(2021) Retro Gamer, iss. 222 pp. 50-57 MAME & Watch

MA

AS GAMING TECHNOLOGY GOES, IT DOESN'T GET MUCH SIMPLER THAN NINTENDO'S GAME & WATCH LCD HANDHELDS. BUT EMULATING THEM ACCURATELY, AND PRESERVING THEM DIGITALLY, IS SUCH A CHALLENGE THAT NINTENDO ITSELF HASN'T EVEN ENTERTAINED THE IDEA. WE MEET THE MAME BENEFACTORS WHO'VE DEVOTED THEIR TIME AND TALENT TO DOING WHAT NINTENDON'T

WORDS BY MARTYN CARROLL

You'll be aware that you can play the arcade version of *Donkey Kong* on the MAME emulator. You probably also know that you can play the multitude of console and computer ports too, since MAME merged with its sister emulator, MESS, back in 2015. Yes, you can even play the Intellivision version, if you so wanted.

But did you know that you can also play the *Donkey Kong* Game & Watch handheld game on MAME? In fact, you can play all 60 official G&W games in MAME right now, from the first release, *Ball*, to the final one, *Mario The Juggler*. And it's as close as you'll get to playing the real thing. There's artwork available that provides the background layers that many of the games require, and even displays the body of the unit (with animated buttons to boot). Look around – all of the screens used in this feature have been grabbed directly from MAME. For anyone who played a G&W game as a kid – perhaps one of the more common ones that were sold in catalogues and toy stores back then – it's amazing to be able to now experience the whole eclectic range.

Given its history, it's hardly surprising that MAME is still seen as just an arcade emulator in many people's eyes. But with the addition of G&W and other electronic games, this is something that veteran MAME developer David Haywood hopes will start to change. "The progress made in areas like this will hopefully help challenge the perception people have over what MAME is and what it can do," he says. "MAME is often seen in the media as some project from two decades ago, where you can take an 18-year-old version, throw it on some cheap single-board computer, and play some arcade games. This viewpoint is a poor reflection of what MAME really is and doesn't do justice to the hard work that has been done in other areas. G&W emulation really shows that MAME is capable of so much more with the right dedication."

For G&W, that dedication was an international effort from a team of folk, stretching back several years. As with any community project, multiple people have been involved at different times in various work streams, so it can be difficult to pin down the exact chain of events. But a good place to start is in 2013, when MAME contributor Sean Riddle chanced upon some interesting patents. Sean, a computer programmer from Oklahoma, has been hacking hardware since the Nineties and has always had an interest in 'oddball' processors.

"While searching Google Patents for some obscure chip," he tells us, "I found the patents for the Konami LCD games *Top Gun*, *Gradius* and *Teenage Mutant Ninja Turtles*. Along with the schematics of the games were drawings of the LCD panels and the full contents of the ROMs! I bought the games off eBay and opened them up, but instead of normal chips, they had 'globs' of epoxy. The die of the chip was glued to the printed circuit board, with tiny wires connecting it to traces on the board, then it had been covered in epoxy to protect it. So I couldn't get to all the pins, including an interesting one labelled 'TEST'. I used a hot-air gun to soften the epoxy so I could remove it, but some stuck to the die. That's when I had to learn about acids."

> "WHILE SEARCHING GOOGLE PATENTS FOR SOME OBSCURE CHIP I FOUND THE PATENTS FOR THE KONAMI LCD GAMES"
> **SEAN RIDDLE**

Sean is describing the process of decapsulating, or 'decapping', a chip. This involves removing the material that protects the die of the chip, allowing the die to be seen. Once it is decapped the ROM data can be visually read from the chip. As for the chip itself, the patents revealed that the handhelds used a 4-bit Sharp MCU (Microcontroller Unit) from the SM5xx family. Around the same time, another MAME contributor 'digshadow' discovered that G&W used the same MCU.

Sean continues, "I eventually mapped the bits on the dies to the bits in the ROM data from the patents. This let me dump other games visually. The G&W games use a normal chip instead of

MAME & WATCH

SEAN RIDDLE

American Sean was instrumental in getting the project started, thanks to his decapping and dumping work. His top G&W title is *Mario The Juggler* "since I also juggle".

HENRIK ALGESTAM

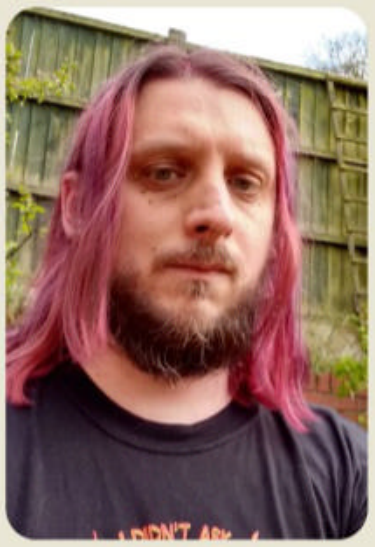
Henrik from Sweden took up the mantle from Sean and dumped the bulk of G&W games. He also cracked the 'melody ROM'. His G&W title of choice is *Climber*.

RYAN HOLTZ

American Ryan helped to acquire the majority of G&W units, personally and through crowd funding. *Squish* is his go-to G&W game, "for the sheer playfield complexity".

LEE ROBSON

Englishman Lee designed and edited the supporting artwork for most of the games. His favourite G&W title is *Rain Shower* because, "It makes me feel close to home."



DAVID HAYWOOD

David's from the UK and he's an advocate of advances made in MAME. The game he keeps coming back to is *Oil Panic* "for its effective use of the dual screen set-up".

BY DESIGN

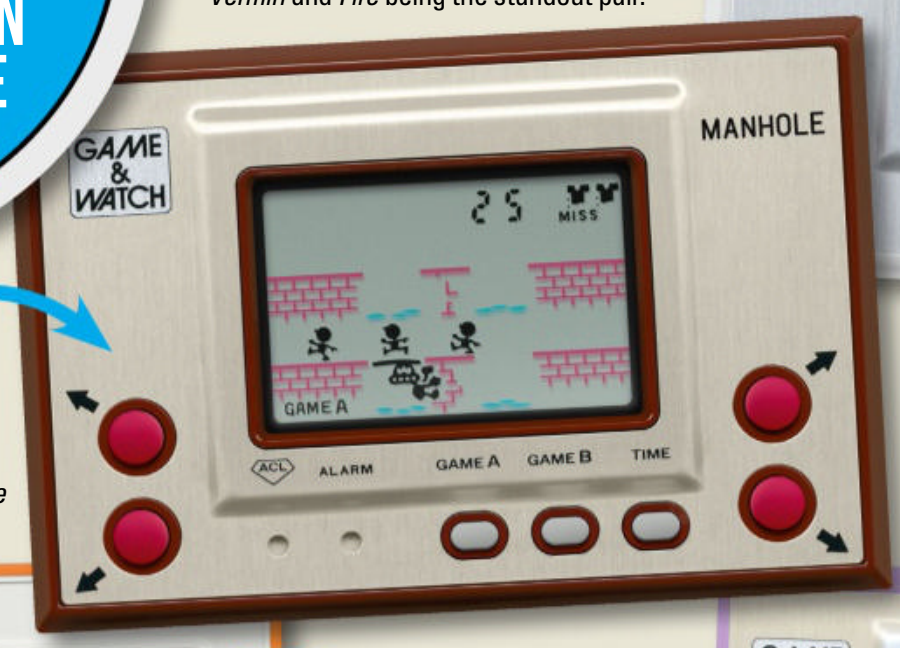
THERE'S MORE THAN ONE TYPE OF GAME & WATCH...

SILVER APRIL 1980

The original models featured a simple, silver-coloured surround that gave the series its name. There were five games in the range – *Ball*, *Flagman*, *Vermin*, *Fire* and *Judge* – and they were simple too, with *Vermin* and *Fire* being the standout pair.

GOLD JANUARY 1981

The surround was now gold, and they came with a foldaway stand, but these were otherwise identical to the Silver models. The titles were *Manhole*, *Helmet* and *Lion*. *Helmet* was released in the UK as *Headache* and is highly prized these days.

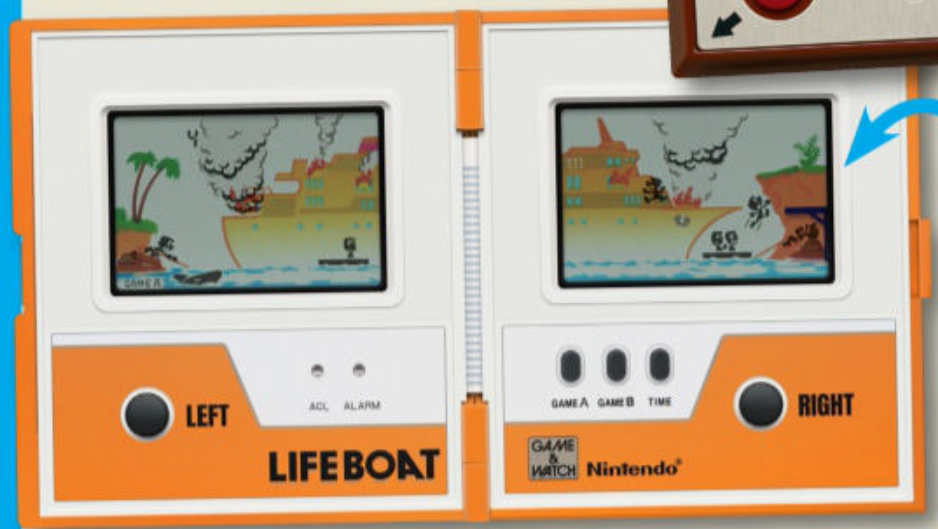


WIDE SCREEN JUNE 1981

The format began to find its stride here, thanks to a larger screen and some strong titles, including three licences: *Popeye*, *Mickey Mouse* and *Snoopy Tennis*. Seven further titles made up the range, including *Parachute*, *Octopus* and a remastered *Fire*.

MULTI SCREEN MAY 1982

The introduction of dual screens proved to be a masterstroke, as did the debut of the famous Nintendo d-pad on *Donkey Kong*. The range was very popular, with 15 titles in total released, including several where the screens were side-by-side.

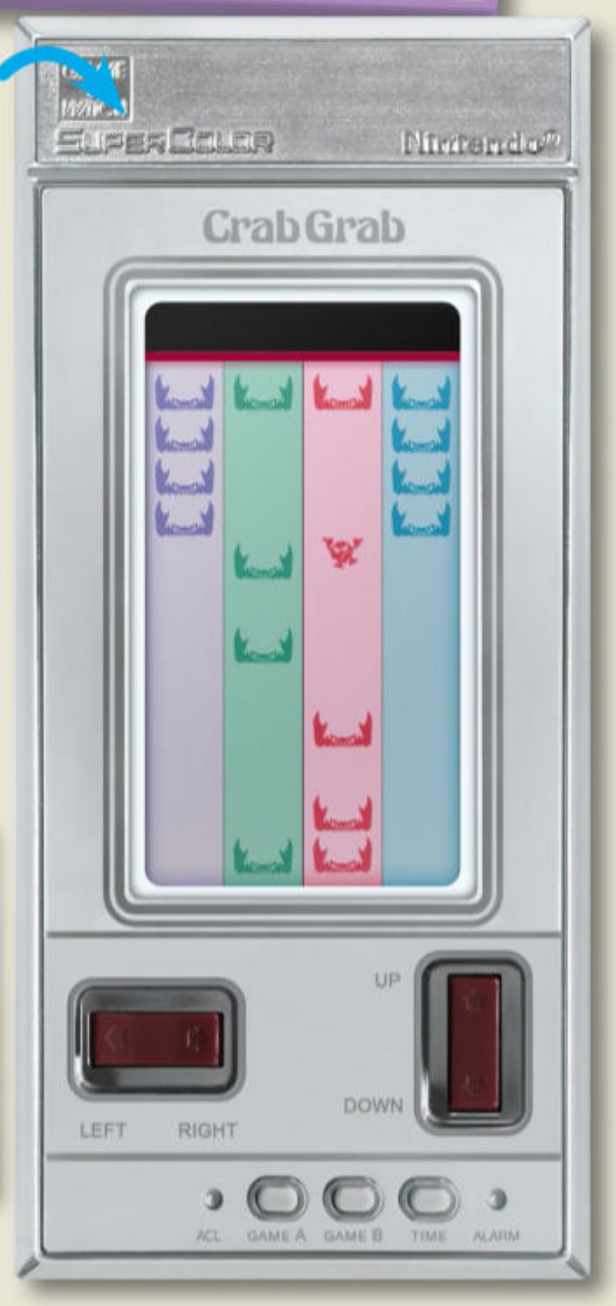


NEW WIDE SCREEN OCTOBER 1982

The 'New' was added thanks to the addition of colourful metallic surrounds to the standard Wide Screen design. Eight titles were released, including updates of old releases, some new ones, and 'standard' versions of games that were released in other ranges.

SUPER COLOR FEBRUARY 1984

Despite the name, and the taller footprint, these were like a throwback to earlier designs, with the colour provided by a simple overlay. Only two titles were released – *Spitball Sparky* and *Crab Grab* – which suggests that the format didn't land well.



CRYSTAL SCREEN JUNE 1986

The last range to be introduced was a real showstopper. These elegant devices featured wide surrounds and transparent screens. The trio of games – *Super Mario Bros*, *Climber* and *Balloon Fight* – were later re-released in the New Wide Screen format.

MICRO VS SYSTEM JULY 1984

Another clever design decision saw the addition of two tiny joypads that slotted into the body of the handheld and allowed for versus play. The three titles were *Boxing* (known in the US as *Punch-Out!!*), *Donkey Kong 3* and *Donkey Kong Hockey*.

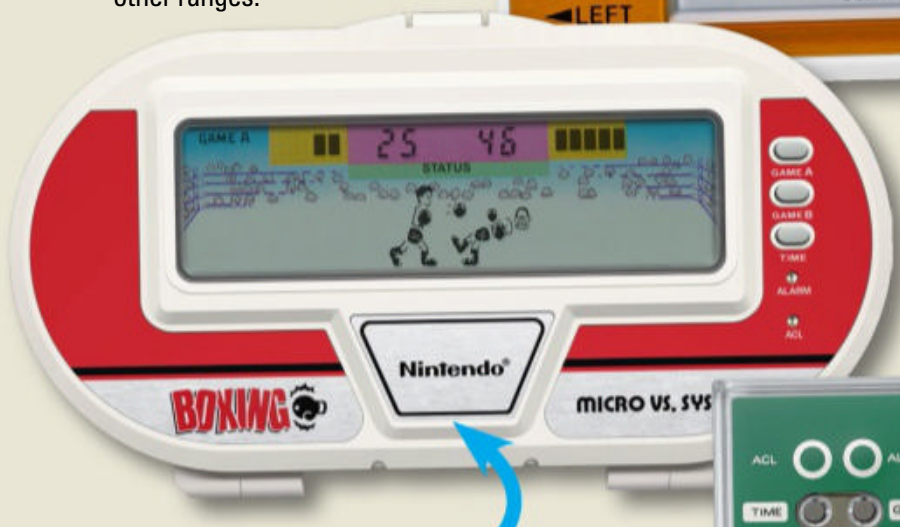


TABLE TOP APRIL 1983

As the name implies, you couldn't slip these in your pocket. Designed to resemble mini coin-ops, the big selling point was the introduction of colour screens. Four titles came in this format: *Donkey Kong Jr*, *Mario's Cement Factory*, *Snoopy* and *Popeye*.

PANORAMA SCREEN AUGUST 1983

These retained the colour screens of the Table Top range, but they were more portable thanks to a foldout design. The titles were a mix of existing Table Top games and new ones, including *Mario's Bombs Away* and *Donkey Kong Circus*.

an epoxied die, so I was able to experiment with the 'TEST' pin. When a signal was applied to it, ROM data was output on some pins! But it turned out that only one 'page' of ROM was output, and there were 44 pages on the chip. I posted the info on a forum and a fellow named Igor Rychenkov shared the process that he discovered to dump the ROM from the Russian clone of the chip, and it worked on these."

Having dumped the ROM contents, the next step was to digitise the LCD screens, in order to grab the 'graphics' for each game. The trick was to somehow photograph the screen with all of its segments showing. "I tried taking photographs of the LCD displays, but using a flash caused reflections and shadows that were difficult to clean up," continues Sean. "There's also the problem of identifying the contacts used to turn on each segment. I wound up cutting up the printed circuit board from one of the games. I cut a hole so that the LCD panel could be backlit and soldered 37 wires to it so I could control each segment independently. LCDs are fairly complex, and to avoid damaging them alternating current must be used, and different voltage levels are needed to avoid 'ghosting'. To get a picture with all of the segments enabled, all the common signals are connected and all the segment signals are connected, then a 3v AC signal is connected to each group of signals. The resulting picture has to be cleaned up to remove dust, scratches and visible crystals, then vectorised with a program like Potrace to create an SVG (Scalable Vector Graphics) file."

As Sean worked on dumping the games in his possession, real life intervened and he had to dial back his involvement. "I had done something like a dozen Konami games, five G&W games and about 100 Tiger Electronics games when my free time got squeezed. The G&W games were by far the most desired, but they were more difficult for a couple of reasons. The LCD panels on all 112 of the Konami and Tiger games were identical, which meant that the same printed circuit board could be used for all of them. In contrast, practically every G&W panel is different. That means a new printed circuit board has to be made for each game. In addition, most of the Konami and Tiger games are fairly common and inexpensive, so it wasn't impractical or unethical to destroy the games to decap the chips and read out the ROM data. The G&W games are less common and more expensive. At this point Henrik Algestam contacted me and wanted to help but didn't know anything about it. Luckily for me he's smart and driven and had the time. He improved on my techniques and dumped all of the remaining G&W games. I'm certain that people would still be waiting on the files if he hadn't taken that on."

Henrik Algestam is a software development consultant from Sweden. He was able to take Sean's work and run with it. "I've always been fascinated by the G&W handhelds," he reveals, "but wasn't involved in preservation until I read about the first G&W games being emulated in MAME in 2017. Once I read up on how this was achieved and learnt about decapping, I contacted Sean and offered him some of my games for decapping. I had many questions about the process and eventually I was able to dump the games myself thanks to his help."

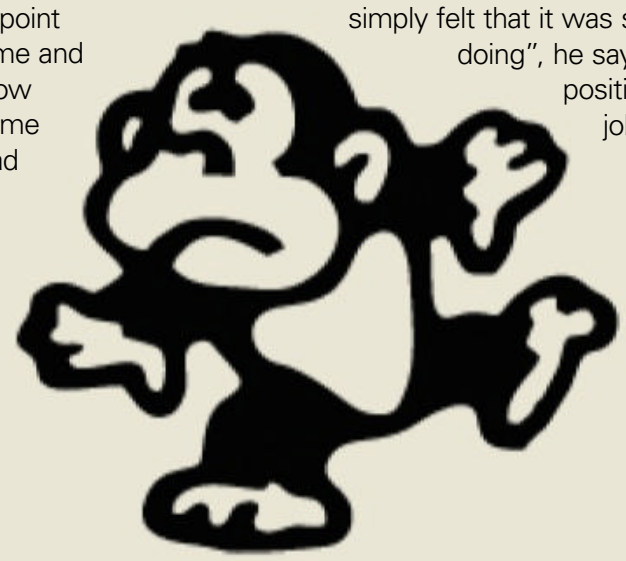
To simplify the process of photographing the LCD screens with all of the segments enabled, Henrik designed custom PCB breakout boards for the different screen variants. "The later colour G&W games are interesting as the LCD display is inversed so that active segments are translucent and a colour inlay provides the colour graphics. What makes these games a bit more difficult to dump is the way the display is assembled in a sandwich-style way with more layers than the standard G&W games."

One element that was easier to digitise were the static background layers that the majority of G&W titles feature. These often just add a visual flourish and splash of colour to monochrome games, but sometimes they're required for the game to be playable (such as the red girders in *Donkey Kong*, or the bumpers and buffers in *Pinball*). "The colour backgrounds are simply scanned with a standard desktop scanner and used in MAME as a background layer behind the LCD layer," says Henrik.

> "THE HARDEST PART OF DUMPING AND EMULATING THESE UNITS WAS ACTUALLY GETTING HOLD OF THEM IN THE FIRST PLACE"
> **HENRIK ALGESTAM**

With the dumping process refined, there remained just one stumbling block – the scarcity of some G&W titles. Given their appeal, and their place in Nintendo's history, many of the rarer releases are in the hands of collectors. They can be picked up on the open market, but they often go for silly money, particularly the early Silver and Gold models, and the coveted Crystal Screen releases. "The hardest part of dumping and emulating these units was actually getting hold of them in the first place," says Henrik. "A few were my own but sourcing the remaining ones has been a team effort. Ryan Holtz has helped out with funding to acquire most of the G&W units."

Ryan Holtz is an American ex-pat currently living in Sweden who works as a programmer at Arrowhead Game Studios. As a long-time contributor to MAME, he watched the preservation effort from the sidelines for a while, before stepping in to help secure the required units. "I simply felt that it was something that needed doing", he says. "I'm in a lucky enough position to have a programming job at a decent salary, thus I tend to contribute funds towards digital preservation when and where I can. Vintage hardware certainly isn't getting any cheaper, after all. For the most part, nothing was



terribly elusive, just expensive. A significant bulk of the G&W library was acquired in one go, when a collector here in Sweden was auctioning off what he had accumulated over the years. I knew it would end up costing a lot, and with that in mind I turned to Twitter, friends and even a few co-workers. Around 70 people in total contributed anywhere from 5-250 USD in order to make it happen. There were 34 units in the auction and the final price ended up being about 1,900 USD."

The remaining units were then located one by one. "The hardest individual unit to track down was *Donkey Kong Circus*, and that was also the most expensive, ending up costing around 1,000 USD," says Ryan. "Fortunately, an anonymous benefactor had appeared by that point and was willing to personally cover the last few acquisitions."

Right now you're possibly wondering if these expensive acquisitions become sacrificial lambs to the slaughter, with the units having to be destroyed in order to be dumped? Thankfully this was not the case. By the time Ryan became involved, Sean, with the help from Igor, had figured out how to dump the chips electronically.

"The first few units were dumped using the acid decapsulation technique," says Ryan, "which is naturally destructive to the unit itself. Once a method for dumping them electronically was discovered, quite a few units were able to be reassembled and resold in order to fund the acquisition of other units.

"That said, the last generation or two of G&W releases had an additional 'melody ROM' in order to have a more compelling auditory experience than simple 'beep' and 'bip' noises. Although Henrik was able to develop a method to more or less recover the melody data, those particular games will still need to be decapped for full optical verification of the ROM contents."

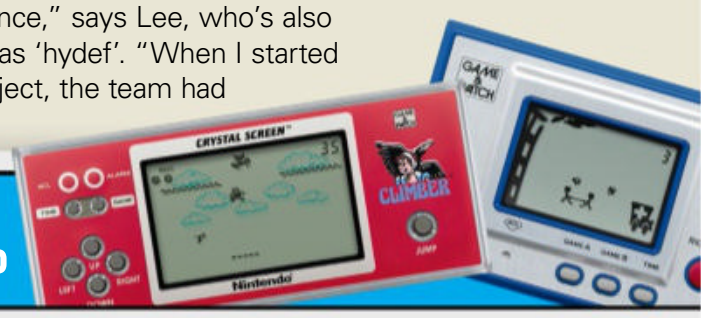
The job of writing the SM5xx emulation and adding it to MAME was undertaken by the contributor known as 'hap' who lives in The Netherlands. He has programmed for MAME since 2008. "Sean and I had already been working on the emulation of early handhelds, mostly games like *Simon* and *Merlin*. It was only natural that other handhelds were to follow, and indeed, we emulated a lot of handheld games and added them to MAME," he explains. "Around 2015, Sean started decapping the Konami LCD handhelds and the first game I got playable in MAME was Konami's *Top Gun*. Sean decapped more games, including some G&W. There was a bug in the emulation that caused most of the G&W games to be unplayable. It turned out to be one-line fix, and suddenly the games made correct noises and responded to inputs."

One remaining problem was how to display the SVG files that held the graphics in vectorised format. "Another MAME developer, Olivier Galibert, added an SVG renderer to MAME to solve that part," says hap. "That's when the ball got rolling and my programming for the MCU emulation and MAME driver was mostly done at this point. New game additions were mostly a matter of copy and pasting, since the games run on very similar hardware. I helped Henrik when he ran into problems adding new G&W dumps to MAME, but other than that, not much more programming was needed. Overall it was a lot of work and a lot of collaboration with other people. It was fun."

> "ALL OF THE CASES ARE BASICALLY FRANKENSTEINS OF WEB FINDS THAT I COBBLED TOGETHER, STRAIGHTENED AND RECOLOURED"
> **LEE ROBSON**

The final touch – the artwork for the games – was provided by Lee Robson, who hails from Newcastle in the UK. "The artwork is something that was desperately needed to complete the experience," says Lee, who's also known as 'hydef'. "When I started this project, the team had

ELECTRONIC TONICS
GREAT GAME & WATCH RELEASES THAT STILL HOLD UP



FIRE
People are bailing out of a burning building and, as the rescuers on the ground, you must bounce them over to the waiting ambulance. The hectic gameplay and high melodrama ensured that this was the first release to really strike a chord – and it remains great fun.

TURTLE BRIDGE
Using turtles as stepping stones, you have to trek back and forth across a river. However, the turtles often get distracted by passing fish and dive underwater, breaking the 'bridge'. Another simple concept that's anything but sedate, as you frantically try to avoid the drink.

OIL PANIC
The first Multi Screen release really delivers on the concept. In the top screen, you catch the oil drips in your can, and when it's full, you empty it over the side – ensuring that the guy with the barrel below is lined up. Clever co-ordination and quick skills are the order of the day.

DONKEY KONG
While everyone remembers the bright orange case, the game is pretty memorable too, being an approximation of the coin-op's opening stage with the addition of a crane-swinging finale. It was the format's first big seller and for many it remains the defining G&W release.

MARIO BROS
Unlike *Donkey Kong*, this outing was not based on the original coin-op. Instead of flipping critters in the sewers, Mario and Luigi are putting in a shift at a bottling company, working in tandem to avoid costly breakages. This is another game that makes good use of the dual screens.

» The popular Multi Screen format debuted in 1982 and would go on to influence the design of the Nintendo DS handheld 22 years later.

already dumped and emulated a fair few of these games and produced some basic artwork. There was also an attempt on the forums by a member to implement the casing into the picture as well and that inspired me to also try and do this, but the best quality I could."

The addition of the cases is something that really brings G&W to life on MAME. They look almost better than the real thing, which begs the question, how has Lee managed to replicate them with such clarity and accuracy? "This may surprise some people, but I've never physically had any of these G&W games during the project. I only played some of them at school in the late-Eighties. All of the cases are basically Frankensteins of web finds that I cobbled together, straightened and recoloured. I then made these into a template that I could modify into new games since the different G&W models – Silver, Wide Screen, Multi Screen and so on – all have a particular styling. So for you to say that the artwork looks almost better than the real thing is a great compliment, as I don't actually know how they look in reality. The end product is supposed to look like a sort of promotional shoot on a plain surface for playing on your desktop

THE ART OF GAME & WATCH

HOW THE DIFFERENT ARTWORK ELEMENTS COME TOGETHER

1 A photograph is taken of the LCD screen with all of the segments enabled. This is then vectorised to create an SVG file which is zipped up alongside the ROM data.

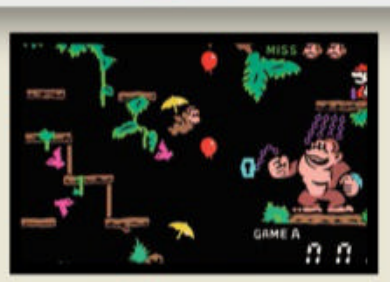
2 The background layer is scanned with a conventional scanner and then touched up to improve the colours. A separate version with a slight depth effect is also produced.

3 The case is created using a mixture of photos, scans and images from the internet. Templates are created so that it's easier to create cases for games in the same range.

4 When the artwork is added to MAME, the SVG file, the background layer(s) and the case image are combined to create the composition. It's as close to the real thing as it gets.

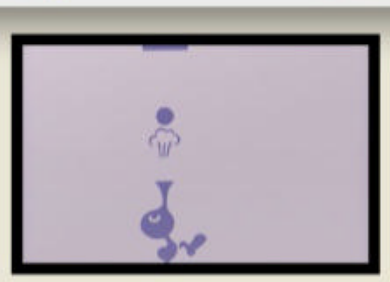
PINBALL

This was the 38th G&W release overall, and yet Nintendo kept redefining what was possible with the LCD technology. Here we have a pinball sim that presents a nice-looking table that's surprisingly playable. The sound is a little grating, but at least you can mute that in MAME.



DONKEY KONG JR

The first Table Top game, and therefore the first G&W release with colour graphics. It's different to the earlier New Wide Screen game, and not necessarily better, but the colour really pops as you traverse a jungle maze and cross a river on another quest to rescue DK.



SPITBALL SPARKY

The G&W range is full of oddities and the Super Color format is chief among them. This game, however, is one of the most inventive available, being a clone of *Breakout* that shouldn't really work, but somehow does. The other Super Color game, *Crab Grab*, is also worth a look.

SUPER MARIO BROS

It wasn't a shock to see *SMB* added to the range, but it was surprising to find that it (kinda) resembled the NES game – including multiple scrolling levels. A wonderful game to play, especially if you're lucky enough to experience it on the original Crystal Screen model.

CLIMBER

Similar to *SMB*, but with vertically-scrolling levels, this is perhaps an even better game. Using the platforms, you climb ever upwards, dodging enemies as you go. You even get to battle an evil dragon boss at the summit! For many G&W fans this remains the go-to game.

MODERN MAKEOVERS

WE EXAMINE THE BEST OF NINTENDO'S FUNKIFIED UPDATES

MANHOLE

From the first *G&W Gallery* (1997), *Manhole* was one of four early titles given a fun modern makeover. Here, Yoshi has to raise the manhole covers to prevent Toads and other irritants from falling through. This original Game Boy title was colourised on Super Game Boy.

VERMIN

This update is the highlight of *G&W Gallery 2* (1998). The rats from the original are replaced by invading Koopas, Fly Guys and Boos which Yoshi must smash before they attack his eggs. Yoshi now moves in a circular direction; the result is akin to a super cute version of *Tempest*.

MARIO'S CEMENT FACTORY

This perhaps should have been retitled *Mario's Cookie Factory*, because now Mario has to manage the flow of cookie dough through his death trap of a factory. At least the lifts are now more forgiving. This was one of 11 updates included on *G&W Gallery Advance* (2002).

PARACHUTE X OCTOPUS

G&W Collection 2 for Nintendo DS (which was a Club Nintendo exclusive) features classic versions of *Parachute*, *Octopus* and this, a clever dual screen mash-up of the two. The action alternates between saving parachutists and stealing treasure from octi's lair.

DONKEY KONG 3

Another charming update found on *G&W Gallery Advance*. Scrawny Stanley from the original is replaced by Mario (of course) who faces off against Donkey Kong in a bubble blastathon. In a neat touch, this and fellow Micro Vs System game *Boxing* offer a two-player link-up mode.

» Nintendo hasn't forgotten about G&W, as evidenced by the limited edition handheld released to celebrate the 35th anniversary of *Super Mario Bros* and the *Zelda* Game & Watch announced at this year's E3.

» The G&W craze kicked off in April 1980 with the release of *Ball*. Several later games would revisit the simple juggling theme.

» There are 60 G&W titles in total – 59 retail releases, and this special edition of *Super Mario Bros* which was given away as part of a competition in Japan. It was limited to 10,000 units.

▶ PC. It's meant to look clean and elegant. Some people don't like that part of it, but I was doing what I like." Lee spent around 18 months working through the backlog and then began to include the new releases as they were added to MAME. "After a while of catching up with the new releases I partnered with Henrik and he'd send me scans of the background layers and scans of the cases if I needed them. This meant that I was able to release the artwork before the next version of MAME. For the background layers I fiddled with the colours depending on how I thought they should appear and gave the graphics a depth/shadow effect, to mimic the polarisation process. I let users have different viewing options so that they can play how they like, by turning the shadows off or even removing the case and being left with only the screen. I think they look good as just screens too. They even have a frame."

Lee worked on the project as a hobby and it was a labour of love – for the most part. "Everything required a lot of going back and forth to refine the way things looked," he admits. "Trying to maintain consistency across the units often meant having to change many files in my templates and the code which decides where they're drawn on the screen. I eventually quit the project shy of doing the lot because it was affecting my mental health and I love to self-sabotage everything I do. Fortunately a fellow called Matthew Marino [DarthMarino] picked up the last few and finished them using earlier assets and his own background work."

The G&W project was effectively completed in August 2020 when the final game, *Donkey Kong Hockey*, was added to MAME (in version 0.223). There are still some items on the to-do list, but these mainly involve dumping rare ROM variants and the 'melody ROM' verification issue that Ryan mentioned. The end result is another coup for MAME and a landmark in game preservation.

"It's definitely a milestone, but also a phenomenal display of teamwork and technical accomplishment," reflects David Haywood, who has produced videos of all of the G&W releases running in MAME for his YouTube channel (search for 'mamehaze'). "Reaching the milestone was the culmination of many years of work and improvements to the MAME codebase to allow for it. It was also a moment of realisation, seeing that MAME could do something that even just ten years ago was considered impossible, and not only do it, but do it convincingly. Many ventures within MAME end up hitting brick walls, where a limit to our understanding is reached or technical roadblocks cannot be overcome. Some also end up stalling as those involved simply become burnt out. But here, the teamwork on display, centred around a driven group of developers with complementary skills, saw this one to fruition. It's something that will remain a highlight of recent development for years to come."

David is also optimistic that it will encourage others to embark on similar projects. "I hope it makes people more curious about the technology they do own and spurs research for cases that are still problematic. Outside of G&W there are still hundreds, if not thousands of similar handhelds, but instead of using known MCUs they're using COB [Chip-On-Board] technology, where everything is self-contained on a die under a single epoxy glob. For many of these there is still no clear path to getting them emulated. Seeing that MAME is capable of handling the emulation side, I hope it might motivate more people to look for solutions to the technical hurdles."

> "NINTENDO COULD, AND I EVEN FEEL SHOULD, REISSUE THE GAMES ON A MODERN PLATFORM"
> **DAVID HAYWOOD**

Now that all of the G&W titles have been emulated, there's always a chance that Nintendo might want in on the progress. After all, the company has revisited the G&W concept multiple times in the past, including the seven compilations released between 1995 and 2008, and the versions later released as DSiWare. And of course, there was the *Super Mario Bros: 35th Anniversary* G&W released in 2020 that was modelled on the Gold range and featured an updated version of the very first G&W title, *Ball*. It's easy to imagine a complete collection for the Switch at some point.

"Nintendo could, and I even feel should, reissue the games on a modern platform," says David, who emphasises that it would cost Nintendo nothing to license them. "The MAME code specific to supporting the G&W units is all available under the BSD 3-Clause licence, which makes it as easy as possible for Nintendo to come along and use that code. The licence doesn't place any restrictions on using it in closed source commercial projects, as long as proper accreditation is given. The recent *Capcom Arcade Stadium* is able to use properly licensed code from current versions of MAME for this reason too. Community emulation ventures shouldn't be seen as at odds with the commercial market, but instead be seen as something that complements it – especially when we're dealing with material like this." ✱

Many thanks to all of the interviewees for their enthusiasm for answering endless questions.

MAME MILESTONES

KEY UPDATES IN THE QUEST TO PRESERVE HANDHELD ELECTRONIC GAMES

MAY 2017 0.186

G&W title *Mickey & Donald* was actually added to Release 0.164 in July 2015, as a non-working game. Here it is finally promoted to working, and included alongside *Boxing*, *Donkey Kong II* and *Mario's Cement Factory*. Several Konami handhelds are also added.

JULY 2017 0.188

The first batch of handheld games from Tiger Electronics are supported, including *Double Dragon*, *Gauntlet* and *Sonic*. More Konami games are added. In terms of G&W, *Mickey Mouse* and its clone *Egg* are now supported, and some titles receive vector backgrounds.

OCTOBER 2018 0.203

After a brief hiatus, support for the remaining G&W titles returns in earnest. This release sees perhaps the most popular game added, the original *Donkey Kong*, plus fellow Multi Screen title *Green House*. Over the next 12 months the bulk of G&W games are added.

AUGUST 2020 0.223

With support for the Micro Vs System title *Donkey Kong Hockey* added in this release, all 60 official G&W titles are working in MAME – an amazing achievement by all those involved. A number of items are still on the to-do list, but all of the games are now perfectly playable.

FEBRUARY 2021 0.229

MAME (and MESS before it) had included support for some Mattel Electronics games previously. More titles are added here, including *Hockey*, *Soccer* and *Basketball*. Work is underway on supporting the first ever handheld LED game, *Mattel Auto Race* from 1976.