but it also shows the character of respirations. While this is a new and important advance in diagnosis, Drs. Nielson and Roth of the Battle Creek Sanitarium have already studied 20,000 spirograms and found that the majority fell under 10 different classifications. Each type was associated with fairly uniform symptoms and disorders which seemed to be characteristic with that particular type of respiration.

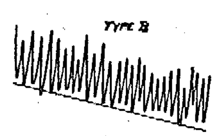
The following number of spirograms have been reprinted to aid you in the diagnosis and treatment of the various conditions which have their effect on the basal metabolic rate.





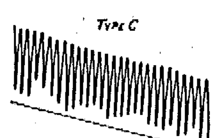
Type **A** is almost identical with a normal respiration. It is characterized by a fairly regular inspiratory (upper) line and a regular expiratory (lower) line. In addition, there is a slight pause at the end of each expiration. There are two subtypes (**A** and A^2), the second showing more irregularity than the first.

Type **A** is the normal and serves as the control. It may be the precursor of others when sufficient cause arises to alter the type. There is hardly a disease process incompatible with a normal type of respiration, but other factors, e.g., puberty or chemical changes of the blood, may incur to bring about a change.



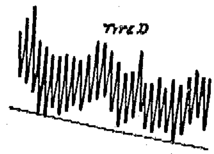
Type **B** is determined by an irregular irregularity of the inspiratory and expiratory lines, especially the former; otherwise it is like the irregular type **A** (A^2).

Type **B** may arise by a dynamic process in the endocrine system. Its most common associations are with types **A** and **H**. Conditions which occur in this type considerably oftener than in the normal type are: hypotension, neurotic and psychotic states, mucous colitis and endocrine disturbances.



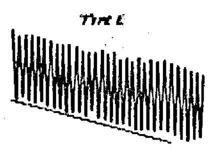
Type **C** is an inverted type. The inspiratory line is practically straight, while the expiratory line is somewhat irregular. The slight pause in each respiration occurs at the end of inspiration instead of at expiration.

Type **C** occurs practically exclusively in women, and hence we believe that it is controlled by some unusual function of the female hormone. We are not in a position to make any other statement concerning it, because of the paucity of our material.



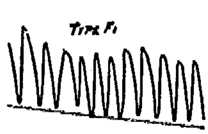
Type **D** shows a periodic and fairly regular wavy contour in both inspiratory and expiratory lines -- a ribbon-like formation. The regularity distinguishes it from type **B**.

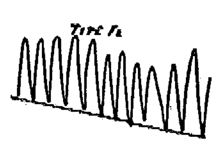
Type **D** is largely, though not exclusively, masculine (about 88 per cent). It occurs in young boys as early as they can be tested (before puberty). In this type there is a peculiar mixture, a tendency to endocrine disturbances with both hyperthyroidism and hypothyroidism, and also a tendency to cardiovascular-renal disease. This is manifested by the retention in the blood of non-protein nitrogen, uric acid and sugar. Osteo-arthritis and obesity also are prevalent in this type, while neurotic and psychotic manifestations and constipation are rare.



Type **E** presents a normal general contour, but in the individual respirations there is no pause either at inspiration or at expiration.

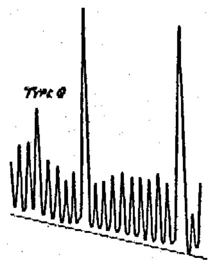
Type **E** though graphically appearing entirely different from the former is nevertheless somewhat similar clinically. It resembles type **D** in retention of non-protein nitrogen, uric acid and sugar in the blood and in the occurrence of osteo-arthritis. But it differs from **D** in prevalence of colitis and neurotic states and in the absence of endocrine disturbances.





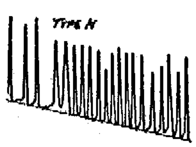
Type **F** is characterized by a normal general contour, but there is a definite pause at inspiration. In this sense it is a reversal of the normal

Type **F** is one of the rare types and has only one association with the normal. There is a low non-protein nitrogen content in the blood and obesity is prevalent.



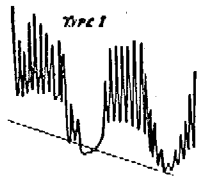
Type **G** has the normal inspiratory line interrupted by frequent and extremely deep inspirations. The intermediate portions of the tracing are normal.

Type **G** is an important type, occurring practically exclusively in the female. It develops in certain girls at puberty. Once established it does not disappear at menopause. Hypertension, myocarditis, obesity and osteo arthritis prevail. Endocrine disturbances are common.



Type **H** shows a definite regular waviness in the inspiratory line. In addition, there is a pronounced pause at each expiration.

Type **H**, the suggestive Cheyne-Stokes type, occurs in childhood but also develops from type **A** with which it is closely related. It is the inevitable precursor of type **I**. A high uric acid content of the blood and myocarditis occur in this type. Its associations with types **A**, **B**, **D**, **G** and **I** are numerous.



Type **I** is the well-known Cheyne-Stokes type. There is periodicity in the entire contour, a tendency to crescendo and diminuendo in the individual respirations and a pause at expiration considerably greater than that encountered in type **H**.

Type **I** is the typical Cheyne-Stokes type and develops from type **H** under certain conditions, among which is a high uric acid content in the blood. This type is seldom seen in a woman. It rarely occurs before the age of 50. While the patients in the majority of the cases in this type have cardiovascular-renal disease or diabetes, there are some who develop it without suffering with either of the diseases mentioned; however, they all have an increase in uric acid.

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