System 87 Machine Gun Chronograph and Target

User's Manual

Oehler Research System 87 Version Beta 9/9/2013

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System 87

Revision History:

CHAPTER 1

Quick Start

Other Oehler chronographs are primarily intended to test ammunition. The System 87 is primarily intended to test guns. Results on target and the firing rate are regarded as the most important parameters measured. Muzzle velocities and times-of-flight to target are regarded as secondary parameters. The System 87 must be used with a Windows PC. Operation of the System 87 is centered about the display and keyboard, not switches and knobs. We've made operation as intuitive as we know how, but you still must read the instructions. If nothing else, please read this quick start section. We've given you a new rope; you can swing like Tarzan or just swing.

Quick Start

1. Install the software on your Windows PC using the disk provided. If the installation does not start automatically, run setupS87.exe.

2. ***Run the System 87 program before you connect the USB cable.*** This will install the proper USB driver. Connect System 87 to PC using the USB cable. There may be a slight delay as the PC and System 87 shake hands for the first time. Connect the screens and downrange target.

3. Run the System 87 program again.

4. From the **System 87 – Main Display** window, select the Setup button. From the menu, select **New/Edit Test Template**.

5. On the setup screen, the distance from Screen 1 to Screen 2 is critical and must be entered correctly. The size of the target square, the expected velocity at the target and temperature must be entered correctly for target scoring. Also set the **Maximum ROF** in the gun column. All other information is for your test records and is optional.

6. You can either use the displayed name for the test or you can assign a new test name. Hit the **Finish** button.

7. After you are returned to the **Main Display** window, hit the **Test** button.

8. A pop-up window will show the PC initializing the System 87. At completion, hit the **Begin Test** push-button.

9. The **Testing Display** will show a green **Ready** indicator at the upper left along with a diagram of your setup and column headings for your results.

10. Fire your burst through the screens. After burst is completed, hit the **GET BURST DATA** button. Results will be displayed.

11. Results can be omitted by highlighting the desired line and hitting the **Omit/Restore** pushbutton or the **O** (oh, not zero) key. Omission will be indicated by dashes across the data. The function will toggle.

12. You can hit the **Summary** button to pop up a statistical summary window.

13. At the end of your group you can either go directly to a **New Group** or go back to the **Main Display**.

14. If all else fails, hit the **Help** button to display the instruction book. You can start with the Quick Tour on page 5.

CHAPTER 2

General Description

There is only one other production system capable of simultaneous measurement of muzzle velocities, rates-of-fire, and target scoring during high-rate burst firing. The Oehler Model 82 has this capability. The Model 82 has been in continual use since its introduction in 1981. The ’82 was designed to use CP/M, a precursor of DOS, and was subsequently adapted for use with DOS. The ‘82 has lost favor because it uses DOS. A redesign is not practical.

Before you attempt to use the System 87, you should visualize the entire process and the relationship between all the events that take place. This is very important in diagnosing problems that might occur during a test, but is even more important in planning and structuring the test to avoid and minimize problems.

The measurement of velocity is simple. Two screens are placed in front of the muzzle at a known distance apart. The first screen senses the passage of the bullet and generates an electrical signal to start a timer. The second screen then senses the passage of the bullet and generates a signal to stop the timer. Velocity is computed from the observed time and distance. The “time-of-day” that the bullet passes the start screen is recorded for subsequent rate-of-fire computations.

The measurement of apparent target impact is also simple in concept. Four microphones are placed at the corners of the downrange target square. Each microphone will detect the arrival of the Mach cone of the passing bullet. The apparent impact point is computed by “triangulation” using the four recorded arrival times at the microphones, the speed of sound calculated from the air temperature, and the estimated speed of the bullet.

You would like to track each bullet and report its muzzle velocity and the corresponding impact point at the target. Things are simple if you can first do the velocity measurement near the muzzle and then do the target measurement downrange. Users expect more. They expect the system to operate at rates slower than 100 rounds per minute and over 6,000 rounds per minute. They expect it to operate with velocities from 400 m/s to well over 1,000 m/s.

Take the Vulcan gun for example. It delivers 6,000 rounds per minute at 1,000 m/s. That’s 10 milliseconds between rounds and 100 milliseconds for a round to travel from gun to target. That means you have 10 rounds in the air before the first round reaches the target. At the target you no longer have a uniform 10 milliseconds between bullets. Variations in muzzle velocities and bullet drag take their toll and the faster bullets tend to overtake the slower bullets. This explains why the factory standard test distance for the Vulcan guns was set at 1,000 inches or 25 meters.

Not only do we have timing and recording problems to worry about, but there are the ever-present noise problems. At the muzzle velocity screens, there is the muzzle blast from the shots and the reverberations from both the muzzle blast shock wave and the reflected Mach cone. The first bullet is out ahead of all these problems, but things get successively nastier as the burst progresses. Add in any discarding sabots and pusher plugs, plus their Mach cones and reverberations and there is a mess.

The approach for the System 87 (and proven for 30 years with the operation of the ’82) is to first break the problem into two parts, with separate systems for muzzle velocity and target. The two

systems operate concurrently within the same System 87 box and are controlled by the same operator, but are independent in many ways. For example, if there is no target installed or if the target fails on one or more shots, the system will still record muzzle velocities and rates of fire. If there are no screens installed, or if the muzzle screens fail for one or more shots, the system will still record target information and rates of fire at the target. If there is only a start screen (or even a microphone), the system will still record epoch times and rate of fire.

The system asks you to specify the maximum expected rate of fire. We don't worry about the maximum rate of fire, but we must know the minimum time between successive rounds. We convert the maximum rate of fire to a minimum time between rounds. After we detect a start event (either start screen or first microphone) we ignore any triggers which occur during this minimum time interval. At the muzzle screens, we ignore any start signals occurring during this interval, but continue to look for a muzzle screen stop signal. At the end of the time interval, we begin to look for the next shot. At the target, we trigger this time with the response for the first microphone and note only the first response from each microphone that occurs within the time window. At the end of the time period, we begin look for the next shot.

At lower rates (typically less than 1,000 rounds per minute), this technique works very well. The rate of 1,000 rounds per minute corresponds to a minimum of 60 milliseconds between rounds. This is long enough for muzzle blast and other nasty things to get past the muzzle screens and for reverberations to clear the target. The moral of the story is that you should not set the maximum expected rate of fire at 6,000 rounds per minute and forget it. You should set the maximum expected rate at perhaps 10 percent over the nominal expected rate to allow a little cushion. Setting it too high just opens the noise window wider.

As rates increase, so do the problems. Consider first the muzzle screens and the velocity measurements. The muzzle blast shock wave will often trigger the screens. It is not a problem at lower rates because the bullet triggers the screens before the blast gets there. Blast induced triggers are ignored until we re-enable the screens in anticipation of the next round. At high rates, the second bullet can reach the start screen before the blast from the first bullet has cleared the stop screen. The obvious solution is to move the screens closer to the muzzle and to decrease the spacing between start and stop screens. The problem with this solution is that lets more intense blast hit the screens and you can also be plagued with problems caused by muzzle flash (both visible and infrared). This calls for baffles between the muzzle and the screens. Plywood baffles are suggested if there are no pusher plugs or sabots involved. With pusher plugs and sabots you must resort to armor "stripper panels" to protect the screens and even the microphones. The purpose of the baffles is to intercept the shock and flash, but allow the bullet to pass.

At the target, the first consideration is that the Mach cone from the first bullet must clear all four microphones before the Mach cone from the second bullet hits any microphone. As a rough rule of thumb, make the side of the microphone square (measured in meters) no more than one-third the minimum time between rounds measured in milliseconds. We measure and display the rate of fire at the target so that you have an indication of the minimum time between rounds at the target. Variations in muzzle velocity and bullet drag lets faster bullets catch up with slower bullets on the way to the target and can give short times or fast rates of fire for some bullets. That's one reason we display rate at the target. You will find that it is frequently better to use a reduced target size even if it means placing the target closer to the gun.

As you approach very high rates of fire, the system configuration becomes critical. We have tested the System 87 in the lab with simulated input signals at up to 10,000 rounds per minute, but we observed several basic precautions. In the discussion, we consider T_{min} , the minimum time between shots at the maximum rate of fire.

- The longest time between muzzle velocity start and stop screens cannot exceed T_{min} plus 3 milliseconds.

- The longest time between first microphone and last microphone cannot exceed T_{min} plus 3 milliseconds. The longest expected time at the target (in milliseconds) is estimated as the target size in feet or three times the target size in meters. You may have to decrease range to target to accommodate dispersion instead of making the target larger. If fluctuations in velocity and retardation cause the indicated ROF at the target to hit higher values, you must use these higher values to compute T_{min} and the largest allowed target size.

- The ever-present blast and reflections become critical at high rates. You must kill these signals and reflections before they trigger either the velocity screens or the microphones.

The fact that the velocity and targeting are almost independent brings up a caution regarding the data interpretation. What is labeled as RND or round number is the displayed data could actually be better considered as a "Line". If all goes perfectly and there are no false triggers or missed signals, then the readings on each line do correspond to one bullet or one round. If either a velocity or a target is missed, the missing value is shown as "- - - -". The velocities and targets may no longer be synchronized. A given burst may show more velocities than target coordinates, or it may show fewer velocities.

The '87 cannot resynchronize the data, but it does record all the raw times for each recognized screen and microphone event. These raw times are preserved in the Excel file so that they can be reexamined at leisure and with all the advantages of hindsight. Examining the data will allow you to do such things as computing the expected target epoch time from muzzle epoch time and the muzzle velocity to match target coordinates with velocities.

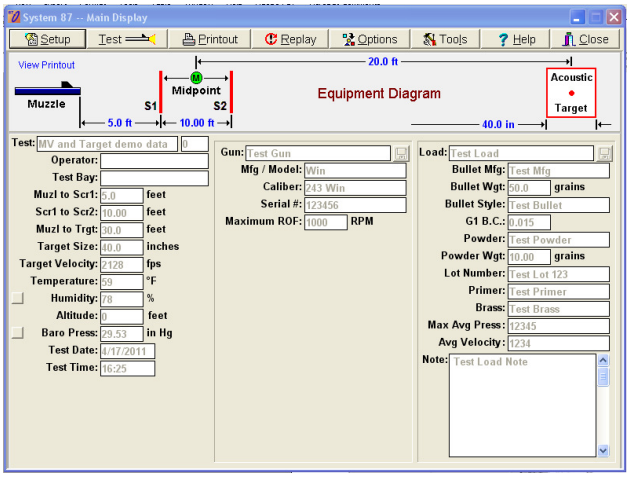
CHAPTER 3

Quick Tour

The best way to learn this system is to install the program in your computer and play along as you read these instructions. Replay some of the tests we've already fired, print them out, and then pretend you're setting up and firing tests of your own. You won't break anything.

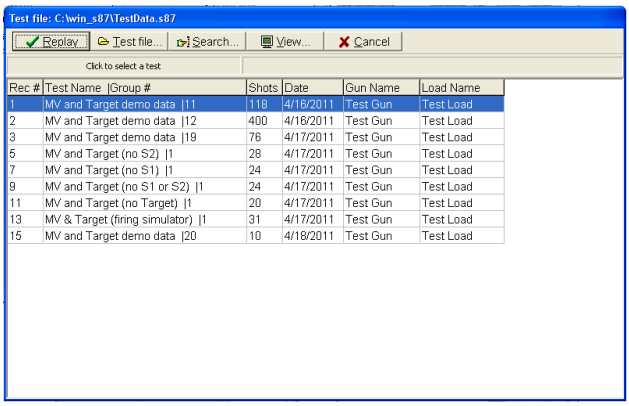
Exit from all other applications and install the System 87 software provided. Operation has been tested with 2000, XP, Vista, and 7 (both 32 and 64 bit). Operation with Windows 98 and NT has not been tested. **Install the System 87 software before you connect the USB cable.**

The System 87 program will start with a title window over the main display. Just hit the OK button to remove the title window.



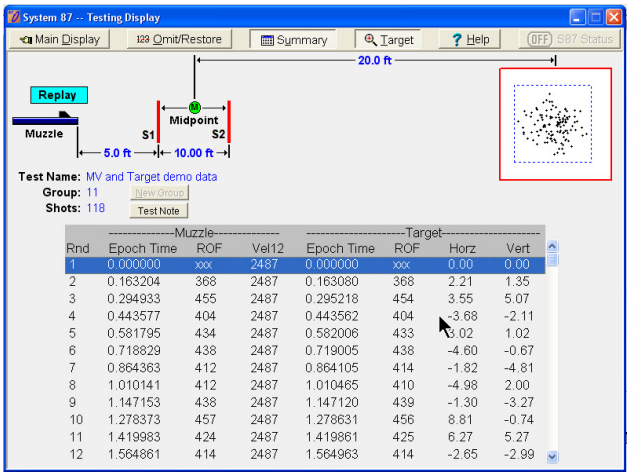
Main Display

The main display shows the test set-up and conditions, the description of the gun and description of the tested load. For information on any recorded burst, select the **Replay** action with the pushbutton.



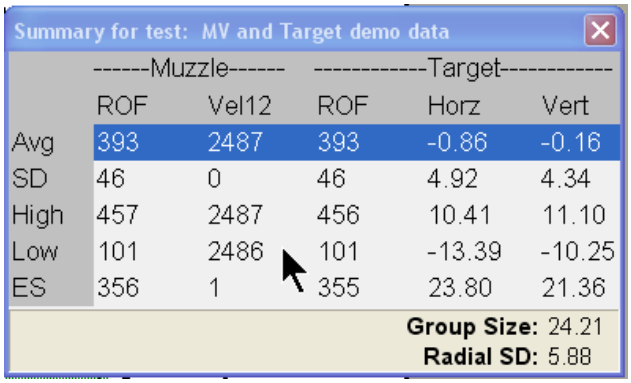
Replay Test List

Here is a list of the previously fired tests. Highlight the test your want to see and initiate the replay of that test with either a double-click on the selected test or a click on the **Replay** button after a test is selected.



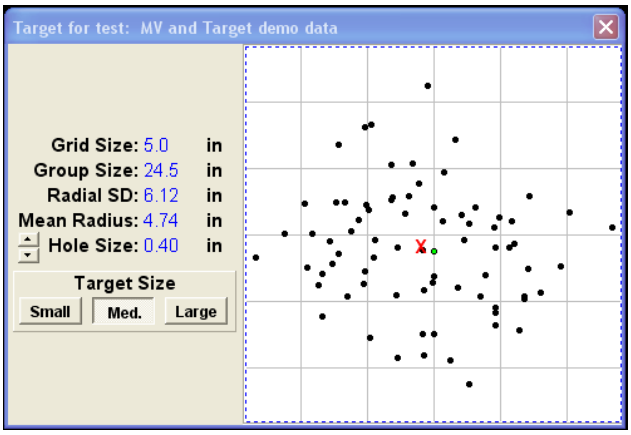
Replay Test Window

This is the test screen that you would have seen at the completion of the firing. You can see the schematic of the test setup and the numeric value of each test parameter of each shot. Use the scroll bar to see results of the entire burst.



Summary

Here is the statistical summary of all parameters just as if you had requested the summary at the end of the test. If the size and resolution of your display permits, you can move the summary window to uncover the primary test window.



Target

The **Target** button brings up the target window showing the group on the target along with the statistics of the group. A red **x** marks the group center and the green filled shot location corresponds the round highlighted in the numerical data. Clicking on any shot will highlight the corresponding line of numeric data.

The **Omit/Restore** pushbutton will alternately omit the data from a round from the summary, or it will restore the data from a round to the summary. Omitted rounds will have a line drawn through the numeric data.

The **Main Display** pushbutton returns you to the Main Display window. In this window you can observe the complete set-up conditions for the test you just replayed. The left-hand column contains the administrative information on the test. The middle column includes all the essential information on the gun. The right-hand column contains the information about the ammunition.

Go back to the Main Display and replay a few more different tests. Play with all the buttons just to become familiar with the actions.

To print a previously fired test, follow a similar procedure. You just hit the **Printout** button instead of the replay button while you are in the Main Display window. Select the test to be printed with a double-click, push the **Printout** button. The **Preview** button is selected by default, and an **OK** will show the preview on your screen. If you really want the report printed on paper, select the **Printer** pushbutton instead of the **Preview** button.

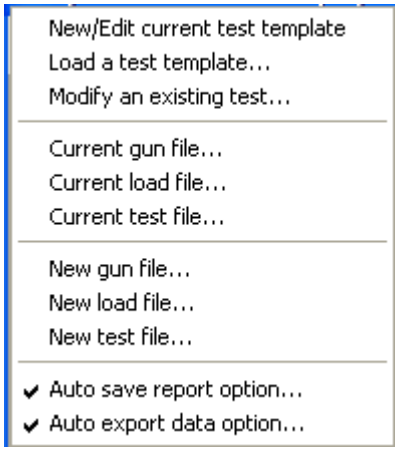
Now that you've replayed some of our tests, and printed copies of our reports, it's time to do your own test. Start from the **Main Display** window using the **Setup** pushbutton. The setup pushbutton will pull down a list of confusing terms. (If you've used the Oehler 43, 83, 84 or 85 you will be right at home.)

In the System 87 program, we refer to the description of a test as a template. A test template is the complete description of a test *excluding* the actual firing data. The template describes what parameters are to be tested, what test equipment is used and how it is arranged (screen spacing), environment (temperature,

wind, barometric pressure, …), gun description, and load description.

You must have a test template prior to each test. *You can continue using an existing test template, you can modify an existing template, or you can edit an existing template and rename it to make a new template.*

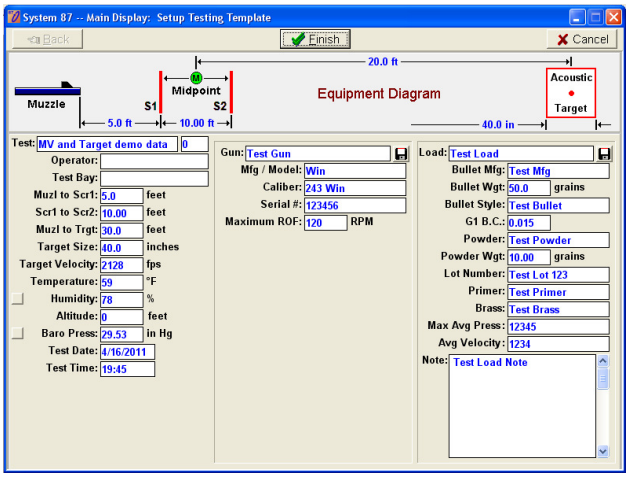
When you are testing, each test will probably be very much like the previous one. You might change ammo lots between tests, or the temperature may change, or you might use a different gun, but chances are you won't change the whole setup. The program works just like that.



Setup Pull-down List

From the Setup pull-down list, choose the **New/Edit current test template** option. This will bring up the Setup Testing Template window.

Proceed to the next screen with the **Next** button.



Main Display – Parameter Entry

Note that this is the only place in the program that you can enter or modify the test conditions, gun information, or load information.

We check and change the parameters from top-to-bottom, left-to-right. The tab key naturally moves you this way.

The test name is very important. The name, with the group number, is used as the file name when the test data is stored in Excel or .pdf format. The appropriate generic extension is appended to the test name. The test name is limited to thirty characters to prevent bloated file names. It is the responsibility of the user to define a naming convention. You may end up with hundreds or thousands of test reports stored in a single folder. When you look for a report or data for a particular test, it will be more convenient if the computer sorts the file names into similar groups. We suggest that the ammo headstamp name (without spaces or punctuation) form the initial part of the test name. Following the headstamp, we suggest that you indicate the gun used. Each user and installation will have its own preference of the hierarchy in test names. It's your decision. The computer doesn't care what names you use, but it will use its standard rules to sort them. Think about it before you start.

Enter the test conditions in the left column. Don't worry about correct date and time; they will update when a test is fired.

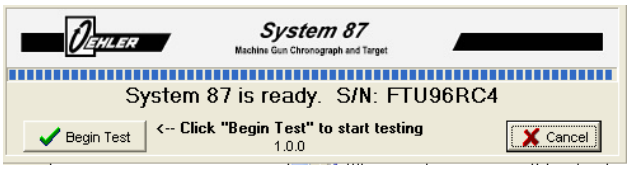
Advance to the **Gun** column. Again, plan ahead when choosing a gun name. We always start with the headstamp (no punctuation or spaces) and then add descriptors as needed. Getting all your 7.62 guns in one group helps you locate any specific gun. **Mfg/Model**, **Caliber**, and **Serial #** are memo fields to the System 87, but you might use them in Excel to analyze the Excel data to determine such information as total rounds fired through a barrel. After you have completed the gun column, click on the little diskette button and **Save** your gun in the gun file. Next time you want to test with that gun, use the same button and **Load** the gun information.

Much of the information requested in the **Load:** column is more related to ammo testing than gun tests. As with the guns, we assign load names starting with the headstamp. You might want to use product numbers or similar. After a load is entered, use the diskette button and **Save** it. It's easier to use the diskette button and **Load** a similar load and change one parameter than to enter a new load from scratch. All entries for the load are considered memo. Note that the headings for the two last entries in the load column can be changed to suit your application.

Much of the information entered for gun and load is not critical for testing, but it is critical for test documentation. You may not appreciate it now, but you will bless it months and years from now when you review your recorded data.

After completing the entry of data into the boxes of the parameter entry screen, finish the process with the **Finish** *pushbutton. This will typically bring up a warning that the test name already exists. You have the choice of either over-writing an existing test template (appropriate only if you are authorized to change the master template) or proceeding with the test using the edited template. Note that proceeding to use the edited template will not change the template or raw data from a previously fired test, and it will not change the master template.. As each test is fired and recorded, template in effect at the time of the test is recorded along with the raw data.*

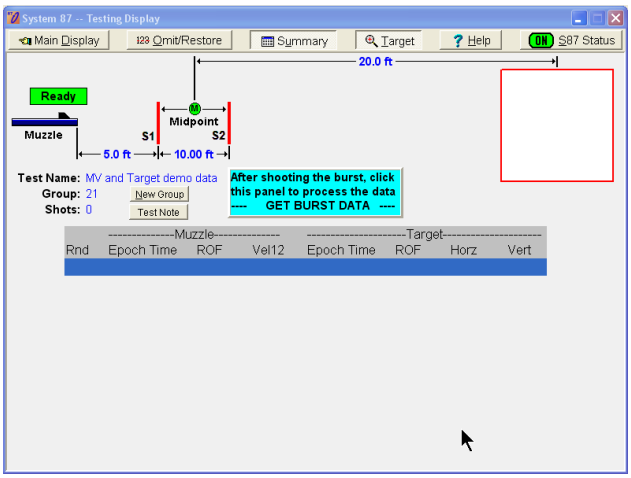
After the template is successfully accepted, you will be returned to the Main Display window. Push the **Test** pushbutton to start the test. This will establish and check the USB connection to the System 87.



Monitor Window

The monitor window will be displayed. You will see a dotted completion bar under the picture of the System 87 front panel as initial checks are performed. The serial number shown is that of the USB module in the System 87. The number shown under "Begin Test" is the version of the System 87 firmware. After the completion bar is finished, push the **Begin Test** button. You must allow the completion bar to finish.

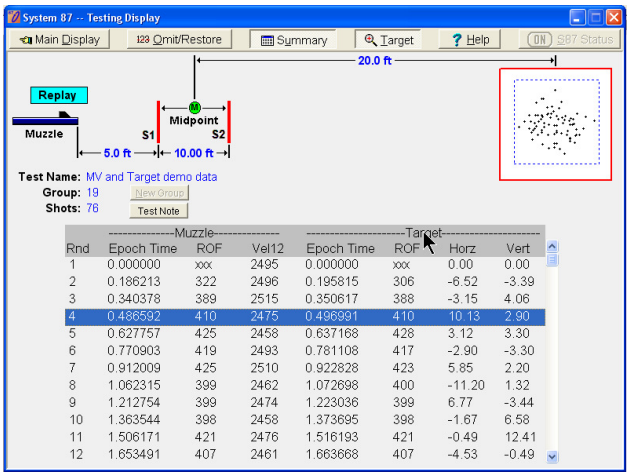
Leaving the monitor window shows the testing display.



Testing Display

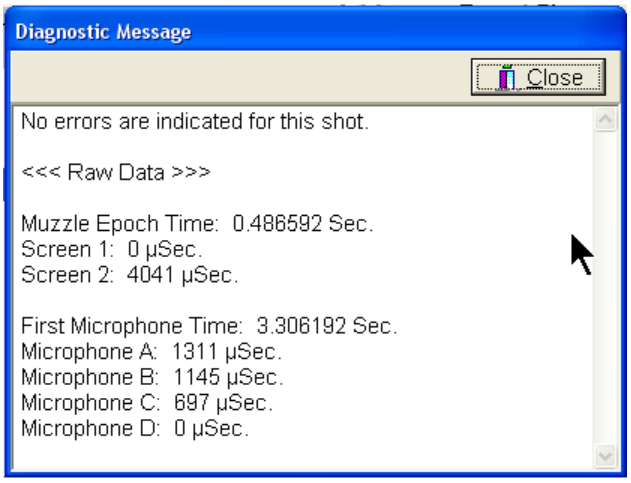
The testing display is your window for actual shooting. You see the graphic picture of your test setup. Pay attention to the green ready light in the upper left of the screen. If the light shows steady green and **Ready**, the system is ready for you to shoot; if it's yellow the system is busy.

Fire the burst. The System 87 will collect the data, but the display will not respond until you point and click on the –GET BURST DATA— panel. The system will respond with the round-by-round results. A slight delay is expected. For example, to process a 400 shot burst will typically take 5 to 10 seconds. The shot-by-shot results are displayed on a list and the target impact points are shown on a graph. Extra windows can be activated to show the statistical summary of the burst and a larger picture of the target. Individual shots can be highlighted with the cursor. The impact of the selected shot will be high-lighted in the target display. Clicking on a specific shot on the target display will highlight the corresponding line in the data. To get a diagnostic window, select and double-click on the round in question.



Testing Display after Shots

To get a diagnostic window showing the raw times for any individual shot, highlight the shot and double click.



Diagnostic Message

The diagnostic message shows the times at which various critical events occurred. It is especially useful for isolating problems with screens or microphones. All the times shown are in seconds or microseconds.. Epoch times are referenced to the first event, Screen 2 is referenced to Screen 1, and Microphone times are referenced to the First Microphone. Any expected event that did not occur is represented by **- - - -**.

If any line of shot data is overwritten by lines or dashes, it is considered to be omitted from the summary. Any shot can be omitted (removed from the summary and target graph), but it will not be erased. You can't remove all evidence of a shot just because you don't like it. The data may be trying to tell you something even if you don't recognize it now.

The S87 Status button located at the upper right corner is especially valuable. The ON indicator is normally green. If you fail to get a response (due to a sensor malfunction, bad cable, etc.), push the S87 Status button. This will cause the system to reestablish connection between the PC and the System 87.

CHAPTER 4

Main Display

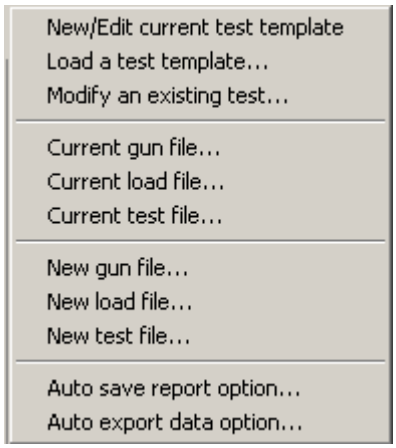
This chapter provides more details on setting up a test. For those who don't really believe in Windows, here are some old-fashioned printed instructions. If you are a Windows purist, we apologize for some of the constraints left in the program. For standardization, we have chosen to restrict some of the options sometimes available in Windows.

If you haven't taken the quick tour described in Chapter 2, we urge you again to take it now. It will help if your have your System 87 program running as you read these explanations.

The Main Display widow is the center of the System 87 software. Everything starts and ends at this window. You leave this window by pushing one of the buttons at the top, and the only controlled exit from the program is back through this window.

Setup Options

The **Setup** button will bring up a list of options.



Setup Options

You must go through the setup options prior to any test *except* when you are firing another group with the same gun and ammo under exactly the same conditions. It's the only place you can enter test information!

The **New/Edit current test template** option lets you define what you want to measure, how your equipment is set up, the environmental conditions, gun information, and load information.

The **Load a test template** option allows you to load any previously defined template. You can add new groups to an earlier test, or you can load an earlier similar test to form the basis for editing. It is anticipated that users will keep common tests in a networked file to assure consistency between gunners and firing bays.

The **Modify an existing test** is a dangerous option. It allows you to correct a previously fired test for information or conditions entered in error. For example, you can correct the distance between screens on a velocity test. Upon any subsequent replay or printing, the test results will reflect the changes you make. You can edit test conditions, fill in extra blanks about the load, or make similar corrections; you can also demolish the validity of a test if you put in the wrong numbers. To note possible alteration of your original recorded data, any replay or print subsequent to a modification will include an "edited" flag in place of the date.

The **Current gun file, Current load file, and Current test file** options allow you to specify the files currently in use by the program. The program will typically search a folder for files with the .s87 suffix and allows you to select the desired

files for use. As a matter of habit, we use .s87 as the suffix for all of these files, and reflect the type of file in the prefix name. For instance, we would use Gundata.s87 or Guns.s87 or similar names for gun files.

The TestData.s87 files are particularly important. These files contain the "mother lode" information for each test, and should be backed up and treated as valuable. You can use the System 87 software installed on any Windows computer with a test data file to replay or print the results of any test contained in the file. You can print the test report and even export both the pdf and Excel files. We suggest starting new test data files (for instance TestData2011.s87, TestData2012.s87, TestDataCharlie.s87 so that your files do not become excessively long.

Here you will also enter the locations for **Auto save report option** ... and **Auto export data option** ... These folders will receive the *pdf* and *Excel* reports automatically generated at the end of each firing test.

The **New gun file, New load file, and New test file** options allow you to create the new files for any of the three functions. If you do a lot of tests, you will probably want to start segregating different types of guns, loads and test data into different test data files. For example, you may want to reserve certain names for networked files of standard test barrels [guns], standard cataloged ammo [loads], and output data from standard tests. Users may generate local files for nonstandard tests and conditions.

Test Button

The **Test** pushbutton starts an actual firing test. It will establish handshaking between the PC and the System 87. If handshaking cannot be established, the most common cause is the USB cable not properly connected. The diagnostic screen will indicate proper connection. If all else fails, then unplug, hesitate, and then replug the USB connection. By the time you get to the actual test screen, there isn't much to do except shoot when the light is green.

Printout Button

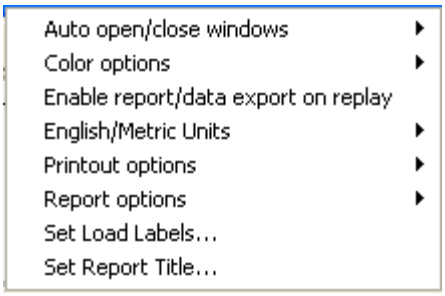
The **Printout** button of the main display is used to print or to view the results of fired tests. Select the test your want to print or view from the list. Hint: *The right mouse button will easily take you back to the last test you selected. You often want to go there*. After one or more tests are selected for printing, hitting the **PrintOut** button will bring up the **Report Setup** screen. It will default to showing a preview of the printed report on the screen. *If you want a real printed copy of the report, hit the printer icon at the top of the preview screen. If you don't hit the printer icon now, you'll have to go through the select process again and select the Printer pushbutton instead of the default Preview button*.

Replay Button

The **Replay** button of the main display is similar in function to the printout button. It allows you to select from a test list and shows the screen of the actual test results with summary and ballistics available. The setup, gun, and load information for the selected test will be displayed on the Main Display when you return from the replay. You can get a consolidated report of both test results and the setup conditions with a printout.

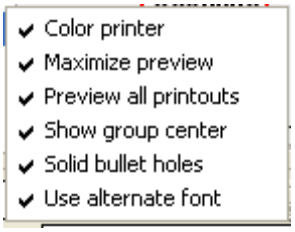
Options Button

Under the **Options** button of the main display, you can change several appearance items.



Options

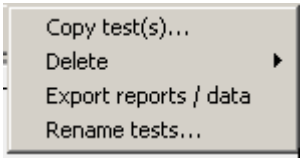
Auto open/close windows provides for automatic opening and positioning of the **Summary** and **Target** windows during a test. The **Color options** affect the display of the testing screen used during actual shooting. **Enable report/data export on replay** allows the export of both report and data during replay. **English/Metric Units** allows you to choose the system of units for display, reports, and data out. **Printout options** affect the content and appearance of the printed reports. **Report options** allow choice between the standard report and a raw data report useful in diagnosing malfunctions. The **Set Load Labels** allows the entry of optional labels for two data fields in the load information. **The Set Report Title** option allows you to put your own report title (for instance, company name can automatically appear as the major heading of each printed report).



Printout Options

Under the printout options you can make several significant selections. Checking the **Maximize preview** spreads the report preview over the entire screen. Checking **Preview all printouts** makes you look at a screen before it wastes a sheet of paper on a printout; it also slows you down when you know what you want to print or want to print multiple reports. **Show Group Center** will cause the location of the group center to be shown on the printout. **Solid bullet holes** will indicate impacts on the target printout as solid black circles; unchecked it will show impacts as hollow circles. Checking **Use alternate font** may help older printers.

Tools Button
(Includes Export to Database)



Tools Options

Under the **Tools** pushbutton of the main display, there are several useful options. The **Copy test(s)** allows you to reorganize your tests and put test results into different test data files. The **Delete** function allows you to delete or scrap tests, guns, loads, or test templates. The **Export reports / data** option allows you to export test data in both *pdf* and *Excel* format to the folders specified in **Setup**. The **Rename tests** ... option allows you to rename your tests. **This can be dangerous!** If you rename tests, you assume responsibility that the changed names of the tests are reflected in all data files and reports.

Close Button

The **Close** button lets you exit the program gracefully.

The **Equipment Diagram** of the main display gives you a picture of the test equipment used for the displayed template. It is automatically updated to show the distances and equipment specified in the setup.

Entering Test Setup

For adequate documentation of each test, you should fill in all the little boxes of the main display. The distance between start and stop screens is essential. If an acoustic target is used, the size of the target, the expected velocity at the target and the air temperature is essential. The other boxes may simply be desired for record. Just fill them all in; we guarantee that you won't have too much data years from now. Note: English units are shown as example. Metric units will appear if metric option is chosen.

Test:

Name the test with a unique name. Tests can be alpha-numerically sorted on all lists, so choose the first few characters carefully. This will determine the test order and grouping on all displayed lists. The box to the right of the test name is the group number of all those tests performed with this same template.

Operator:

The name of the gunner or operator is an optional bit of data.

Test Bay:

The number or name of the test bay is optional.

Muzl to Scr1: feet

Enter the distance from the muzzle of your gun to the start screen.

Scr1 to Scr3: feet

Enter the distance between the start and stop muzzle screens.

Muzl to Trgt: feet

Enter the distance from muzzle to target.

Target Size: inches

Enter the length of one side of the target square as x.xxx inches.

Temperature: F

Enter the current temperature in degrees Centigrade.

Humidity: %

Enter the relative-humidity percentage.

Altitude: feet

Enter the altitude at the firing range in feet above sea level. An accuracy of 100 feet is normally sufficient for ballistic coefficient calculations.

Baro Press: in Hg

Enter the current reported barometric pressure in inches of mercury. If you do not know the current pressure, use the standard value of 29.92.

Reported pressures are corrected to sea level. The program corrects the reported pressure to the actual pressure at your altitude. If you know the raw pressure at your location, hit the button to the left of the box and the program will then accept the raw pressure.

Date: Time:

The program automatically picks up the time and date from the computer when a test is fired.

Entering Gun Data

Most gun data is entered only one time for any gun, but it can be edited. Learn to use the little load and store icon located immediately to the right of the gun name box. It will save much time.

The various entries in the gun file are.

Gun Name:
Enter the name of your gun. We find it most convenient to use the headstamp caliber numbers as the initial characters. That way it's easier to find guns in a list.

Mfg/Model:, Caliber:, Serial #:
These entries are optional.

Maximum ROF:
Enter the maximum anticipated rate of fire. This parameter is used to adjust the hold-off time between scoring of successive shots and is critical to system performance.

Entering Load Data

All load data is for your memo use only. Load data may be reused many times. Again, it will be to your advantage to learn how to save and store loads in the load file. We would expect normal production loads to be stored in a networked load file.

Load Name:
As with guns, we prefer to start load name with the numerals of the headstamp designation. This grouping makes it easier to find loads in the list. You may want to use catalog numbers or other product identification.

Bullet Mfg:
This is optional.

Bullet Wgt: Gr
This is optional.

Bullet Style:
This is optional.

BC:
This is optional.

Powder:
This is optional.

Powder Wgt: Grains
This is optional.

Lot Number:
This is optional, but almost as important for your records as powder type and weight.

Primer:
This is optional.

Brass:
This is optional.

Max Avg Press:
This is optional and is simply for convenient reference.

Avg Velocity:
This is optional and is simply for convenient reference.

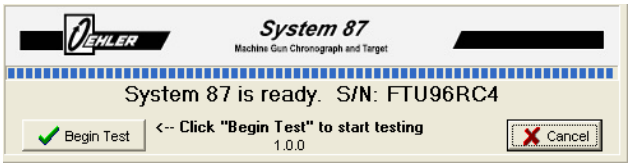
Note that the last two above headings can be altered to record any other parameter of regular interest. See **Set Load Labels** under the **Options** list of the Main Display.

Note:
You can add a short note about this load.

CHAPTER 5

Testing Display

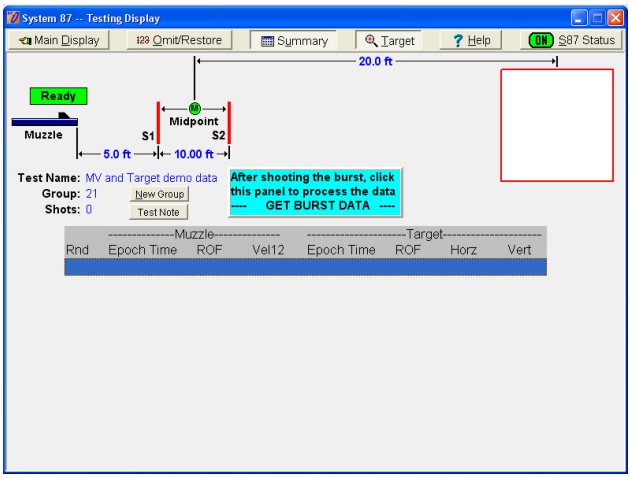
After the template is successfully saved, you will be returned to the Main Display window. Push the **Test** pushbutton to start the test. This will establish and check the USB connection to the System 87.



Monitor Window

The monitor window will be displayed. You will see a dotted completion bar under the picture of the System 87 front panel as initial checks are performed. After the completion bar finishes, push the **Begin Test** button. You must allow the completion bar to finish.

Leaving the monitor window shows the testing display.



Testing Display

The testing display is your window for actual shooting. You see the graphic picture of your test setup. Pay attention to the green ready light in the upper left of the screen. If the light shows steady green and **Ready**, the system is ready for you to shoot.

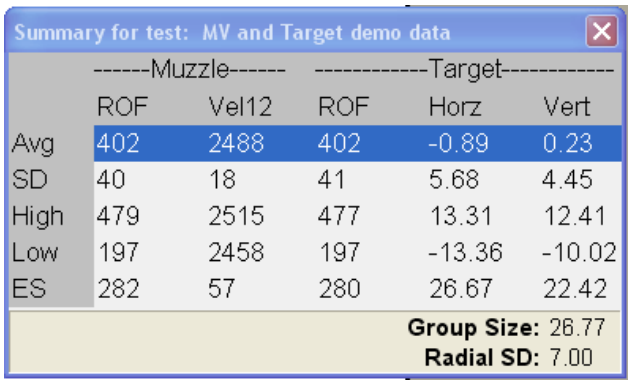
Across the top of the Testing Display are five buttons.

The **Main Display** button returns you to the Main Display window.

The **Omit/Restore** pushbutton will alternately omit the data from a round from the summary, or it will restore the data from a round to the summary. Omitted rounds will have a line drawn through the numeric data.

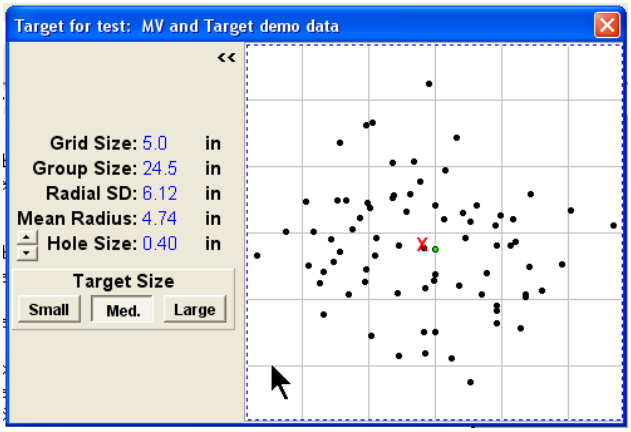
If any line of shot data is overwritten by lines or dashes, it is omitted from the summary. When the System 87 detects known abnormal data, it will automatically omit that shot from the summary. Any shot, or shots, can be omitted (removed from the summary), but they will not be erased. You can't remove all evidence of a shot just because you don't like it. The data may be trying to tell you something even if you don't recognize it now.

The **Summary** button pops up a window including a summary of all valid rounds fired.



Summary

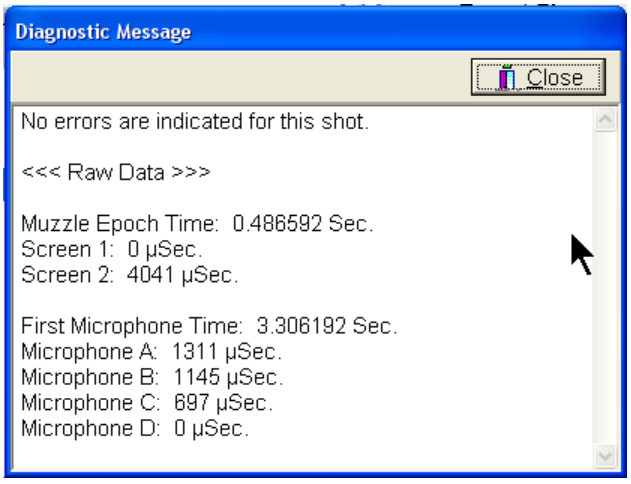
If the size and resolution of your display permits, you can move the summary window to uncover the primary test window.



Target

The **Target** button brings up the target window showing the group on the target along with the statistics of the group. A red **x** marks the group center and the green filled shot location corresponds the round highlighted in the numerical data. Clicking on any shot will highlight the corresponding line of numeric data. You can select the size of the target window as well as the apparent size of the bullet hole. Selecting a hole size comparable to actual bullet size causes the target display to appear similar to an actual physical target. Note the symbol << at the upper left portion of the target window. Clicking this symbol minimizes the left panel of the target for tight display screens. Clicking on the >> symbol will restore the panel.

The S87 Status button located at the upper right corner is especially valuable. The ON indicator is normally green. If you fail to get a response (due to a sensor malfunction, bad cable, etc.), push the S87 Status button. This will cause the system to reestablish connection between the PC and the System 87.



Diagnostic Message

The diagnostic message shows the times at which various critical events occurred. It is especially useful for isolating problems with screens or microphones. All the times shown are in seconds or microseconds.. Epoch times are referenced to the first event, Screen 2 is referenced to Screen 1, and Microphone times are referenced to the First Microphone. Any expected event that did not occur is represented by **- - - -**.

The **Help** button is available for those hints you need to keep going.

The **Test Note** button can be opened at any time before, during, or after the test. The only restriction is that you must make your notes before you ask for a new group. This is the ideal spot for any alibis or other notes. These notes will be printed on the test report and will be available during any replay. Notes can be added or modified during replay.

If you make any changes in distances or other data during a replay, it is good practice to record such changes and reasons in the notes.

The **New group** Button. After you fire at least one shot, you can start a new group. The data from all shots is cleared from the screen and the group number increments as soon as you hit [N]. Use [N] to start a new group only if you have no comments to add to your existing group and you have no changes to make regarding conditions, gun, or load. If you hit [N] and then exit to the setup screen, the setup screen will have the group number of the new group.

Any time you end a test with the new group button or otherwise, the system can automatically write the test report in *pdf* and *Excel* to the appropriate folders designated in setup. The test name and group number will be used as the file name. If the "raw" report option has been selected, then "raw" will be included in the file name.

Measurement Channels

The column headings shown on the testing screen are those you previewed on the Setup screen. They include:

Rnd

The round number of the shot within the burst.

Epoch Time

The time in microseconds at Screen 1 since the beginning of the burst.

Vel12

The velocity in feet [meters] per second measured from screen #1 to screen #2. It is commonly called the instrumental velocity.

Rate

The rate of fire in rounds per minute observed from the preceding round.

EpochT

The time in microseconds at the target plane since the beginning of the burst.

RateT

The rate of fire in rounds per minute observed from the preceding round as measured at the target.

Horiz

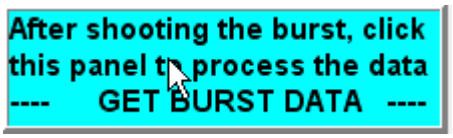
The horizontal coordinate of the apparent impact point at the target.

Vert

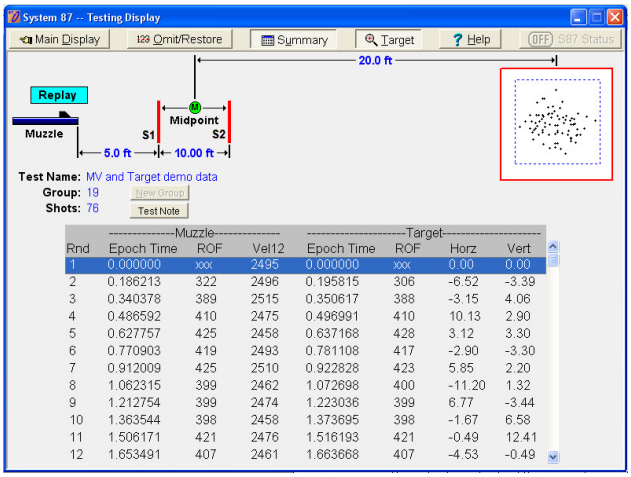
The vertical coordinate of the apparent impact point at the target.

If the system did not recognize proper input signals for any measurement channel, that measurement will be shown as dashes, --- . Highlight the shot and double-click to get the computer's guess of what went wrong on that shot. If a record contains dashes instead of data, or if the data is over-written with dashes, the record is omitted from the summary. Omitted data can be restored and included in the summary by hitting the **Omit/Restore** button.

At the testing screen you are instructed to fire the burst.



After the burst is fired, signal the computer by clicking the window. Your data will then be displayed in a window that can be scrolled.



Testing Display, Burst Fire

In the statistical summary, the average rate of fire is computed as the average of all the individual rates of fire. You can manually compute average ROF for the entire burst or burst segments by using the difference in epoch time for the desired beginning and ending rounds.

CHAPTER 5

Acoustic Target

Acoustic Target Background

Oehler has been making acoustic targets for measuring the apparent impact points of supersonic bullets since 1982. These systems are used extensively by the government, defense contractors, and ammunition makers.

The principle of the acoustic target is simple. Any supersonic projectile carries with it a Mach cone or "sonic boom." Four microphones detect the time at which the Mach cone arrives at the target. Given the location of each microphone, the speed of sound in air, and assuming that the bullet travels perpendicular to the target, it is possible to compute the apparent path of the bullet. The System 87 relies on the operator to provide a realistic estimate of projectile velocity at the target and computes the speed of sound in air from the operator's input of temperature.

Accuracy of the acoustic target is best with higher velocities (typically over 500 m/s). At higher velocities the Mach cone is sharp and skinny; this allows good accuracy in computing the target impact coordinates. We observe typical accuracies for the four-microphone system to be in the order of 0.15% of the side of the microphone square. For example, if each side is 2 meters inches, the coordinates are typically accurate to 3 mm. If each side is 3 meters inches, the coordinates are typically accurate to 5 mm. At lower velocities (say 420 m/s) the system still works, but accuracy is reduced.

Accuracy of the scoring is diminished near the corners of the target square. Stated accuracies apply within the circle inscribed within the target square. Best accuracy is obtained near the center of the target.

Shooters using conventional paper targets have learned that it matters not if the target face is slightly slanted with respect to the bullet path or line-of-sight to the gun. The firing results observed on the target are immune to small errors in angle. **This does not hold true for the acoustic target.** For example, if you have a target with 2 meter sides, and you tilt the top 1 cm toward the gun, you can raise the reported acoustic target impact point by 1 cm at velocities slightly above the speed of sound. This effect is most critical if the target scoring is referenced to a specific aim point on the target plane, but it has little effect on the precision or group size measurements. The error is reduced at higher velocities.

The tilt effect will significantly affect group size measurement if the acoustic target frame is allowed to tilt back and forth during the burst or group.

Acoustic Target Setup

The acoustic target is shipped as a set of four microphones, four short BNC/BNC cables, an **8336 Downrange Amplifier** with power supply. You must supply a square wooden frame on which to mount the microphones.

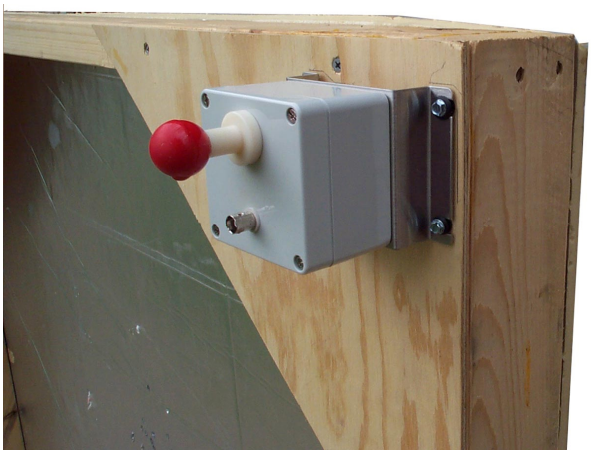
Typical Microphone Frame

The accuracy of the target system is influenced by your choice of target size. If you make the target larger, it will be easier to shoot within the square, but target accuracy will suffer. You can make the target more accurate by making it smaller, but you are more likely to hit a microphone with a stray shot.

If you are shooting in a square or rectangular "walk-in" tunnel, we suggest that the microphones be mounted against the walls or ceiling to form the largest possible square and to allow an armor plate deflector to be mounted in front of each microphone. Microphones must be located sufficiently far back from the armor plate that a 45° Mach cone can strike the microphone. For example, if the microphone is "shaded" by 10 cm, the shield should be at least 10 cm in front of the microphone.

If you are shooting through a reduced diameter tunnel into a target room, we suggest a frame with the sides of the microphone square equal to the inside diameter of the tunnel. This will hide the microphones from the shooter. Make sure that the frame is spaced away from the mouth of the tunnel to allow the Mach cone to strike the microphones properly.

The actual microphone element is the hemisphere atop the lollipop mounted on the gray box. The microphone element is ceramic and is quite fragile. The Mach cone sound wave must hit each microphone directly. Mount the microphones on a wooden square frame so that the four balls form the corners of the target square. Point each lollypop directly toward the gun.



Microphone Detail

Be sure that the microphones are mounted to wood, and use the rubber grommets to provide isolation from shock waves transmitted through the frame to the microphone. Mounting the microphones on a metal frame or bracket is an invitation to

trouble. (Sound can travel through a metal frame fifteen times as fast as it travels through air. A Mach cone striking a metal frame can travel through the frame and into the back side of the microphone before the airborne Mach cone impacts the microphone element.)

If paper targets are to be mounted on the same wooden frame with the microphones, use a cardboard, "foamcore" or "cellotex" sheet to hold the target. Bullets striking the wooden frame can sometimes cause target errors.

The system can be made to work at over 1000 yards if you use Category 5 cable typically used for computer networks. This cable is readily available and relatively inexpensive for limited use. Connections can be made with the connector pin-out normally associated with local area networks.

If the long-range installation is permanent, we urge the use of the "direct burial, gopher-proof" cable commonly used for telephone service. The Category 5 cable is adequate for indoor use, but is soft and tender. Rodents love to eat it.

The target square should be approximately level and perpendicular to the path of the bullet. If the microphones shift (even fore and aft) as you fire a group, the apparent impact points will also shift and the target system looses accuracy.

Connect the cables from the microphones to the inputs of the downrange amplifier box. **As viewed from the gun,** the microphones are designated

A D

B C

If signals from microphones are crossed, the groups may appear flipped, inverted, rotated, or as a single line. There is only one way to connect the mics properly; there are twenty-three wrong ways.

APPENDIX A

Correcting Data

Sooner or later you will have a test record in which you have entered the wrong distances, temperature, load information, or other data. You will want to salvage and correct the data for the actual conditions. It can be done but you should leave clear tracks of the edit in the notes section. The corrections entered will apply only to the one group.

Begin the correction process from the **Setup** pushbutton of the **Main Display**. From the menu, select **Modify an existing test**. Load the desired test and make any desired modification.

After you return to the **Main Display**, we urge you to **Replay** the test you just modified, and make notes describing the nature of the correction.

The corrected group has now been saved. **Replay** it for a quick look at the corrected data, or use **Printout** for a corrected copy of the test. The procedure makes accurate corrections for small errors in distances and conditions.

APPENDIX B

Calibration

There is no "Blessed" procedure for the calibration of the projectile velocity measurement systems. Iron-clad calibration of chronographs requires the use of projectiles of known velocity; such projectiles are simply not available. The calibration and use procedures outlined utilize the desired concepts of traceability whenever they are available and appropriate.

The accuracy of any digital chronograph system is primarily influenced by four considerations.

Time Base Frequency The actual frequency of the time base oscillator must be within expected tolerances of the nominal frequency.

Digital Counting and Computation The time required for the projectile to pass between start and stop sensors is determined by counting the cycles of the time base signal. Assumed distance is divided by the observed time to determine velocity. Such counting and computations are commonplace and are normally subject to gross failures but not small errors.

Spacing Between Projectile Sensors Because velocity is computed from the formula VELOCITY = DISTANCE / TIME, the distance is just as important as the time. It is often assumed that the distance is simply the mechanical distance between the screens. In reality, the true distance is the distance that the projectile travels between the electronic start and stop signals.

Projectile Detection The passage of a projectile must be detected at each sensor to mark the start and stop of the measured time interval. The time accuracy of this detection is most critical to the velocity measurement, but the detection process occurs in the "use" environment and cannot practically be simulated in the calibration laboratory. Any errors or delays in the detection process directly influence the actual distance the projectile travels between start and stop signals. This is the most important, and the most ignored, aspect of chronograph accuracy and reliability.

System 87 Specific

Take these considerations in order as they apply to the System 87.

The time base frequency can be calibrated with conventional calibration laboratory procedures. Remove the cover, apply power to the unit, and measure the frequency of the signal of the crystal oscillator of the 40-pin 5213 module. The frequency of the oscillator should be 3.666666 MHz resulting in a clock frequency of 66.000000 MHz for the processor. This frequency is most easily measured at the terminals of the crystal using a 10/1 probe for minimal loading. If the frequency is within 0.015% of nominal (between 3.666116 and 3.667216 MHz), the chronograph is considered to be calibrated.

The digital counting and computation is assumed to be correct. No calibration is required or suggested. If verification is required, we suggest use of the Oehler Model 77 Firing Simulator as a source of trigger pulses at known time intervals..

The spacing between projectile sensors must be accurately determined during the operation and use of the system. Appropriate calibration and use of measurement devices is assumed.

Model 57 Photoelectric Screens

We cannot provide a calibration certificate for the M57 screens simply because we don't know how to provide a "blessed" calibration. We can, and do, test function to assure ourselves and our customers that the screens will work for their intended purpose. Asking for calibration of the screens is almost like asking for a calibration of a pocket knife; safety, function, accuracy, etc. are so dependent on the user and conditions of use that the calibration certificate doesn't mean much.

Triggering a photoelectric screen with a light source driven by a specific electrical signal can yield a screen output at a measurable time delay. This test measures only the response of the electronic detector portion of the screen; it does not measure the performance of the light source or the optical path of the screen.

It is theoretically possible to calibrate screens using either micro-flash or high-speed x-ray triggered by the screen output to locate the projectile at the time the screen triggered. This procedure would be prohibitively expensive to implement, and would still demonstrate performance only in the laboratory environment with a projectile of a specific size, shape, and velocity.

In the practical world, measuring the velocity of common air rifle "BB" at 250 fps or faster is a realistic (actually very difficult) test of screen function and system operation. It's not a blessed calibration, but we've used it for forty years.

It should be noted that the velocities are computed from measured time and distance. The distance used is typically the spacing between screens. This is an approximation; the actual distance should be the distance that the projectile travels during the time between start and stop signals. This distance is prohibitively difficult to measure. After many years of firing many shots through redundant screen setups, we consider that a 1/8 inch or 3 mm uncertainty in screen spacing is an appropriate rule-of-thumb even though distance between screens is measured exactly.

Redundant Measurements

The difficulty of calibration leaves one suggested alternative. If the velocity measurement is critical, make a redundant measurement of the velocity at each shot. Use a second system completely independent of the first. The differences in the velocity readings from the two systems provide an intuitive measure of the accuracy of the measurements. Such an arrangement will usually detect the common errors caused by muzzle flash, muzzle blast, interfering light, or even the simple errors in screen spacing.

APPENDIX C

Firmware Protocols

Introduction
The System 87 Ballistics Machine Gun Chronograph and Target System is designed to measure muzzle velocities, rates of fire, and acoustic target hits in burst mode. The System 87 supports the parametric measurements of rate of fire, muzzle velocities, and down range targeting.

Event Timing and Capture
The following time events are captured and returned to the PC using eight synchronized hardware timers with a resolution of slightly less than 1uS. Because of hardware limitations of the GPT counters, each count is exactly 0.969696 uS. The raw times are converted to microseconds with double-precision prior to display or export. Data for up to 400 rounds is returned.

- Velocities and Target

FirstMic	Latched Rise Edge	DMA Timer 0 (32-bit)
Start	Latched Rise Edge	DMA Timer 1 (32-bit)
Microphone D	Latched Rise Edge	DMA Timer 2 (32-bit)
Stop	Latched Rise Edge	DMA Timer 3 (32-bit)

- Targeting Only

Microphone A	Latched Rise Edge	GPT Timer 0 (16-bit)
Microphone B	Latched Rise Edge	GPT Timer 1 (16-bit)
Microphone C	Latched Rise Edge	GPT Timer 2 (16-bit)
Microphone D	Latched Rise Edge	GPT Timer 3 (16-bit)

Hardware Interface
The hardware interface to the PC is an industry standard USB interface. The USB module is a Future Technology UM232R. The appropriate driver can be downloaded from their website, http://www.ftdichip.com.

The system departs from normal RS-232. It allows a reset signal to be passed through unused control lines. The user can reset the system 87 hardware through the USB module by setting DTR low for 5mS then resetting it high.

Application Programming Interface

The Application Programming Interface to the System 87 Ballistics Measurement Unit is the ASCII alpha upper case, character set. Communications use a master-slave protocol with the measurement unit in the slave role. The PC is the master. The command and response character set is defined below.

Character	Software Command	Firmware Response
D	Dump Data Set	Send Full Data Set from last operation
E	Echo	Echo Last Command "E" - Verify USB Communications
F	Build Test Data Set	Worst Case File size Data = 100000000 + Data field #
M	Machine Gun	Burst Velocity and Burst Targeting
N	Send Next Data Block	Hand shaking within the Data Dump Routine
X	Abort Current Task	Abort task and return to Ready
Z	Data Transfer Complete/Terminated	Hand shaking within the Data Dump Routine
R	Ready	Ready response is sent from System 87 unit to PC

Command Character set

The firmware immediately enters the "Ready" state following a hardware reset. It transmits an **R** and then awaits a command in the Ready state. The firmware always comes back to Ready state at the completion of any command. Upon receipt of a character the firmware determines if it is a valid command. Invalid commands are echoed back, and the firmware returns to the Ready state. Valid commands are echoed as program execution is vectored to the appropriate measurement routine during which the firmware continues to monitor for commands. At any point in the execution of a command the execution can be aborted with the "Abort Current Task" command. Upon completion of commands the firmware always returns to the Ready state.

The Machine Gun task requires further information from the software: Two times, Tmin and TmaxTgt are used by the firmware during the burst.

Communication Protocol for Data Dump

The date file is organized in Blocks and Fields. Each block contains four Fields as indicated below.

|<---------- Block 1----------→|---------- Block 2----------→|
|<Field 1>,<Field 2>,<Field 3>,<Field 4>,| <Field 5>,<Field 6>,<Field 7>,<Field 8>,|

All Fields are comma separated. All data is formatted ASCII alpha or a formatted 32bit positive integer value, (0, through 999999999). Note that the values for Microphone1[], Microphone2[], Microphone3[], and Microphone4[], are 16-bit positive integers.

The firmware transfers a Block of data then waits for a command "N" to transfer the next Block or a "Z" to abort Data Dump. The software can request multiple Blocks to be transferred by issuing multiple block transfer commands. After transfer of the final block the firmware will poll for an acknowledgment "Z" that the file transfer is complete.

Data File Format

Block 1:
Field 1 = Last Command/Measurement completed
Field 2 = Number of shots
Field 3 = 0
Field 4 = Field Count = 8 + (8 * Number of Shots)
Block 2:
Field 5 = FirstMic[i]
Field 6 = Start[i]
Field 7 = MicD[i]
Field 8 = Stop[i]
Block 3:
Field 9 = Microphone 1[i]
Field 10 = Microphone 2[i]
Field 11 = Microphone 3[i]
Field 12 = Microphone 4[i]
…
Repeat Blocks 2 and Block 3 until data for "Number of shots" is reported.
…

Block N (N = Field Count / 4)
Field 813 = Reserved Status Code 1 =Q
Field 814 = Firmware Revision =xxx
Field 815 = Check Sum Field
Field 816 = "Z"

APPENDIX D

System 87 Organization

The purpose of the System 87 is to measure rates of fire, velocities, and target information of tested guns and preserve the results of these measurements in a form that is easily interpreted by the operator and is recorded for archives and future interpretations.

The System 87 uses test names for each test. The test name consists of a root test name plus a successive group number of various tests fired using this name. You must be able to locate the results of previous tests, either by shuffling through many printed test reports or by searching in a computer. Fortunately, the gun and ammo industry has the names and a way to make the first sort of test results, test guns, and test ammunition. The headstamp name is unique, concise, and universally recognized. We urge that test names, gun name, and ammunition names use a headstamp name as the initial characters. To conserve space on lists and displays, we suggest that only numerals and letters be used without spaces or symbols. For instance, 556, 762, 50BMG are recognizable and unique identifiers. If all test names begin with these characters, any search is narrowed considerably.

After a space, the nature of the test can be described. Following the headstamp the user may add to the test name at his discretion.

It is recognized that the gunner wants to enter minimal information into the computer before firing the test. However, you want to see complete information on any test reports and data. If the gunner doesn't provide all the desired archival information, it must come from somewhere and be properly associated with the test.

The System 87 uses what we call "templates" to define the test name and conditions and to describe just what is to be measured. In the environment of multiple test tunnels shared by many operators, standardization of the tests is a high priority. Operator data-entry with the associated errors must be minimized, yet the operator must retain the capability to properly record any departures from the provided script. The traditional means of minimizing data entry errors is allowing choice from a predetermined list. For instance, each test tunnel would include its own set of templates. Given a sample of 762 ammo for the standard ROF test, the operator would look for and load the template labeled "762 xxxxxxx". The template would already include entries for tunnel designation, appropriate screen locations, environment, etc. The operator would probably insert his name. The template would default to a particular gun, but this could be readily changed by selecting and loading a new gun, filed under "762 xxxx . . .". The template would include a default load file. That file too can be readily changed by selecting from a list of "762 . . ." standard load files.

After making the appropriate selections, the operator will have the freedom to make changes to the template; any changes made will be reflected in the printed test report and exported data. If changes are made to the template, the operator will be given an option to save (overwrite) the existing template. If the operator elects to overwrite, he will be prompted "Are you authorized to make this change?" Only if the operator claims authorization will the original template be altered. The operator may use the edited template during his test session without saving it, but the template will revert to its original

form for later tests. We envision a structure of test templates, gun files, and load files in which the operators have the freedom to make required changes, but are restricted from making inadvertent changes. Just as Windows has administrators, users and guests, we envision a similar protocol for use of the System 87. We feel ham-strung by the Vista requirements for administrator permission for relatively minor changes, but we do appreciate the warning that we are making potentially damaging changes. The System 87 will give the warning, but it won't tie you hands.

We envision that the "master" test templates would be established by supervisors or proven capable operators. These templates will be stored locally in the tunnel where they are used (and can provide information unique to that tunnel or setup). Test data and any special templates will be written to folders local to the tunnel. Reports and exported test data stored in folders at each tunnel will be periodically "mined" and reviewed by an administrator and then placed in appropriate archives.

We suggest that the gun files be created and maintained at one common network location and need not be stored at individual tunnels. If a gun is available for use, the most current data is automatically available.

Load data files are not critical. Again, we suggest that files for common catalog and production items be established and maintained in one common network folder. The System 87 makes practically no use of the information included in the load data; it is required as a "memo" to assure a complete record of your test.

APPENDIX E

Firing Simulator

Oehler has provided firing simulators for use with their ballistic instrumentation systems beginning with the Model 75 Simulator thirty-five years ago. The 8225 Test Module was an important component of the Model 82 modular system. Oehler hastily built a firing simulator used in the development and demonstrations of the System 85. This simulator provided an adequate representation of firing signals generated during pressure and velocity testing, but simulation of the acoustic target was minimal and there was no provision for simulation of automatic fire.

The initial users of the System 85 were unanimous in expressing their need for a firing simulator. Firing simulators are used at every workbench where we test System 85 units and even simpler instruments. When we needed a better firing simulator for development tests of the new machine-gun-chronograph/target system, we were forcibly reminded that a firing simulator is an essential part of any modern ballistic test system. The firing simulator is now built-in as standard in both the System 85 and System 87.

The built-in firing simulator is independent of the System 85 processor and computer. It is powered by an internal battery and is activated only when the user pushes the BANG button. It is controlled by its own microprocessor to generate a fire signal, a pressure signal, muzzle velocity start and stop four signals from an acoustic target.

The simulator must be connected to the System 85 inputs just as you would connect other input sensors. A short Ethernet cable along with four short BNC/BNC cables are provided. If you want to connect both pressure channels, use an extra BNC cable and T.

Operation of the simulator is controlled by the BANG pushbutton along with the settings of two toggle switches. Pushing the BANG button powers the simulator; hold it down firmly until the firing test is completed. There will be a three-second delay as the system stabilizes, and then the red LED will blink at each shot.

The SHOTS toggle switch controls the number of simulated shots provided in response to one continual push of the BANG button.

- A setting of **1** SHOT is the single-shot or most basic mode. Only one shot is fired in response to the BANG input. If the button is held for more than three seconds after the shot is fired, the pressure signal assumes a value of exactly +7.00 volts dc. This can be verified with an external dc voltmeter to assure calibration. If required, the internal potentiometer R8 should be adjusted to provide the exact +7.00 volts dc.

- A setting of **20** SHOTS conveniently fills the output screen and page with a 20 shot test.

- A setting of **200** SHOTS demonstrates capability of handling longer burst of automatic fire.

The RPM toggle switch controls the firing rate of repeated simulated shots provided in response to one continual push of the BANG button.

- A setting of **20** RPM must be used for all shots for which FIRE or PRESSURE signals are expected. If the RPM is set at 20 for a test of 20 SHOTS, then a special set of pressure signals are generated. The first pressure signal will be at +7 volts, the second will be at +6, the third at +5, and they will continue to step down one volt with each shot. The 8th shot will go to +8 volts and the sequence will be repeated. The 16th shot will begin a new partial sequence. This repeated sequence can verify the accuracy of the pressure readings over the common operating range.

- A setting of **1000** RPM corresponds to the highest rate of fire most individual automatic weapons. The simulator will generate appropriate START and STOP muzzle velocity signals along with acoustic target microphone signals for each shot of a burst.

- A setting of **6000** RPM corresponds to rates of fire expected from the Vulcan or Mini-gun. The simulator will generate appropriate START and STOP muzzle velocity signals along with acoustic target microphone signals for each shot of a burst.

Users will find that the firing simulator makes a wonderful training aid for system operators. Using the simulator, the novice operator can practice connecting the system, setting up tests, firing tests, manipulating test reports and exported data, and can perform all the operations required of an operator. Supervisors can familiarize themselves with system operation before they must train the gunners.

Experienced operators can use the simulator to replace questioned input sensors with known valid signals to isolate problems or simulate faults. A bad cable is still a bad cable even if used with a simulator. A missing sensor signal will show up as bad on the raw time display of the '85 in response to a missing connection to the simulator.

Proper system response to the known signals from the simulator provides a realistic check and verification of system function and performance. In the practical world, such verification is often more valuable than formal calibration.

Battery

We chose a battery power supply because we tired of finding the proper adapter and plugging in a simulator each time we wanted to use it. Borrowing power from the system under test voids the independence between simulator and test system. A 9-volt lithium battery is required for proper operation.

The first symptom of low battery voltage will be a lower than expected reading on the 8-volt pressure pulse. If you fire a 20-shot pressure test sequence and the 8-volt reading is low while pressure readings of 7 volts and below appear to be correct, it is likely a battery problem. Remove the system cover and replace the battery with a known fresh lithium battery.

Please observe the battery polarity during installation. There is no power switch, and the circuit is not "idiot proof".

Using the Firing Simulator

A report generated with the firing simulator is shown on the next page. The user has no options to set the times and voltages generated by the firing simulator. This means that the user must input the proper distances, temperature, pressure scale factors, and filter choice to see outputs that correspond to a typical ballistics test.

Study the report presented. Of special importance are

- Muzl to Scr1: 5.00 feet
- Scr1 to Scr4: 10.00 feet
- Muzl to Trgt: 240.00 feet
- Target Size: 36.00 inches
- Temperature: 49 ˚F
- Baro Press: 29.53 in Hg
- Vel Correction: 0
- Press Correction 0
- Offset Press 0
- Press/Volt 10000
- Filter: Bessel 22kHz
- B.C. 0.300

This choice of input parameters should yield a muzzle velocity of 3333 fps, time-of-flight to target of approximately 72 ms, velocity at target of 3088 fps, an observed BC of approximately 0.325, targeted shots arranged in a 20-inch square, and pressures of 70K, 60K, 50K, 40K, 30K, 20K, 10K, 80K, 70K, …

It is not uncommon for the first shot at 70K to be slightly low. This is a characteristic of the simulator not being completely stabilized before the first shot is fired and does not reflect an error on the part of the measuring system.

If the pressure reading expected to be 80K is low while all lower readings are as expected, it is probably due to low voltage on the battery of the simulator module.

Remember, there is a delay of approximately three seconds between BANG button actuation and the simulated shot. This time is required for the simulator to power-up and stabilize. You must push and hold the button for the duration of the test. The red indicator light will blink as each shot is fired.

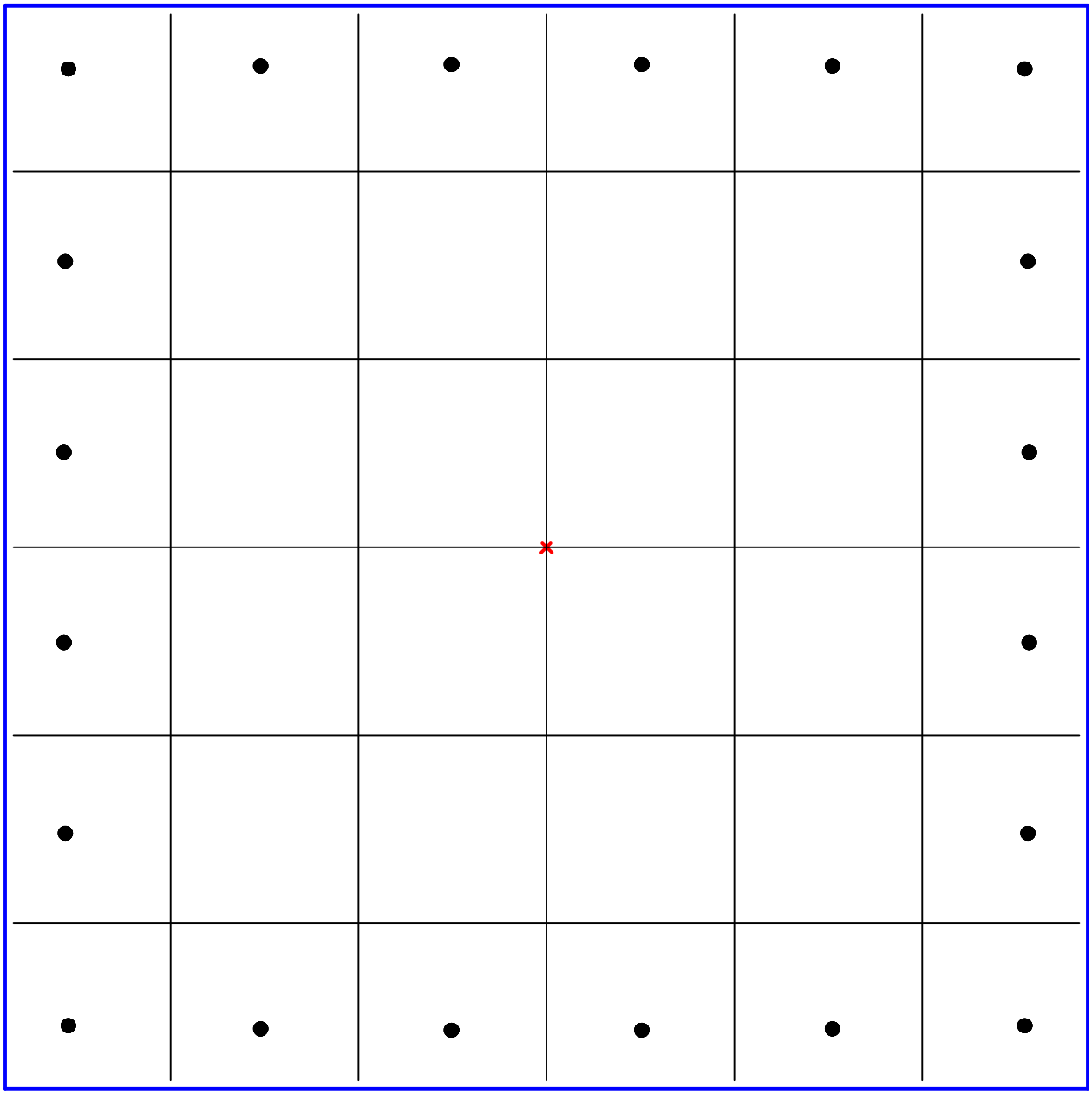
Test Using Model 77 Firing Simulator

Test: Simulator M77 Burst Mode Test 1
Operator: GS
Test Bay: Oehler Tech 1
Muzl to Scr1: 5.0 **feet**
Scr1 to Scr2: 10.00 **feet**
Muzl to Trgt: 240.0 **feet**
Target Size: 36.0 **inches**
Target Velocity: 2875 **fps**
Temperature: 59 **°F**
Humidity: 78 **%**
Altitude: 0 **feet**
Baro Press: 29.53 **in Hg**
Test Edit: 1/23/2013
Test Time: 14:24
File: G:\Sys 87-77 SN001\TestData.s87
Reports: G:\Sys 87-77 SN001\

Gun: Simulator M77
Mfg/Model: Oehler Built-In
Caliber:
Serial #: 001
Maximum ROF: 1200 **RPM**

Load: Simulator M77
Bullet Mfg:
Bullet Wgt: 0.0 **grains**
Bullet Style:
B.C.: 0.469
Powder:
Powder Wgt: 0.00 **grains**
Lot Number:
Primer:
Brass:
Max Avg Pre...
Avg Velocity:
Note: Burst test with built in M- 77 firing simulator.

Target Grid Size: 4.0 inches



Rad SD: 10.07 inches **Group Size: 28.80 inches** **Mean Radius: 8.40 inches**

SYSTEM 87 SHOT DATA

	Muzzle			Target			
Rnd	**Epoch Time**	**ROF**	**Vel12**	**Epoch Time**	**ROF**	**Horz**	**Vert**
1	0.000000	xxx	3335	0.00000	xxx	-10.18	-10.18
2	0.059997	1000	3334	0.06000	1000	-6.09	-10.25
3	0.119995	1000	3334	0.11999	1000	-2.02	-10.27
4	0.179993	1000	3334	0.17999	1000	2.02	-10.27
5	0.239991	1000	3335	0.23999	1000	6.08	-10.25
6	0.299988	1000	3334	0.29999	1000	10.18	-10.18
7	0.359986	1000	3334	0.35999	1000	10.24	-6.09
8	0.419984	1000	3335	0.41998	1000	10.26	-2.02
9	0.479982	1000	3334	0.47998	1000	10.27	2.02
10	0.539980	1000	3334	0.53999	1000	10.24	6.09
11	0.599978	1000	3335	0.59999	1000	10.17	10.18
12	0.659976	1000	3335	0.65998	1000	6.08	10.24
13	0.719973	1000	3334	0.71998	1000	2.02	10.27
14	0.779971	1000	3335	0.77998	1000	-2.02	10.27
15	0.839969	1000	3335	0.83998	1000	-6.09	10.24
16	0.899966	1000	3334	0.89998	1000	-10.18	10.18
17	0.959964	1000	3334	0.95998	1000	-10.24	6.09
18	1.019962	1000	3335	1.01997	1000	-10.29	2.02
19	1.079959	1000	3334	1.07997	1000	-10.27	-2.02
20	1.139957	1000	3334	1.13997	1000	-10.24	-6.09
21	1.199955	1000	3335	1.19997	1000	-10.18	-10.17
22	1.259952	1000	3334	1.25997	1000	-6.09	-10.25
23	1.319951	1000	3334	1.31996	1000	-2.02	-10.27
24	1.379949	1000	3334	1.37996	1000	2.02	-10.27
25	1.439947	1000	3335	1.43997	1000	6.08	-10.25
26	1.499944	1000	3334	1.49997	1000	10.18	-10.18
27	1.559942	1000	3334	1.55996	1000	10.24	-6.09
28	1.619940	1000	3335	1.61996	1000	10.26	-2.02
29	1.679937	1000	3334	1.67996	1000	10.27	2.02
30	1.739935	1000	3334	1.73996	1000	10.24	6.09
31	1.799933	1000	3335	1.79996	1000	10.17	10.18
32	1.859931	1000	3335	1.85996	1000	6.08	10.24
33	1.919928	1000	3334	1.91995	1000	2.02	10.27
34	1.979926	1000	3334	1.97995	1000	-2.02	10.27
35	2.039924	1000	3335	2.03995	1000	-6.09	10.24
36	2.099921	1000	3334	2.09996	1000	-10.18	10.18
37	2.159920	1000	3334	2.15995	1000	-10.24	6.09
38	2.219918	1000	3335	2.21994	1000	-10.29	2.02
39	2.279915	1000	3334	2.27994	1000	-10.27	-2.02
40	2.339913	1000	3334	2.33995	1000	-10.24	-6.09
41	2.399911	1000	3335	2.39995	1000	-10.18	-10.17
42	2.459908	1000	3334	2.45995	1000	-6.09	-10.25
43	2.519906	1000	3334	2.51994	1000	-2.02	-10.27
44	2.579904	1000	3334	2.57994	1000	2.02	-10.27
45	2.639902	1000	3335	2.63994	1000	6.08	-10.24
46	2.699899	1000	3334	2.69994	1000	10.18	-10.18
47	2.759897	1000	3334	2.75994	1000	10.24	-6.09
48	2.819895	1000	3335	2.81993	1000	10.26	-2.02
49	2.879892	1000	3334	2.87993	1000	10.27	2.02
50	2.939890	1000	3334	2.93994	1000	10.24	6.09
51	2.999888	1000	3335	2.99994	1000	10.17	10.18
52	3.059886	1000	3334	3.05993	1000	6.09	10.24
53	3.119884	1000	3334	3.11993	1000	2.02	10.27
54	3.179882	1000	3335	3.17992	1000	-2.03	10.27
55	3.239879	1000	3334	3.23993	1000	-6.09	10.24
56	3.299877	1000	3334	3.29993	1000	-10.18	10.18
57	3.359875	1000	3335	3.35993	1000	-10.25	6.09
58	3.419872	1000	3334	3.41992	1000	-10.27	2.02
59	3.479870	1000	3334	3.47992	1000	-10.27	-2.02

SYSTEM 87 SHOT DATA

	Muzzle			Target			
Rnd	**Epoch Time**	**ROF**	**Vel12**	**Epoch Time**	**ROF**	**Horz**	**Vert**
60	3.539868	1000	3335	3.53992	1000	-10.25	-6.08
61	3.599865	1000	3334	3.59992	1000	-10.18	-10.18
62	3.659863	1000	3334	3.65992	1000	-6.09	-10.24
63	3.719861	1000	3335	3.71991	1000	-2.03	-10.27
64	3.779858	1000	3334	3.77991	1000	2.02	-10.27
65	3.839856	1000	3334	3.83992	1000	6.09	-10.24
66	3.899855	1000	3335	3.89992	1000	10.17	-10.18
67	3.959852	1000	3334	3.95991	1000	10.24	-6.09
68	4.019850	1000	3334	4.01991	1000	10.27	-2.02
69	4.079848	1000	3335	4.07991	1000	10.26	2.02
70	4.139845	1000	3334	4.13991	1000	10.24	6.09
71	4.199843	1000	3334	4.19991	1000	10.18	10.18
72	4.259841	1000	3335	4.25991	1000	6.08	10.24
73	4.319838	1000	3334	4.31990	1000	2.02	10.27
74	4.379836	1000	3334	4.37990	1000	-2.02	10.27
75	4.439834	1000	3335	4.43990	1000	-6.10	10.24
76	4.499831	1000	3334	4.49990	1000	-10.18	10.18
77	4.559829	1000	3334	4.55990	1000	-10.24	6.09
78	4.619827	1000	3335	4.61989	1000	-10.29	2.02
79	4.679824	1000	3334	4.67989	1000	-10.27	-2.02
80	4.739823	1000	3334	4.73990	1000	-10.24	-6.09
81	4.799821	1000	3335	4.79990	1000	-10.19	-10.18
82	4.859818	1000	3334	4.85989	1000	-6.09	-10.24
83	4.919816	1000	3334	4.91989	1000	-2.02	-10.27
84	4.979814	1000	3335	4.97989	1000	2.01	-10.27
85	5.039811	1000	3334	5.03989	1000	6.09	-10.24
86	5.099809	1000	3334	5.09989	1000	10.18	-10.18
87	5.159807	1000	3335	5.15989	1000	10.23	-6.09
88	5.219804	1000	3334	5.21988	1000	10.27	-2.02
89	5.279802	1000	3334	5.27988	1000	10.27	2.02
90	5.339800	1000	3335	5.33988	1000	10.23	6.09
91	5.399797	1000	3334	5.39988	1000	10.18	10.18
92	5.459795	1000	3334	5.45988	1000	6.09	10.24
93	5.519793	1000	3335	5.51987	1000	2.01	10.27
94	5.579791	1000	3334	5.57987	1000	-2.02	10.27
95	5.639789	1000	3334	5.63988	1000	-6.09	10.24
96	5.699787	1000	3335	5.69988	1000	-10.19	10.18
97	5.759784	1000	3334	5.75987	1000	-10.24	6.09
98	5.819782	1000	3334	5.81987	1000	-10.27	2.02
99	5.879780	1000	3335	5.87987	1000	-10.29	-2.02
100	5.939777	1000	3334	5.93987	1000	-10.24	-6.09
101	5.999775	1000	3334	5.99987	1000	-10.18	-10.18
102	6.059773	1000	3335	6.05987	1000	-6.10	-10.24
103	6.119770	1000	3334	6.11986	1000	-2.02	-10.27
104	6.179768	1000	3334	6.17986	1000	2.02	-10.27
105	6.239766	1000	3335	6.23986	1000	6.08	-10.24
106	6.299763	1000	3334	6.29987	1000	10.18	-10.18
107	6.359761	1000	3334	6.35986	1000	10.24	-6.09
108	6.419760	1000	3335	6.41985	1000	10.26	-2.02
109	6.479757	1000	3334	6.47985	1000	10.27	2.02
110	6.539755	1000	3334	6.53986	1000	10.24	6.09
111	6.599753	1000	3335	6.59986	1000	10.17	10.18
112	6.659750	1000	3334	6.65985	1000	6.09	10.24
113	6.719748	1000	3334	6.71985	1000	2.02	10.27
114	6.779746	1000	3335	6.77985	1000	-2.03	10.27
115	6.839743	1000	3334	6.83985	1000	-6.09	10.24
116	6.899741	1000	3334	6.89985	1000	-10.18	10.18
117	6.959739	1000	3335	6.95985	1000	-10.25	6.09
118	7.019736	1000	3334	7.01984	1000	-10.27	2.02

SYSTEM 87 SHOT DATA

	Muzzle			Target			
Rnd	Epoch Time	ROF	Vel12	Epoch Time	ROF	Horz	Vert
119	7.079734	1000	3334	7.07984	1000	-10.27	-2.02
120	7.139732	1000	3335	7.13984	1000	-10.25	-6.09
121	7.199729	1000	3334	7.19985	1000	-10.18	-10.18
122	7.259728	1000	3334	7.25984	1000	-6.09	-10.24
123	7.319726	1000	3335	7.31984	1000	-2.03	-10.27
124	7.379723	1000	3334	7.37983	1000	2.02	-10.27
125	7.439721	1000	3334	7.43984	1000	6.09	-10.24
126	7.499719	1000	3335	7.49984	1000	10.17	-10.18
127	7.559716	1000	3334	7.55984	1000	10.24	-6.09
128	7.619714	1000	3334	7.61983	1000	10.27	-2.02
129	7.679712	1000	3335	7.67983	1000	10.26	2.02
130	7.739709	1000	3334	7.73983	1000	10.24	6.09
131	7.799707	1000	3334	7.79983	1000	10.18	10.18
132	7.859705	1000	3335	7.85983	1000	6.08	10.24
133	7.919702	1000	3334	7.91982	1000	2.02	10.27
134	7.979700	1000	3334	7.97982	1000	-2.02	10.27
135	8.039698	1000	3335	8.03983	1000	-6.10	10.24
136	8.099696	1000	3334	8.09983	1000	-10.18	10.18
137	8.159694	1000	3334	8.15982	1000	-10.24	6.09
138	8.219692	1000	3335	8.21982	1000	-10.29	2.02
139	8.279689	1000	3334	8.27981	1000	-10.27	-2.02
140	8.339687	1000	3334	8.33982	1000	-10.24	-6.09
141	8.399685	1000	3335	8.39982	1000	-10.19	-10.18
142	8.459682	1000	3334	8.45982	1000	-6.09	-10.24
143	8.519680	1000	3334	8.51981	1000	-2.02	-10.27
144	8.579678	1000	3335	8.57981	1000	2.01	-10.27
145	8.639675	1000	3334	8.63981	1000	6.09	-10.24
146	8.699673	1000	3334	8.69981	1000	10.18	-10.18
147	8.759671	1000	3335	8.75981	1000	10.23	-6.09
148	8.819668	1000	3334	8.81980	1000	10.27	-2.02
149	8.879666	1000	3334	8.87980	1000	10.27	2.02
150	8.939664	1000	3335	8.93981	1000	10.23	6.09
151	8.999662	1000	3334	8.99981	1000	10.18	10.18
152	9.059660	1000	3334	9.05980	1000	6.09	10.24
153	9.119658	1000	3335	9.11980	1000	2.01	10.27
154	9.179655	1000	3334	9.17980	1000	-2.02	10.27
155	9.239653	1000	3334	9.23980	1000	-6.09	10.24
156	9.299651	1000	3335	9.29980	1000	-10.19	10.18
157	9.359648	1000	3334	9.35980	1000	-10.24	6.09
158	9.419646	1000	3334	9.41979	1000	-10.27	2.02
159	9.479644	1000	3335	9.47979	1000	-10.29	-2.02
160	9.539641	1000	3334	9.53979	1000	-10.24	-6.09
161	9.599639	1000	3334	9.59979	1000	-10.18	-10.18
162	9.659637	1000	3335	9.65979	1000	-6.10	-10.24
163	9.719634	1000	3334	9.71978	1000	-2.02	-10.27
164	9.779632	1000	3334	9.77978	1000	2.02	-10.27
165	9.839631	1000	3335	9.83979	1000	6.08	-10.24
166	9.899628	1000	3334	9.89979	1000	10.18	-10.18
167	9.959626	1000	3334	9.95978	1000	10.24	-6.09
168	10.019624	1000	3335	10.01978	1000	10.26	-2.02
169	10.079621	1000	3334	10.07978	1000	10.27	2.02
170	10.139619	1000	3334	10.13978	1000	10.24	6.09
171	10.199617	1000	3335	10.19978	1000	10.17	10.18
172	10.259614	1000	3334	10.25978	1000	6.09	10.24
173	10.319612	1000	3334	10.31977	1000	2.02	10.27
174	10.379610	1000	3335	10.37977	1000	-2.03	10.27
175	10.439607	1000	3334	10.43977	1000	-6.09	10.24
176	10.499605	1000	3334	10.49978	1000	-10.18	10.18
177	10.559603	1000	3335	10.55977	1000	-10.25	6.09

SYSTEM 87 SHOT DATA

	Muzzle			Target			
Rnd	**Epoch Time**	**ROF**	**Vel12**	**Epoch Time**	**ROF**	**Horz**	**Vert**
178	10.619600	1000	3334	10.61976	1000	-10.27	2.02
179	10.679599	1000	3334	10.67976	1000	-10.27	-2.02
180	10.739597	1000	3335	10.73977	1000	-10.25	-6.09
181	10.799594	1000	3334	10.79977	1000	-10.18	-10.18
182	10.859592	1000	3334	10.85976	1000	-6.09	-10.24
183	10.919590	1000	3335	10.91976	1000	-2.03	-10.27
184	10.979587	1000	3334	10.97976	1000	2.02	-10.27
185	11.039585	1000	3334	11.03976	1000	6.09	-10.24
186	11.099583	1000	3335	11.09976	1000	10.17	-10.18
187	11.159580	1000	3334	11.15976	1000	10.24	-6.09
188	11.219578	1000	3334	11.21975	1000	10.27	-2.02
189	11.279576	1000	3335	11.27975	1000	10.26	2.02
190	11.339573	1000	3334	11.33975	1000	10.24	6.09
191	11.399571	1000	3334	11.39976	1000	10.18	10.18
192	11.459569	1000	3335	11.45975	1000	6.08	10.24
193	11.519567	1000	3334	11.51974	1000	2.02	10.27
194	11.579565	1000	3334	11.57974	1000	-2.02	10.27
195	11.639563	1000	3335	11.63975	1000	-6.10	10.24
196	11.699560	1000	3334	11.69975	1000	-10.18	10.18
197	11.759558	1000	3334	11.75974	1000	-10.24	6.09
198	11.819556	1000	3335	11.81974	1000	-10.29	2.02
199	11.879553	1000	3334	11.87974	1000	-10.27	-2.02
200	11.939551	1000	3334	11.93974	1000	-10.24	-6.09

SYSTEM 87 SUMMARY DATA

	Muzzle		Target		
	ROF	**Vel12**	**ROF**	**Horz**	**Vert**
Avg	1000	3335	1000	0.00	0.00
SD	0	1	0	8.45	8.45
HI	1000	3335	1000	10.27	10.27
LO	1000	3334	1000	-10.29	-10.27
ES	0	1	0	20.56	20.55

Comment: M77 simulator burst test.