AN EMPIRICAL SYSTEM FOR THE IDENTIFICATION OF SMOOTH BORE, CAST IRON CANNON

A Thesis

by

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ABSTRACT

An Empirical System for the Identification of
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In an attempt to overcome problems inherent in the current subjective method of identifying unmarked cannons, a systematic approach to cannon studies is developed based on objective, quantifiable cannon characteristics. The system is designed to facilitate data gathering, storage and manipulation through computerization of the collected data. Using the computer programs provided, large amounts of data can be correlated and analyzed.

Specific physical characteristics of cannons are described and instructions are given on how to record those characteristics. Most details either are recorded as direct measurements or calculated from direct measurements. By standardizing recording techniques and nomenclature, data collected by various researchers can be analyzed.

This objective, quantified system forms the foundation for a long-term study of cannons with the ultimate goal of establishing an identification key for field researchers.

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INTRODUCTION

Placing a shipwreck into its proper historical context is one of the most difficult tasks facing an archaeologist. Even the most basic aspect of the endeavor, dating the wreck, may prove an arduous task. Barring the discovery of an artifact which bears incontestable proof of the identity of a wreck, a rare event indeed, the process involves months or years of analyzing excavation data, recovered artifacts and historical records. Generally, several lines of evidence are traced concurrently but independently with each reaching a more or less certain conclusion. Through this process, known as convergence of evidence, the independent lines of inquiry ideally will lead to a common end - the identification of the wreck.

The certainty of any conclusions reached varies with the number of converging lines of evidence traced to a common end. In other words, the more pointers to the identification of the wreck, the higher the probability of being correct. All artifacts recovered from a wreck, no matter how inconsequential they may at first appear, must be carefully analyzed and worked into the puzzle of clues. Unfortunately, some of the most common artifacts from historic shipwrecks, particularly cannons, are also the hardest to classify.

Cannons, in addition to their presence on virtually all military ships, were standard equipment on merchant ships until the early part of the nineteenth century. Because of their sheer mass, cannons tend

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This thesis will employ the American Antiquity pattern for format and style.

to survive long periods of immersion in sea water relatively well. Also because of their mass, they were often left behind on shipwrecks that were otherwise heavily salvaged. Therefore, cannons are one of the most frequently discovered artifact types found on historic wrecks and probably the most easily identified on a coarse level. However, to refine the identification to year, nationality, manufacturer or other truly useful category can be extremely difficult, if not impossible, given the current state of reference material on the subject.

This study is the foundation of a long-term effort to rectify the lack of useful identification references for cannons, particularly smooth bore, muzzle loading pieces. A tangible need exists for such a citable reference which a researcher unfamiliar with the intricacies of cannon characteristics may use to identify an artifact found on an archaeological site. This thesis provides a standardized recording system and a method of manipulating recorded data whereby a corpus of information on guns will be collected. Eventually, a cannon identification key will be produced from this corpus of information.

Current State of the Literature

A complete bibliography of cannon literature would be a weighty tome indeed. To quote Ian V. Hogg, author of Artillery: Its Origin, Heyday and Decline, "the literature on the subject is not only catholic but immense" (1970:304). The earliest use of cannons was concurrent with the invention of the printing press. All the technical writers and historians who felt they had something to say about the subject have kept those presses busy since the beginning. Such a panoply of

references would at first appear to be a boon to the researcher. However, a single word suffices to describe all of the works to date when considering the subject of identifying cannons. That word is 'inadequate'.

The modern researcher trying to identify cannons using archival sources is handicapped by a factor common to all of the contemporary authors, from Biringuccio (1540) and Tartaglia (1547) through Muller (1780) and up to the end of the era: they lived during the era they wrote about. Understandably, they were not writing cannon identification keys for the convenience of archaeologists or historians 400 years later. These people were, in the main, technical writers producing expansive manuscripts on broad subjects. Their descriptions of cannons were almost universally very basic: length, calibre, weight of shot. Sometimes they provide a few extra details such as weight of gun, or length of bore. The rare illustration was generally not to scale. Such scanty descriptions are, today, insufficient to date a gun with accuracy.

Twentieth century authors writing books on muzzle loading cannons are, by definition, writing histories. These authors take one of two approaches. The first approach relies primarily on information from archives and contemporary authors. As a result of this approach, the works of these authors, exemplified by Ivan V. Hogg's mentioned above, B.P. Hughes's British Smooth-bore Artillery (1969) and Lewis's Armada Guns (1961), are subject to the same limitations as the works on which they are based. These books are extremely valuable works on cannons in

general but limited in their ability to date guns, especially unmarked guns.

The second approach to the study of cannons is the compilation of photographic collections of existing guns either in the form of catalogs or popular 'coffee table books'. Although often based on tremendous scholarship, the popular books tend to be of little use in identifying cannons for two reasons. First, they naturally are concerned with unusual or elaborately decorated guns which have survived in various public or private collections. The photographs are taken primarily for visual effect rather than accurate recording and no scale or dimensions are provided. Second, and more important, the information provided in the text is generally unreferenced. Guns (1965) by Dudley Pope, A History of Artillery (1969) and Fortress (1975) by Ian Hogg, and Naval Gun (1978) by Ian Hogg and John Batchelor are excellent examples of the genre.

Catalogs of museum collections, on the other hand, can be very useful if the photographs are intended to be accurate renditions and if either the photographs have scales or dimensions of the guns are given in the text. These books, such as H.L. Blackmore's The Armouries of the Tower of London - Ordnance (1976), provide invaluable comparative examples. As with the guns represented in popular books, however, the cataloged collections are made up of historically important, unusual or esthetically interesting cannons. The common gun, i.e. the type of gun most often used in battle, is seldom exhibited. This is particularly true of sixteenth- and seventeenth-century guns. Such is the nature of

most museum collections and for this they cannot be faulted. The situation is little comfort to the archaeologist faced with identifying an unmarked gun, however.

Modern periodical literature offers some of the best information to be found on the subject simply because much of it is written by researchers who have been trying to identify specific guns. The International Journal of Nautical Archaeology has published several informative articles in this vein, e.g. Guilmartin, 1982; Ruhge, 1984. However, none of the periodical literature has attempted to establish an objective system for the identification of cannons.

Identifying Cannons - the Current Subjective Approach

Many times the identification of a cannon is simplified by the presence of the date of manufacture and/or the name of the founder on the piece. Bronze guns and later cast iron guns (late eighteenth century onwards) are likely to bear such marks. Cast iron guns of the sixteenth, seventeenth and early eighteenth centuries, however, are unlikely to be marked in any way. Identifying these unmarked guns, then, is the problem facing the researcher. Virtually all past and present attempts at identification rely on the extremely subjective judgments of someone who has looked at enough guns to be generally regarded as an 'expert' on the subject. Of the many who claim to be knowledgable in this field, the few true experts, such as Mr. A.C. Carpenter, are those who have studied the subject intensively for decades. Mr. Carpenter, formerly employed by and now a consultant to the Tower of London, has investigated cannons for over 35 years. Even

he readily admits that identifying old guns is a very subjective undertaking (personal communication, 1985).

One example of the difficulties inherent in the current subjective system of cannon identification will serve to illustrate the problem. The Bermuda Maritime Museum has in its collection a cast iron cannon recovered from the sea very near a shipwreck which is potentially of great importance to the heritage of Bermuda. The wreck may be that of the Sea Venture, the ship bearing colonists to Jamestown, Virginia, in 1609 when it ran onto the reefs of Bermuda. This incident provided the British contact with Bermuda which led to colonization about three years later. The cannon at the Bermuda Maritime Museum is the only one found in the vicinity of the wreck and is a potential key in verifying the identification of the wreck. The initials RFP are engraved into the top of the gun but no other marks are present. In the late 1970s, a representative of the Museum attempting to identify the gun contacted nine authorities on cannons spread through Sweden, England, the U.S., Scotland, the Netherlands, Denmark, West Germany, and Australia (Mardis, 1981). Photographs, drawings and dimensions were sent to each person. In spite of their familiarity with the current literature and with the large collections for which they were directly responsible, the nine authorities reached no general consensus other than that the gun is probably a 'minion', an early name for a specific size of gun. The date of manufacture and the foundry where the gun was cast are still uncertain. Even the initials remain unidentified. Obviously, a more objective approach to the identification of cannons is necessary.

Another serious problem is the multitude of rumors regarding cannon characteristics which pass between students of cannon research as 'facts' or 'rules' although their origins are lost in obscurity, i.e. they cannot be cited. They are intended to aid identification but actually tend to complicate and confuse matters. The vertical position of trunnions on the barrel of a cannon will serve as an example. One of the first verbal rules a researcher encounters is that trunnions were initially very low and gradually were raised to the center of the barrel. Variations of this rule can be heard: trunnions started high and dropped; trunnions started high, dropped and rose again; trunnions started low, rose and dropped again. As no dates or measurable quantities are ever attached to the supposed changes in position, this rule actually confuses rather than enlightens. One need not examine too many cannons from various periods to realize that a pattern of changing trunnion position does exist and a search of contemporary literature tends to confirm this. However, until such time as that pattern is quantified and charted, the knowledge of its existence is useless. Again the need for an objective, quantified cannon identification key is obvious.

Identifying Cannons - the Proposed Objective Approach

As stated above, this thesis will lay the foundation for a quantitative and therefore objective cannon identification system. The quantitative approach to cannon studies has two important elements. The first is to simply record the frequency of occurrance of certain observed characteristics. Just as the subjective system of cannon identification has certain objective aspects, e.g. length of gun and

bore diameter, the subjective element cannot be completely removed from the proposed objective system. Judgments still are necessary to classify certain shapes which cannot be easily described by simple numeric values. However, if the characteristics are well defined, much of the subjective element is removed. Although observed cannon characteristics are also the basis of the subjective system of cannon identification, they have never been properly quantified. In other words, their frequency of occurrance and rate of change have never been computed, graphically represented nor statistically analyzed.

The second element of the quantitative approach is the calculation of numeric values to represent specific cannon characteristics. These values will generally be ratios or percentages which identify shapes, positions or dimensions that cannot be measured directly.

The recorded frequency of observed characteristics and the numeric values calculated to represent specific characteristics are entered into the computer database system defined by this thesis for manipulation and analysis. The computer facilitates correlations of large amounts of data which will indicate trends not otherwise visible. These trends can then be statistically analyzed and charted. The resulting information will be the basis for the eventual development of a cannon identification key.

As a test of the recording and quantification system, this thesis will analyze trunnion positions for a small sample of British cannons. The results of the analysis will be represented graphically in the concluding chapter of the thesis.

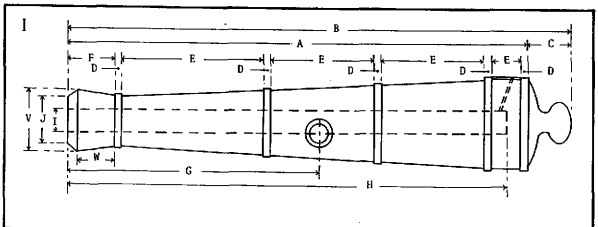
Predicting Evolutionary Characteristics

At the outset of the study, considerable care has been taken to determine which cannon characteristics may be valid indicators of the date of manufacture of any given gun and how best to represent those characteristics for the purposes of charting evolutionary steps. Some characteristics can be represented better verbally and some mathematically. Listed below are the physical characteristics currently predicted as indicators of cannon identity which are calculated values rather than measurements taken directly from the cannons. Listed with the characteristics are the calculations which define them.

All predicted characteristics, including those measured directly from the gun (Figure 1), have been developed on the basis of the following three factors listed in order of importance: references to the characteristic in contemporary literature, observation of varying characteristics made while personally measuring and recording guns in the field, discussions with other researchers interested in the field of identifying cannons.

Trunnion Position. The position of the trunnions on the barrel of a cannon is expressed mathematically as two ratios, one vertical and the other horizontal. Both ratios will be a value between zero and one rounded to the nearest thousandth. Also, both values are automatically calculated by the computer program as explained in the Database File section of this thesis.

The horizontal ratio (HR) is the distance of the axis of the



I. Overall View
- A. length of gun
- B. length overall
- C. length of cascabel
- D. width of ring
- E. distance between rings
- F. distance from last ring to muzzle
- G. distance from face of muzzle to trunnion axis
- H. length of bore
- I. diameter of bore
- J. diameter of face of muzzle
- V. maximum diameter of muzzle
- W. distance from last ring to maximum diameter of muzzle

II. Ring Detail
- D. width of ring
- K. diameter aft of ring
- L. diameter of ring
- M. diameter forward of ring

III. Trunnion Detail
- N. gun diameter at trunnion axis
- O. distance from top of gun to trunnion axis
- P. trunnion length at top
- Q. trunnion shoulder (rimbase) length at top
- R. distance across trunnions
- S. shoulder (rimbase) diameter
- T. trunnion base diameter
- U. trunnion end diameter

Figure 1. Cannon schematic showing standardized measurement points.

trunnions from the face of the muzzle divided by the length of the gun.

The vertical ratio (VR) is the vertical distance of the axis of the trunnions from the top of the barrel divided by the diameter of the barrel at the axis of the trunnions. Using the dimensions as listed in Figure 1, the two ratios of the trunnion position can be expressed as follows:

$$HR = \frac{G}{A} \qquad VR = \frac{O}{N}$$

Thickness of Metal. The thickness of the metal in the barrel of the gun is calculated at three points. The first point, the vent thickness (VT), is at the rear (proximal) end of the vent field (Figure 2) next to the base ring. This location corresponds to value M, Figure 1, for the base ring. If the gun has no ring at the end of the vent field, then the diameter of the barrel should be taken just forward of the base ring as this value is nearly equal to that at the vent.

The second point, the chase thickness (CT), is on the forward (distal) side of the last ring, located between the chase and the muzzle (Figure 2). This location corresponds to value M , Figure 1, for that last ring. If the gun bears no ring at this point, the smallest diameter of the barrel in the chase should be used.

The third point, the muzzle thickness (MT), is located at the point of maximum diameter of muzzle swell (value V, Figure 1). This dimension does not apply to a gun without a flared muzzle.

The thickness of metal is calculated by subtracting the diameter of the bore (value I, Figure 1) from the diameter of the gun, dividing the result by two and rounding to the nearest hundredth. The thickness

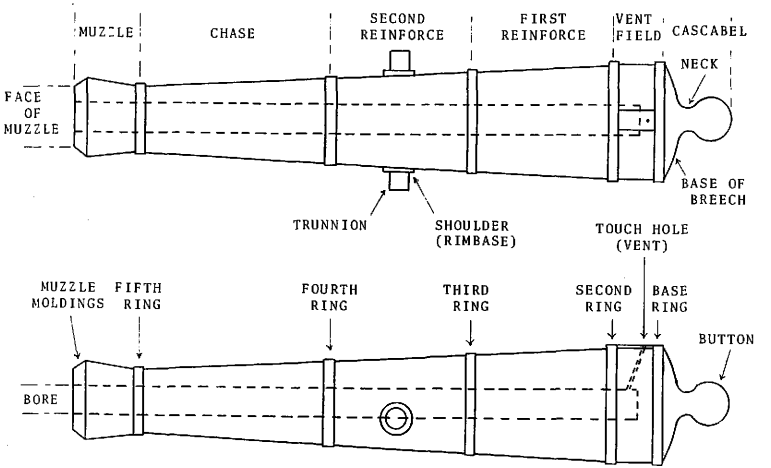


Figure 2. Cannon schematic showing names of various parts.

of the gun at the three locations is mathematically expressed as follows:

$$VT = \frac{K-I}{2} \qquad CT = \frac{M-I}{2} \qquad MT = \frac{V-i}{2}$$

Flare of the Muzzle. The maximum diameter of the muzzle divided by the distance between the last ring and the point of maximum diameter of the muzzle (value W, Figure 1) gives the ratio of the flare of the muzzle (MF). This is a relative value which measures the rate of the flare and should not be confused with the absolute values of maximum muzzle diameter or muzzle length which are used to derive the value. This value will not apply to tapered or cylindrical muzzles. Using the values from Figure 1, the muzzle flare can be expressed as:

$$MF = \frac{V}{W}$$

Values obtained from this calculation, rounded to the nearest tenth, will range between zero and approximately three with 1.0 being a 'square' muzzle, i.e. the length equals the maximum diameter.

Center of Gravity Ratio. Using the Cannon.calc program described on page 30 of this thesis, the center of gravity (COG) of a gun can be calculated. The center of gravity is expressed as a position at a given distance from the face of the muzzle of the gun along the longitudinal axis. Although the center of gravity expressed in this manner is useful for any single gun, it is not very informative when comparing many guns of different lengths and shapes. As a more useful comparative figure, the Cannon.calc program also computes the center of gravity ratio (COGR). This figure is derived by dividing the overall

length of the gun by the distance of the center of gravity from the face of the muzzle. The result is expressed as a decimal fraction rounded to the nearest thousandth.

Again using the dimensions from Figure 1, the center of gravity ratio can be expressed as:

$$COGR = \frac{COG}{B}$$

Breech Preponderance. The breech preponderance is a measure of the tendency of the gun to sit breech down/muzzle up when resting on its trunnions. This value is calculated by the Cannon.calc program as the difference in weight between the muzzle end and the breech end of the gun divided vertically at the axis of the trunnions. The actual weight of the trunnions is inconsequential here as it is distributed evenly between muzzle and breech sections. The Cannon.calc program will also calculate the breech preponderance of a given gun as a percentage derived by dividing the total weight of the gun by the the breech preponderance weight. As with the center of gravity ratio discussed directly above, this percentage is a more informative figure than breech preponderance weight when discussing guns of various weights.

Calibre or Length in Calibres. Although in the latter days of muzzle loading cannons the term 'caliber' always referred to the bore diameter, early writers often used the word to signify a measurement of the bore length. Specifically, calibre was the length of the bore divided by the diameter of the bore. Using the values from Figure 1, this can be mathematically represented as:

$$\text{calibre} = \frac{H}{I}$$

Alternatively, some fifteenth and sixteenth century writers referred to the bore diameter as the calibre just as in later times but also calculated the above ratio of bore length to bore diameter and termed the result the 'length of the bore in calibres'.

This ratio, whether called the calibre or the length of the bore in calibres, was very important to early cannon manufactures. In the days of black powder with its unpredictable burning qualities, gunners and cannon founders believed that the muzzle velocity and accuracy of the piece was a direct result of this ratio. That is, higher calibre guns, in terms of the bore length/diameter ratio, were thought to be inherently more accurate. Whether this was actually the case or not is hotly debated today and will not be dealt with in this study. However the ratio will be tracked by the recording system and will be called the calibre. The bore diameter will be called the bore diameter.

The above cannon characteristics are only those which are derived mathematically. Other characteristics which are traced by this system are derived visually or measured directly from the gun. Those features are discussed on pages 23-28 of this thesis, under the explanation of the Cannon Recording Form.

THE CANNON ANALYSIS SYSTEM

The goal of quantifying cannon data will be realized only if the record of each cannon contains specific, standardized information. That information is determined by the particular features of cannons which the researcher is attempting to quantify. The ideal study would include all cannon characteristics pertinent to the identification of guns. However, this study is made necessary because we do not yet know which characteristics those are. Therefore, the following cannon analysis system is designed to be extensive enough to incorporate measurements and details the significance of which, or lack thereof, will become apparent only through analysis of the collected data.

This thesis develops a four part system to standardize the recording and analysis of cannons. The four parts are the 'hardcopy file', the computer calculations program (Cannon.calc), the computerized database file and the programs to manipulate the computerized database file (Figure 3).

To properly use the cannon analysis system, the following procedure should be used.

1. The cannon must be adequately recorded in the field using the Cannon Recording Form discussed below. The tools and equipment listed for the cannon recording kit, Appendix B, are sufficient to record the dimensions and details of cannons required by the Form. The information collected in the field is the core of the hardcopy file.

2. Certain calculations are made using dimensions taken from the

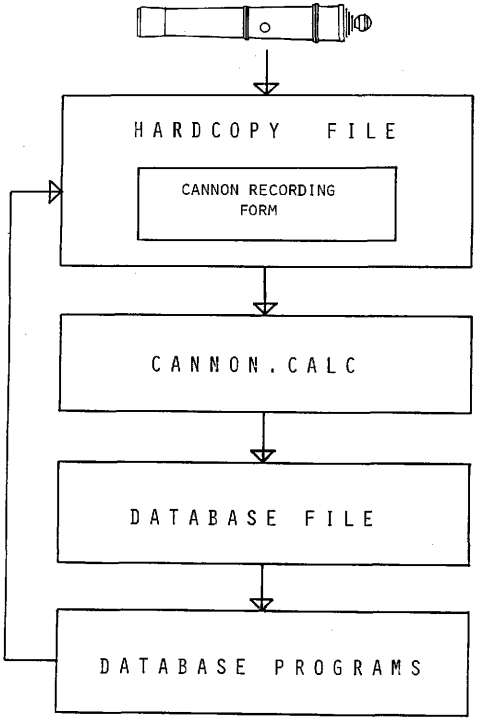


Figure 3. The four part system for the study of cannons.

gun. These calculations are the basis of the quantification of cannon data. Some of the mathematical formulas are simple enough to be done easily by hand and others are more complicated. The latter are figured by the Cannon.calc computer program discussed in the next chapter of this thesis.

3. Data from both the Cannon Recording Form and the Cannon.calc program are entered into the computer database where they can be manipulated to extract information not readily observable in the hardcopy file. Computer printouts of this new information then become part of the hardcopy file.

The hardcopy file is explained in detail here and the computer related components of the system are discussed in a later section of this thesis.

The hardcopy file, a term borrowed from computer science, contains all of the information which is gathered on any cannon, particularly that which cannot be or is not intended to be entered into the computer. Included in the file are the completed Cannon Recording Form, photographs, drawings, latex peels, computer printouts and anything else which is part of the record of a gun. One section of the hardcopy file is the Quick Reference File which contains a single 5" X 8" card for each gun. On each card is a photograph of the gun and basic identification information including date of the gun, location, length, bore diameter, and cannon type. The Quick Reference File is sorted by date of the gun and includes, for comparative purposes, cannons which have been identified in published literature.

The heart of the hardcopy file and the foundation for the Cannon Analysis System is the Cannon Recording Form. If the Form is not well designed and properly used, the rest of the system will be ineffective.

The Cannon Recording Form

In order to standardize cannon measurements taken by various researchers, a recording form must be specific in the information requested yet flexible enough to account for the tremendous variations in cannon design. The Cannon Recording Form meets those requirements.

Every effort should be made during the initial examination of any gun to record all the information requested by the Cannon Recording Form. Experience has shown that one seldom has a second opportunity to examine a gun in the field.

The Cannon Recording Form, version 12/03/85 (Figure 4), has four specific purposes:

1. The Form is intended to serve as a guide for the field researcher who is recording muzzle loading cannons. Given the wide variation in muzzle loading cannons, without regard to either early or late breech loading pieces, a form specific to each type would be extremely difficult to design . Therefore, the current revision of the Form provides for recording measurements and details which will not be used on all guns. For example, the Form provids spaces for recording seven rings along the barrel of the gun even though very few guns will have more than five and many will have none. The Form, then, serves as a guideline, a simple reminder of the things which should be recorded

Form number:_____ Cannon:_____ Page 1 of __

Date recorded: Recorded by:

Location:

Date of gun: Gun type: Metal Type:

Sketch (supplement with detail sketches where appropriate):

DIMENSIONS

Length of gun: Overall length:

Rings:	base	2	3	4	5	6	7
dia. aft							
dia. of							
dia. fore							
width molding							
code							
distance between rings							

molding codes: B = Band O = Ogee F = Fillet
A = Astragal R = Round S = Shape

Distance from last ring to - maximum muzzle diameter:
- face of muzzle:

rev 12/03/85

Form number:_____ Cannon:_____ Page 2 of __

Touch hole - diameter:
distance from base ring to touch hole center:

Trunnions:	right	left
diameter at base		
diameter at end		
length on top		
distance between faces		

position:

distance from face of muzzle to axis of trunnions:

diameter of barrel at axis of trunnions:

distance from top of gun to axis of trunnions:

shoulder (rimbase) - diameter: length at top:

Muzzle (sketch with dimensions) - maximum diameter of swell:

muzzle shape code: molding code:

muzzle shape codes:
S = Swelled Cone T = Tapered Cone B = Bell
C = Cylinder ## = # of Muzzle Moldings

Bore - diameter: length: rifled (Y/N):

Cascabel (supplement with sketch showing dimensions):

button shape code: base of breech shape code:

molding codes - base of breech: neck: button:

button shape codes:
C = Cylinder CL = Cylinder w/Loop K = Knob
KL = Knob w/Loop HL = Horizontal Loop VL = Vertical Loop
base of breech shape codes:
F = Flat C = Conical S = Spherical H = Hollowed

rev 12/03/85

Form number:_____ Cannon:_____ Page 3 of __

MARKINGS

Left Trunnion:

latex peel___ photograph___ tracing___ other___

Right Trunnion:

latex peel___ photograph___ tracing___ other___

Breech Area:

latex peel___ photograph___ tracing___ other___

Other:

latex peel___ photograph___ tracing___ other___

COMMENTS

rev 12/03/85

Figure 4. The three pages of the Cannon Recording Form.

if they are present on any particular gun.

2. The Form supplies adequate measurements and detail for the researcher to produce an accurate scale drawing.

3. The Form is part of the permanent record, i.e. the hardcopy file, of each documented gun. The permanent record will also contain photographs and drawings as described below.

4. The Form supplies the raw data to be used in the analysis and quantification of changing cannon characteristics over time. The nature and extent of the information recorded is sufficient to allow several levels of varying characteristics to be examined concurrently. A hypothetical example of such multilevel analysis might be the study of the variation of muzzle molding as a subset of the variation of muzzle shape as a subset of the calibre of guns manufactured by a specific foundry. The same example may be stated more specifically as the analysis of the variation of muzzle moldings on 32 pdr cannon with bell shaped muzzles manufactured by the Carron Iron Works.

Over fifty specific measurements are requested on the Cannon Recording Form and many more may be included in supplementary sketches required for particular features of each gun. In addition, several parts of the gun are given standardized descriptive codes. These codes are the markers for characteristics which evolved during the era of muzzle loading cannons and are the major building blocks for developing an identification key for cannons. The dimensions of gun characteristics will provide the detail necessary to fill out the key.

Nomenclature, Orientation and Units of Measure. Where possible, the nomenclature used in this study for parts of a cannon (Figure 2) is historically accurate. Often, however, a historic term is specific to certain styles of cannons, dated characteristics, or manufacturers. In that case, the term is avoided to preserve the general nature of the study. For example, all bands encircling the barrel of a gun are referred to simply as rings regardless of whether they are reinforce rings or decorative rings. These two types of rings are easily confused, and their actual function is not important to the study.

For all references to position on a gun for this study, imagine standing at the breech end of the gun with the muzzle facing away. The muzzle is then referred to as the forward or distal end and the cascabel is the aft, rear or proximal end. When oriented properly, right and left trunnions become obvious.

Although as a general rule archaeologists work in metric units of measure, this study of cannons is done in standard engineering units of feet, inches and hundredths of inches. The guns covered in the study were designed in feet and inches and can best be analyzed in those units. Historical accuracy is sacrificed when a gun traditionally known as an 8 footer becomes a 2.43 meter gun or a 32 pounder is listed as a 13.3 kg cannon.

Revision 12/03/85 of the Cannon Recording Form resulted from attempts to work with several earlier versions designed by the author over a period of nearly two years. All previous versions proved inadequate in one way or another.

Details of Cannon Recording Form. Most entries on the Form are self-explanatory; those which are not are further explained below.

Form Number. Each Form has a sequentially assigned number, the first Form being '1', the second '2', etc. All pages of the Form used to record a single cannon bear the same Form Number. This is the key entry for tracking any particular record in the computer database and therefore must be unique for each cannon. A temporary Form Number may be assigned in the field but if that number conflicts with a number already in the file, a new, permanent Form Number will be assigned by the computer operator.

Cannon. Enter an arbitrary or preassigned number or alphanumeric code associated with the cannon. For example, if the gun is part of a museum collection, the museum's accession number should be entered here. Or, if the gun is one of several in a specific location which are otherwise undifferentiated, a location code and a series number might be entered, i.e. 'Alamo-3'. Since any Form Number assigned in the field may be temporary, the entry under Cannon should be unique enough for the recorder to be able to track the gun by this designation.

Location. Enter the name of the place where the gun is located. If in a museum, the gun's location would include the name of the institution and location of the institution, including country, as in 'Bermuda Maritime Museum, Bermuda'. No attempt should be made here to explain that the gun is in the broom closet of the third floor janitorial storeroom; that information should go under

Comments, accompanied by a sketch map if necessary.

Date of Gun. List the exact or approximate year when the gun was manufactured. If the gun bears a founding date on its surface, that date should be entered. If a subjective estimate of the date of the gun is made the entry should be followed by a question mark, i.e. '1730?'. A range of dates may be entered, such as '1780-1810', or a century may be specified in the form '19th c'.

Gun Type. Give the appropriate contemporary designation for the cannon. A sixteenth century gun might be a saker, culverine or whatever name is appropriate for the dimensions of that gun, while a nineteenth century piece might be a 24 pdr, a 32 pdr, etc. Such designations are often difficult to establish, especially before the recorded dimensions have been analyzed. Therefore, this entry often will be left blank.

Metal Type. Enter the type of metal from which the gun was made: bronze, cast iron, or wrought iron, as appropriate.

Length of Gun. Measure the distance from the face of the muzzle to the rear of the base ring (Figure 1). Although it does not take into account the cascabel, this measurement is properly known as the Length of the Gun.

Overall Length. Enter the Length of Gun plus the additional length of the cascabel, i.e. the distance from the face of the muzzle to the end of the cascabel.

Rings. A table is provided to record measurements and descriptive codes for any ring along the length of the gun. The first ring is

the base ring, sometimes known as the breech ring, and subsequent rings are numbered sequentially toward the muzzle. The diameter of the barrel is taken on both sides of each ring, as the rings are positioned where the barrel changes size in steps rather than in a gradual taper. Molding codes (Figure 5) are single alpha designations, listed on page one of the Cannon Recording Form (Figure 4) , which represent the physical shapes of the components of each ring. The molding codes are also used for the muzzle, base of breech, cascabel neck and cascabel button.

Trunnions. The right and left trunnions are measured separately as their sizes often vary slightly. The measurements of the position of the trunnions are necessary to calculate vertical and horizontal ratios which will be used to trace their relative position through time.

Muzzle shape codes. Muzzle codes are illustrated in Figure 6-A. The molding codes from page one of the Form, illustrated in Figure 5, are also used to provide additional shape descriptions.

Bore - rifled (Y/N). Although this study is concerned with muzzle loading, smooth bore cannons, certain exceptions to this rule, specifically the Palliser pattern guns, must be noted. Palliser cannons are nineteenth century smooth bore guns which were converted to rifled muzzle loaders (RMLs) by the insertion of rifled sleeves into the enlarged bore. This entry on the Form is intended to cover these and other exceptional guns.

Cascabel. This area is very difficult to classify in simple terms

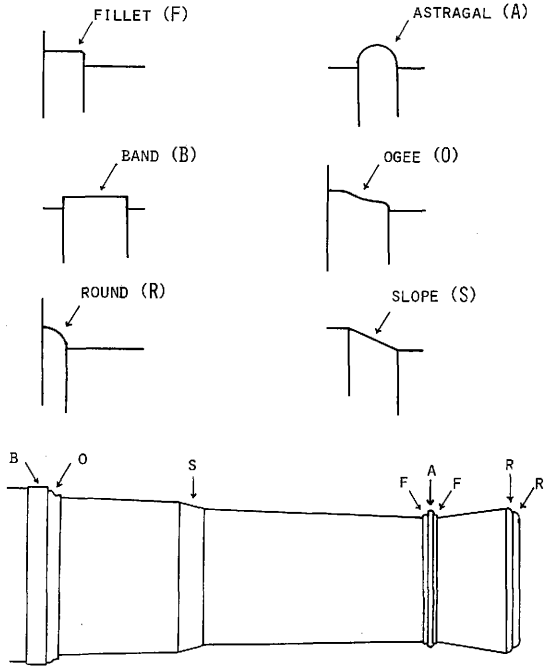


Figure 5. Molding shapes and associated codes with a hypothetical example.

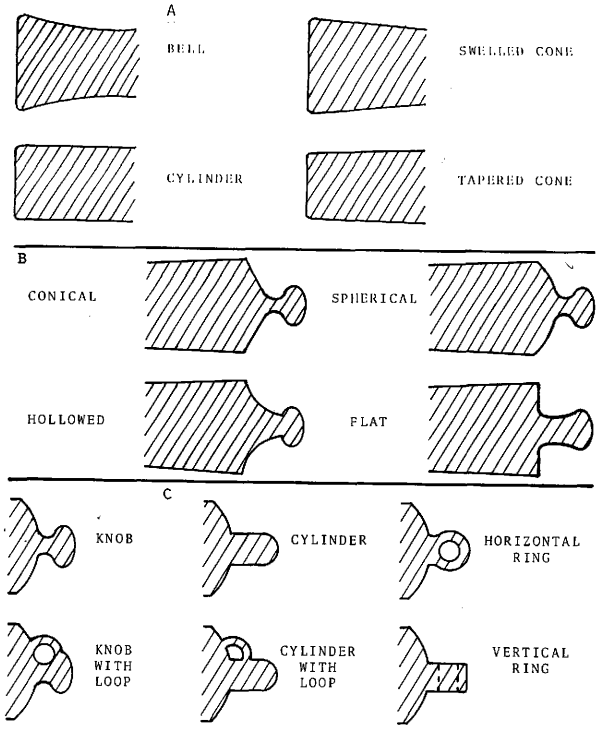


Figure 6. Categories of shapes as listed in this study: A - muzzle, B - base of breech, C - cascabel button.

because of the rapidly changing shape and the tremendous amount of variation between guns. However, the cascabel generally consists of three distinct features: the base of the breech, the neck and the button (Figure 2). The neck, a simple constriction between the base of the breech and the button, may not be discernable on some pieces, particularly those with cylindrical buttons. The other two features have been assigned codes to provide a descriptive entry for their physical appearance. Both of these, the base of breech shape code (Figure 6-B) and the button shape code (Figure 6-C), are listed on page two of the Cannon Recording Form. The molding codes from page one, illustrated in Figure 5, provide additional shape descriptions.

Markings. The trunnions and the breech area of a gun are the most likely places to bear marks of any kind. However, marks may appear virtually anywhere on a gun. Bronze guns in particular are often highly ornamented. As all possible positions for marks or decorations cannot be provided for on the Cannon Recording Form, space is allocated for recording the trunnions, the breech and one additional area. Additional pages must be added to the Form to record other marks. Space also is provided for entering recording methods used to supplement the sketch of a mark on the Form. These methods include latex peel, photography, tracing and, to cover any additional possibilites, 'other'.

Comments. Any information pertinent to the gun which is not recorded elsewhere on the Form should be recorded here. Some possible

entries include: the exact location of the gun, the physical condition of the gun, observations on associated guns or equipment and the presence ofunusual features.

Supplementary Recording Techniques

Page three of the Cannon Recording Form includes space to identify any supplementary recording techniques. Supplementary techniques may include latex peels, photography, tracings, rubbings, or other applicable methods. These techniques are commonly used in archaeology and, with the exception of photography, need no further explanation.

The photographic record is an essential part of the hardcopy file. Both color slides and black and white prints should be part of the record of each cannon. When it is not feasible to use both types of film, cost will probably be the deciding factor in which film to use. If the researcher is able to bear the extra cost of converting color slides to black and white prints, then slides are the preferred choice. If the conversion cost is considered too high, black and white film is preferred for the following reasons. First, processing is much simpler and can be done easily by the photographer, archaeologist or other researcher with access to darkroom equipment. Second, black and white prints are required by many publishers. Third, black and white prints are needed for the cannon quick reference file.

Records such as those that make up the hardcopy file generally are ends in themselves, but for this thesis they serve as a vital first step toward the computerized quantification and analysis of changing cannon characteristics.

THE COMPUTER FUNCTIONS

After the Cannon Recording Form has been filled out, data is extracted from it for computer manipulation and analysis. Initially, certain numeric values are entered into a Basic language program called Cannon.calc which performs calculations on those values. The results of those calculations are combined with other information from the Form and entered into the computer database file. More calculations are performed automatically upon entering information into the database file. The information in the database file can be manipulated easily for statistical and graphical analyses.

Cannon.calc Program

The Cannon.calc program, Appendix C, is designed as an intermediate step between the Cannon Recording Form and the computer database file. Its purpose is to perform certain complicated or lengthy calculations thereby saving time and increasing accuracy. The three basic functions of the Cannon.calc program are to calculate the weight, center of gravity and breech preponderance of a cast iron or bronze cannon. Although written in MS-BASIC for the Texas Instruments Professional Computer, the program can be converted into any other version of BASIC computer language such as Appplesoft BASIC.

The Cannon.calc program assumes that a cannon is symmetrical around its longitudinal axis although such is seldom the case. This assumption is legitimate because the few small asymmetrical protuberances on any given gun, including the trunnions, have little effect on the values calculated by this program. This can be proven

simply by adjusting the values entered into the program and observing the results.

To make its calculations, the program uses dimensions and information collected on or derived from the Cannon Recording Form. All necessary information is requested by the program as it is needed; however, certain preparations must be made prior to using the program.

On a drawing of the cannon, divide the length of the gun into sections based on the surface features. The accuracy of the calculations will increase with the number of sections into which the gun is divided. The best way to divide a gun is to consider the length of the barrel between each pair of rings as a separate section. Each ring also should be considered a section. In order to figure the breech preponderance, the section of the barrel containing the trunnions must be divided into two sections with a common border at the axis of the trunnions. In addition, the base ring either must be a section by itself or must be the proximal (aft - toward the cascabel) end of a section. The base ring must not be in the middle or at the forward end of a section because its position is used by the program to calculate the length of the gun and the average diameter of the barrel.

Figure 7 illustrates a gun of the early 1800s divided into sections for the purpose of the Cannon.calc program. A cannon with fewer natural divisions, i.e. fewer rings, may be divided into fewer sections. Note that the sections are numbered sequentially beginning at the muzzle. If the diameter of the barrel changes abruptly, the point of that change should mark the border between two sections.

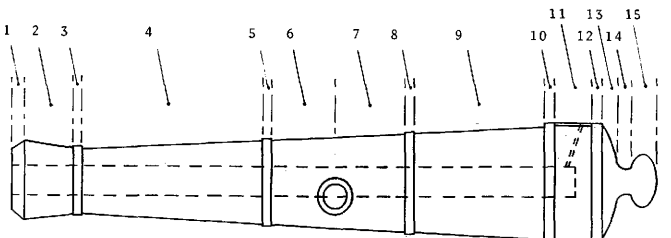


Figure 7. A cannon as it might be divided into sections for the Cannon.calc program.

Once the gun has been divided into sections, the average diameter of each section must be calculated. If the section is an even taper, the average diameter is determined by adding together the diameters of the two ends of the section and dividing the sum by two. If the section is a ring, the average diameter may have to be estimated or measured from a scale drawing. Although increased accuracy at this stage certainly will increase the accuracy of the calculated weight, good estimates of diameter are generally quite adequate. Inaccuracies of a fraction of an inch will vary the final figure only by a few pounds, a negligible amount considering the hundreds or thousands of pounds most guns weigh.

The Cannon.calc program calculates in decimal units of inches and pounds. Accordingly, values must be entered in decimal inches. If other units are entered, e.g. centimeters, the program will not register an error but the calculations will be incorrect.

When the program is operating, it will initially ask the following six questions:

1. Is the gun bronze or cast-iron? (enter B or C)

   Based on the answer to this question, the program will automatically choose the appropriate weight per unit volume of the given metal.

2. Total number of sections?

   Enter the number of sections into which the gun is divided. In the example (Figure 10), the gun is divided into 15 sections.

3. Diameter of bore?

   Self-explanatory.

4. Through how many sections does the bore extend?

   Enter the total number of sections through which the bore extends, plus the section in which the bore ends. If the bore length can not be determined directly, the position of the vent can be used as a rough estimate of the end of the bore. Greater accuracy will be obtained in all of the calculations if the end of the bore corresponds with the division between two sections of the gun, but this is not absolutely necessary.

5. Which section contains the base ring?

   Enter the number of the section which contains the base ring, counting from the muzzle end of the gun. As noted above, the base ring must be a section by itself or must form the proximal end of a section.

6. Which section has its forward end at the axis of the trunnions?

   Self-explanatory.

Once these questions have been answered, the program will ask for the length and average diameter of the first section. When that information is entered, the volume of the section in cubic inches and the weight of the section in pounds will be displayed. The program will continue in this manner through the total number of sections as provided in the first question above.

When the dimensions of all of the sections have been entered, the program makes the following calculations and displays the results under the title 'Total Values'.

1. Overall length of gun: XX.XX inches

   This length is the total distance from the face of the muzzle to the end of the cascabel knob.

2. Length of gun: XX.XX inches

   This length, from the face of the muzzle to the cascabel end of the base ring, is properly known as the 'length of the gun' in standard cannon terminology.

3. Average diameter for overall length of gun: XX.XX inches

   This figure is the average diameter of the gun including the cascabel.

4. Average diameter for length of gun: XX.XX inches

   This figure is the average diameter of the gun not including the cascabel.

5. Total volume of metal in gun: XXXX.XX cubic inches

   Allowance is made for the void of the bore in this calculation.

6. Total weight of gun: XXXX.XX lbs

   Weight is figured at the rate of 450 pounds per cubic foot of cast iron or 520 pounds per cubic foot of bronze, as appropriate.

7. Weight by Hogg's formula: XXXX.XX lbs

   O.F.G. Hogg (1970:266) gives formulas for roughly

calculating the weight of both bronze and cast-iron guns. The formula for a cast-iron cannon is:

$$2.5\ (D^2\ L - \frac{5}{6}\ d^2\ l)$$

'D' is the average external diameter of the gun in inches, 'd' is the diameter of the bore in inches, 'L' is the overall length in feet and 'l' is the length of the bore in feet. The formula for a bronze gun is the same except for the substitution of 3 for 2.5. For the sake of comparison, the Cannon.calc program uses dimensions calculated by it to run Hogg's formula and the results are displayed.

8. Amount Hogg Overweight: XX.XX%

The weight calculated by dividing the gun into sections and the weight calculated by Hogg's formula are compared and the difference is displayed as a percentage of the former method. Experience has shown that Hogg's formula consistently results in a heavier figure for any given gun than the procedure used by the Cannon.calc program. If a negative percentage is displayed, however, the Hogg formula has produced a weight below that of the Cannon.calc program procedure. Because it divides a gun into many closely calculated subdivisions, the Cannon.calc program should be inherently more accurate than Hogg's formula.

After the Total Values have been viewed, the program will display a table of lengths and weights for all sections and provide an opportunity to change the values for any section. If the operator

wishes to change a value, he must enter either a new weight or a new length or both for the chosen section. The program will not recalculate weight from a new length of a section. Once any desired changes are made or if no changes are desired, the following values are calculated and displayed:

1. Position of center of gravity is XX.XX inches from face of muzzle

   The center of gravity is given as a distance in inches from the face of the muzzle along the axis of the bore. The trunnions are not figured in the total weight of the gun but their weight and position have little effect on the center of gravity. This can easily be proven by calculating the weight of the trunnions, adding that weight to either the extreme muzzle section or breech section of the gun and, when the program gives the operator the opportunity to modify sectional values, entering the new weight for that section. The adjusted center of gravity as recalculated by the program will be displaced from the original position by only a few tenths of an inch at most.

2. Center of gravity ratio is 0.XXX

   The overall length of the gun divided by the distance of the center of gravity from the face of the muzzle is the center of gravity ratio. The result is expressed as a decimal fraction rounded to the nearest thousandth. The center of gravity ratio is more meaningful than the position of the

center of gravity when discussing guns of various lengths. The fact that the center of gravity is 42 inches from the muzzle of one gun and 35 inches from the muzzle of a shorter gun is not as significant as the fact that the center of gravity is 0.630 of the overall length of the gun from the muzzle on both guns.

3. The breech preponderance of the gun is XX.XX lbs or XX.XX% of the weight of the gun.

   The breech preponderance is a measure of the tendency of the gun to sit breech down/muzzle up when resting on its trunnions, calculated as the difference in weight between the muzzle end and the breech end of the gun divided vertically at the axis of the trunnions. The actual weight of the trunnions is inconsequential here as it is split evenly between muzzle and breech sections. The Cannon.calc program will also calculate the breech preponderance of a given gun as a percentage, derived by dividing the total weight of the gun by the breech preponderance weight. As with the center of gravity ratio discussed directly above, this percentage is a more informative figure when discussing guns of various weights.

Again, the program will give the operator a chance to modify sectional values. This provides a good opportunity to see how changing the weight of a given section of the gun will effect its center of gravity and breech preponderance. Change the desired values and

compare the adjusted results.

After all calculations for a gun are complete, the program will provide an opportunity to enter data on another cannon without restarting the program.

The values calculated by the Cannon.calc program should be recorded and entered into the hardcopy file. This information, along with other data from the Cannon Recording Form, must then be entered into the computer database file.

THE DATABASE FILE

The key to analyzing the mass of data which will be collected using the recording method developed above is the cannon database file, supplemented by programs to manipulate the data in the file.

The Database File - General Information

The Database file consists of selected information about each gun which is entered into the computer via a commercial database program. From the many database programs available, dBase II (copyright Ashton-Tate 1984) was selected for this application because of the size of the file it can manipulate, up to 65,000 records, and because of its extensive programmable capabilities. In addition, dBase II is available for a great number of computers.

In order to use the file and to get the maximum amount of information from it, some familiarity with dBase II is necessary. Once the dBase II program has been activated on the computer and the dot prompt is displayed, the operator need only type DO CANNONS to start the database file programs. From that point, the operator is automatically guided through the programs, i.e. the programs are menu driven. Whenever an action is required by the computer, a list of three to five possible actions, a menu, is displayed and the operator is asked to choose one. Through the menus, the following actions can be selected: exit the program, view records previously entered into the file, change records previously entered into the file, add new records to the file, delete records already in the file, undelete previously deleted records, search the file for records with specific entries in any field, and print any record or the complete file. The

printed copy may be in either a tabular format, using a limited number of fields predefined in the program, or a full page layout which includes all the fields for each record. Again, a familiarity with the dBase II command structure is desirable as this knowledge allows the operator to print the information in the database file in any format.

The operator is given a choice of two ways to add records to the database file. One of the two choices, marked 'for experienced users only', does not double check the data being entered and does not give the operator much opportunity to correct mistakes. Data entry is faster through this option, however, and mistakes can be corrected later through the file editing process. See The Database File - Technical Information beginning on page 45 of this thesis for further explanation of adding and editing records.

The thirty-one information fields which comprise the record of a single cannon are shown (Figure 8) in the format in which they are always displayed on the computer screen. Most of the information on this form comes directly from the Cannon Recording Form and has been explained in that section. Those items not covered in the discussion of the form or otherwise needing further explanation are treated below.

Calibre. For this study, the calibre is the ratio of the length of the bore to the bore diameter. If the bore length and bore diameter are known when the data is entered into the file from the Cannon Recording Form, the calibre will be figured automatically by the program and the value entered into the appropriate space. See page 14 of thesis for a further explanation of calibre.

Form Number:	Cannon Number:
Location:	
Gun Type:	Nation:
Metal Type:	Year Manufactured:
Overall Length:	Length of Gun:
Bore Length:	Bore Diameter:
Calibre:	Rifled:
Gun Weight:	Weight of Iron Shot:
Diameter at axis of trunnions:	
Trunnion Position -	
Horizontal:	Horizontal Ratio:
Vertical:	Vertical Ratio:
Muzzle Shape:	Muzzle Flare Ratio:
Muzzle Thickness:	
Chase Thickness:	Vent Thickness
Base of Breech Shape:	Button Shape:
Breech Preponderance: %	Center of Gravity Ratio:
Founders Mark:	
Comments:	

Figure 8. Printout of the blank data entry form displayed when adding records to the database.

Gun weight. Obtaining the weight of a large mass of metal such as a cannon is often impossible when recording guns in the field. Therefore, the Cannon.calc program described above is provided to calculate the weight of the gun quite accurately using the dimensions gathered on the Cannon Recording Form. A discussion on the calculation of the weight of a gun begins on page 35 of this thesis. If the weight is marked on the gun, the calculations from

the Cannon.calc program may be used to compare with the marked value. Note that the weight of the gun is not figured automatically by the database program.

Weight of iron shot. If the diameter of the bore is entered and the barrel is not rifled, the weight of an iron shot to fit the bore will be calculated by the database program and the value entered automatically on the appropriate line. Since rifled guns did not fire spherical projectiles, the weight of their projectiles cannot be calculated using only the bore diameter.

The method used by the program to determine the weight of a spherical shot varies with the date of the gun. Any gun dated prior to 1650 is calculated with a windage of one quarter inch. In other words, the diameter of the shot is one quarter inch less than the diameter of the bore. This was a standard value in the early days of cannon development and was intended to insure that the shot did not jam in the bore. However, as the loss of propellent gases around the ball was excessive and the ball tended to bounce down the barrel to the detriment of both the accuracy of the shot and the longevity of the gun, efforts were made to reduce the windage. Using the reference of O.F.G. Hogg (1970:60) to John Muller's work (1768), the windage for British guns between 1650 and 1756 is calculated at a shot diameter to bore diameter ratio of 20:21. After 1756, the ratio is figured at 24:25. These values are very uncertain due to discrepancies and inconsistencies in both Hogg's and Muller's works. Therefore, the results of the

calculation are rounded to the nearest tenth of a pound; greater accuracy is not justified.

Trunnion position. The Horizontal position is the distance from the face of the muzzle to the axis of the trunnions. Similarly, the Vertical position is the distance from the top of the gun to the axis of the trunnions. If these two values and the diameter of the gun at the axis of the trunnions are all entered from the Cannon Recording Form, the Horizontal Ratio and the Vertical Ratio will be calculated automatically by the program. The derivation of these two values is explained on pages 9-11 of this thesis. Basically, the horizontal ratio is the horizontal position divided by the length of the gun. The vertical ratio is the vertical position divided by the diameter of the barrel at the axis of the trunnions.

Center of Gravity Ratio. The Cannon.calc program will calculate the center of gravity of the gun and the center of gravity ratio. The center of gravity is given as a point at a calculated distance from the muzzle along the axis of the gun, i.e. along the centerline of the bore. The center of gravity ratio is the overall length of the gun divided by the distance from the face of the muzzle to the center of gravity. For a more complete explanation of how these values are derived, see page 13 of this thesis.

Breech Preponderance. The breech preponderance is a measure of the tendency of the gun to sit breech down/muzzle up when resting on

its trunnions. The Cannon.calc program will calculate the breech preponderance of a given gun both as a weight in pounds and as a percentage. The weight is simply the difference between the weight of the muzzle end of the gun and the weight of the breech end of the gun divided at the axis of the trunnions. The breech preponderance percentage is derived by dividing the total weight of the gun by the the breech preponderance weight. For more information on breech preponderance, refer to page 14 of this thesis.

The Database File - Technical Information

The database file, labeled CANNONS, is a dBase II primary use database file (.DBF). The current hardware/software configuration on which the file resides consists of a Texas Instruments Portable Professional Computer, with 256 kilobytes internal ROM and a built-in ten megabyte hard disc, running dBase II Relational Database Management System, Version 2.41, copyright Ashton-Tate 1984. The structure of the file (Figure 9) consists of thirty-one fields of various lengths for a total of 445 characters. As dBase II only allows for thirty-two fields per record, a secondary file would be necessary to include cannon dimensions in the computerized file.

A series of programs written in the dBase II programming language (Figure 10 and Appendix D) provides the following file handling capabilities.

Field	Name	Type*	Width	Decimal Places	Full Name
1	form:no	N	6	0	form number
2	cannon:no	C	10	-	cannon number
3	location	C	60	-	location
4	gun:type	C	20	-	gun type
5	nation	C	10	-	nation
6	metal:type	C	12	-	metal type
7	year	C	7	-	year
8	oa:length	N	6	2	overall length
9	bar:length	N	6	2	length of gun
10	bore:len	N	6	2	bore length
11	bore:dia	N	5	2	bore diameter
12	calibre	N	2	0	calibre
13	rifled	C	1	-	rifled
14	gun:weight	N	7	2	gun weight
15	fe:shot:wt	N	5	1	weight of iron shot
16	trunnion:h	N	6	2	trunnion position horizontal
17	hor:ratio	N	5	3	trunnion position horizontal ratio
18	trunnion:v	N	5	2	trunnion position vertical
19	dia:at:tru	N	5	2	diameter at trunnions
20	vert:ratio	N	5	3	trunnion position vertical ratio
21	muzzle	C	2	-	muzzle shape
22	cascabel	C	2	-	base of breech shape
23	button	C	2	-	button shape
24	br:prepond	N	5	2	breech preponderance
25	cog	N	5	3	center of gravity ratio
26	founder	C	20	-	founder
27	muzle:flar	N	4	2	muzzle flare ratio
28	vent:thik	N	5	2	vent thickness
29	chase:thik	N	5	2	chase thickness
30	muzle:thik	N	5	2	muzzle thickness
31	comments	C	200	-	comments
	Total characters = 445				

*N = Numeric, C = character

Figure 9. The structure of the CANNONS.DBF file.

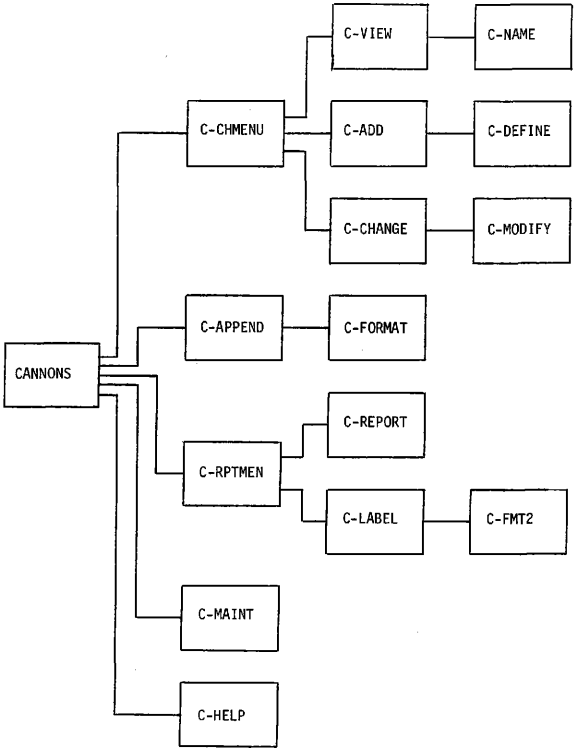


Figure 10. Schematic of the programs for manipulating the cannon database file.

Data entry. New records can be added to the database file by choosing either of two options on the Main menu which is displayed after entering DO CANNONS at the dBase II dot prompt. However, the subprograms activated by the two choices are fundamentally different in operation.

Option one on the Main menu is View, Edit, Add or Delete Records. If the operator chooses this option, another subprogram is called, C-CHMENU, which displays the Update menu. Option three on the update menu, 'Add new entries', activates the C-ADD file. C-ADD presents the blank data entry form (Figure 8). If the return key is struck when the first field, Form Number, is blank, the subprogram exits back to the Update menu. If a value has been entered in the Form Number field, the program checks the database file to verify that the Form Number just entered is unique. Should the Form Number be duplicated, the program informs the operator and returns to the Update menu. Otherwise, data entry continues until all desired data has been entered into the record. Once this is done, the C-ADD program automatically will calculate the calibre, weight of iron shot, vertical trunnion ratio and horizontal trunnion ratio. These values are then entered into the record by the program and saved with the information entered by the operator. After the save operation is performed, a new blank record is presented to the operator.

Option two on the main menu is 'Data Quick Entry - for experienced users'. If this option is chosen, the blank data

entry form, Figure, 8 is displayed immediately without the intermediate Update menu. Under this option, however, the form is displayed through the C-APPEND subprogram in conjunction with the C-FORMAT format file.

This option for data entry is faster than the previously discussed option because it does not perform the data checks which the latter does. Specifically, the quick entry option does not verify that each new Form Number is a unique entry. When using this option, the operator must be familiar with the data already entered, the data being entered and the operation of the system. Also, the operator is not given as many opportunities to correct entered data before it is saved.

Another factor which speeds up data entry somewhat is repositioning of the automatic calculations within the program cycle. Under option one on the Main menu, the automatic calculations are done after each record is entered. Under option two, they are not done until the operator chooses to quit entering records, regardless of how many records have been entered during that session. When the operator ends a session of data entry, the C-APPEND subprogram returns to the first record entered during that session, makes the necessary calculations, enters the new values and proceeds to do the same for each subsequent record.

Viewing records. If the operator wishes to examine records contained in the database file with no intention of changing the records, option one of the Main menu should be chosen. The Update menu

will be displayed from which option one, 'View existing entries', may be selected. The subprogram C-VIEW is then called and displays the first record using the format in Figure 8. The operator is then given the option to skip ahead or back one record at a time or to find a specific entry. If the return key is struck without choosing an option, the Update menu again is displayed.

Upon selecting the FIND option when viewing records, the operator is asked for the name of the field containing the data to be located. If the program determines that the field name entered is valid, the operator is prompted for the values to be sought. Either numeric or character data may be located. For the operator the FIND operation is probably the most technical aspect of the database file program as it allows the normal arithmetic operators (=, <, >, <=, >=) to be used plus the dBase II symbol for substrings ($). In addition, the logical operators AND, OR and NOT can be used to enter a second operator and value. As an example, the Year Manufactured field might be searched for '>1800 AND <=1820', i.e. greater than 1800 and less than or equal to 1820. Each of the operators and values is requested individually and the logical operator with its subsequent value is optional.

Any field in the database structure can be searched with the FIND option using any of the operators with the exception that a numeric field cannot be searched using the substring function. The program flags any attempt to do this and informs the operator.

When the FIND option locates a record with the desired information, that record is displayed, the operator is then given the option to continue searching the file for other records with the same information or to discontinue the search. If the search is discontinued, the program again displays the first record with the SKIP and FIND options.

Record editing, deleting and undeleting. Option one on the Main menu calls the subprogram C-CHANGE which asks for the Form Number of the record to be edited, deleted or undeleted. The subprogram then displays the requested record using the format in Figure 8. The operator is asked if he wishes to change, delete or undelete the record. If the CHANGE option is taken, the subprogram C-MODIFY is called which allows any field in the displayed record to be altered. After the alterations are made and confirmed as correct by the operator, they are saved to the file and the computer again asks for the Form Number of the file to be edited.

If the DELETE or UNDELETE options are chosen while the record is displayed, the C-CHANGE subprogram takes the appropriate action using standard dBase II commands. If the record is deleted, the word 'DELETED' is displayed at the top of the screen. If a previously deleted record is undeleted, the word 'DELETED' is erased from the screen. A deleted record does not disappear from the database file until 'File Maintenance' option is chosen from the Main menu as described below.

Printing reports. Option three from the Main menu, Report, allows the user to print the records or information from the records in the database file. This option calls the C-RPTMEN subprogram which displays the Report menu. Two options are available on the Report menu: tabular printout and form printout.

Option one, tabular printout, activates the C-REPORT subprogram. This subprogram prints the following fields from each record in the database file: Form Number, Cannon Number, Year Manufactured, Nationality, Trunnion Position Horizontal Ratio, Trunnion Position Vertical Ratio and Founder. These fields are printed in a tabular format on a page eighty columns wide.

The dBase II program has extensive report formatting capabilities through which any field in the database file structure can be printed. As stated in the section above on the database file, a familiarity with dBase is helpful to the operator wishing to print different fields using a tabular format within the eighty columns to which many printer are limited. The present fields were chosen because they pretain more directly to the present study.

Choosing option two, form printout, activates the C-LABEL subprogram and through it the C-FMT2 format file. Under this option, each record is printed with the same format as displayed on the screen. The operator can print a single record or the entire file. One record is printed per standard 8.5" X 11" sheet of paper. Therefore, printing an entire file containing a

thousand records would require a thousand pieces of paper.

File maintenance. To clear deleted records from the database file, option four, File Maintenance, must be chosen. This option calls the C-MAINT subprogram which simply issues the dBase 'pack' command. The operator is warned that this subprogram removes all records marked for deletion and is given the opportunity to cancel the command. Upon completion of the pack command, the subprogram returns to the Main menu.

Help. Choosing option five, Help, from the Main menu activates the subprogram C-HELP which is a short text file with information on how to use the program.

SUMMARY

This thesis has established an objective, quantitative system for gathering, storing and manipulating information on smooth bore, cast iron cannons. Information storage and manipulation are facilitated through computerization of the collected data. Using the computer programs provided, large amounts of data can be analyzed with the goal of establishing an identification key for smooth bore, cast iron cannons. The key will be based on characteristics which are measurable or calculable. These characteristics are specified and illustrated in this thesis.

During the development of this systematic approach, a small number of cannons were recorded to test the adequacy of the recording methods and the ability of the system to correlate collected information. As an example of the systems's capabilities, a calculated characteristic of cannons, specifically the ratio indicating vertical trunnion position, was analyzed to determine the validity of that characteristic as a diagnostic trait for determining the date of cannons.

The Trunnion Problem

As discussed in the introduction to this thesis (page 7), one of the popular hypotheses which circulates among those who study cannons concerns the vertical position of a cannon's trunnions. The most often heard form of this hypothesis is that the position of the trunnions correlates directly with the age of the gun - the lower the trunnion, the older the gun. At best this statement must be classified as a weak hypothesis since it appears to have no basis in published research. A

more accurate classification is 'rumor'. However, one often hears researchers in the field refer to a particular cannon as very early, generally sixteenth or early seventeenth century, because it has very low trunnions. The lack of citable references does not seem to hinder the making of quick judgements which often carry through to published reports.

The variation in vertical position of trunnions receives little discussion in cannon publications. One notable exception is O.F.G Hogg's Artillery: its Origin, Heyday and Decline (1970:59). In his brief treatment of changing trunnion positions, Hogg refers to John Muller's book, A Treatise of Artillery, written in 1768. Hogg relates how Muller, then Professor of Fortification and Artillery at the Royal Military Academy, complained that no valid reason existed to place the axis of the trunnion far below the axis of the bore and, in reality, such positioning only made the gun recoil dangerously. According to Hogg, "In 1756, Muller raised the trunnions to the centre of the bore, an improvement which greatly lessened the strain on the carriage."

The year 1756, then, would appear to be pivotal in the study of the vertical position of trunnions. However, Muller was a mathematician and theoretician who did not actually manufacture guns. Nor did he set policy for the manufacture of guns, although he may have had some influence in that realm. Was his theory translated into actual practice by gun manufacturers?

Certainly the Americans did not move the trunnions to the center of the barrel in the mid-1700s. Lieut.-Colonel Louis de Toussard, in

The American Artillerist's Companion published in 1809, over 50 years after Muller supposedly raised the trunnions, illustrates 'modern' cannon with the trunnions placed very low on the barrel.

Adding to the confusion is the discussion of trunnion position by John Gibbon more than 100 years after Muller's work. In The Artillerist's Manual (1860:61), Gibbon talks briefly about the relative merits of the position of the trunnion axis in relation to the bore axis. He states that, at the time of his writing, some countries placed the trunnions above the bore axis and some placed them below the bore axis, while in the United States "the axis of the trunnions is in the same plane with the axis of the piece, which transmits the recoil directly to the trunnions." At least on an international scale, the literature seems to indicate that the trunnions were still wandering up and down on the barrel right up to the end of the smooth bore era in the latter half of the nineteenth century.

One of the benefits of an empirical study is that it often tells us when the written record departs from fact. Can the objective system of cannon studies developed in this thesis, which relies on empirical data, help to clarify the problem of trunnion position? Although based on a small sample, the following chart of variations in vertical trunnion position (Figure 11) is very revealing.

Using information from six reliably dated cannon spread over a 250 year period, a graph plotting the vertical trunnion ratio on the horizontal axis and time on the vertical axis has been drawn. For this graph, the vertical ratios figured by the Cannon.calc program have been

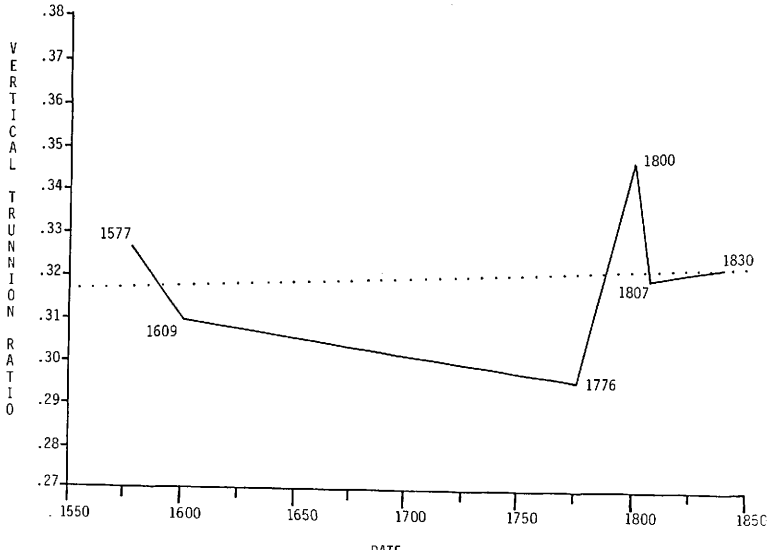


Figure 11. Variation in the vertical position of trunnions.

converted to indicate the distance of the axis of the trunnions from the top of the barrel rather than from the bottom of the barrel. This allows the range of trunnion position ratios to increase up the vertical axis rather than decrease. In this way, the plotted position is represented more realistically since trunnions which are physically higher on a gun plot correspondingly higher on the graph.

Note that the actual range of the trunnion position for the six guns lies between 0.29 and 0.35, never actually reaching the midpoint of the barrel at 0.50 even as late as 1830. Note also that the second highest position is from the earliest cannon, dated 1577.

Probably the most significant aspect of this graph is the relative positions of the two guns dated 1776 and 1800. Both of these guns are British and both are reliably dated. Both the highest and lowest trunnion positions of the sample are represented over this 24 year period within the latter decades of the smooth bore cannon era.

Although admittedly a very small sample, the data from these six guns tend to support the literary evidence that trunnion position is extremely unreliable as a diagnostic trait for dating cannons. The general trend, as indicated by the dotted line on the graph, shows a gradual rise in trunnion position over the 250 year range. However, the actual plotted trunnion positions vary so widely in this small sample that the indicated trend is meaningless.

A much larger, international sample population is needed to determine if trunnion positions might correlate with date when other characteristics are considered concurrently. In other words, perhaps

trunnion position correlates with date for all British cannons or for all British cannons of a certain size.

This thesis provides the foundation for a long-term, quantitative study of cannons. Information from this study will be used to establish an identification key which will aid researchers working on historic sites even if they have little firsthand knowledge of cannons.

Secondarily, this thesis provides evidence that the vertical position of trunnions on the barrel of a cannon is probably not a reliable indicator of the age of a cannon. This information attests to both the advisability of caution in unsupported, on-site speculation which too easily and too often gets translated into published fact and the need for an objective, quantitive approach to cannon studies such as presented in this thesis.

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APPENDIX A - CANNON RECORDING FORM

The following three pages contain an example of the Cannon Recording Form which has been properly filled out for a cast-iron signal gun in the possession of the Bermuda Maritime Museum.

Form number: 3 Cannon: 85:04 Page 1 of 4

Date recorded: Feb 18, 1985 Recorded by: S. Hoyt

Location: Bermuda Maritime Museum

Date of gun: 19th c Gun type: signal Metal Type: cast iron

Sketch (supplement with detail sketches where appropriate):

DIMENSIONS

Length of gun: 28" Overall length: 31.5"

Rings:	base	2	3	4	5	6	7
dia. aft	5.25	4.75	4.00	4.20	—	—	—
dia. of	5.50	5.25	4.20	5.60	—	—	—
dia. fore	5.90	4.70	3.70	3.10	—	—	—
width	1.70	0.75	1.10	0.70	—	—	—
molding code	BOF	FAF	BOF	FAF	—	—	—
distance between rings	2.06	9.20	8.40	---	---	---	

molding codes: B = Band O = Ogee F = Fillet
A = Astragal R = Round S = Slope

Distance from last ring to - maximum muzzle diameter: 3.25
- face of muzzle: 5.125

rev 12/03/85

Form number: 3 Cannon: 85:04 Page 2 of 4

Touch hole - diameter: 0.20

distance from base ring to touch hole center: 1.06

Trunnions:	right	left
diameter at base	1.70	1.70
diameter at end	1.60	1.60
length on top	1.60	1.60
distance between faces	7.50	

position -

distance from face of muzzle to axis of trunnions: 15.75

diameter of barrel at axis of trunnions: 4.06

distance from top of gun to axis of trunnions: 2.75

shoulder (rimbase) - diameter: 2.06 length at top: .12

Muzzle (sketch with dimensions) - maximum diameter of swell: 4.12

muzzle shape code: B3 molding code: RRR

muzzle shape codes:
S = Swelled Cone T = Tapered Cone B = Bell
C = Cylinder #M = # of Muzzle Moldings

Bore - diameter: 1.60 length: 26 rifled (Y/N): N

Cascabel (supplement with sketch showing dimensions) -

button shape code: K base of breech shape code: C

molding codes - base of breech: ROF neck: -- button: A

button shape codes:
C = Cylinder CL = Cylinder w/Loop K = Knob
KL = Knob w/Loop HL = Horizontal Loop VL = Vertical Loop
base of breech shape codes:
F = Flat C = Conical S = Spherical H = Hollowed

rev 12/03/85

Form number: 3 Cannon: 85.04 Page 3 of 4

MARKINGS

Left Trunnion:

latex peel____ photograph____ tracing____ other____

Right Trunnion:

latex peel____ photograph____ tracing____ other____

Breech Area:

NONE

latex peel____ photograph____ tracing____ other____

Other:

NONE

latex peel____ photograph____ tracing____ other____

COMMENTS

foundry Bailey, Pegg and Company - chamber area of bore blocked - mold line visible along top and bottom of gun - found mounted as stanchion on street corner with pipe forced into muzzle - dated by A.C. Carpenter - presently locate in the BMM Marine Artifact Conservation Lab

APPENDIX B - RECORDING TOOLS

As stated above, the Cannon Recording Form is intended to be a guideline to the information which must be recorded; it never can include of all the dimensions and characteristics which define every gun. In the same way, the following list of tools which comprise the Cannon Recording Kit (Figure 7) is meant as a guideline. Although the author has found every item on the list useful, not all are necessary to complete the task. Additional equipment, such as a Polaroid camera, may be desirable. If the gun to be measured is underwater, suitable replacements must be found for any tool which would be damaged in that environment.

The Cannon Recording Kit.

Tape measure, steel blade, retracting, 16 foot

Tape measure, cloth, 6 foot

Flashlight

Calipers, 12 inch

Calipers, sliding arm, 30 inch

Calipers, sliding arm, 6 inch

Photographic equipment

- Camera
- Black and white film
- Color film
- Photo scales
  - Yardstick, six inch, three inch
- Tripod

Flat metal bar

24 inches long X 1/2 inch wide X 1/8 inch thick

Contour Gauge

Molding clay

Cannon Recording Forms

Blank paper

Graph paper

Pencils and pens

Dental pick

APPENDIX C - CANNON.CALC LISTING

```
10 REM CANNON-CALC PROGRAM
20 REM WRITTEN IN MS-BASIC (FOR TEXAS INSTRUMENTS COMPUTERS)
30 REM AUTHOR STEVE HOYT
40 REM ******** ALL INPUT MUST BE IN INCHES AND DECIMALS ********
50 DIM L(30), DI(30), V(30), W(30), TEMP(30)
60 COLOR 7 : GOTO 10000
700 REM ROUND OFF VALUE TO NEAREST HUNDREDTH
710 R = INT ((R+.005)  * 100) / 100 : RETURN
800 REM ROUND OFF VALUE TO NEAREST THOUSANDTH
810 R = INT ((R+.0005) * 1000) / 1000 : RETURN
1000 REM DISPLAY WEIGHT OF ALL SECTIONS AND OFFER TO CHANGE VALUES
1010 SD = 0 : S = 0 : WT = 0 : D = 0 : COG = 0
1020 CLS
1030 FOR I = 1 TO NS
1040     PRINT "SECTION ";I
1045     LOCATE I,18 : PRINT "WEIGHT:  ";W(I)
1050     LOCATE I,35 : PRINT "LENGTH:  ";L(I)
1060     TEMP(I) = W(I)
1070 NEXT I
1075 PRINT
1080 X = CSRLIN : INPUT "WANT TO CHANGE ANY VALUES (Y/N)?  ",C$
1090 IF C$ <> "Y" AND C$ <> "N" THEN LOCATE X,1 : GOTO 1080
1100 IF C$ = "Y" THEN GOTO 5000
```

```
2000 REM FIGURE CENTER OF GRAVITY AND CENTER OF GRAVITY RATIO
2010 FOR I = 1 TO NS
2020     D = (L(I) / 2) + WT
2030     WT = WT + L(I)
2040     SD = SD + (TEMP(I) * D)
2050     S = S + TEMP(I)
2060 NEXT I
2070 COG = SD / S
2080 R = COG : GOSUB 700 : COG = R
2090 PRINT : PRINT : PRINT "POSITION OF CENTER OF GRAVITY IS ";:COLOR 4
2100 PRINT COG;: PRINT " INCHES ";: COLOR 7 : PRINT " FROM FACE OF
     MUZZLE."
2110 RCOG = TL / COG
2120 R = RCOG : GOSUB 700 : RCOG = R
2130 PRINT : PRINT "CENTER OF GRAVITY RATIO IS ";: COLOR 4:
2140 PRINT RCOG : COLOR 7
3000 REM CALCULATE BREECH PREPONDERANCE AS WEIGHT AND PERCENTAGE
3010 REM LOOP TO FIGURE WEIGHT OF BREECH END OF GUN
3020 FOR I = TS TO NS : BW = BW + W(I) : NEXT I
3030 BP = (2 * BW) - TW
3040 R = BP : GOSUB 700 : BP = R
3050 PBP = BP / TW
3060 R = PBP : GOSUB 800 : PBP = R
3070 PRINT : PRINT "THE BREECH PREPONDERANCE IS ";: COLOR 4 : PRINT
     BP;:
```

```
3080 PRINT "LBS OR "; PBP ; "%." : COLOR 7
4000 REM OFFER TO RECALCULATE OR CALCULATE ANOTHER GUN
4010 PRINT
4020 X = CSRLIN : INPUT "WANT TO CHANGE VALUES AND RECALCULATE
     (Y/N)";G$
4030 IF G$ <> "Y" AND G$ <> "N" THEN LOCATE X,1 : GOTO 4020
4040 IF G$ = "Y" THEN GOTO 5000
4050 PRINT
4060 X = CSRLIN : INPUT "WANT TO CALCULATE ANOTHER GUN (Y/N)"; A$
4070 IF A$ <> "Y" AND A$ <> "N" THEN LOCATE X,1 : GOTO 4060
4080 IF A$ = "Y" THEN RUN
4090 PRINT : PRINT "IT'S CERTAINLY BEEN FUN! SEE YOU LATER."
4100 END
5000 REM CHANGE VALUES
5010 CLS : PRINT "ENTER THE NUMBER OF THE SECTION WHICH YOU ";
5020 INPUT "WISH TO CHANGE:  ",NC
5030 IF NC > NS THEN GOTO 6000
5040 PRINT : PRINT "SECTION " ; NC ; "     WEIGHT :  " ; W(NC) ;
5050  PRINT "    LENGTH:  " ; L(NC)
5060 PRINT : PRINT " NEW WEIGHT" ;: INPUT TEMP(NC) : W(NC) = TEMP(NC)
5070 PRINT : PRINT "  NEW LENGTH" ;: INPUT L(NC)
5080 TW = 0
5090 FOR I = 1 TO 50 : NEXT I
5100 CLS
5110 FOR I = 1 TO NS
```

```
5120     PRINT I;" WEIGHT:  "; TEMP(I); TAB(30) ; "LENGTH:  ";L(I)
5130     TW = TW + TEMP(I)
5140 NEXT I
5150 WT = 0 : SD = 0 : S = 0 : COG = 0 : D = 0 : BW = 0
5160 GOTO 1080
6000 REM ADD NEW SECTIONS TO CURRENT GUN CALCULATIONS
6010 FOR I = 1 TO 3 : PRINT CHR$(7) : NEXT I
6020 CLS : PRINT "THIS IS SECTION ";: COLOR 4 : PRINT NC;: COLOR 7 :
     PRINT " AND YOU ORIGINALLY ENTERED ";: COLOR 4 : PRINT NS;:
     COLOR 7 : PRINT " SECTIONS."
6030 X = CSRLIN : INPUT "DO YOU INTEND TO ADD NEW SECTIONS (Y/N)"; C$
6040 IF C$ <> "Y" AND C$ <> "N" THEN LOCATE X,1 : GOTO 6030
6050 IF C$ = "N" THEN GOTO 5010
6060 IF NC = NS + 1 THEN NS = NS + 1 : GOTO 5060
6070 PRINT : PRINT "SINCE ";NC;" IS NOT THE NEXT CONSECUTIVE NUMBER
     AFTER ";NS
6080 PRINT "YOU WILL HAVE TO RE-ENTER WITH THE NEXT NUMBER.
6090 PRINT : PRINT "HIT ANY KEY WHEN READY."
6100 A$ = INKEY$ : IF A$ = "" THEN 6100
6110 A$ = "" : GOTO 5010
10000 REM CALCULATIONS FOR VOLUME AND WEIGHT OF CANNON SECTIONS
10020 CLS : A$ = "" : PRINT "IS THE GUN BRONZE OR CAST-IRON ";
10030 X = CSRLIN : INPUT "(ENTER B OR C)";C$
10040 IF C$ <> "B" AND C$ <> "C" THEN LOCATE X,1 : GOTO 10030
10045 IF C$ = "B" THEN F = .3009 ELSE F = .2604
```

```
10046 IF C$ = "B" THEN H = 3 ELSE H = 2.5
10050 PRINT : INPUT "TOTAL NUMBER OF SECTIONS";NS
10060 PRINT : INPUT "DIAMETER OF BORE";D2
10070 PRINT : INPUT "HOW MANY SECTIONS DOES THE BORE EXTEND THROUGH";N
10080 PRINT : INPUT "WHICH SECTION CONTAINS THE BASE RING";BR
10090 PRINT : INPUT "WHICH SECTION HAS ITS FORWARD END AT THE AXIS OF
      THE TRUNNIONS";TS
10100 FOR I = 1 TO NS
10110 CLS
10120 PRINT "SECTION ";I : PRINT : PRINT
10130 INPUT "LENGTH:  ",L(I)
10140 PRINT : INPUT "AVERAGE DIAMETER:  ",D1(I)
10150 REM CALCULATE VOLUME OF SECTION BEYOND BORE
10160 IF I > N THEN PRINT : V(I) = L(I) * ((.5 * D1(I))^2) * 3.1416 :
      R = V(I) : GOSUB 700 : V(I) = R : PRINT "VOLUME OF SECTION "; I ;
      " = " ; V(I) ; " CUBIC INCHES" : PRINT : GOTO 10190
10170 REM CALCULATE VOLUME OF SECTION WITH BORE
10180 PRINT : V(I) = .7854 * (D1(I)^2 - D2^2) * L(I) : R = V(I) : GOSUB
      700 : V(I) = R : PRINT "VOLUME OF SECTION "; I ; " = "; V(I) ; "
      CUBIC INCHES" : PRINT
10190 REM CALCULATE WEIGHT OF SECTION
10210 W(I) = V(I) * F : R = W(I) : GOSUB 700 : W(I) = R : PRINT "WEIGHT
      OF SECTION "; I; " = "; W(I); " LBS" : PRINT : A$ = ""
```

```
10220 IF I = NS THEN PRINT : PRINT "THIS IS THE LAST SECTION." : PRINT
      "HIT ";: COLOR 4 : PRINT "RETURN";: COLOR 7 : PRINT " WHEN READY
      TO CONTINUE." : GOTO 10240
10230 PRINT "HIT ";: COLOR 4 : PRINT "RETURN";: COLOR 7 : PRINT " WHEN
      READY TO ENTER NEXT SECTION."
10240 A$ = INKEY$ : IF A$ <> CHR$(13) THEN 10240
10250 NEXT I
10260 REM PRINT TO SCREEN ALL VALUES INCLUDING CALCULATED VALUES
10270 CLS : PRINT "TOTAL VALUES" : PRINT
10280 REM LOOP TO CALCULATE TOTAL LENGTH, DIAMETER, VOLUME, WEIGHT
10290 FOR J = 1 TO NS
10300 TL = TL + L(J) : TD = TD + D1(J) : TV = TV + V(J) : TW = TW +
      W(J)
10310 NEXT J
10320 REM LOOP TO CALCULATE BORE LENGTH
10330 FOR K = 1 TO N : BL = BL + L(K) : NEXT K
10340 REM LOOP TO CALCULATE LENGTH OF GUN AND AVERAGE DIAMETER OF
      LENGTH OF GUN
10350 FOR K = 1 TO BR : LB = LB + L(K) : AV = AV + D1(K) : NEXT K
10360 REM CACLULATE AVERAGE DIAMETER OVER LENGTH OF GUN
10370 AV = AV/BR
10380 PRINT "OVERALL LENGTH OF GUN:  ";: COLOR 4 : PRINT TL; " INCHES"
      : COLOR 7
10390 PRINT "LENGTH OF GUN:  ";: COLOR 4 : PRINT LB; " INCHES": COLOR 7
10400 REM CALCULATE AVERAGE DIAMETER OF OVERALL LENGTH
```

```
10410 AD = TD / NS : R = AD : GOSUB 700 : AD = R : PRINT "AVERAGE
      DIAMETER FOR OVERALL LENGTH OF GUN:  ";: COLOR 4 : PRINT AD;
      " INCHES" : COLOR 7
10420 R = AV : GOSUB 700 : AV = R : PRINT "AVERAGE DIAMETER OF LENGTH
      OF GUN:  ";: COLOR 4 : PRINT AV;" INCHES": COLOR 7
10430 R = TV : GOSUB 700 : TV = R : PRINT "TOTAL VOLUME OF METAL IN
      GUN:  ";: COLOR 4 : PRINT TV;" CUBIC INCHES" : COLOR 7
10440 R = TW : GOSUB 700 : TW = R : PRINT "TOTAL WEIGHT OF GUN:  ";:
      COLOR 4 : PRINT TW;" LBS": COLOR 7
10450 REM CALCULATE WEIGHT BY METHOD IN O.F.G. HOGG
10460 BL = BL / 12 : LB = LB / 12
10470 W2 = H * (((AV^2) * LB) - ((5/6) * ((D2^2) * BL)))
10480 R = W2 : GOSUB 700 : W2 = R
10490 PRINT "WEIGHT BY HOGG'S FORMULA:  ";: COLOR 4 : PRINT W2;" LBS"
      : COLOR 7
10500 REM CALCULATE HOW MUCH HOGG'S FORMULA DIFFERS FROM PROGRAM
10510 WP = W2 - TW : WP = 100 * (WP / TW) : R = WP : GOSUB 700 : WP = R
      : PRINT "AMOUNT HOGG OVERWEIGHT:  ";: COLOR 4 : PRINT WP;"%":
      COLOR 7
10520 PRINT : PRINT "HIT ";: COLOR 4 : PRINT "RETURN";: COLOR 7 : PRINT
      " TO FIGURE CENTER OF GRAVITY AND BREECH PREPONDERANCE." : A$=""
10530 A$ = INKEY$ : IF A$ <> CHR$(13) THEN 10530
10540 GOTO 1000
10550 REM                END OF LISTING - CANNON.CALC PROGRAM
```

APPENDIX D - DBASE II PROGRAM LISTINGS

The following pages contain the listing of the database file handling programs written in the dBase II programming language.

program	page
CANNONS.PRG	74
C-VIEW.PRG	78
C-NAME.PRG	92
C-CHMENU.PRG	97
C-DEFINE.PRG	100
C-MODIFY.PRG	102
C-ADD.PRG	109
C-REPORT.PRG	118
C-RPTMEN.PRG	123
C-LABEL.PRG	125
C-APPEND.PRG	133
C-CHANGE.PRG	136
C-MAINT.PRG	144
C-FORMAT.FMT	146
C-FMT2.FMT	149
C-HELP.PRG	152

```
* CANNONS.PRG
* MAIN MENU FOR CANNONS DBF SYSTEM
* Author:  Steven D. Hoyt
* Date Created:  9/29/85
* Last Modified:  11/1/85
*
SET TALK OFF
SET CONFIRM ON
SET ECHO OFF
SET BELL OFF
SET COLON OFF
SET DEFAULT TO A:
* define border lines to pass to subprograms
STORE '----------------------------------------' + ;
      '----------------------------------------' to dashes
STORE '||                                      ' + ;
      '                                      ||' to border
*
USE CANNONS
*
DO WHILE T
*
ERASE
@ 1,0 SAY dashes
@ 2,0 SAY border
```

```
@ 2,2 SAY ' C A N N O N    R E C O R D I N G    P R O G R A M'
@ 2,53 SAY '  -  M A I N    M E N U'
@ 3,0 SAY dashes
@ 4,0 SAY border
@ 5,0 SAY border
@ 6,0 SAY border
@ 7,0 SAY border
@ 8,0 SAY border
@ 9,0 SAY border
@ 10,0 SAY border
@ 11,0 SAY border
@ 12,0 SAY border
@ 13,0 SAY dashes
@ 5,23 SAY ' 0. Exit'
@ 6,23 SAY ' 1. View, Edit, Add or Delete Records'
@ 7,23 SAY ' 2. Data Quick Entry - for experienced users'
@ 8,23 SAY ' 3. Report'
@ 9,23 SAY ' 4. File Maintenance'
@ 10,23 SAY ' 5. Help'
STORE 6 to selectnum
DO WHILE selectnum < 0 .OR. selectnum> 5
   STORE ' ' to select
   @ 13,33 SAY ' select : : '
   @ 13,42 GET select PICTURE '#'
   READ
```

```
   STORE VAL(select) to selectnum
ENDDO
*
DO CASE
   CASE selectnum = 0
      SET COLON ON
      SET BELL ON
      SET TALK ON
      SET DEFAULT TO E:
      CLEAR
      RETURN
   CASE selectnum = 1
      RELEASE selectnum, select
      DO C-CHMENU
   CASE selectnum = 2
      RELEASE selectnum, select
      DO C-APPEND
   CASE selectnum = 3
      RELEASE selectnum, select
      DO C-RPTMEN
   CASE selectnum = 4
      RELEASE selectnum, select
      DO C-MAINT
   CASE selectnum = 5
      RELEASE selectnum, select
```

```
      DO C-HELP
ENDCASE
*
ENDDO T
*
* EOF CANNONS.PRG
```

```
* C-VIEW.PRG
* Called from C-CHMENU.PRG
* Author:  Steven D. Hoyt
* Date 10/12/85
* Last modified 12/21/85
*
ERASE
CLEAR GETS
SET CONFIRM ON
SET ECHO OFF
SET BELL OFF
SET TALK OFF
SET DEBUG OFF
SET INDEX TO
GOTO TOP
STORE 0 to flag
*
*print form
@ 2,0 SAY dashes
   STORE 3 to count
   DO WHILE count < 20
      @ count,0 SAY '¦¦'
      @ count,78 SAY '¦¦'
      STORE count + 1 to count
   ENDDO
```

```
@ 20,0 SAY dashes
*
*begin main program loop
*
DO WHILE T
* define variables here
STORE " " to choice
STORE T to badans
   IF *
      @ 0,65 SAY "  DELETED  "
   ELSE
      @ 0,65 SAY "           "
   ENDIF
*
*fill form with information from first record
@ 1,4 SAY "Form Number:  "
@ 1,18 SAY form:no
@ 1,40 SAY "Cannon Number:  "
@ 1,56 SAY cannon:no
@ 3,4 SAY "Location:  "
@ 3,15 SAY location
@ 4,4 SAY "Gun Type:  "
@ 4,15 SAY gun:type
@ 4,40 SAY "Nation:  "
@ 4,49 SAY nation
```

```
@ 5,4 SAY "Metal Type:  "
@ 5,17 SAY metal:type
@ 5,40 SAY "Year Manufactured:  "
@ 5,61 SAY year
@ 6,4 SAY "Overall Length:  "
@ 6,21 SAY oa:length
@ 6,40 SAY "Length of Gun:  "
@ 6,56 SAY bar:length
@ 7,4 SAY "Bore Length:  "
@ 7,18 SAY bore:len
@ 7,40 SAY "Bore Diameter:  "
@ 7, 56 SAY bore:dia
@ 8,4 SAY "Calibre:  "
@ 8,14 SAY calibre
@ 8,40 SAY "Rifled:  "
@ 8,49 SAY rifled
@ 9,4 SAY "Gun Weight:  "
@ 9,17 SAY gun:weight
@ 9,40 SAY "Weight of Iron Shot:  "
@ 9,62 SAY fe:shot:wt
@ 10,4 SAY "Diameter of gun at trunnion axis:  "
@ 10,40 SAY dia:at:tru
@ 11,4 SAY "Trunnion Position -"
@ 12,10 SAY "Horizontal:  "
@ 12,23 SAY trunnion:h
```

```
@ 12,40 SAY "Horizontal Ratio:  "
@ 12,59 SAY hor:ratio
@ 13,10 SAY "Vertical:  "
@ 13,21 SAY trunnion:v
@ 13,40 SAY "Vertical Ratio:  "
@ 13,56 SAY vert:ratio
@ 14,4 SAY "Muzzle Shape:  "
@ 14,19 SAY muzzle
@ 14,40 SAY "Muzzle Flare Rate:  "
@ 14,66 SAY muzle:flar
@ 15,4 SAY "Muzzle Thickness:  "
@ 15,23 SAY muzle:thik
@ 16,4 SAY "Chase Thickness:  "
@ 16,22 SAY chase:thik
@ 16,40 SAY "Vent Thickness:  "
@ 16,57 SAY vent:thik
@ 17,4 SAY "Base of Breech Shape:  "
@ 17,27 SAY cascabel
@ 17,40 SAY "Button Shape:  "
@ 17,55 SAY button
@ 18,4 SAY "Breech Preponderance:          %"
@ 18,27 SAY br:prepond
@ 18,40 SAY "Center of Gravity Ratio:  "
@ 18,66 SAY COG
@ 19,4 SAY "Founders Mark:  "
```

```
@ 19,20 SAY founder
@ 21,4 SAY "Comments:  "
@ 21,15 SAY comments
@ 24,0
*
   IF flag=1
      STORE "Y" to choice
      STORE T to badans
      SET COLON ON
      @ 24,20 SAY 'Continue Search (Y/N)?  '
      DO WHILE badans
         @ 24,45 GET choice PICTURE "!"
         READ
         IF choice$'YN'
            STORE F to badans
            SET COLON OFF
         ENDIF
      ENDDO
      IF choice="Y"
         CONTINUE
         IF .NOT. EOF
            LOOP
         ELSE
            @ 24,0
            @ 24,20 SAY "END OF FILE"
```

```
            STORE " " to choice
            STORE 0 TO count
              DO WHILE count < 50
                 STORE count+1 to count
              ENDDO
            STORE 0 to flag
            @ 24,0
          ENDIF
        ELSE
          STORE 0 TO flag
          @ 24,0
        ENDIF
      ENDIF
STORE " " to choice
@ 24,20 SAY '(F)ind, Skip (A)head or (B)ack '
STORE T to badans
DO WHILE badans
   SET COLON ON
   @ 24, $ GET choice PICTURE "!"
   READ
   IF choice$"FAB "
      STORE F to badans
      SET COLON OFF
   ENDIF
ENDDO
```

```
@ 24,0
DO CASE
   CASE choice="A"
      SKIP
      IF .NOT. EOF
         LOOP
      ELSE
         @ 24,26 SAY "This is the last record"
         GOTO BOTTOM
         STORE 1 to count
         DO WHILE count < 50
            STORE count + 1 to count
         ENDDO
         RELEASE count
         @ 24,0
         LOOP
      ENDIF
  CASE choice="B"
      IF # > 1
         SKIP-1
         LOOP
      ELSE
         @ 24,26 SAY "This is the first record"
         GOTO TOP
         STORE 1 to count
```

```
        DO WHILE count <50
           STORE count + 1 to count
        ENDDO
        RELEASE count
        @ 24,0
        LOOP
     ENDIF
  CASE choice="F"
     SET COLON ON
     STORE "                                  " to field
     STORE " " to field1
     STORE "                    ";
           to value1
     STORE "                    ";
           to value2
     STORE "   " to logic:op
     STORE "  " to rel:op1
     STORE "  " to rel:op2
     STORE " " to param
     STORE " " to param1
     STORE " " to kind
     STORE "Y" to response
* establish search parameters
     DO WHILE field = '                                  '
     @ 24,0
```

```
@ 24,17 SAY 'NAME OF FIELD TO SEARCH ' GET field
READ
* capitalize field name
STORE TRIM(!(field)) to field
STORE field to field1
DO C-NAME
IF field = 'unknown'
   ? CHR(7)
   @ 24,0
   @ 24,10 SAY field1+' is not a valid field name!'
   STORE 0 to count
      DO WHILE count < 50
         STORE count + 1 to count
      ENDDO
   STORE '                                    ' to field
   LOOP
ELSE
   STORE field1 to field
   STORE '                    ' to value1
   STORE '                    ' to value2
ENDIF
ENDDO
*
ERASE
@ 2,24 SAY '* * SEARCH PARAMETERS * *'
```

```
      @ 4,10 SAY "FIELD TO BE SEARCHED IS -"
      @ 4,36 SAY field
      @ 6,7 SAY 'FIRST OPERATOR (=, <, >, <=, >=, $) ' GET rel:op1
      @ 8,7 SAY "FIRST VALUE TO SEARCH FOR " GET value1
      @ 11,3 SAY 'THE FOLLOWING SEARCH PARAMETERS ARE OPTIONAL:'
      @ 13,7 SAY 'LOGICAL OPERATOR (AND, OR, NOT) ' GET logic:op
      @ 15,7 SAY 'SECOND OPERATOR ' GET rel:op2
      @ 17,7 SAY 'SECOND VALUE ' GET value2
      READ
      DO C-NAME
      SET COLON OFF
      STORE TRIM(rel:op1) to rel:op1
      STORE TRIM(!(value1)) to value1
      IF logic:op <> '   '
         STORE "."+TRIM(!(logic:op))+"." to logic:op
         STORE TRIM(rel:op2) to rel:op2
         STORE TRIM(!(value2)) to value2
      ENDIF
* position pointer
      GOTO TOP
* use & to substitute memvars in LOCATE command
      IF rel:op1 = '$' .OR. rel:op2 = '$'
         IF kind = 'N'
            ? CHR(7)
            @ 23,10 SAY "Can't search for part of a numeric field!"
```

```
      STORE 0 to count
      DO WHILE count < 40
         STORE count + 1 to count
      ENDDO
      ERASE
      @ 2,0 SAY dashes
      STORE 3 to count
      DO WHILE count < 20
         @ count,0 SAY '¦¦'
         @ count,78 SAY '¦¦'
         STORE count + 1 to count
      ENDDO
      @ 20,0 SAY dashes
      LOOP
ELSE
   IF logic:op = " "
      STORE value1+' '+rel:op1+' '+field to param
      STORE value1+' '+rel:op1+' '+field to param1
   ELSE
      IF rel:op1='$' .AND. rel:op2='$'
         STORE value1+' '+rel:op1+' '+field+' '+logic:op+' ';
             +value2+' '+rel:op2+' '+field to param
         STORE value1+' '+rel:op1+' '+field1+' '+logic:op+' ';
             +value2+' '+rel:op2+' '+field1 to param1
      ELSE
```

```
            IF rel:op1='$' .AND. rel:op2<>'$'
               STORE value1+' '+rel:op1+' '+field+' '+logic:op;
                  +' '+field+' '+rel:op2+' '+value2 to param
               STORE value1+' '+rel:op1+' '+field1+' '+logic:op;
                  +' '+field1+' '+rel:op2+' '+value2 to param1
            ELSE
               STORE field+' '+rel:op1+' '+value1+' '+logic:op;
                  +' '+value2+' '+rel:op2+' '+field to param
               STORE field1+' '+rel:op1+' '+value1+' '+logic:op;
                  +' '+value2+' '+rel:op2+' '+field1 to param1
            ENDIF
         ENDIF
      ENDIF
   ENDIF
ELSE
   IF logic:op = "   "
      STORE field+' '+rel:op1+' '+value1 to param
      STORE field1+' '+rel:op1+' '+value1 to param1
   ELSE
      STORE field+' '+rel:op1+' '+value1+' '+logic:op+' '+field;
         +' '+rel:op2+' '+value2 to param
      STORE field1+' '+rel:op1+' '+value1+' '+logic:op+' ';
         +field1+' '+rel:op2+' '+value2 to param1
   ENDIF
ENDIF
```

```
LOCATE ALL FOR &param
IF EOF
   ERASE
   ? CHR(7)
   ? CHR(7)
   @ 12,10 SAY 'NO ENTRY LOCATED FOR:'
   @ 14,15 SAY param1
   @ 23,10 SAY 'Press any key to continue...'
   SET CONSOLE OFF
   WAIT
   SET CONSOLE ON
   ERASE
   GOTO TOP
   @ 2,0 SAY dashes
   STORE 3 to count
   DO WHILE count < 20
      @ count,0 SAY '¦¦'
      @ count,78 SAY '¦¦'
      STORE count + 1 to count
   ENDDO
   @ 20,0 SAY dashes
   LOOP
ENDIF
GOTO #
STORE 1 TO flag
```

```
      ERASE
      @ 2,0 SAY dashes
         STORE 3 to count
         DO WHILE count < 20
            @ count,0 SAY '¦¦'
            @ count,78 SAY '¦¦'
            STORE count + 1 to count
         ENDDO
      @ 20,0 say dashes
      LOOP
   CASE choice=" "
      RELEASE choice
      RETURN
ENDCASE
ENDDO T
* EOF C-VIEW.PRG
```

```
* C-NAME.PRG
* Called from C-VIEW.PRG
* Author:  Steven D. Hoyt
* Date created:  10/21/85
* Last modified:  12/21/85
*
*  this subprogram converts the users field name to the corresponding
*  database field name and checks for Character or Numeric field type
STORE 0 to count
DO CASE
   CASE field = 'FORM NUMBER'
      STORE 'form:no' to field
      STORE 1 to count
   CASE field = 'CANNON NUMBER'
      STORE 'cannon:no' to field
      STORE 1 to count
   CASE field = 'LOCATION'
      STORE 'location' to field
      STORE 1 to count
   CASE field = 'GUN TYPE'
      STORE 'gun:type' to field
      STORE 1 to count
   CASE field = 'NATION'
      STORE 'nation' to field
      STORE 1 to count
```

```
CASE field = 'METAL TYPE'
   STORE 'metal:type' to field
   STORE 1 to count
CASE field = 'YEAR MANUFACTURED'
   STORE 'year' to field
   STORE 1 to count
CASE field = 'OVERALL LENGTH'
   STORE 'oa:length' to field
   STORE 1 to count
CASE field = 'LENGTH OF GUN'
   STORE 'bar:length' to field
   STORE 1 to count
CASE field = 'BORE LENGTH'
   STORE 'bore:len' to field
   STORE 1 to count
CASE field = 'BORE DIAMETER'
   STORE 'bore:dia' to field
   STORE 1 to count
CASE field = 'CALIBRE'
   STORE 'calibre' to field
   STORE 1 to count
CASE field = 'RIFLED'
   STORE 'rifled' to field
   STORE 1 to count
CASE field = 'GUN WEIGHT'
```

```
      STORE 'gun:weight' to field
      STORE 1 to count
   CASE field = 'WEIGHT OF IRON SHOT'
      STORE 'fe:shot:wt' to field
      STORE 1 to count
   CASE field = 'DIAMETER OF GUN AT TRUNNION AXIS'
      STORE 'dia:at:tru' to field
      STORE 1 to count
   CASE field = 'HORIZONTAL'
      STORE 'trunnion:h' to field
      STORE 1 to count
   CASE field = 'HORIZONTAL RATIO'
      STORE 'hor:ratio' to field
      STORE 1 to count
   CASE field = 'VERTICAL'
      STORE 'trunnion:v' to field
      STORE 1 to count
   CASE field = 'VERTICAL RATIO'
      STORE 'vert:ratio' to field
      STORE 1 to count
   CASE field = 'MUZZLE SHAPE'
      STORE 'muzzle' to field
      STORE 1 to count
   CASE field = 'MUZZLE FLARE RATE'
      STORE 'muzle:flar' to field
```

```
    STORE 1 to count
CASE field = 'MUZZLE THICKNESS'
    STORE 'muzle:thik' to field
    STORE 1 to count
CASE field = 'CHASE THICKNESS'
    STORE 'chase:thik' to field
    STORE 1 to count
CASE field = 'VENT THICKNESS'
    STORE 'vent:thik' to field
    STORE 1 to count
CASE field = 'BASE OF BREECH SHAPE'
    STORE 'cascabel' to field
    STORE 1 to count
CASE field = 'BUTTON SHAPE'
    STORE 'button' to field
    STORE 1 to count
CASE field = 'BREECH PREPONDERANCE'
    STORE 'br:prepond' to field
    STORE 1 to count
CASE field = 'CENTER OF GRAVITY RATIO'
    STORE 'cog' to field
    STORE 1 to count
CASE field = 'FOUNDERS MARK'
    STORE 'founder' to field
    STORE 1 to count
```

```
   CASE field = 'COMMENTS'
      STORE 'comments' to field
      STORE 1 to count
ENDCASE
IF count = 0
   STORE 'unknown' to field
   RETURN
ENDIF
* check for character or numeric field
STORE TYPE(&field) to kind
* put quotes around values in character type field
IF kind = 'C'
   STORE "'"+TRIM(value1)+"'" to value1
   STORE "'"+TRIM(value2)+"'" to value2
ENDIF
RETURN
* EOF C-NAME.PRG
```

```
* C-CHMENU.PRG
* Called from CANNONS.PRG
* Author:  Steven D. Hoyt
* Date:  10/13/85
* Last modified:  12/13/85
*
SET TALK OFF
SET BELL OFF
SET COLON OFF

DO WHILE T

ERASE
@  1, 0 SAY dashes
@  2, 0 SAY border
@  2,13 SAY "C A N N O N   F I L E  -  U P D A T E   M E N U"
@  3, 0 SAY dashes
@  4, 0 SAY border
@  5, 0 SAY border
@  6, 0 SAY border
@  7, 0 SAY border
@  8, 0 SAY border
@  9, 0 SAY border
@ 10, 0 SAY border
@ 11, 0 SAY dashes
```

```
@  5,26 SAY " 0. Exit"
@  6,26 SAY " 1. View existing entries"
@  7,26 SAY " 2. Change, Delete, Undelete existing entries"
@  8,26 SAY " 3. Add new entries"
STORE  4 TO selectnum
DO WHILE selectnum < 0 .OR. selectnum >  3
   STORE " " TO select
   @ 11,33 SAY " select : : "
   @ 11,42 GET select PICTURE "#"
   READ
   STORE VAL(select) TO selectnum
ENDDO

DO CASE
   CASE selectnum= 0
      RELEASE selectnum, select
      ERASE
      RETURN
   CASE selectnum= 1
      DO C-VIEW
   CASE selectnum= 2
      DO C-CHANGE
   CASE selectnum= 3
      DO C-ADD
ENDCASE
```

```
ENDDO T

* EOF: C-CHMENU.PRG
```

```
* C-DEFINE.PRG
* Called from C-ADD.PRG
* Author:  Steven D. Hoyt
* Date created:  10/26/85
* Last modified:  12/21/85
*
* defines variables to use in C-ADD subprogram
*
STORE 0 to zform:no
STORE '          ' to zcannon:no
STORE '                                                    ';
   to zlocation
STORE '                    ' to zgun:type
STORE '          ' to znation
STORE '            ' to zmtl:type
STORE '       ' to zyear
STORE 0.00 to zoa:length
STORE 0.00 to zbar:len
STORE 0.00 to zbore:len
STORE 0.00 to zbore:dia
STORE 0 to zcalibre
STORE ' ' to zrifled
STORE 0.00 to zgun:wt
STORE 0.0 to zfe:st:wt
STORE 0.00 to ztrunn:h
```

```
STORE 0.000 to zhor:ratio
STORE 0.00 to ztrunn:v
STORE 0.00 to zdia:at:tr
STORE 0.000 to zver:ratio
STORE 0.00 to zbr:prep
STORE 0.000 to zcog
STORE '  ' to zmuzzle
STORE 0.00 to zmzl:flar
STORE 0.00 to zmzl:thik
STORE 0.00 to zchs:thik
STORE 0.00 to zvnt:thik
STORE '  ' to zcascabel
STORE '  ' to zbutton
STORE '                    ' to zfounder
STORE '                                                    ';
   + '                                                     ';
   + '                                                     ';
   + '                    ' to zcomments
RETURN
*EOF C-DEFINE.PRG
```

```
* C-MODIFY.PRG
* Called from C-CHANGE.PRG
* Author:  Steven D. Hoyt
* Date created:  10/12/85
* Last modified:  12/21/85
*
STORE T to add:data
STORE form:no to zform:no
STORE cannon:no to zcannon:no
STORE location to zlocation
STORE gun:type to zgun:type
STORE nation to znation
STORE metal:type to zmtl:type
STORE year to zyear
STORE oa:length to zoa:length
STORE bar:length to zbar:len
STORE bore:len to zbore:len
STORE bore:dia to zbore:dia
STORE calibre to zcalibre
STORE rifled to zrifled
STORE gun:weight to zgun:wt
STORE fe:shot:wt to zfe:st:wt
STORE dia:at:tru to zdia:at:tr
STORE trunnion:h to ztrunn:h
STORE hor:ratio to zhor:ratio
```

```
STORE trunnion:v to ztrunn:v
STORE vert:ratio to zver:ratio
STORE muzzle to zmuzzle
STORE muzle:flar to zmzl:flar
STORE muzle:thik to zmzl:thik
STORE chase:thik to zchs:thik
STORE vent:thik to zvnt:thik
STORE cascabel to zcascabel
STORE button to zbutton
STORE br:prepond to zbr:prep
STORE cog to zcog
STORE founder to zfounder
STORE comments to zcomments
* data entry loop
DO WHILE add:data
CLEAR GETS
@ 1,18 GET zform:no PICTURE '999999'
@ 1,56 GET zcannon:no PICTURE '!!!!!!!!!!'
@ 3,15 GET zlocation;
   PICTURE '!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!'
@ 4,15 GET zgun:type PICTURE '!!!!!!!!!!!!!!!!!!!!'
@ 4,49 GET znation PICTURE '!!!!!!!!!!'
@ 5,17 GET zmtl:type PICTURE '!!!!!!!!!!!!'
@ 5,60 GET zyear PICTURE '!!!!!!!'
@ 6,21 GET zoa:length PICTURE '999.99'
```

```
@ 6,56 GET zbar:len PICTURE '999.99'
@ 7,18 GET zbore:len PICTURE '999.99'
@ 7,56 GET zbore:dia PICTURE '99.99'
@ 8,14 GET zcalibre PICTURE '99'
@ 8,49 GET zrifled PICTURE '!'
@ 9,17 GET zgun:wt PICTURE '9999.99'
@ 9,62 GET zfe:st:wt PICTURE '999.9'
@ 10,40 GET zdia:at:tr PICTURE '99.99'
@ 12,23 GET ztrunn:h PICTURE '999.99'
@ 12,59 GET zhor:ratio PICTURE '9.999'
@ 13,21 GET ztrunn:v PICTURE '99.99'
@ 13,56 GET zver:ratio PICTURE '9.999'
@ 14,19 GET zmuzzle PICTURE '!!'
@ 14,66 GET zmzl:flar PICTURE '9.99'
@ 15,23 GET zmzl:thik PICTURE '99.99'
@ 16,22 GET zchs:thik PICTURE '99.99'
@ 16,57 GET zvnt:thik PICTURE '99.99'
@ 17,27 GET zcascabel PICTURE '!!'
@ 17,55 GET zbutton PICTURE '!!'
@ 18,27 GET zbr:prep PICTURE '99.99'
@ 18,66 GET zcog PICTURE '9.999'
@ 19,20 GET zfounder PICTURE '!!!!!!!!!!!!!!!!!!!!'
@ 21,15 GET zcomments PICTURE '!!!!!!!!!!!!!!!!!!!!;
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!;
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!;
```

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!'
READ
CLEAR GETS
@ 24,0
* calculate vertical ratio of trunnions
   IF ztrunn:v <> 0.0 .AND. zdia:at:tr <> 0.0
      STORE  ztrunn:v/zdia:at:tr to zver:ratio
   ENDIF
* calculate horizontal ratio of trunnions
   IF ztrunn:h <> 0.0 .AND. zbar:len <> 0.0
      STORE ztrunn:h/zbar:len to zhor:ratio
   ENDIF
* calculate weight of iron shot
   IF zbore:dia <> 0.0 .AND. zrifled <> 'Y'
*     allow for windage at 1/4 inch before 1650
      IF zyear < '1650'
         STORE zbore:dia - 0.25 to zshot:dia
*     allow for windage at ratio of 20:21 between 1650 and 1756
      ELSE
         IF zyear >= '1650' .AND. zyear < '1756'
            STORE (zbore:dia/21)*20 to zshot:dia
*     windage after Muller (1756) at ratio of 24:25 with bore dia
*     from Hogg, O.F.G., 'Artillery...', page 60
         ELSE
            STORE (zbore:dia/25)*24 to zshot:dia
```

```
         ENDIF
      ENDIF
*     volume of a sphere
      STORE (3.1416*((zshot:dia*zshot:dia)*zshot:dia))/6 to zvolume
*     weight of iron ball at 4 oz per cubic inch of iron
      STORE zvolume*4.167 to zweight
      STORE zweight/16 to zfe:st:wt
   ENDIF
*  calculate calibre as number of bore diameters to bore length
   IF zbore:dia <> 0.00 .AND. zbore:len <> 0.00
      STORE zbore:len/zbore:dia to zcalibre
   ENDIF
STORE ' ' to choice
STORE T to badans
SET COLON ON
DO WHILE badans
@ 24,10 SAY '(S)ave, (R)eenter, (A)bort  ' GET choice PICTURE '!'
READ
IF choice$"SRA"
   STORE F to badans
   @ 24,0
   SET COLON OFF
ENDIF
ENDDO
DO CASE
```

```
   CASE choice='R'
      LOOP
   CASE choice='S'
REPLACE form:no WITH zform:no, cannon:no WITH zcannon:no, location ;
WITH zlocation, gun:type WITH zgun:type, nation WITH znation ;
metal:type WITH zmtl:type, year WITH zyear, oa:length WITH zoa:length
REPLACE bar:length WITH zbar:len, bore:len WITH zbore:len, bore:dia ;
WITH zbore:dia, calibre WITH zcalibre, rifled WITH zrifled ;
gun:weight WITH zgun:wt, fe:shot:wt WITH zfe:st:wt, trunnion:h WITH ;
ztrunn:h
REPLACE hor:ratio WITH zhor:ratio, trunnion:v WITH ztrunn:v ;
dia:at:tru WITH zdia:at:tr, vert:ratio WITH zver:ratio, muzzle WITH ;
zmuzzle, cascabel WITH zcascabel, button WITH zbutton, founder WITH ;
zfounder
REPLACE muzle:flar WITH zmzl:flar, muzle:thik WITH zmzl:thik ;
chase:thik WITH zchs:thik, vent:thik WITH zvnt:thik, comments WITH ;
zcomments, br:prepond WITH zbr:prep, cog WITH zcog
      STORE F to add:data
   CASE choice = 'A'
      STORE F to add:data
ENDCASE
ENDDO
ERASE
@ 2,0 SAY dashes
  STORE 3 to count
```

```
   DO WHILE count < 20
      @ count,0 SAY '¦¦'
      @ count,78 SAY '¦¦'
      STORE count + 1 to count
   ENDDO
@ 20,0 SAY dashes
RELEASE choice, count, add:data, badans
RELEASE ALL LIKE z*
RETURN
* EOF C-MODIFY.PRG
```

```
* C-ADD.PRG
* Called from C-CHMENU.PRG
* Author:  Steven D. Hoyt
* Date created:  10/12/85
* Last modified:  12/21/85
*
ERASE
* define variables here
DO C-DEFINE
* print border
@ 2,0 SAY dashes
  STORE 3 to count
  DO WHILE count < 20
     @ count,0 SAY '¦¦'
     @ count,78 SAY '¦¦'
     STORE count+1 to count
  ENDDO
@ 20,0 SAY dashes
STORE T to add:data
* data entry loop
DO WHILE add:data
CLEAR GETS
* set up blank form
@ 1,4 SAY "Form Number:  "
@ 1,18 GET zform:no PICTURE '999999'
```

```
READ
IF zform:no = 0
   STORE F to add:data
   LOOP
ELSE
   LOCATE ALL for form:no = zform:no
     IF .NOT. EOF
        ERASE
        @ 12,20 SAY "Form Number "
        @ 12,$+1 SAY STR(zform:no,6)
        @ 12,$+1 SAY " already exists!"
        ? CHR (7)
        ? CHR (7)
        STORE 0 to count
        DO WHILE count <50
           STORE count + 1 to count
        ENDDO
        STORE F to add:data
        LOOP
     ELSE
        GOTO TOP
     ENDIF
ENDIF
@ 1,40 SAY "Cannon Number:  "
@ 1,56 GET zcannon:no PICTURE '!!!!!!!!!!'
```

```
@ 3,4 SAY "Location:  "
@ 3,15 GET zlocation PICTURE:
   '!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!'
@ 4,4 SAY "Gun Type:  "
@ 4,15 GET zgun:type PICTURE '!!!!!!!!!!!!!!!!!!!!'
@ 4,40 SAY "Nation:  "
@ 4,49 GET znation PICTURE '!!!!!!!!!!'
@ 5,4 SAY "Metal Type:  "
@ 5,17 GET zmtl:type PICTURE '!!!!!!!!!!!!'
@ 5,40 SAY "Year Manufactured:  "
@ 5,60 GET zyear PICTURE '!!!!!!!'
@ 6,4 SAY "Overall Length:  "
@ 6,21 GET zoa:length PICTURE '999.99'
@ 6,40 SAY "Length of Gun:  "
@ 6,56 GET zbar:len PICTURE '999.99'
@ 7,4 SAY "Bore Length:  "
@ 7,18 GET zbore:len PICTURE '999.99'
@ 7,40 SAY "Bore Diameter:  "
@ 7,56 GET zbore:dia PICTURE '99.99'
@ 8,4 SAY "Calibre:  "
@ 8,14 GET zcalibre PICTURE '99'
@ 8,40 SAY "Rifled:  "
@ 8,49 GET zrifled PICTURE 'l'
@ 9,4 SAY "Gun Weight:  "
@ 9,17 GET zgun:wt PICTURE '9999.99'
```

```
@ 9,40 SAY "Weight of Iron Shot:  "
@ 9,62 GET zfe:st:wt PICTURE '999.9'
@ 10,4 SAY "Diameter of gun at trunnion axis:  "
@ 10,40 GET zdia:at:tr PICTURE '99.99'
@ 11,4 SAY "Trunnion Position -"
@ 12,10 SAY "Horizontal:  "
@ 12,23 GET ztrunn:h PICTURE '999.99'
@ 12,40 SAY "Horizonal Ratio:  "
@ 12,58 GET zhor:ratio PICTURE '9.999'
@ 13,10 SAY "Vertical:  "
@ 13,21 GET ztrunn:v PICTURE '99.99'
@ 13,40 SAY "Vertical Ratio:  "
@ 13,56 GET zver:ratio PICTURE '9.999'
@ 14,4 SAY "Muzzle Shape:  "
@ 14,19 GET zmuzzle PICTURE '!!'
@ 14,40 SAY "Muzzle Flare Rate:"
@ 14,66 GET zmzl:flar PICTURE '9.99'
@ 15,4 SAY "Muzzle Thickness:"
@ 15,23 GET zmzl:thik PICTURE '99.99'
@ 16,4 SAY "Chase Thickness:"
@ 16,22 GET zchs:thik PICTURE '99.99'
@ 16,40 SAY "Vent Thickness:"
@ 16,57 GET zvnt:thik PICTURE '99.99'
@ 17,4 SAY "Base of Breech Shape:  "
@ 17,27 GET zcascabel PICTURE '!!'
```

```
@ 17,40 SAY "Button Shape:  "
@ 17,55 GET zbutton PICTURE '!!'
@ 18,4 SAY "Breech Preponderance:        "
@ 18,27 GET zbr:prep PICTURE '999.99'
@ 18,40 SAY "Center of Gravity Ratio:  "
@ 18,66 GET zcog PICTURE '9.999'
@ 19,4 SAY "Founders Mark:  "
@ 19,20 GET zfounder PICTURE '!!!!!!!!!!!!!!!!!!!!'
@ 21, 4 SAY "Comments:  "
@ 21,15 GET zcomments PICTURE '!!!!!!!!!!!!!!!!!!!!;
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!;
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!;
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!'
READ
CLEAR GETS
@ 24,0
* calculate vertical ratio of trunnions
   IF zver:ratio = 0.000 .AND. ztrunn:v <> 0.0 .AND. zdia:at:tr <> 0.0
      STORE  ztrunn:v/zdia:at:tr to zver:ratio
   ENDIF
* calculate horizontal ratio of trunnions
   IF zhor:ratio = 0.000 .AND. ztrunn:h <> 0.0 .AND. zbar:len <> 0.0
      STORE ztrunn:h/zbar:len to zhor:ratio
   ENDIF
* calculate weight of iron shot
```

```
   IF zfe:st:wt = 0.0 .AND. zrifled <> 'Y' .AND. zbore:dia <> 0.0
*     allow for windage at 1/4 inch before 1650
      IF zyear < '1650'
         STORE zbore:dia - 0.25 to zshot:dia
*     allow for windage at ratio of 20:21 between 1650 and 1756
      ELSE
         IF zyear >= '1650' .AND. zyear < '1756'
            STORE (zbore:dia/21)*20 to zshot:dia
*     windage after Muller (1756) at ratio of 24:25 with bore dia
*     from Hogg, O.F.G., 'Artillery...', page 60
         ELSE
            STORE (zbore:dia/25)*24 to zshot:dia
         ENDIF
      ENDIF
*     volume of a sphere
      STORE (3.1416*((zshot:dia*zshot:dia)*zshot:dia))/6 to zvolume
*     weight of iron ball at 4.167 oz per cubic inch of iron
      STORE zvolume*4.167 to zweight
      STORE zweight/16 to zfe:st:wt
   ENDIF
*  calculate calibre as number of bore diameters to bore length
   IF zbore:dia <> 0.00 .AND. zbore:len <> 0.00 .AND. zcalibre = 0
      STORE zbore:len/zbore:dia to zcalibre
   ENDIF
STORE ' ' to choice
```

```
STORE T to badans
SET COLON ON
DO WHILE badans
@ 24,10 SAY 'IS EVERYTHING CORRECT? (Y/N)  ' GET choice PICTURE '!'
READ
IF choice$"YN"
   STORE F to badans
   @ 24,0
   SET COLON OFF
ENDIF
ENDDO
IF choice='N'
   LOOP
ENDIF
APPEND BLANK
REPLACE form:no WITH zform:no, cannon:no WITH zcannon:no, location ;
WITH zlocation, gun:type WITH zgun:type, nation WITH znation ;
metal:type WITH zmtl:type, year WITH zyear, oa:length WITH zoa:length
REPLACE bar:length WITH zbar:len, bore:len WITH zbore:len, bore:dia ;
WITH zbore:dia, calibre WITH zcalibre, rifled WITH zrifled;
gun:weight WITH zgun:wt, fe:shot:wt WITH zfe:st:wt, trunnion:h WITH ;
ztrunn:h
REPLACE hor:ratio WITH zhor:ratio, trunnion:v WITH ztrunn:v ;
dia:at:tru WITH zdia:at:tr, vert:ratio WITH zver:ratio, muzzle WITH ;
zmuzzle, cascabel WITH zcascabel, button WITH zbutton, founder WITH ;
```

```
zfounder
REPLACE muzle:flar WITH zmzl:flar, muzle:thik WITH zmzl:thik ;
chase:thik WITH zchs:thik, vent:thik WITH zvnt:thik, comments WITH ;
zcomments, br:prepond WITH zbr:prep, cog WITH zcog
*
DO C-DEFINE
STORE ' ' to choice
STORE T to badans
SET COLON ON
@ 24,0 SAY CHR(7)
DO WHILE badans
@ 24,20 SAY 'ADD ANOTHER RECORD? (Y/N)  ' GET choice PICTURE '!'
READ
IF choice$'YN'
   STORE F to badans
   SET COLON OFF
ENDIF
ENDDO
IF choice = 'Y'
   RELEASE ALL LIKE z*
   DO C-DEFINE
   LOOP
ENDIF
STORE F to add:data
ENDDO
```

```
RELEASE choice, count, add:data, badans

RELEASE ALL LIKE z*

RETURN

* EOF C-ADD.PRG
```

```
* C-REPORT.PRG
* Called from C-RPTMEN.PRG
* Author:  Steven D. Hoyt
* Date Created.: 11/01/85
* Last Modified:  12/15/85
*
SET MARGIN TO 0
SET COLON ON
SET CONFIRM ON
SET EJECT OFF
STORE '============================================================;
====================' to zequals
STORE 1 TO zpagenum
STORE 254 TO zline
STORE "CANNON FILE - ABBREVIATED ENTRY REPORT" TO zpagehdg
STORE (80-LEN(zpagehdg))/2 TO zcol:hdg
*
* ---Open the datafile and print the report.
USE CANNONS
ERASE
@ 2, 0 SAY zpagehdg
@ 2,72 SAY DATE()
@ 3, 0 SAY dashes
STORE " " TO zselect
```

```
@ 5,0 SAY "Output to the screen or printer? [S/P] ";
      GET zselect PICTURE "!"
READ
DO CASE
   CASE zselect = "S"
      ERASE
      STORE 20 TO zpagelen
   CASE zselect = "P"
      SET MARGIN TO 16
      SET FORMAT TO PRINT
      STORE 56 TO zpagelen
   OTHERWISE
      ERASE
      RETURN
ENDCASE
DO WHILE .NOT. EOF
   IF zline > zpagelen
      IF zselect = "S"
         IF zpagenum > 1
            @ 22,0 SAY "Hit any key to continue!"
            SET CONSOLE OFF
            WAIT
            SET CONSOLE ON
         ENDIF
         ERASE
```

```
ELSE
   IF zpagenum > 1
      EJECT
   ENDIF
ENDIF
@ 0,0 SAY " "
@ 1,5 SAY DATE()
@ 1,62 SAY "PAGE NO."
@ 1,70 SAY STR(zpagenum,3)
@ 2,zcol:hdg SAY zpagehdg
@ 3,0 SAY zequals
*
* ---Generate column headings.
@ 5,  0 SAY "FORM #"
@ 5,  8 SAY "CANNON #"
@ 5, 20 SAY "YEAR"
@ 5, 29 SAY "NATIONALITY"
@ 5, 42 SAY "H. RA"
@ 5, 49 SAY "V. RA"
@ 5, 56 SAY "FOUNDER"
@ 6,  0 SAY "------"
@ 6,  8 SAY "----------"
@ 6, 20 SAY "-------"
@ 6, 29 SAY "----------"
@ 6, 42 SAY "-----"
@ 6, 49 SAY "-----"
```

```
      @ 6, 56 SAY "--------------------"
      STORE  zpagenum+1 TO zpagenum
      STORE 8 TO zline
   ENDIF
   *
   * ---Print field entries
   @ zline,  0 SAY $(STR(FORM:NO, 6, 0),1,  6)
   @ zline,  8 SAY $(CANNON:NO,1, 10)
   @ zline, 20 SAY $(YEAR,1,  7)
   @ zline, 29 SAY $(NATION,1, 10)
   @ zline, 42 SAY $(STR(HOR:RATIO,  5, 3),1,  5)
   @ zline, 49 SAY $(STR(VERT:RATIO,  5, 3),1,  5)
   @ zline, 56 SAY $(FOUNDER,1, 20)
   STORE zline+1 TO zline
   SKIP
ENDDO
IF zselect = "S"
   @ zline+1,0 SAY "End of File - Hit any key to continue!"
   SET CONSOLE OFF
   WAIT
   SET CONSOLE ON
ELSE
   EJECT
ENDIF
SET FORMAT TO SCREEN
```

```
RELEASE ALL LIKE z*

RETURN

* EOF: C-REPORT.PRG
```

```
* C-RPTMEN.PRG
* Called from CANNONS.PRG
* Author: Steven D. Hoyt
* Date created: 10/31/85
* Last modified: 12/12/85
*
SET COLON OFF

DO WHILE T

ERASE
@  1, 0 SAY dashes
@  2, 0 SAY "¦¦"
@  2,13 SAY "C A N N O N    F I L E    -    R E P O R T    M E N U"
@  2,78 SAY "¦¦"
@  3, 0 SAY dashes
STORE 4 to count
DO WHILE count <10
   @ count,0 SAY "¦¦"
   @ count,78 SAY "¦¦"
   STORE count + 1 to count
   LOOP
ENDDO
@ 10, 0 SAY dashes
```

```
@  5,30 SAY " 0. exit"
@  6,30 SAY " 1. columnar output"
@  7,30 SAY " 2. label output"
STORE  3 TO selectnum
DO WHILE selectnum < 0 .OR. selectnum >  2
   STORE " " TO select
   @ 10,33 SAY " select : : "
   @ 10,42 GET select PICTURE "#"
   READ
   STORE VAL(select) TO selectnum
ENDDO

DO CASE
   CASE selectnum= 0
      RETURN
   CASE selectnum= 1
      DO C-REPORT
   CASE selectnum= 2
      DO C-LABEL
ENDCASE

ENDDO T
* EOF C-RPTMEN.PRG
```

```
* C-LABEL.PRG
* Called from C-RPTMEN.PRG
* Author:  Steven D. Hoyt
* Date Created:  11/01/85
* Last Modified:  12/21/85
*
SET CONFIRM ON
SET COLON ON
SET MARGIN TO 5
SET EJECT OFF
STORE 0 to zflag
STORE 1 TO zpagenum
STORE 0 to zform:no
STORE "CANNON FILE - COMPLETE RECORD" TO zpagehdg
STORE (80-LEN(zpagehdg))/2 TO zcol:hdg
*
* ---Open the datafile and print the report.
USE CANNONS
ERASE
@ 2, 0 SAY zpagehdg
@ 2,72 SAY DATE()
@ 3, 0 SAY dashes
STORE " " TO zselect
@ 5,5 SAY "Print a (S)ingle record or (C)omplete file? [S/C]   "
STORE T TO zbadans
```

```
DO WHILE zbadans
   @ 5,$ GET zselect PICTURE '!'
   READ
   IF zselect$'SC '
      STORE F TO zbadans
   ENDIF
ENDDO
DO CASE
   CASE zselect = "S"
      @ 8,5 SAY "Form Number of record to print?  ";
          GET zform:no PICTURE '999999'
      READ
      IF zform:no=0
         ERASE
         RELEASE ALL LIKE z*
         RETURN
      ENDIF
      LOCATE ALL FOR form:no=zform:no
      IF EOF
         ERASE
         ? CHR(7)
         ? CHR(7)
         @ 12,10 SAY "No entry located for Form Number "
         @ 12,43 SAY zform:no
         @ 23,20 SAY "Press any key to continue..."
```

```
   SET CONSOLE OFF
   WAIT
   SET CONSOLE ON
   RELEASE ALL LIKE z*
   ERASE
   RETURN
ENDIF
SET FORMAT TO C-FMT2
READ
SET FORMAT TO
STORE ' ' to zselect
STORE T to zbadans
@ 24,30 SAY '(P)rint or (A)bort?  '
DO WHILE zbadans
   @ 24,51 GET zselect PICTURE '!'
   READ
   IF zselect$'PA'
      STORE F to zbadans
   ENDIF
ENDDO
IF zselect = 'A'
   RELEASE ALL LIKE z*
   ERASE
   RETURN
ENDIF
```

```
      STORE 1 to zflag
      SET FORMAT TO PRINT
*
   CASE zselect = "C"
      SET FORMAT TO PRINT
*
   CASE zselect = ' '
      RELEASE ALL LIKE z*
      ERASE
      RETURN
ENDCASE
STORE '==========================================================;
==============' to zequals
STORE '----------------------------------------------------------;
--------------' to zdashes
DO WHILE .NOT. EOF
   @ 5,5 SAY DATE()
   @ 5,60 SAY "PAGE NO."
   @ 5,69 SAY STR(zpagenum,3)
   @ 6,zcol:hdg SAY zpagehdg
   @ 7,0 SAY zequals
*
@ 9,0 SAY "Form Number:  "
@ 9,14 SAY form:no
@ 9,40 SAY "Cannon Number:  "
```

```
@ 9,56 SAY cannon:no
@ 10,0 SAY  zdashes
@ 12,0 SAY "Location:  "
@ 12,11 SAY location
@ 14,0 SAY "Gun Type:  "
@ 14,11 SAY gun:type
@ 14,40 SAY "Nation:  "
@ 14,49 SAY nation
@ 16,0 SAY "Metal Type:  "
@ 16,13 SAY metal:type
@ 16,40 SAY "Year Manufactured:  "
@ 16,61 SAY year
@ 18,0 SAY "Overall Length:  "
@ 18,17 SAY oa:length
@ 18,40 SAY "Length of Gun:  "
@ 18,56 SAY bar:length
@ 20,0 SAY "Bore Length:  "
@ 20,14 SAY bore:len
@ 20,40 SAY "Bore Diameter:  "
@ 20, 56 SAY bore:dia
@ 22,0 SAY "Calibre:  "
@ 22,10 SAY calibre
@ 22,40 SAY "Rifled:  "
@ 22,49 SAY rifled
@ 24,0 SAY "Gun Weight:  "
```

```
@ 24,13 SAY gun:weight
@ 24,40 SAY "Weight of Iron Shot:  "
@ 24,62 SAY fe:shot:wt
@ 26,0 SAY "Diameter at axis of trunnions:  "
@ 26,32 SAY dia:at:tru
@ 28,0 SAY "Trunnion Position - "
@ 30,10 SAY "Horizontal:  "
@ 30,23 SAY trunnion:h
@ 30,40 SAY "Horizontal Ratio:  "
@ 30,59 SAY hor:ratio
@ 32,10 SAY "Vertical:  "
@ 32,21 SAY trunnion:v
@ 32,40 SAY "Vertical Ratio:  "
@ 32,57 SAY vert:ratio
@ 34,0 SAY "Muzzle Shape:  "
@ 34,15 SAY muzzle
@ 34,40 SAY "Muzzle Flare Rate:"
@ 34,66 SAY muzle:flar
@ 36,0 SAY "Muzzle Thickness:"
@ 36,19 SAY muzle:thik
@ 38,0 SAY "Chase Thickness:"
@ 38,18 SAY chase:thik
@ 38,40 SAY "Vent Thickness:"
@ 38,57 SAY vent:thik
@ 40,0 SAY "Base of Breech Shape:  "
```

```
@ 40,23 SAY cascabel
@ 40,40 SAY "Button Shape:  "
@ 40,55 SAY button
@ 42,0 SAY "Breech Preponderance:"
@ 42,23 SAY br:prepond
@ 42,29 SAY "%"
@ 42,40 SAY "Center of Gravity Ratio:  "
@ 42,66 SAY cog
@ 44,0 SAY "Founders Mark:  "
@ 44,16 SAY founder
@ 40,42 SAY "Other Marks Present (Yes/No):  "
@ 40,73 SAY marks:pres
@ 42,0 SAY "Color Photo:  "
@ 42,14 SAY colr:photo
@ 42,30 SAY "B/W Photo:  "
@ 42,42 SAY bw:photo
@ 42,56 SAY "Scale Drawing:  "
@ 42,72 SAY scale:dwg
@ 44,0 SAY "Comments:  "
@ 44,11 SAY comments
STORE zpagenum+1 to zpagenum
EJECT
IF ZFLAG = 1
   SET FORMAT TO SCREEN
   RELEASE ALL LIKE z*
```

```
   ERASE
   RETURN
ENDIF
SKIP
ENDDO
SET FORMAT TO SCREEN
RELEASE ALL LIKE z*
ERASE
RETURN
* EOF: C-LABEL.PRG
```

```
* C-APPEND.PRG
* Called from CANNONS.PRG
* Author:  Steven D. Hoyt
* Date created:  9/29/85
* Last modification:  12/12/85
*
ERASE
SET CONFIRM ON
SET BELL OFF
SET TALK OFF
SET ECHO OFF
SET COLON OFF
GOTO BOTTOM
STORE # + 1 to recnum
* invoke format file
SET FORMAT TO C-FORMAT
*
APPEND
* release format file
SET FORMAT TO
* check for new entries made
     GOTO BOTTOM
     IF # < recnum
```

```
      RETURN
      ENDIF
* update new records
      GOTO recnum
      DO WHILE .NOT. EOF
*     calculate vertical ratio of trunnions
   IF vert:ratio = 0.000 .AND. trunnion:v <> 0.0 .AND. dia:at:tru <> 0.0
            REPLACE vert:ratio WITH trunnion:v/dia:at:tru
         ENDIF
*     calculate horizontal ratio of trunnions
   IF hor:ratio  = 0.000 .AND. trunnion:h <> 0.0 .AND. bar:length <> 0.0
            REPLACE hor:ratio WITH trunnion:h/bar:length
         ENDIF
*     calculate weight of iron shot
         IF fe:shot:wt = 0.0 .AND. rifled <> "Y"
*           allow for windage at 1/4 inch before 1650
               IF year < "1650"
                  STORE bore:dia - 0.25 to shot:dia
*           allow for windage at ratio of 20:21 between 1650 and 1756
               ELSE
                  IF year >="1650" .AND. year < "1756"
                     STORE (bore:dia/21) * 20 to shot:dia
*           windage after Muller (1768) at ratio of 24:25 with bore dia.
*           from HOGG, O.F.G., 'ARTILLERY...', PAGE 60
                  ELSE
```

```
                    STORE (bore:dia / 25) * 24 TO shot:dia
                ENDIF
            ENDIF
*           volume of a sphere
        STORE (3.1416 * ((shot:dia * shot:dia) * shot:dia))/6 TO volume
*           weight of ball at 4.167 oz per cubic inch of iron
            STORE volume * 4.167 to weight
                REPLACE fe:shot:wt WITH weight / 16
        ENDIF
*   calculate calibre as number of bore diameters to bore length
        IF bore:dia <> 0.00 .AND. bore:len <> 0.00
            REPLACE calibre WITH bore:len / bore:dia
        ENDIF
*
    SKIP
    ENDDO
*
RELEASE recnum, shot:dia, volume, weight
SET COLON OFF
RETURN
* EOF C-APPEND.PRG
```

```
* C-CHANGE.PRG
* Called from C-CHMENU.PRG
* Author:  Steven D. Hoyt
* Date created:  10/29/85
* Last modified:  12/21/85
*
ERASE
SET CONFIRM ON
SET ECHO OFF
SET BELL OFF
SET TALK OFF
SET INDEX TO
GOTO TOP
*print form
@ 2,0 SAY dashes
   STORE 3 to count
   DO WHILE count < 20
      @ count,0 SAY '¦¦'
      @ count,78 SAY '¦¦'
      STORE count + 1 to count
   ENDDO
@ 20,0 SAY dashes
*
STORE T to search
*
```

```
DO WHILE search
*
STORE 0 to sform:no
CLEAR GETS
SET COLON ON
@ 12,15 SAY 'Enter form number of record to be changed  ';
GET sform:no PICTURE '999999'
READ
SET COLON OFF
* check for entry made
IF sform:no = 0
   STORE F to search
   LOOP
ENDIF
*  search
   LOCATE ALL FOR form:no = sform:no
*  check for entry located
   IF EOF
      @ 12,0 SAY border
      @ 12,15 SAY 'No record with form number '
      @ 12,$+1 SAY STR(sform:no,6)
      @ 12,$+1 SAY ' located!'
      @ 21,0 SAY ' '
      ? CHR(7)
      ? CHR(7)
```

```
      STORE 0 to count
      DO WHILE count < 50
         STORE count + 1 to count
         LOOP
      ENDDO
      @ 12,0 SAY border
      GOTO TOP
      LOOP
   ELSE
      @ 12,0 SAY border
      GOTO #
* display data from chosen record
STORE T to badans
   IF *
      @ 0,65 SAY "  DELETED  "
   ELSE
      @ 0,65 SAY "           "
   ENDIF
*
*fill form with information from first record
@ 1,4 SAY "Form Number:  "
@ 1,18 SAY form:no
@ 1,40 SAY "Cannon Number:  "
@ 1,56 SAY cannon:no
@ 3,4 SAY "Location:  "
```

```
@ 3,15 SAY location
@ 4,4 SAY "Gun Type:  "
@ 4,15 SAY gun:type
@ 4,40 SAY "Nation:  "
@ 4,49 SAY nation
@ 5,4 SAY "Metal Type:  "
@ 5,17 SAY metal:type
@ 5,40 SAY "Year Manufactured:  "
@ 5,61 SAY year
@ 6,4 SAY "Overall Length:  "
@ 6,21 SAY oa:length
@ 6,40 SAY "Length of Gun:  "
@ 6,56 SAY bar:length
@ 7,4 SAY "Bore Length:  "
@ 7,18 SAY bore:len
@ 7,40 SAY "Bore Diameter:  "
@ 7, 56 SAY bore:dia
@ 8,4 SAY "Calibre:  "
@ 8,14 SAY calibre
@ 8,40 SAY "Rifled:  "
@ 8,49 SAY rifled
@ 9,4 SAY "Gun Weight:  "
@ 9,17 SAY gun:weight
@ 9,40 SAY "Weight of Iron Shot:  "
@ 9,62 SAY fe:shot:wt
```

```
@ 10,4 SAY "Diameter of gun at trunnion axis:  "
@ 10,40 SAY dia:at:tru
@ 11,4 SAY "Trunnion Position -"
@ 12,10 SAY "Horizontal:  "
@ 12,23 SAY trunnion:h
@ 12,40 SAY "Horizontal Ratio:  "
@ 12,59 SAY hor:ratio
@ 13,10 SAY "Vertical:  "
@ 13,21 SAY trunnion:v
@ 13,40 SAY "Vertical Ratio:  "
@ 13,56 SAY vert:ratio
@ 14,4 SAY "Muzzle Shape:  "
@ 14,19 SAY muzzle
@ 14,40 SAY "Muzzle Flare Rate:"
@ 14,66 SAY muzle:flar
@ 15,4 SAY "Muzzle Thickness:"
@ 15,23 SAY muzle:thik
@ 16,4 SAY "Chase Thickness:"
@ 16,22 SAY chase:thik
@ 16,40 SAY "Vent Thickness:"
@ 16,57 SAY vent:thik
@ 17,4 SAY "Base of Breech Shape:  "
@ 17,27 SAY cascabel
@ 17,40 SAY "Button Shape:  "
@ 17,55 SAY button
```

```
@ 18,4 SAY "Breech Preponderance:        %"
@ 18,27 SAY br:prepond
@ 18,40 SAY "Center of Gravity Ratio:  "
@ 18,66 SAY cog
@ 19,4 SAY "Founders Mark:  "
@ 19,20 SAY founder
@ 21,4 SAY "Comments:  "
@ 21,15 SAY comments
@ 24,0
*
STORE " " to choice
@ 24,20 SAY '(C)hange, (D)elete or (U)ndelete record  '
STORE T to badans
DO WHILE badans
   SET COLON ON
   @ 24, $ GET choice PICTURE "!"
   READ
   IF choice$"CDU "
      STORE F to badans
      SET COLON OFF
   ENDIF
ENDDO
@ 24,0
DO CASE
   CASE choice="C"
```

```
   DO c-modify
CASE choice="D" .OR. choice="U"
   IF choice="D"
        DELETE
        @ 0,65 SAY '  DELETED  '
     ELSE
        RECALL
        @ 0,65 SAY '           '
   ENDIF
   STORE 0 to count
   DO WHILE count < 50
      STORE count+1 to count
   ENDDO
   ERASE
   @ 2,0 SAY dashes
     STORE 3 to count
     DO WHILE count < 20
        @ count,0 SAY '¦¦'
        @ count,78 SAY '¦¦'
        STORE count+1 to count
     ENDDO
  @ 20,0 SAY dashes
CASE choice=" "
   STORE F to search
   LOOP
```

```
ENDCASE

ENDIF

ENDDO

RELEASE choice, badans, sform:no, search, count

RETURN

* EOF C-CHANGE.PRG
```

```
* C-MAINT.PRG
* Called from CANNONS.PRG
* Author:  Steven D. Hoyt
* Date created:  12/12/85
* Last modified:  12/12/85
*
ERASE
SET CONFIRM ON
SET COLON ON
STORE "FILE MAINTENANCE UTILITY" to zpagehd
STORE (80-LEN(zpagehd))/2 to zcolhdg
@ 2,zcolhdg SAY zpagehd
@ 2,72 SAY date()
@ 3,0 SAY dashes
@ 4,0 SAY " "
TEXT
     This program PERMANENTLY removes all records currently marked for
     deletion. Type 'Y' to continue with the deletion or any other key
     to abort.
ENDTEXT
STORE "N" to zrespons
@ 15,35 SAY "CONTINUE?  "
@ 15,46 GET zrespons PICTURE '!'
READ
IF zrespons = "Y"
   @ 16,0 SAY " "
```

```
   SET TALK ON
   PACK
   SET TALK OFF
   @ 20,0 SAY "Hit any key to return to main menu."
   SET CONSOL OFF
   WAIT
   SET CONSOL ON
ENDIF
ERASE
SET COLON OFF
RELEASE ALL LIKE Z*
RETURN
EOF C-MAINT.PRG
```

```
* C-FORMAT.FMT
* Called from C-APPEND.PRG
* Author:  Steven D. Hoyt
* Date created:  11/03/85
* Last modified:  12/21/85

* fill form with information from first record
@ 1,4 SAY "Form Number:  "
@ 1,18 GET form:no PICTURE '999999'
@ 1,40 SAY "Cannon Number:  "
@ 1,56 GET cannon:no  PICTURE '!!!!!!!!!!'
@ 3,4 SAY "Location:  "
@ 3,15 GET location  PICTURE '!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!;
!!!!!!!!!!!!!!!!!!!!'
@ 4,4 SAY "Gun Type:  "
@ 4,15 GET gun:type PICTURE '!!!!!!!!!!!!!!!!!!!!'
@ 4,40 SAY "Nation:  "
@ 4,49 GET nation PICTURE '!!!!!!!!!!'
@ 5,4 SAY "Metal Type:  "
@ 5,17 GET metal:type PICTURE '!!!!!!!!!!!!'
@ 5,40 SAY "Year Manufactured:  "
@ 5,61 GET year PICTURE '!!!!!!!'
@ 6,4 SAY "Overall Length:  "
@ 6,21 GET oa:length PICTURE '999.99'
@ 6,40 SAY "Length of Gun:  "
```

```
@ 6,56 GET bar:length PICTURE '999.99'
@ 7,4 SAY "Bore Length:  "
@ 7,18 GET bore:len PICTURE '999.99'
@ 7,40 SAY "Bore Diameter:  "
@ 7, 56 GET bore:dia PICTURE '99.99'
@ 8,4 SAY "Calibre:  "
@ 8,14 GET calibre PICTURE '99'
@ 8,40 SAY "Rifled:  "
@ 8,49 GET rifled PICTURE 'l'
@ 9,4 SAY "Gun Weight:  "
@ 9,17 GET gun:weight PICTURE '9999.99'
@ 9,40 SAY "Weight of Iron Shot:  "
@ 9,62 GET fe:shot:wt PICTURE '999.9'
@ 10,4 SAY "Diameter of gun at trunnion axis:  "
@ 10,40 GET dia:at:tru PICTURE '99.99'
@ 11,4 SAY "Trunnion Position -"
@ 12,10 SAY "Horizontal:  "
@ 12,23 GET trunnion:h PICTURE '999.99'
@ 12,40 SAY "Horizontal Ratio:  "
@ 12,59 GET hor:ratio PICTURE '9.999'
@ 13,10 SAY "Vertical:  "
@ 13,21 GET trunnion:v PICTURE '99.99'
@ 13,40 SAY "Vertical Ratio:  "
@ 13,56 GET vert:ratio PICTURE '9.999'
@ 14,4 SAY "Muzzle Shape:  "
```

```
@ 14,19 GET muzzle PICTURE '!!'
@ 14,40 SAY "Muzzle Flare Rate:"
@ 14,66 GET muzle:flar PICTURE '9.99'
@ 15,4 SAY "Muzzle Thickness:"
@ 15,23 GET muzle:thik PICTURE '99.99'
@ 16,4 SAY "Chase Thickness:"
@ 16,22 GET chase:thik PICTURE '99.99'
@ 16,40 SAY "Vent Thickness:"
@ 16,57 GET chase:thik PICTURE '99.99'
@ 17,4 SAY "Base of Breech Shape:  "
@ 17,27 GET cascabel PICTURE '!!'
@ 17,40 SAY "Button Shape:  "
@ 17,55 GET button PICTURE "!!"
@ 18,4 SAY "Breech Preponderance:        %"
@ 18,27 GET br:prepond PICTURE '99.99'
@ 18,40 SAY "Center of Gravity Ratio:  "
@ 18,66 GET cog PICTURE '9.999'
@ 19,4 SAY "Founders Mark:  "
@ 19,20 GET founder PICTURE '!!!!!!!!!!!!!!!!!!!!'
@ 21,4 SAY "Comments:  "
@ 21,15 GET comments PICTURE '!!!!!!!!!!!!!!!!!!!!;
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!;
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!;
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!'
* EOF C-FORMAT.FMT
```

```
* C-FMT2.FMT
* Called from C-LABEL.PRG
* AUTHOR:  Steven D. Hoyt
* Date created:  11/03/85
* Last modified:  12/21/85
*
@ 1,4 SAY "Form Number:  "
@ 1,18 SAY form:no
@ 1,40 SAY "Cannon Number:  "
@ 1,56 SAY cannon:no
@ 3,4 SAY "Location:  "
@ 3,15 SAY location
@ 4,4 SAY "Gun Type:  "
@ 4,15 SAY gun:type
@ 4,40 SAY "Nation:  "
@ 4,49 SAY nation
@ 5,4 SAY "Metal Type:  "
@ 5,17 SAY metal:type
@ 5,40 SAY "Year Manufactured:  "
@ 5,61 SAY year
@ 6,4 SAY "Overall Length:  "
@ 6,21 SAY oa:length
@ 6,40 SAY "Length of Gun:  "
@ 6,56 SAY bar:length
@ 7,4 SAY "Bore Length:  "
```

```
@ 7,18 SAY bore:len
@ 7,40 SAY "Bore Diameter:  "
@ 7, 56 SAY bore:dia
@ 8,4 SAY "Calibre:  "
@ 8,14 SAY calibre
@ 8,40 SAY "Rifled:  "
@ 8,49 SAY rifled
@ 9,4 SAY "Gun Weight:  "
@ 9,17 SAY gun:weight
@ 9,40 SAY "Weight of Iron Shot:  "
@ 9,62 SAY fe:shot:wt
@ 10,4 SAY "Diameter of gun at trunnion axis:  "
@ 10,40 SAY dia:at:tru
@ 11,4 SAY "Trunnion Position -"
@ 12,10 SAY "Horizontal:  "
@ 12,23 SAY trunnion:h
@ 12,40 SAY "Horizontal Ratio:  "
@ 12,59 SAY hor:ratio
@ 13,10 SAY "Vertical:  "
@ 13,21 SAY trunnion:v
@ 13,40 SAY "Vertical Ratio:  "
@ 13,56 SAY vert:ratio
@ 14,4 SAY "Muzzle Shape:  "
@ 14,19 SAY muzzle
@ 14,40 SAY "Muzzle Flare Rate:"
```

```
@ 14,66 SAY muzle:flar
@ 15,4 SAY "Muzzle Thickness:"
@ 15,23 SAY muzle:thik
@ 16,4 SAY "Chase Thickness:"
@ 16,22 SAY chase:thik
@ 16,40 SAY "Vent Thickness:"
@ 16,57 SAY vent:thik
@ 17,4 SAY "Base of Breech Shape:  "
@ 17,27 SAY cascabel
@ 17,40 SAY "Button Shape:  "
@ 17,55 SAY button
@ 18,4 SAY "Breech Preponderance:        %"
@ 18,27 SAY br:prepond
@ 18,40 SAY "Center of Gravity Ratio:  "
@ 18,66 SAY cog
@ 19,4 SAY "Founders Mark:  "
@ 19,20 SAY founder
@ 21,4 SAY "Comments:  "
@ 21,15 SAY comments
* EOF C-FMT2.FMT
```

```
* C-HELP.PRG

* Called from CANNONS.PRG

* Author:  Steve Hoyt

* Date created: 12/13/85

* Last modified:  12/27/85

*

ERASE

@ 1,15 SAY "HELP    HELP    HELP    HELP    HELP    HELP    HELP"

@ 2,0 SAY dashes

TEXT


The CANNONS database file program is a menu driven program.  Most
aspects of the program are self explanatory and a little experimenting
generally will answer any questions.  Brief explanations on the
following topics are given in this help file:

                    Adding records to the database
                    Printing reports
                    Searching records for specific information

ENDTEXT

@ 23,0 SAY "Strike any key (except ESC) to continue..."

SET CONSOLE OFF

WAIT

SET CONSOLE ON


ERASE

@ 1,19 SAY "HELP   -   ADDING RECORDS TO THE DATABASE"

@ 2,0 SAY dashes
```

```
TEXT


Records can be added to the database through either of two options
from the main menu.
                    Option 1 activates a program which performs a
special check on the data entered.  Specifically, it will not allow
entry of a Form Number which is already on a record in the file.  If
this is attempted, the program will tell you and return to the menu.
Also, you will be given several opportunities to correct mistakes in
the data entered before the record is added to the database file.
Indeed, you will have to tell the computer when the record is ready to
be added to the file.
                    Option 2 activates a program which is faster than
Option 1 but which does not prevent entering duplicate Form Numbers.
Having duplicate Form Numbers can be a problem when searching for a
particular form.  Also, option 2 gives little opportunity to correct
mistakes.  Once the return key is struck at the end of the COMMENTS
field, that record is immediately added to the file.
     NOTE: to abort either ADD RECORDS option, simply hit return
without entering any data when the flashing cursor is in the Form
Number field.

ENDTEXT

@ 23,0 SAY 'Strike any key (except ESC) to continue...'

SET CONSOLE OFF

WAIT

SET CONSOLE ON


ERASE

@ 1,29 SAY 'HELP   -    PRINTING RECORDS'

@ 2,0 SAY dashes

TEXT


Two print options are available through 'REPORT' on the Main Menu:
Tabular printout and Form printout.  Both print options are set up for
an 80 column printer using letter size paper (66 lines).
```

```
     Tabular printout produces a list of the following fields from the
complete database file:  Form Number, Cannon Number, Year Manufactured,
Nationality, Trunnion Position Horizontal Ratio, Trunnion Position,
Vertical Ratio and Founder.  The output can be printed on the screen
for preview before sending it to the printer.
     Form printout produces output formated just as it is displayed
when being added to the database file.  All thirty-one fields are
printed for each record and one record is printed per page.  You have
the option of printing a single record or automatically printing the
entire database file.

ENDTEXT

@ 23,0 SAY 'Hit any key (except ESC) to continue...'

SET CONSOLE OFF

WAIT

SET CONSOLE ON



ERASE

@ 1,5 SAY 'HELP - SEARCHING FOR SPECIFIC INFORMATION - SCREEN 1'

@ 2,0 SAY dashes

TEXT


Using the FIND option when VIEWing records, the entire file can be
searched for records containing specific entries in any field.  If you
enter F for FIND When given the choice, you will be asked which field
you wish to search.  You will then be asked what information you wish
to search for in that field. Although telling the computer what you
want to look for may appear a little daunting at first, the process is
really quite simple and can be mastered quickly.
     First, enter the 'operator'.  The available operators are: =
(equals), < (less than), > (greater than), <= (less than or equal to),
>= (greater than or equal to), and $ (part of).  If what you want to
search for is exactly the same as what you will enter next as the
'first value' then you will use the '=' operator.  If it is a number
that is less than or greater than what you will enter, use the
appropriate '<' or '>' operator, etc.  If you want to search for an
entry using only part of that entry as the first value, use the $
operator.
```

```
ENDTEXT

@ 23,0 SAY 'Strike any key (except ESC) to continue...'

SET CONSOLE OFF

WAIT

SET CONSOLE ON

ERASE

@ 1,5 SAY 'HELP - SEARCHING FOR SPECIFIC INFORMATION - SCREEN 2'

@ 2,0 SAY dashes

TEXT

Examples:  Field to be searched is Year Manufactured and you are
     looking for any record with the year 1810 in that field.  Enter =
     as the operator and 1810 as the first value.
          Field to be searched is Year Manufactured and you are
     looking for any cannon manufactured on or before 1800.  Enter <=
     as the operator and 1800 as the first value.
          Field to be searched is Location and you are looking for a
     record of a gun located at a Yacht Club but you can't remember the
     name of the club.  Enter $ as the operator and Yacht as the value.

The logical operators AND, OR and NOT simply allow you to further
define the search.
          Field to be searched is Year Manufactured and you are
     looking for records of guns made between 1600 and 1650.  Enter >
     as the first operator, 1600 as the first value, AND as the logical
     operator, < as the second operator, 1650 as the second value.

      EXPERIMENT              EXPERIMENT              EXPERIMENT
ENDTEXT

@ 23,0 SAY 'Hit any key (except ESC) to continue...'

SET CONSOLE OFF

WAIT

SET CONSOLE ON

ERASE

RETURN

* EOF C-HELP.PRG
```

VITA

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EDUCATION

B.A in Anthropology from Colorado State University, May 1979
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PROFESSIONAL EXPERIENCE

Marine Archaeologist/Conservator
Bermuda Maritime Museum, Ireland Island, Bermuda
May 1984 to present

Archaeological Project Director, Pedro Bank Survey, Jamaica
Institute of Nautical Archaeology, College Station, Texas
1981 to 1983

Research Assistant/Staff Member
Texas A&M University/Institute of Nautical Archaeology
November 1982 to May 1984

Chief Archaeological Diver, Freeport Harbor (45 Foot Project)
Institute of Applied Sciences, Denton, Texas
October 1981

Archaeological Field Investigator, Molassas Reef Wreck
Institute of Nautical Archaeology, College Station, Texas
November 1980

Archaeological Field Investigator, Cayman Islands Project
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Summer 1980

Archaeological Diver, Port Royal Project, Jamaica
Texas A&M University/Institute of Nautical Archaeology
Summer 1981 and 1982

Survey Field Crew Supervisor, Red Wash & Moon Lake Projects, Utah
Centuries Research, Montrose, Colorado
Summer 1979

Excavation Supervisor, Torres Cave Expedition, Colorado
Colorado Archaeological Society, Denver, Colorado
Summer 1977