



An Operating Manual

(adapted from the original 1983 edition)

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PART ONE: GETTING STARTED

SMALL, SMALLER, SMALLEST...

Railroad models have been around almost as long as the real thing. And like their full-size counterparts, they have appeared in a variety of gauges over the years: HO is the most popular with modelers, but O, N, and Z are also common. Each has its adherents and particular features: O and HO offer large models and the opportunity for exquisite detail. N and Z models are tiny, but the railroads they run on don't take up much space.

Now comes an astounding new development in ultra-miniaturization — *BINARY GAUGE* — and with it the most radical advance in the hobby since the electric motor was introduced at the turn of the century: computer-based model railroading.

By substituting binary numbers — strings of zeros and ones — for mechanical components, *Binary Gauge* offers some unique and powerful features:

- You don't have to buy engines, cars, track, and switches — everything you need is on the program disk.
- *Binary Gauge* trains never jump the tracks. Derailments are a thing of the past.
- *Binary Gauge* couplers are automatic — and they really work, every time.
- *Binary Gauge* switches are completely remote controlled.
- *Binary Gauge* engines never stall — because the track never gets dirty.



But that's only the beginning. Haven't you always dreamed of operating a really large railroad? When you build your empire in *Binary Gauge* it can go on forever, and your family will never frown at your selfish consumption of valuable living space — nor will they banish you to the garage, the cellar, or the attic.

- You can have hundreds of cars, scores of switches, miles and miles of track.
- You never have to think about wiring.
- You can landscape everything in a few hours: trees, buildings, trestles, mountains — create whatever your heart desires and never get your hands dirty.

NOT QUITE PERFECT

Alas, nothing is perfect. *Binary Gauge* trains are small. Smaller than N, smaller yet than minuscule Z. So small, you can't even touch — since they operate on your TV set or computer monitor. In the binary number system used by Apple and all computers, each digit can have only two values — one or zero, on or off. In *Binary Gauge* there are no fine gradations — either things exist or they don't.

Each railroad display is a picture in Apple low-resolution graphics consisting of a 40 x 40 array of colored blocks.

- Each section of track = 1 block.
- Each car = 1 block.
- The minimum train move = 1block.



- Engines — those marvels of super-detailing — have a front and a rear: each engine = 2 blocks.

Crude, you say? Well, watching a *Binary Gauge* railroad in operation is a little like looking down from an airplane — and from high altitude at that. So if fine scale modeling is important, *Binary Gauge* is not for you. On the other hand, if what you like to do best is operate trains — read on!

BOOT CAMP

The fundamental requirement for *Binary Gauge* is the host computer. Once upon a time this meant boot up your Apple 2, but nowadays it means launch your emulator. (The very capable emulator called *APPLEWIN* is recommended for Windows users.)

- Click on the DRIVE 1 BUTTON and select Binary_Gauge_SYSTEM.dsk.
- Click on the APPLE BUTTON to boot it.
- If you choose <1> from the following menu, you'll be asked to insert a "railroad disk." Once you start building your own railroads, this will mean a disk file swap. But for now, don't worry, the *Binary Gauge* Demonstration Railroad is on the System disk. Just press RETURN.
- When you need to change disk files, remember they all must be loaded into DRIVE 1.



THE DISPATCHER

Once your emulator kicks in, you will see a menu that looks like this:

```
DISPATCHER
TOY TRAINS IN BINARY GAUGE
MAKE A CHOICE:
<1> RUN THE RAILROAD
<2> RUN THE EMPIRE BUILDER
<3> READ RR  COMMANDS
<4> READ BUILDER COMMANDS
<5> READ RR  NOTES
<6> RUN RR  STATUS WRITER
<7> CATALOG
<Q> QUIT
```

The Dispatcher gives you access to the various functional parts of the *Binary Gauge* system. It also provides a quick reference guide to the railroad command keys, the Empire Builder command keys and the operating rules of the road. And if you want to check the files on your disk, there's a handy catalog command.

KNOBS & LEVERS

Eventually you will want to build your own *Binary Gauge* railroad empires, but for now let's try out the ready-to-run demonstration pike included on the disk.



The first step is to familiarize yourself with the railroad command keys. If you press 3, the Dispatcher will show you a new display:

RAILROAD COMMANDS

F FORWARD R REVERSE H HALT

1 2 3 4 5 SPEED CONTROL

← NEXT SWITCH LEFT → NEXT SWITCH RIGHT

SPACE CANCEL SWITCH CHOICE

C COUPLE CARS U UNCOUPLE CARS

X EXCHANGE ENGINES <A> &
(MUST BE HALTED & UNCOUPLED)

! RESET MOVE COUNTER

* QUIT (ENGINE MUST BE UNCOUPLED)

FORWARD, REVERSE, HALT

Most of the commands are straightforward, but some are not entirely obvious. Pressing the **F** key causes the active engine to run in the forward direction. **R** puts it into reverse, and **H** causes an immediate halt. Fine. But how do you tell which end of a *Binary Gauge* engine is which? There are two answers: first, try fooling around with the controls until you figure it out. Not a bad method, especially since there is no danger of your breaking anything as you experiment. The second answer is this: as provided in the demonstration railroad, the two engines are colored as follows:

- Engine <A> is WHITE in front, AQUA in back.
- Engine is DARK BLUE in front, AQUA in back.



F commands <A> to proceed with its white section leading, and to move with its dark blue section showing the way. **R** moves them both in the direction of their aqua sections. (Deeper into this manual, you will learn how to change these colors if you prefer something else.)

1 2 3 4 5

You can speed up or slow down by pressing the number keys **1** through **5**. (Why not 1 through 8, which is how real units work? I don't know what I was thinking way back when I built this thing.)

- When a command is issued that starts an engine or changes its direction, its speed defaults to throttle position **1**.

ARROW & SWITCHES

You can use the left and right arrow keys to steer your trains through the switches wherever tracks branch.

- Press ← to send your train onto the LEFT branch at the next switch it encounters.
- Press → to send your train onto the next RIGHT branch.
- Pressing SPACE cancels switch commands.
- After the train encounters a switch, left and right commands are cancelled automatically.

That's all there is to remote controlled switching in *Binary Gauge*!



COUPLING MADE AUTOMATIC

You can't make cars into trains without couplers. In *Binary Gauge* the links, pins, hooks, and iron handshakes are replaced by a list in the computer's memory. You can add or delete items from that list, and in so doing couple and uncouple cars. It's easy and reliable.

First, maneuver your engine (or train) next to a string of standing cars and press the **C** key. You will see this message:

COUPLE -- <F>RONT OR <R>EAR?

If the string of cars is in front of the engine, press **F**. If to the rear, press **R**. Then press RETURN. *Binary Gauge* will then ask:

HOW MANY CARS?

Key in the number you wish to couple. Press RETURN again. Note that if you tell the computer to couple 15 cars and 10 are available, it will ignore the nonexistent 5, couple the rest and return with the message:

10 CARS COUPLED

NOTE: cars on-screen can be coupled to a train that is partly off-screen. On the other hand, if you don't specify **F** or **R**, or if you ask to couple -10 cars or ZQ cars or another engine, the computer will reply:

NO CARS COUPLED

Each *Binary Gauge* train consists of a single engine and up to 20 cars. When you reach the length limit in a coupling command, you will see this message:

MAXIMUM TRAIN LENGTH



To reverse the procedure and uncouple cars, first halt your train, then press U. The computer will ask you the same set of questions:

UNCOUPLE -- <F>RONT OR <R>EAR?
HOW MANY CARS?

Proceed as you did in coupling, specifying front or rear and the number of cars to be uncoupled (5, say). The computer will carry out your instructions with the message:

5 CARS UNCOUPLED

NOTE: if any part of a train is off-screen, no cars can be uncoupled. This prevents you from leaving cars in limbo. Also note: you cannot uncouple an engine from itself.

That's all there is to it. No "Big Hook" is ever needed.

X MARKS THE EXCHANGE

There are two engines available in *Binary Gauge*, but only one is active at a time. (For reasons that will soon become clear, it isn't always possible to keep an eye on both at once.) You can transfer control from one to the other by pressing the X key, provided that both engines are halted and uncoupled.

MOVES COUNT

Do you enjoy switching contests? Does your mind run to hellishly difficult yards and industrial areas of alarming complexity? *Binary Gauge* includes a move counter which records every start and stop for each engine. Press the exclamation key (!) to reset. And you don't have to fudge on spotting cars — in *Binary Gauge*, the fits are exact. (For more on switching contests, see the Appendix.)



QUITTING TIME

What happens to everything when you turn the computer off? All that hard work hauling cars here and there — is it obliterated when the power switch is thrown? Not if you quit by pressing the asterisk key (*). The current status of your railroad empire will be meticulously saved to disk, and you will find everything right where you left it when you come back later.

AT THE THROTTLE

Now you know enough to try things out. From the Dispatcher menu, select choice <1> — press the **1** key. You will see this message:

INSERT RAILROAD DISK & PRESS <RETURN>

The *Binary Gauge* Demonstration Railroad is already in the emulator drive as part of the Master Disk, so go ahead and press RETURN. A new display (in sixteen colors!) will appear. This is a *Binary Gauge* DIVISION called MIDYARD.

Below the graphic display are some lines of text. The first one identifies the railroad division by name. The others are your instrument panel — they show you which engine is active, whether you're traveling forward or reverse, which direction you will proceed through the next switch (if you have commanded left or right), your throttle setting, and the active engine's move total.

So — press **F** or **R** and start things moving. After you have experimented with the switches and coupling procedures, put together a train and head for one of the display edges. Don't stop — let it roll right out of sight. Going, going, gone...

What happened? After the train disappeared, the emulator drive whirled, a new railroad segment appeared, and the train continued its journey. You have just discovered the point of *Binary Gauge*: the trains are small, they



don't have much detail, but the railroad can go on forever. Stop now by pressing the asterisk key (*). The computer asks:

WOULD YOU LIKE TO RETURN
TO THE DISPATCHER <Y/N>?

This is your option to quit the *Binary Gauge* program. For now, press Y. The computer reminds you:

INSERT DISPATCHER DISK
AND PRESS <RETURN>

It's already there, so press RETURN and read on...

PART TWO: LONG DIVISION

RULES OF THE ROAD

How does it work? First of all, no true iron-horse empire will ever be crammed into a single computer display, so a *Binary Gauge* railroad is broken up into DIVISIONS that are displayed one at a time. Each division consists of a single lo-res display; 1024 bytes worth of memory. A virtual floppy disk can hold about 80 divisions. The divisions are linked to each other in a grid pattern according to the numbers which are part of their Disk Operating System (DOS) file names. Here is an example of a valid division array:

DIV-0/7

DIV-0/8 DIV-1/8 DIV-2/8 DIV-3/8

DIV-0/9 DIV-1/9 DIV-3/9

DIV-0/10 DIV-1/10 DIV-2/10 DIV-3/10

DIV-2/11



NOTE that the first part of the composite number increases from left to right (west to east) and the second part from top to bottom (north to south). As your train travels off the edge of one division (DIV-2/8, say), the *Binary Gauge* program automatically calls up the next one (DIV-1/8 if you're traveling west, DIV-3/8 if you're eastbound).

NOTE: it appears that some divisions are missing from the above example. That's okay. There is no rule requiring your railroad to fill in all available blanks. If you happen to send a train off the edge of the world the *Binary Gauge* program will gently retrieve it from the great void. You can simply have a long line of divisions stretching from coast to coast — with an occasional branch line, if that's your inclination. The only requirement is that divisions be given file names of the correct form:

- DIV-[horizontal #]/[vertical #] (*note the slash character!*)

RUNNING ON LO-RES

Although *Binary Gauge* trains look like video game images, they are actually guided along their tracks, just as if they were riding the high iron. That's why the computer doesn't have to restrict their travel to any given set of patterns. There are no flanges on the wheels, however. (No wheels, either!)

Instead a track-finding computer subroutine examines the screen ahead of the train, finds the black lines, and carefully positions the cars on them. For those of you interested in programming, here are the important considerations:

- *Binary Gauge* was written in Applesoft BASIC and compiled into machine language for (relatively) high-speed execution with Microsoft's TASC. (The compiled code runs 14 times faster than interpreted BASIC.)



- Trains are lists. Each car and engine section consists of three items:
 - x position;
 - y position;
 - and color.

The track locator finds x and y, and a plotting subroutine uses that information to plot the colors.

- Coupling and uncoupling procedures manipulate the train list. When cars are deleted from a train, they become part of the background. The computer then remembers them as part of the overall graphic display.

When you get ready to build your own *Binary Gauge* railroad, remember: each division is a lo-res graphics display 40 blocks wide by 40 blocks tall.

- Each section of track and each piece of rolling stock occupies exactly 1 block.
- The minimum radius "curve" is 45 degrees. If left to itself, a train will attempt to run straight-ahead. If that's not possible it will try to go left 45 degrees, and if that doesn't work it will try to go right. (The arrow keys allow you to alter this sequence and direct your trains through the switches.) If the track runs out, the train stops.

In order for trains to pass successfully from one division to another, care must be taken to align the tracks where they touch each edge. Otherwise, trains will be left in off-screen limbo.



FORBIDDEN COLORS

Colors are significant in *Binary Gauge*. The program uses them as a sort of code to figure out what's what. Unless explicitly ordered otherwise:

- Track is black (color #0).
- Tunnels are grey (color #10).
- The following colors may be used as cars:

magenta (#1)	purple (#3)	dark green (#4)
medium blue (#6)	light blue (#7)	orange (#9)
pink (#11)	yellow (#13)	
- The following colors are forbidden from becoming cars:

black (#0)	dark blue (#2)	grey (#5)
brown (#8)	grey (#10)	light green (#12)
aqua (#14)	white (#15)	

All sixteen colors may be used on any given division, but be careful where you put them. Color blocks adjacent to the track will be examined by the track-finding and coupling subroutines in the normal course of their duties. These tireless electronic genies can become confused if they find something unexpected. A #10 grey warehouse touching the track would be unwise, for example. So would a magenta barn. Thoughtfully, the coupling subroutine does not recognize forbidden colors as rolling stock. This saves you from the embarrassment of coupling up your scenery and hauling it away. (Not that it wouldn't be fun to create a dark green forest and then "log" it...)

The plotting subroutine also checks the track: if black color #0), it plots the train; if grey (color #10), it ignores everything — and the train enters a tunnel.



DISK DIRECTORY

Although the demonstration railroad is supplied on the same disk as the *Binary Gauge* Master Disk, that doesn't mean the railroads you build yourself should be located there. On the contrary: that's why the Dispatcher asks you to insert your railroad disk before running a railroad why it reminds you to re-insert the *Binary Gauge* Master Disk if you wish to return to the Dispatcher menu when you're through.

PART THREE: CONSTRUCTION

TV BENCHWORK

By now, you have probably discarded these instructions and run trains all over the demonstration railroad, coupling and uncoupling, watching how the trains move through the switches, admiring (cough!) the various divisions.

Sooner or later, however, you will want to add divisions or build your own railroad. Those of you who are used to screw-and-glue construction methods pay close attention: since *Binary Gauge* is computer-based, there is no plaster of Paris, no benchwork, no wiring. Instead, there is a program called EMPIRE BUILDER. Using this tool you can literally draw railroad divisions on your computer monitor. Select choice #4 from the Dispatcher menu — press **4** — and take a look at the resulting display:



EMPIRE BUILDER COMMANDS

GO UP - I

GO LEFT - J K - GO RIGHT

M - GO DOWN

- C CYCLE CURSOR COLOR
- D DRAW IN CURSOR COLOR
- E ERASE TO UNDERLYING BACKGROUND
- F FLOAT CURSOR OVER DRAWING
- S SELECT STARTING BACKGROUND
- R RECALL A PICTURE FROM DISK
- S SAVE A PICTURE TO DISK
- * QUIT

BLESS THE CURSOR

When you select choice #2 from the Dispatcher menu, the Empire Builder program will run and you will find yourself looking at a black screen with a red dot in the center. That dot is the CURSOR — a color block which tells you where your building activities will be located.

The pound sign key (#) generates starting backgrounds. Each time you press it the screen and cursor are painted a new color. After all sixteen colors have been displayed, they recycle automatically. Try it. Now, press # until dark green fills the screen — the forest primeval, if you will.

By pressing the **C** key you can cycle the cursor color directly. For the moment, try light green (color #2). The keyboard diamond formed by the **I**, **J**, **K**, and **M** keys (or your **arrow** keys) is what you use to move the cursor around the screen (one block at a time) :



I - cursor up

cursor left - **J** **K** - cursor right

M - cursor down

DRAW, ERASE, FLOAT

By pressing the **D** key you command the DRAW mode. Now, as you move the cursor you leave a trail of light green, clearing away the wilderness. By pressing the **C** key a few more times, you can turn the cursor black (color #0). Now you're ready to lay track. Don't worry about making everything exact at first — just sketch it in.

Once you've got some track laid out, and possibly some rough scenery as well, position the cursor over a light green block adjacent to the track and press the **E** key. This will cause the computer to think of light green as the underlying background color. You can now ERASE track very simply by moving the cursor over unwanted black blocks. If you accidentally erase too much, place the cursor over a black block, press **E**, and erase the green back to black!

As you work, you will want to move the cursor across sections of the railroad picture without affecting anything at all. Press the **F** key to FLOAT the cursor over everything without drawing or erasing.

SAVE YOUR WORK

After playing with Empire Builder for a few minutes, you will quickly become familiar with the various controls and find yourself swiftly moving the cursor back and forth, cycling from DRAW to ERASE as needed, occasionally FLOATing to other sections of the picture.



When you're ready to SAVE a division, press the **S** key. The Empire Builder will query you as follows:

SAVE FILE NAME:

You can respond with any file name recognized by Apple DOS, but if you want to save a *Binary Gauge* division, you must take care to give it a file name like DIV-3/6 or DIV-14/2, depending on how it fits into your overall plan. (Make sure you place a *slash character* between the numbers!)

(NOTE: check your emulator for saving and loading details.)

Be careful in choosing file names. You can recover from some mistakes in naming and numbering by using the DOS command to RENAME files. On the other hand, it's no fun to erase a file already on your disk by saving another one using the same name. To help you keep track of things, the Empire Builder always displays whatever file name you have most recently used in a recall or save operation.

(NOTE: Whenever you want to list the files on your disk while running Empire Builder, you can get a CATALOG by pressing **S** or **R** and then typing CAT as the requested file name.)

If you change your mind and decide not to save the picture after all, simply press RETURN. (If you have already started writing a name when you get cold feet, you can still escape. Press the left arrow ← until the cursor is back to the beginning of the name and then press RETURN.)

(NOTE: Empire Builder has no provision to LOCK files on disk, and you shouldn't LOCK them either. In operation, *Binary Gauge* re-saves division files whenever a train leaves the screen. If the files are locked the program will crash.)

Once you've told the Empire Builder to save your work, the cursor will appear on the left just below the colored display. This allows you to write a



line of descriptive text to go with your creation. This line can be anything you want but for *Binary Gauge* purposes a division name and label will be helpful (see the demonstration railroad). If you want to copy a line of text already written, sweeping the cursor over the letters and spaces with the right arrow (→) will do the job. When you're satisfied with your prose, press RETURN. When the file is written, the computer will print:

DONE

TRIED BY ERROR

If you are adding to a railroad that already exists, you can try out your new division simply by driving a train onto it. There is nothing like operating a new section of track for a while to uncover flaws in the design. For example, you may want trains to proceed left through a particular switch but unless otherwise commanded, they go straight. Maybe your track didn't line up properly with track from the adjoining division. Or possibly you have drawn track along the picture edge, in which case trains will attempt to exit to another division. (For an appreciation of some of the subtleties of track planning, examine the demonstration railroad.)

Whenever you want to revise a track plan (or just improve the scenery), return to the Empire Builder via the Dispatcher menu and take another look at the offending division.

TOTAL RECALL

You can recall divisions simply by pressing **R**. The computer prompts:

RECALL FILE NAME:



Write the name and press RETURN. Your emulator's virtual disk drive will virtually whirr, and the named division will appear. (That is, if it is actually stored on the disk currently in DRIVE 1. If not, the prompt will reappear, asking you to try again.)

SNAPSHOTS

If you would like to see a railroad division in various stages of construction, select Empire Builder from the Dispatcher menu and recall the following files, one after another:

CONSTRUCT. 1
CONSTRUCT. 2
CONSTRUCT. 3
CONSTRUCT. 4
CONSTRUCT. 5

The final version of this division appears in the demonstration railroad as DIV-76 (BIG RIVER).

RAILROAD STATUS

Whenever you begin an operating session, *Binary Gauge* needs to find out what division to start you out on, which engine to use, and where to locate it. It also checks a list of forbidden colors to find out which ones are allowed to be cars and which ones to use for track, tunnels, and engines. It does so by consulting a disk file called RR STATUS. Each time you quit by pressing the asterisk key (*) *Binary Gauge* remembers these things by writing updated information back into the RR Status file.

When you create your own railroad you can't begin to use it until you have also created a RR Status file. (You only need to do this one time for each railroad: once the file exists, the *Binary Gauge* will be happy to take over



and maintain it.) The RR STATUS WRITER has been designed to help you. Run it by selecting choice #6 from the Dispatcher menu. The program will lead you through the details on a step-by-step basis (with many chances to abort and exit safely) as you tell it the important facts:

- Which division to place each engine on;
- Where to locate each engine on its division;
- what colors to use for each engine;

Be aware: you don't draw engines the way you do rolling stock. The program does it for you. Carefully examine the position you want each engine to occupy, keeping in mind that x-values range left-to-right from 0 through 39 and y-values range top-to-bottom from 0 through 39.

And to keep things simple, select your engine colors from the standard set of forbidden colors: 2,5,8,12,14,15.)

AT YOUR PERIL

Throughout this manual, references have been made to black track, grey tunnels, and a set of "forbidden colors." With any luck, the impression has been planted in your brain that these colors are fixed. They're not. If you insist, the RR Status Writer will help you specify non-standard forbidden colors for the track, tunnels, engines, and whatever scenery you wish to have adjoin the track. Proceed with extreme caution here, remembering that railroads which have odd forbidden colors probably cannot operate with those that use the standard set.



DRIVING THE GOLDEN BYTE

If you're like most model railroaders, the idea of actually finishing a project once and for all is anathema. You needn't worry about the situation in *Binary Gauge*. With storage space for up to 80 railroad divisions in each virtual floppy disk file, you've got plenty of room for growth. But what's more important: railroads can continue from disk to disk without any computer limitation whatsoever.

The technique is simple: just switch railroad disks in the drive when the computer detects the edge of the world (next division unavailable) and continue on your way. If you prefer, you can include a warning label in the line of descriptive text below the last division on each disk. Use Empire Builder to write it.

(NOTE: the only requirement is that all the divisions on each railroad have unique names of the proper form, no matter which disk they are on. In other words, no two divisions in any single railroad can have the same numerical designation.)

So, John Henry, if you start running out of energy on your transcontinental pike, you can always lay track part way and meet a friend's railroad somewhere on the border between two floppies.

(Remember: BACK UP YOUR FILES!)

THE USES OF ENTERTAINMENT

Possibly, like many others, you purchased your Apple without any clearly foreseen uses in mind, but with a lot of curiosity about the silicon revolution that is spreading into every corner of our lives. Well, here it comes — right into our favorite pastime. Happy electronic railroading!



APPENDIX

Binary Gauge is a model railroading system, not a video game. Nevertheless, if you are interested in switching puzzles, perhaps you should try moving both engines to DIV-15 on the demonstration railroad. There you will find a contest layout for two players. To start, position engines and cars as shown on the display. The rules are simple:

1. The object of the game is to move all your cars from the incoming main line through the yard to the outgoing lead track in fewer moves than your opponent.
2. You and your opponent each command one engine and five cars:
 - <A>'s rolling stock is yellow;
 - 's rolling stock is blue;
3. You must move a single car to the outgoing lead track on each turn.
4. You may spot any cars (except those already delivered to their respective lead tracks) and your own engine wherever you feel will most help your chances to win as long as you don't completely block your opponent.
5. You have completed your turn when:
 - a. the required car has been moved;
 - b. You are satisfied with your position.(NOTE: you can still move your own engine and rearrange cars after you drop the required car.)
6. Signify the end of your turn by hitting the X key to exchange engines.
7. When all cars are on the outgoing lead track with their engines, the game is over. If you expended fewer moves than your opponent, then you win.

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