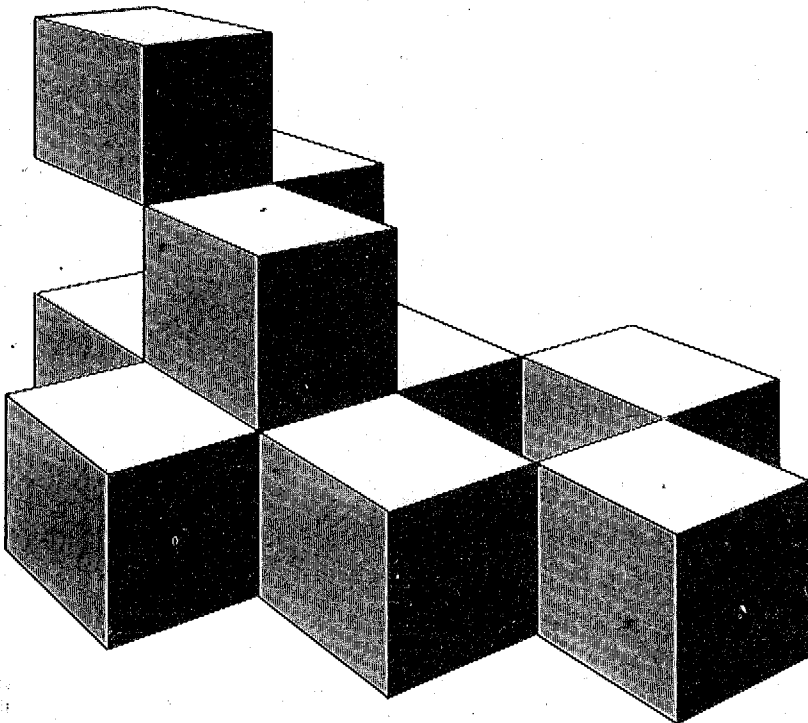


BOOK

4

INSTRUCTION MANUAL
FOR THE COMPUTERIZED
MODULAR LUNG
ANALYZER
P-1200
P-1201



The Collins
Modular
Lung
Analyzer System

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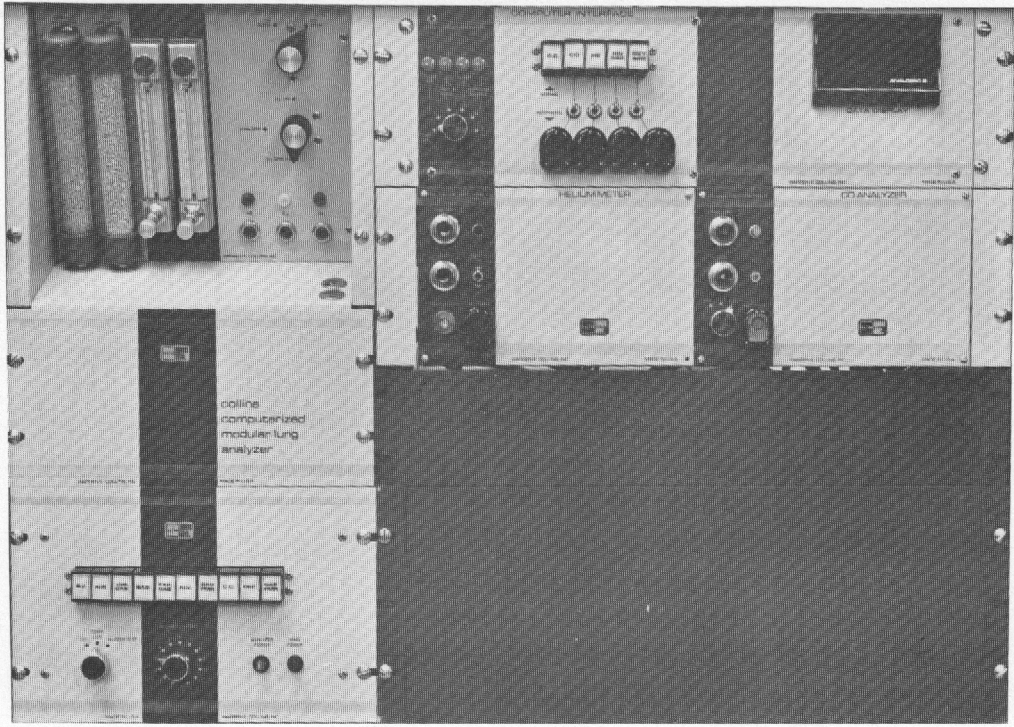
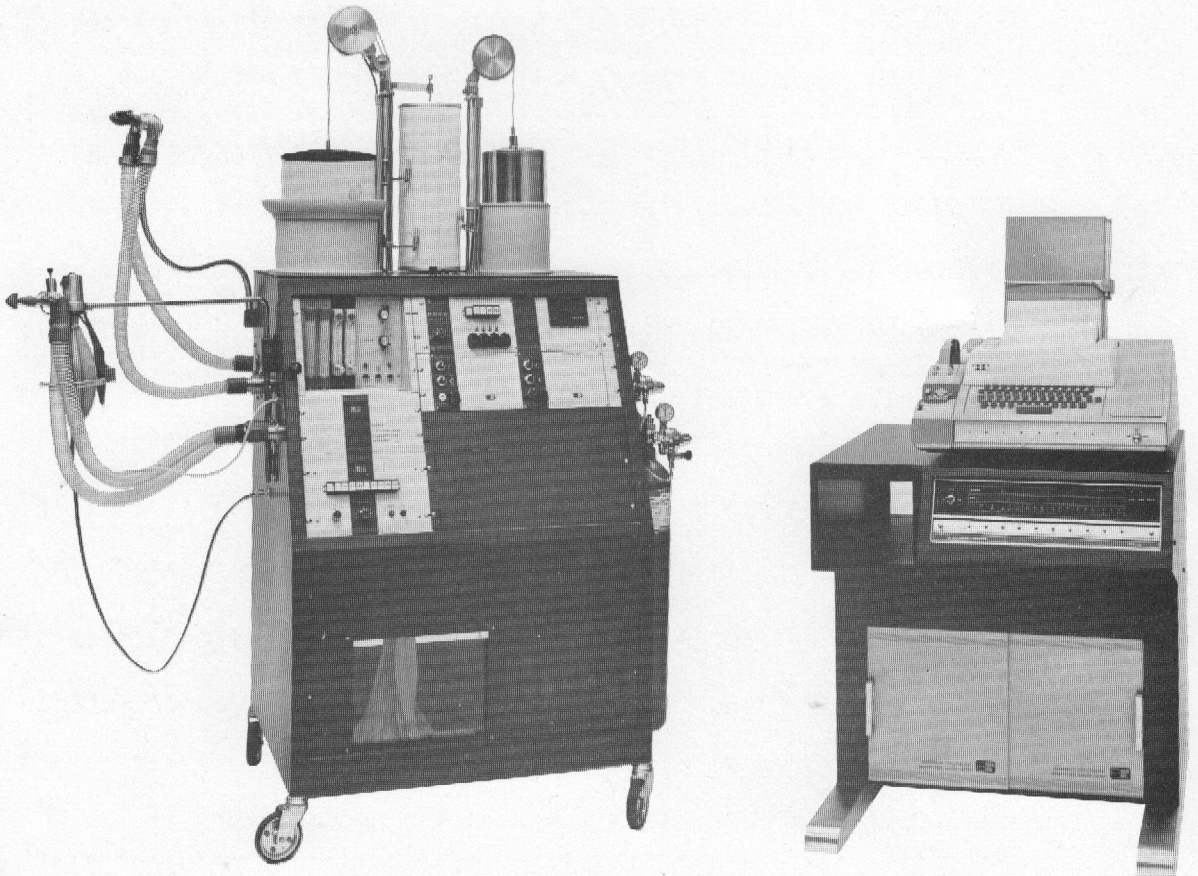


FIG 1



I. INTRODUCTION

- I.1. The desire to routinely test many subjects without becoming overburdened with calculations and the desire to standardize testing protocol has prompted the development of the computerized modular lung analyzer. This unit controls tests of forced expiration, maximum breathing capacity, diffusing capacity, residual volume and oxygen consumption and immediately calculates and prints the results.

- I.2. The system consists of a slightly modified modular lung analyzer, including the Gaensler-Smith 5-way mouthpiece, a digital computer, a teletype, an interface module and a computer program to control the entire system. Figure 2 (page 10) shows the overall structure of the program. The other portions of the system are described in Books 1 and 3 of this set of manuals, and the manual for the computer. This manual assumes a knowledge of Books 1 and 3.

II. START UP PROCEDURE

- II.1. Turn the Computer power key switch to the "ON" position.
- II.2. Turn the small knob on the right front of the Teletype to the "LINE" position.
- II.3. Set the Computer data toggle switches (top row) to 00006, i.e., numbers 13 and 14 up, all others down.
- II.4. Reset the system and start the program by pushing upwards on the computer stop/reset switch and upwards on the start/continue switch. Teletype will print word "OPTION".

- II.5. Push "MAIN POWER" and "ANALYZER POWER" switches on low left panel on modular cabinet to "ON" position. At this point, the kymograph or the buzzer may start. DO NOT BE ALARMED, proceed with step 6.
- II.6. Turn computer power key switch to "LOCK"
- II.7. Depress "CTL" on teletype. Teletype should respond "SEQUENCE BROKEN, TEST ABORTED" and will print word "OPTION".

III. PRINCIPLES OF OPERATION

- III.1. In general, the principles of operation of the Computerized Modular Lung Analyzer are identical with those of the non-computerized model. The prime consideration has been to relieve the technician of the laborious tasks of data recording and calculation while not attempting to replace those tasks which require interaction with the patient, such as instruction or encouragement.
- III.2. Principles of performing dynamic ventilatory studies is as described in Section F, Book I except monitors volume, controls the kymograph, and performs all calculations.
- III.3. Principles of performing the single breath diffusing capacity test is as described in Section III of Book 3 except that the wash-out box has been eliminated; wash-out is directly into the main box-balloon system. Here also the computer monitors volume, and when the patient's respiratory maneuver is complete, the computer pumps the collected sample through the analyzers and calculates the results.
- III.4. Principle of residual volume determination is basically as described in Section G of Book I, but the computer prepares the meter and, during the breathing procedure, adds oxygen from the oxygen

spirometer to keep the base line horizontal. In addition to performing a maximal expiratory maneuver at the end of the rebreathing period, the patient should also perform one or more maximum inspiratory maneuvers; this permits the computer to determine the total lung capacity and RV/TLC ratio. Oxygen consumption is measured during the second through the fifth minutes of helium rebreathing by monitoring the volume of the oxygen spirometer at the beginning and end of this period; a correction is made to the total amount consumed based on the difference in end-expiratory positions at the start and end of the period. The rate of oxygen uptake is then determined as follows:

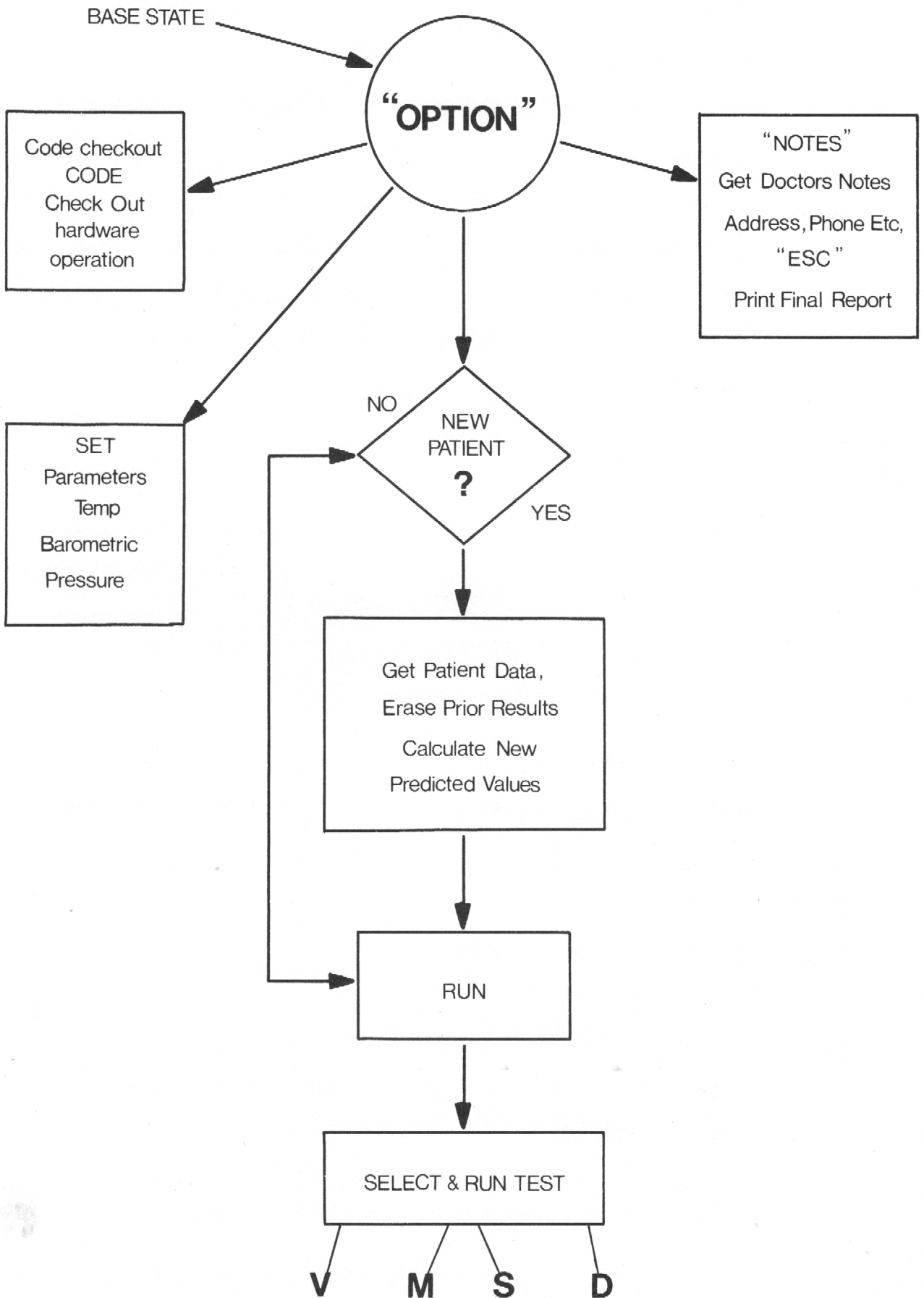
$$V_{O_2} = \frac{1}{T} [(V_0 (b) - V_0 (e)) - (V_m (e) - V_m (b))] \times \text{ATPS Factor}$$

Where T = time of the measurement; about 4 minutes but slightly longer since it goes from end-expiration to end-expiration at least four minutes later.

III.5. $V_0 (b)$, $V_0 (e)$ are the volume of the oxygen spirometer at the beginning and the end of the time period. $V_m (b)$, $V_m (e)$ are the volume of the main spirometer at the beginning and end of the time period, and ATPS factor is the factor for changing gas volume from ambient temperature and pressure, saturated with water vapor, to standard dry conditions.

III.6. Total ventilation is determined by the computer adding the volume expired on each breath. At the conclusion of the test, the computer calculates and prints all results.

**FIGURE 2
OVERALL PROGRAM FLOW**



IV. SETTING PARAMETERS

- IV.1. Computer is in base state (OPTION). Hit "P".
- IV.2. Type the spirometer temperature in degrees centigrade then hit the return key.
- IV.3. Type the barometric pressure in millimeters of mercury then hit the return key.
- IV.4. The computer will calculate BTPS and STPD correction factors and predicted values of vital capacity, FEV₁, etc. The computer returns to the base state and types "OPTION".

V. ENTERING NEW PATIENT

- V.5. Respond "R" when the computer types "OPTION". The computer then types "NEW PATIENT". If the patient about to be tested is the same and it is desired to retain the results of the previous tests, type "N" and the computer types "RUN 1", otherwise, type "Y".
- V.6. If the operator typed "Y" the computer types "PATIENT DATA".
- V.7. Enter the patient's identifying code; any twelve characters or less are acceptable. In case of error, typing asterisk (*) erases the last character typed and prints it.
- V.8. Enter the patient's sex; M for Male and F for Female. The computer then types the entire word; hit return key.
- V.9. Enter the patient's age in years; hit return key.
- V.10. Enter the patient's weight in pounds; hit return key.
- V.11. Enter the patient's height in inches (no fractions are permitted); hit return key.
- V.12. Enter the volume to be washed out before collecting a sample in the single breath CO diffusing test; volume is measured in milliliters. Hit return key.

V.13. If the patient's residual volume is known, and is not going to be determined again, enter the known values in milliliters, otherwise enter zero. This value will be used for the determination of total alveolar volume and computing the diffusion capacity of the lungs; if this value is zero, the alveolar volume will be calculated using the single breath helium dilution. Performing a residual volume determination resets this value to be the one just determined. Hit return key, computer types "READY GO".

VI. EQUIPMENT CHECK-OUT

- VI.1. Respond "C" when computer types "OPTION".
- VI.2. When computer types "CODE", type one of the numbers from the table listed below, followed by hitting the return key and verify the appropriate response.
- VI.3. The computer types "CODE", if further testing is desired go to step 2, otherwise hit return key.
- VI.4. The computer returns to the base state and types "OPTION".

VII. EQUIPMENT CHECK-OUT CODES AND THEIR EXPECTED EFFECTS

<u>Code</u>	<u>Effect</u>
0	Set meter to read CO concentration
1	Set meter to read HE concentration
2	Set meter to read main spirometer volume
3	Set meter to read oxygen spirometer volume
4	Turn kymograph on low speed
5	Turn kymograph on medium speed
6	Turn kymograph on high speed
7	Turn kymograph off

- 8 Turn all small sampling circuit valves and blower off
- 9 Turn blower on
- 10 Set CO and HE meter input to room air
- 11 Set CO and HE meter input to inspired gas
- 12 Set CO and HE meter input to sample bag
- 13 Set CO and HE meter input to steady state expired gas
- 14 Set CO and HE meter input to steady state alveolar gas
- 15 Evacuate the single breath sample bag
- 16 Turn the sample pump on
- 17 Turn the sample pump off
- 18 Buzzer on
- 19 Buzzer off
- 20 5-way expirate valve energized (open) flush light
- 21 5-way expirate valve de-energized (close)
- 22 5-way sample collecting valve energized (open) alv. light
- 23 5-way sample collecting valve de-energized (close)
- 24 5-way square mouthpiece valve energized Insp. light
- 25 5-way square mouthpiece valve de-energized (room air)
- 26 Add helium valve open
- 27 Add helium valve closed
- 28 Add oxygen valve open
- 29 Add oxygen valve closed
- 30 Add air valves (2) energized
- 31 Add air valves (2) de-energized

VIII. FINAL PRINTOUT

VIII.1. Hit space bar, computer types "OPTION", respond "0".

VIII.2. Enter any notes desired, we suggest standardizing at

least part of them as follows:

1. Date
2. Patient's name (last name first)
3. Patient's street address
4. Patient's city and state
5. Patient's telephone number
6. Testing location
7. Comments on patient's cooperation or any other pertinent data

VIII.3. Terminate notes by hitting the "ESC" key.

VIII.4. The computer prints the stored results, followed by the notes

VIII.5. Computer returns to base state and types "OPTION".

EQUIPMENT CONDITIONS FOR TESTS

<u>TEST EQUIPMENT</u>	<u>VITAL CAPACITY</u>	<u>MBC</u>	<u>RESIDUAL VOLUME</u>	<u>CO DILUTION (SINGLE BREATH)</u>
Spirometer Bell	Big	Big	Small with 3 weights	Small
Sode Lime In?	No	No	Yes	Doesn't matter
Mouthpiece	Single large tube w/card-board mouthpiece, stopper in other hole		Double tube w/by-pass valve & rubber mouthpiece	Gacnsler-Smith 5-Way Valve
Noseclip	Yes	Yes	Yes	Yes
RV/BB Valve	In	In	In	Out
Kymograph Speed	Fast	Fast	Slow	Fast
Initial Spirometer Volume	Mid-position	Mid-Position	Empty	Full
Other	----	----	Oxygen spirometer filled; main spirometer circuit flushed w/room air; He meter zeroed	CO and He meters zeroed on room air and set to 1,000 on inspired gas; tubing flushed with inspired gas

For all tests, the computer control button under the meter and the computer control button above the blower speed control should be depressed, and the manual control for the 5-way valve should be fully counter-clockwise. With the spirometer button under the meter depressed, and the main spirometer empty, the meter should read 940 to 960.

IX. LUNG STUDY I

A. Forced Vital Capacity

A.1. Parameters set.

A.2. Use the 14 liter bell in spirometer and no soda lime container.

NOTE: Whenever the spirometer bell is changed the pulley must be checked and adjusted so that when the spirometer is empty, the digital meter reads 950 to 965 when the "MAIN SPIROMETER" button below the meter is depressed. If this does not occur, lift the chain slightly off the pulley, rotate the pulley, reseal the chain, and check the reading again. When the reading is correct, depress "COMP. CON." button to return to computer control.

A.3. Remove tubes from the free breathing valve to the modular cabinet connections. Place the single large tube to connection with thermometer; place rubber stopper (supplied with accessories) in other hole.

A.4. After the computer types "RUN", type "V". The computer types "READY GO".

A.5. Raise the bell two-thirds of the way out of the water. The patient places the mouthpiece in his mouth and the noseclip is affixed, patient breathes normally. When the patient seems settled, hit space bar. The patient continues breathing normally until buzzer sounds, then he finishes the expiration he is making, inspires maximally and immediately performs a forced maximal expiration. The patient should be encouraged during maneuvers to obtain maximum effort. The computer starts the kymograph, sounds the buzzer as the patient begins to expire, stores and analyzes the spirogram (the buzzer stops as soon as the computer recognizes the patient has stopped

expiring, and the data is recorded up to 40 seconds from this time) and prints the results (FEV) (FEV₁). Computer then types "RUN 2". If it is desired to repeat test, return to step 4, otherwise type "M" for maximum breathing capacity (Maximum voluntary ventilation).

B. Maximum Breathing Capacity (Maximum Voluntary Ventilation) 15 Second Duration

- B.1. Raise the bell to mid-point. (14 liter bell and no soda lime container)
- B.2. Type "M", computer types "READY GO".
- B.3. Patient places mouth on mouthpiece, has noseclip affixed and breathes normally.
- B.4. When the patient seems settled, hit space bar. When buzzer sounds, patient must then begin to breathe as deeply and as rapidly as possible. Patient continues until the buzzer stops. The computer starts the buzzer at the beginning of a normal expiration and then times 15 seconds while accumulating total volume expired. Again patient should be encouraged during maneuvers to obtain maximum effort.
- B.5. Data is recorded and results printed.
- B.6. Computer then types "RUN 3".

C. Helium Residual Volume, Resting Spirometry and Oxygen Uptake

- C.1. Remove the 14 liter bell from spirometer.
- C.2. Place filled soda lime container in well and place the 7 liter bell in position.
- C.3. Depress "MAIN SPIROMETER" button and adjust spirometer pulley until digital meter reads at least 950 to 965. Use same procedure for O₂ spirometer bell.

- C.4. Remove single large tube and rubber stopper in cabinet connections.
- C.5. Connect two tubes from free breathing valve to cabinet connections.
Place rubber mouthpiece on free breathing valve.
- C.6. Open the helium tank.
- C.7. Open free breathing valve to room air and place three weights on bell.
- C.8. Depress "RV" button and adjust blower control until the bell is in the balanced state. After the bell is balanced push the "OFF" button on the blower control panel and allow bell to come to base position. Close free breathing valve and push "COMPUTER CONTROL" button.
- C.9. Depress "MAIN SPIROMETER" button on interface and turn oxygen control knob on flow panel to "O₂ SPIR." position. Allow oxygen to fill spirometer until a meter reading of between 60 and 70 is obtained. Turn off oxygen tank and return oxygen control knob to "OFF" position. Depress "COMPUTER CONTROL" button.
- C.10. Type "S". After the computer types "READY GO", make sure the helium tank is open, then hit the space bar. The computer adds helium and types "HE₁" (Helium meter reading after helium added), "HE₂" (Helium meter reading after room air added). This requires about two minutes. Computer then types "START PATIENT".
- C.11. At this point, the patient has noseclip affixed and mouthpiece in position. When the patient is at the end of an expiration, turn the free breathing valve to connect him to the system. The computer responds with "RUN" indicating the beginning of test. The patient breathes quietly for at least five minutes while the computer calculates minute ventilation and oxygen uptake and computer adds oxygen as required to maintain a stable base line. (The first minute is ignored). After the first minute, helium concentration is

printed every 30 seconds once the helium concentration has stabilized, but in any case after seven minutes has elapsed. The system is ready to perform spirometry, a message is printed telling the operator to select the desired respiratory maneuver ("E" or "I"), or to stop the test by typing "Q".

NOTE: NEITHER INSPIRATORY CAPACITY NOR EXPIRATORY RESERVE SHOULD BE ATTEMPTED UNLESS THE PATIENT'S BASE LINE HAS BEEN STABLE FOR AT LEAST THREE RESPIRATIONS IMMEDIATELY PRECEDING THE MANEUVERS.

C.12. "E" for Expiratory Reserve: For "E" the computer sounds a buzzer while the patient is inspiring. This inspiration should be finished normally and the following expiration should be maximal. This maneuver may be repeated by typing "E".

C.13. "I" for Inspiratory Capacity: For "I" the computer adds air so that the volume of gas in the spirometer is at least 4-1/2 liters and then sounds the buzzer while the patient is expiring. This expiration should be maximal. This maneuver may also be repeated by again typing "I".

C.14. Type "Q" to terminate spirometry and start print out of Residual Volume results.

D. Single Breath Diffusing Capacity Test (DLCO)

Flush residual gas from box-balloon.

D.1. Turn "CO" knob on the flow panel to "CO OPEN" position.

D.2. Fill balloon with 3000 ppm CO and 10% helium mixture. While balloon is filling, lift relief valve on automated valve briefly, in order to flush breathing tubes with inspired gas mixture.

- D.3. Push "MAIN SPIROMETER" button on interface panel and check main spirometer for 950 to 970 reading on meter readout. Push "AIR" and "GAS PUMP" buttons to draw room air through helium and CO analyzers. With pump running, push "HELIUM" button on interface panel, and set meter to zero with zero knob on helium control panel; with the pump still running push "CO" button on interface panel and set meter to zero with zero knob on CO control panel.
- D.4. Push "INSPIRED GAS" and "GAS PUMP" buttons to draw inspired gas through the analyzer. Push "HELIUM" button on computer interface and set to 1,000 with helium gain knob. Push "CO" button and set to 1,000 with CO gain knob.
- D.5. Raise main spirometer bell leaving 1/2 inch in water. Place buttons on interface and push-button panel in "COMPUTER CONTROL" position. Place automated valve knob in "COMPUTER CONTROL" position. Pull RVBB knob out to place in "BOX BALLOON" position.
- D.6. Hit "D", computer types "READY GO". The alveolar sample bag is evacuated fully.
- D.7. With noseclip in place, patient is attached to mouthpiece on automated valve.
- D.8. Patient is instructed to expire completely and signal the operator when he has expired as completely as possible. On signal, the operator types any key on the teletype to start the computer. At the sound of the buzzer the patient should inspire as rapidly and as fully as possible and hold his breath at this maximal level. Valves prevent any expiration except leakage at mouthpiece. After 10 seconds the buzzer stops and the patient should expire as rapidly as possible.

D.9. Computer switches the mouthpiece valve so that the patient inspires gas from the box balloon system after 10 seconds, switches the valves again so that he expires into the box. The computer monitors the volume of expiration. When the selected volume is washed out, the valves are switched so that alveolar sample is collected. When the sample bag is full, the patient is again switched to room air, the sample is pumped through the analyzer for about 40 seconds and the results are calculated. This test may be repeated by again typing "D".

X. TERMINATING TESTING

X.1. When all desired tests have been completed, hit return key to return the system to the point where it will accept new commands, the base state. As usual, when it enters the base state, the computer types "OPTION=".

X.2. During a test, hitting the CTRL and X keys on the teletype will reset all valves, etc., but not results, and will return the system to the base state; it then types "OPTION=".

XI. LUNG STUDY 2

This program is similar to the existing program for the Lung Study 1. In Lung Study 2, the Residual Volume Test has been eliminated and the Inspiratory Vital Capacity and Oxygen Up-take have been added as separate tests.

To load tape and set parameters for Lung Study 2, follow the procedures given for Lung Study 1.

A. Forced Vital Capacity (FVC)

A.1. Follow the procedure described in Lung Study 1, under Forced Vital Capacity.

B. Maximum Breathing Capacity (MVV)

B.1. Follow the procedure described in Lung Study 1, under Maximum Breathing Capacity.

C. Inspiratory Vital Capacity (IVC)

C.1. Remove soda lime container.

C.2. Place 14 liter bell into position.

C.3. Open free breathing valve to room air and place two weights on bell.

C.4. Depress "RV" button and adjust blower control until the bell is in a balanced state. Push "OFF" button and allow bell to come to base position. Close free breathing valve and push "COMPUTER CONTROL" button.

C.5. Depress "MAIN SPIROMETER" button and adjust spirometer pulley until digital meter reads at least 950-965.

C.6. Raise bell to mid-position.

C.7. With noseclip affixed, attach patient to free breathing valve.

C.8. Hit "V", computer types, "READY GO".

C.9. When patient seems settled, switch patient into circuit and hit space bar. Kymograph will then start. After four breathes the buzzer will sound. Patient inspires normally, then expires

normally, then expires fully until a maximum expiration is reached, then inspires fully, then returns to normal breathing. Buzzer and kymograph stop.

C.10. Inspiratory Capacity and Expiratory Reserve are printed. Computer then types "SAVE". Type "Y" to save and "N" to not save.

D. O₂ Uptake

- D.1. Place filled soda lime container in well and place 14 liter bell in position.
- D.2. With two weights on bell, balance bell as performed on Inspiratory Vital Capacity test.
- D.3. Press spirometer button and adjust spirometer pulley until digital meter reads at least 950-965. Use same procedure for O₂ spirometer bell.
- D.4. Depress spirometer button on interface and turn oxygen control knob on flow panel to O₂ spirometer position. Allow oxygen to fill spirometer until a meter reading of between 60 and 70 is obtained.
- D.5. Raise main spirometer bell to mid-position.
- D.6. Type "O", computer types "READY GO".
- D.7. With noseclip affixed, attach patient to free breathing valve.
- D.8. Hit space bar and switch patient into breathing circuit at end expiratory position.
- D.9. The patient breathes quietly for four minutes. The first minute is ignored and the last three are used to measure ventilation and O₂ uptake.
- D.10. Test ended, results are printed.
- D.11. Hit space bar, computer types "OPTION", respond "O".

- D.12. Computer prints "NUMBER OF COPIES DESIRED". Respond with number of copies desired. (0 will cause 64,000 copies of the report.)
- D.13. Enter any notes desired, we suggest standardizing data as in Lung Study 1.
- D.14. Terminate notes by hitting "ESC" key.
- D.15. The computer prints the stored results, followed by the notes.
- D.16. Computer returns to base state and types "OPTION".
- E. DLCO
- E.1. Follow the procedure described in Lung Study 1, under DLCO.

APPENDIX A

I. Teletype Operation

- I.1. An ASR teletype is really four devices; keyboard, printer, reader and punch, which can be operated in various combinations. Power must be turned on by the operator. The switch is beside the keyboard and is labeled line/off local. When this switch is set to local, power is on; but the machine is off-line and can be used like a typewriter. Moreover, in an ASR, turning on the punch allows the operator to punch a tape from the keyboard, and running the reader allows a tape to control the printer. (If the punch is also on, it duplicates the tape.) The tape moves in the reader from back to front with the feed holes closer to the left edge. To load tape, set the switch to free, release cover guard by opening the latch at the right, place the tape so that the sprocket wheel teeth engage the feed holes, close the cover guard, and set the switch to stop.
- I.2. To load tape in the punch, raise the cover, feed the tape manually from the top of the role into the guide at the back. Move the tape through the punch by turning the friction wheel, then close the cover. Turn on

the punch with the unit in local and punch about two feet of lead by pressing "HERE IS" on the control.

II. Loading Programs

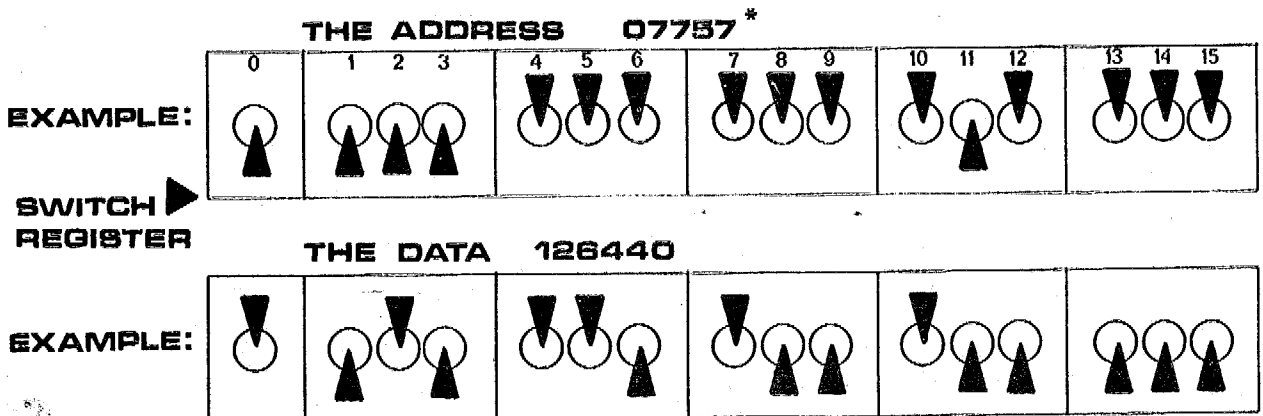
II.1. Before a program can be executed, it must be brought into memory. If the memory is empty, one must use the data switches to deposit a bootstrap loader, which is ordinarily used only to bring in a more extensive binary loader. This latter program is then used to read the object tapes of all other programs. The binary loader usually resides in high core, however, it is not disturbed by any of the standard software. But if an undebugged user routine inadvertently destroys the binary loader, it can be restored by first reloading the bootstrap manually. When program loss occurs or when loading program for any reason, the following procedure should be followed:

- a.1. Place computer key to "ON" position, teletype to "LINE" position.
- b.2. Press the "STOP" switch on computer.
- c.3. Set data switches to 07757 (see figure 3, page 26) and press the examine switch.
- d.4. The address lights should indicate 07757 and the data lights should indicate 126440 this address is the beginning of the bootstrap loader.
- e.5. Check entire bootstrap by pressing "EXAMINE NEXT" switch and checking the data lights for correspondence with the bootstrap listing below:

<u>Address</u>	<u>Data</u>
07757	126440
07760	063610
07761	000777
07762	060510
07763	127100

FIGURE 3 OCTAL TO BINARY CONVERSIONS

OCTAL NUMBER	SWITCH BANK			REPRESENTATION
	4	2	1	
0				000
1				001
2				010
3				011
4				100
5				101
6				110
7				111



*When indicating a particular address switch zero is always in the down position and essentially ignored.

07764	127100
07765	107003
07766	000772
07776	001400
07770	060110
07771	004766
07772	044402
07773	004764

- f.6. If the data in a particular address is incorrect set data switches for the correct word. Be sure the address lights indicate the address where data is to be loaded, and press the "DEPOSIT" switch. After depositing the correct word use the "EXAMINE NEXT" switch to check the remainder of the bootstrap.
- g.7. To recheck any particular bootstrap address simply set switches to the desired address and press examine switch. Address light will indicate the address and data lights will be the word in that address.
- h.8. Once verified that bootstrap is correct set switches to the binary load address, which is 07770. Load binary tape in teletype reader, put reader on "START" position and press "RESET" and "START" on computer. Tape should load completely and stop at the end. After the tape is loaded processor stops with 07776 displayed on the address lights.
- i.9. After loading binary tape, set switches to main program load address, which is 07777, and proceed as in step h.8. That is, teletype to "START" position and "RESET" and "START" on computer. Tape should load completely and type "OPTION" when complete.

- j. The binary loader computes a checksum over every data block and starts block read. If a checksum failure occurs over a block, the loader halts with 107726 displayed in the address lights. Reposition the tape to the beginning of the last block, read and press continue. If the checksum failure again occurs, the object tape is probably in error. Generate a new tape before attempting to load program again.
- k.10. Program is loaded and running. Place address switches to 00006 (switches 13 and 14 up). This is the main program's starting location.

APPENDIX B

I. Manual Operation of Collins Computerized Modular Lung Analyzer

- I.1. Supply oxygen to the main spirometer during Residual Volume studies. Place the oxygen knob on the front panel to the "MAIN SPIROMETER" position. Oxygen flow is then controlled via the flow meter on the front panel.
- I.2. For adding Helium to the main spirometer depress the "HELIUM" button on the front panel.
- I.3. To read Helium or Carbon Monoxide concentrations, depress the appropriate switch on the interface panel.
- I.4. For single breath diffusion studies a rotary switch on the interface panel has been added to control the five-way mouthpiece valve. Rotating this switch clockwise, cycles the valve through test sequences.
1. Room Air
 2. Inspired

3. Expired
4. Alveolar Sample
5. Back to Room Air

I.5. Other than these variances, follow the Modular Lung Analyzer directions.