In the Matter of

CERTAIN PERSONAL COMPUTERS AND COMPONENTS THEREOF

Investigation No. 337-TA-140

USITC PUBLICATION 1504

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United States International Trade Commission / Washington, D.C. 20436

UNITED STATES INTERNATIONAL TRADE COMMISSION

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CERTAIN PERSONAL COMPUTERS AND COMPONENTS THEREOF	Investigation No. 337-TA-140

COMMISSION ACTION AND ORDER

Procedural History

On January 31, 1983, Apple Computer Inc. (Apple) filed a complaint with the Commission under section 337 of the Tariff Act of 1930 (19 U.S.C. § 1337). On the basis of that complaint, the Commission instituted this investigation on March 2, 1983. The notice of investigation defined its scope as the determination of whether there is a violation of section 337 in the importation of certain personal computers and components thereof into the United States, or in their sale, by reason of alleged:

(1) Infringement of the claims of U.S. Letters Patent 4,136,359;

(2) Infringement of the claims of U.S. Letters Patent 4,278,972;

(3) Direct or contributory infringement of U.S. Copyright Reg. No. TX 873-203 and U.S. Copyright Reg. No. TX 886-569;

(4) Misappropriation of trade dress;

the effect or tendency of which is to destroy or substantially injure an industry, efficiently and economically operated, in the United States. On June 13, 1983, the Commission amended the notice of investigation to substitute "simulation of trade dress, trademark infringement, misappropriation of a property right, or passing off" for "misappropriation of trade dress."

The following firms were named respondents in the notice of investigation:

(1) Golden Formosa Microcomputer Co., Ltd. a/k/a Guan Haur Industrial Co. ("Guan Haur"), Taipei, Taiwan.

(2) Sunrise Computer Service Co., Ltd. ("Sunrise"), Taipei, Taiwan.

(3) Jardine Strauss International, Ltd. ("Jardine"), Taipei, Taiwan.

(4) Fantastic Merchandise Inc. ("Fantastic"), Taipei, Taiwan.

(5) A-Tek Enterprises Co., Ltd. ("A-Tek), Taipei, Taiwan.

(6) Leader Trading Co. ("Leader"), Kowloon, Hong Kong.

(7) Fuji Trading Co. ("Fuji"), Kowloon, Hong Kong.

(8) Reliant Engineering Co. ("Reliant"), Hong Kong.

(9) STC Limited ("STC"), Taipei, Taiwan.

(10) Yen Enterprises ("Yen"), Taipei, Taiwan.

(11) Business Computer Alliance Systems Co., Ltd. ("Business Computer"), Taipei, Taiwan.

(12) Microtronics, Singapore.

(13) Taiwan Machine Trading Co. ("TMT"), Philadelphia, Pennsylvania.

(14) North American Research Corp. ("NAR"), Arlington, Virginia.

(15) J.E. Computer Co., Ltd. ("JEC"), Taipei, Taiwan.

(16) Apollo Computer Co., Ltd. ("Apollo"), Taipei, Taiwan.

(17) Oriental Investments Ltd. ("Oriental"), Zurich, Switzerland.

(18) Collins International Trading Corp. ("Collins"), Encino, California.

(19) Formula International, Inc. ("Formula"), Hawthorne, California.

(20) Powtek Electronics Co., Ltd. ("Powtek"), Taipei, Taiwan.

On July 1, 1983, the notice of investigation was amended to add the following firm as a respondent: Syscom 2, Inc. ("Syscom"), Carson City, Nevada.

On July 29, 1983, the notice of investigation was amended to dismiss A-Tek, Microtronics, Powtek, and Fuji. The complaint was withdrawn as to Syscom.

At the prehearing conference, Apple abandoned its allegation of simulation of trade dress, trademark infringement, misappropriation of a property right, or passing off. Of the respondents, only Collins and Guan Haur participated in the evidentiary hearing before the presiding officer (ALJ). The ALJ issued her initial determination (ID) on December 9, 1983, finding that there is a violation of section 337. Complainant Apple, respondents Collins and Guan Haur, and the Commission investigative attorney petitioned for review of the ID.

On January 20, 1984, the Commission issued a notice that it had determined to review all issues presented in the investigation, including, but not limited to, the issues raised in the petitions for review of the ID. On February 10, 1984, the Commission held a hearing on the ID and on relief, the public interest, and bonding.

Action

Having reviewed the record and the arguments presented, the Commission has determined (1) that a violation of section 337 exists, (2) that a general exclusion order is the appropriate remedy, (3) that the public interest factors enumerated in section 337(d) (19 U.S.C. § 1337(d)) do not preclude issuance of a general exclusion order, and (4) that the bond during the Presidential review period should be in the amount of 200 percent of the entered value of the imported personal computers and components thereof.

Order

Accordingly, it is hereby ORDERED THAT--

1. Personal computers and components thereof which are made in accordance with any of the claims of U.S. Letters Patent 4,136,359 or U.S. Letters Patent 4,278,972 are excluded from entry into the United States except under license of the patent owner for the remaining term of the patent.

2. Personal computers and components thereof which incorporate computer programs substantially similar to the programs protected by copyright registration No.TX 873-203, or copyright registration No. TX 809-449, or copyright registration No. TX 886-569, including any supplementary copyright registrations relating thereto now outstanding, are excluded from entry into the United States except under license of the copyright owner for the remaining term of the copyright.

3. Personal computers and components thereof which are less than complete when imported but which include a motherboard identical to any motherboard of the Apple II series of personal computers which are the subject of this investigation are excluded from entry into the United States except under license of the owner of all the patents or copyrights in paragraphs (1) and (2) above.

4. Personal computers and components thereof which are less than complete when imported but which the U.S. Customs Service is satisfied are designed and intended to be employed by the owner, importer, consignee or agent of either to make a personal computer or component thereof which directly infringes any of the patents and copyrights in paragraph (1) or (2) above are excluded from entry into the United States except under license of the owner of the respective patents and copyrights in paragraphs (1) or (2) above.

5. It is the intent of this order (A) to remedy the violation of section 337 we have found (B) without disrupting lawful trade in personal computers and components thereof. Any beneficiary or any person adversely affected by this order may petition this Commission for a modification or clarification of the order to ensure that this intent is achieved. The Commission may also modify or clarify this order on its own motion.

6. The articles ordered to be excluded from entry into the United States shall be entitled to entry under bond in the amount of 200 percent of the entered value of the subject articles from the day after this order is received by the President pursuant to subsection (g) of section 337, until such time as the President notifies the Commission that he approves or disapproves this action, but, in any event, not later than 60 days after the date of receipt of this action; and

7. Notice of this Action and Order shall be published in the Federal Register.

By order of the Commission

Kenneth R. Mason
Secretary

Issued: March 9, 1984

VIEWS OF THE COMMISSION [1]

On January 20, 1984, the Commission determined to review the initial determination (ID) of the administrative law judge (ALJ) in Certain Personal Computers and Components Thereof, Inv. No. 337-TA-140. [2] The ALJ issued the ID on December 9, 1983, and determined that there was a violation of section 337 of the Tariff Act of 1930 [3] on the basis that: (1) the patents and copyrights involved are valid, enforceable and infringed; (2) there is an "industry, efficiently and economically operated, in the United States," within the meaning of section 337; and (3) the importation of the subject articles has the tendency to substantially injure that industry. [4]

We concur in the finding of a violation of section 337 on the basis that (1) the patents and copyrights involved are valid, enforceable, and infringed;

1/ The following abbreviations are used in this opinion:
ALJ = Administrative Law Judge;
ID = ALJ's Initial Determination;
CX = complainant's exhibit;
RX (respondent's name) = respondent's exhibit;
TR = transcript of evidentiary hearing before ALJ;
CTR = transcript of Commission hearing on ALJ's initial determination on violation and on remedy, public interest, and bonding;
CHB = complainant's prehearing brief for the Commission hearing;
RHB (respondent's name) = respondent's prehearing brief for the Commission hearing;
CPB = complainant's posthearing brief for the Commission hearing;
RPB (respondent's name) = respondent's posthearing brief for the Commission hearing.

2/ The Commission's review was conducted pursuant to Rule 210.54-.56, 19 C.F.R. § 210.54-.56.

3/ 19 U.S.C. § 1337.

4/ Patent and copyright infringement were the only alleged unfair practices remaining in the investigation at the time the ALJ issued the ID.

(2) there is an "industry, efficiently and economically operated, in the United States;" and (3) the importation of the subject articles has the tendency to substantially injure that industry. However, we have modified the ID in accordance with the standards adopted for review in our rules. 5/ We have found some conclusions of material fact clearly erroneous and some legal conclusions erroneous. Additionally, we have provided more complete reasoning in some instances where we have concurred in the finding of the ALJ.

PROCEDURAL HISTORY

On January 31, 1983, Apple Computer Inc. (Apple) filed a complaint with the Commission under section 337 of the Tariff Act of 1930. On the basis of that complaint, the Commission instituted this investigation on March 2, 1983. 6/ The notice of investigation defined its scope as the determination of whether there is a violation of section 337 in the importation of certain personal computers and components thereof into the United States, or in their sale, by reason of alleged:

(1) Infringement of the claims of U.S. Letters Patent 4,136,359;

(2) Infringement of the claims of U.S. Letters Patent 4,278,972;

(3) Direct or contributory infringement of U.S. Copyright Reg. No. TX 873-203 and U.S. Copyright Reg. No. TX 886-569; and

(4) Misappropriation of trade dress; 7/

5/ Rule 210.54-.56; 19 C.F.R. § 210.54-.56.

6/ 48 F.R. 9970 (March 9, 1983).

7/ On June 13, 1983, the Commission amended the notice of investigation to substitute "simulation of trade dress, trademark infringement, misappropriation of a property right, or passing off" for "misappropriation of trade dress." 48 F.R. 28563 (June 22, 1983). At the prehearing conference, Apple abandoned the allegation of simulation of trade dress, trademark infringement, misappropriation of a property right, or passing off. TR (Prehearing Conference, September 1, 1983) 7-9.

the effect or tendency of which is to destroy or substantially injure an industry, efficiently and economically operated, in the United States.

The following firms were named respondents in the notice of investigation:

(1) Golden Formosa Microcomputer Co., Ltd. a/k/a Guan Haur Industrial Co. ("Guan Haur"), Taipei, Taiwan.

(2) Sunrise Computer Service Co., Ltd. ("Sunrise"), Taipei, Taiwan.

(3) Jardine Strauss International, Ltd. ("Jardine"), Taipei, Taiwan.

(4) Fantastic Merchandise Inc. ("Fantastic"), Taipei, Taiwan.

(5) A-Tek Enterprises Co., Ltd. ("A-Tek"), Taipei, Taiwan.

(6) Leader Trading Co. ("Leader"), Kowloon, Hong Kong.

(7) Fuji Trading Co. ("Fuji"), Kowloon, Hong Kong.

(8) Reliant Engineering Co. ("Reliant"), Hong Kong.

(9) STC Limited ("STC"), Taipei, Taiwan.

(10) Yen Enterprises ("Yen"), Taipei, Taiwan.

(11) Business Computer Alliance Systems Co., Ltd. ("Business Computer"), Taipei, Taiwan.

(12) Microtronics, Singapore.

(13) Taiwan Machine Trading Co. ("TMT"), Philadelphia, Pennsylvania.

(14) North American Research Corp. ("NAR"), Arlington, Virginia.

(15) J.E. Computer Co., Ltd. ("JEC"), Taipei, Taiwan.

(16) Apollo Computer Co., Ltd. ("Apollo"), Taipei, Taiwan.

(17) Oriental Investments Ltd. ("Oriental"), Zurich, Switzerland

(18) Collins International Trading Corp. ("Collins"), Encino, California.

(19) Formula International, Inc. ("Formula"), Hawthorne, California.

(20) Powtek Electronics Co., Ltd. ("Powtek"), Taipei, Taiwan.

On July 1, 1983, the notice of investigation was amended [8/] to add the

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8/ 48 F.R. 31308 (July 7, 1983).

following firm as a respondent: Syscom 2, Inc. ("Syscom"), Carson City, Nevada. On July 29, 1983, the notice of investigation was amended to dismiss A-Tek, Microtronics, Powtek, and Fuji. 9/ The ID states that "the complaint was withdrawn" as to Syscom. 10/

Of the respondents, only Collins and Guan Haur participated in the evidentiary hearing. The ALJ issued the ID on December 9, 1983, finding that there is a violation of section 337. Complainant Apple, respondents Collins and Guan Haur, and the Commission investigative attorney petitioned for review of the ID. 11/

On January 20, 1984, the Commission issued a notice that it had determined to review all issues presented in the investigation, including, but not limited to, the issues raised in the petitions for review of the ID. 12/ On February 10, 1984, the Commission held a hearing on the ID and on relief, the public interest, and bonding.

PARTIES 13/

Complainant Apple is a California corporation having its principal place of business at 20525 Mariani Avenue, Cupertino, California 95014. Apple is the owner of the '359 and '972 patents and the copyrights in issue.

9/ 48 F.R. 35527 (August 4, 1983).

10/ The ID does not identify the respondent, but it is apparent from the record that it is Syscom. TR (Prehearing Conference, September 1, 1983) 4. The appropriate way to delete a respondent is by a motion to terminate leading to an initial determination granting the motion to terminate. We have determined to consider that such an initial determination has been made and consider it as part of the subject of this review. We approve the termination of Syscom as a respondent.

11/ Rule 210.54, 19 CFR § 210.54, governs petitions for review. The Commission may also order review on its own motion. Rule 210.55, 19 CFR § 210.55.

12/ 49 F.R. 3279 (January 26, 1984).

13/ This is limited to those parties who actually participated in the evidentiary hearing before the ALJ and who petitioned for review of the ID (other than the Commission investigative attorney).

Respondent Guan Haur is a Taiwanese company with its principal place of business at Basement 371, Jiin Jou Street, Taipei, Taiwan.

Respondent Collins is a California corporation with its principal place of business at 16311 Ventura Boulevard, Suite 500, Encino, California 91436.

PATENTS INVOLVED [14/]

1. The '359 patent

United States Letters Patent 4,136,359, entitled "Microcomputer For Use With Video Display," was issued January 23, 1979, to Stephen G. Wozniak. The patent was based on application Serial No. 786,197, filed April 11, 1977. The '359 patent is assigned to complainant Apple.

The '359 patent contains 8 claims, including independent claims 1 and 5. Claim 1 claims an improved timing apparatus in a microcomputer for use with a video display "whereby the color graphics on a raster scanned cathode ray tube are sharply defined in the vertical direction." Claim 5 claims an improved timing apparatus in a microcomputer for use with a video display device "whereby well-defined color graphics may be readily stored and displayed on said video display."

2. The '972 patent

United States Letters Patent 4,278,972, entitled "Digitally-Controlled Color Signal Generation Means For Use With Display," was issued on July 14, 1981, to Stephen G. Wozniak. The patent was based on application Serial No. 110,409, filed January 8, 1980, which was a continuation of application

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14/ The '359 patent and the '972 patent are reproduced in the Appendix.

Serial No. 910,125, filed May 26, 1978 (now abandoned), which was a division of application Serial No. 786,197, filed April 11, 1977 (now the '359 patent). The '972 patent is assigned to complainant Apple.

The '972 patent contains 11 claims, of which claims 1 and 8 are independent claims. Claim 1 claims a digitally controlled color signal generation means for use with a color video display adapted to receive color signals having a color subcarrier reference signal of frequency N, "whereby a color signal suitable for use with the video display is generated." Claim 8 claims a digitally controlled color signal generation means for use with a color video display adapted to receive color signals having a color subcarrier reference signal of frequency N, "whereby a color signal suitable for use with the video display is developed at an output of said sampling means."

COPYRIGHTS INVOLVED [15]

1. Registration No. TX 873-203

The copyright which is the subject of this registration is for a work entitled "Autostart ROM," a computer program. The deposit copy, which was introduced into evidence, is a hard copy printout in hexadecimal-coded machine language, i.e., each byte is represented as two hexadecimal numbers. [16] The program is 2048 bytes long, filling the hexadecimal-coded memory addresses F800 to FFFF.

15/ The U.S. Customs Service presently prohibits importation of computers which infringe the copyrights in issue under Part 133, Subpart E of the Customs Regulations, 19 C.F.R. Part 133, Subpart E, which relates to importations violating the copyright laws.

16/ The Autostart ROM program appears in machine and assembly language form in Apple's physical exhibit AH. TR 594-597.

The Autostart ROM program is an operating system program, as opposed to a translator or applications program. 17/ It is a relatively short program and, indeed, is actually a collection of about 70 shorter programs which are referred to as "subroutines." These subroutines or groups of these subroutines instruct the microprocessor to perform certain housekeeping functions. Like all operating system programs, the Autostart ROM program is used every time the computer is used, no matter what applications program is being run. For this reason, like many other operating system programs, it is permanently stored in "read-only memory," referred to as ROM. The machine language in which the Autostart ROM program is written is that used by the 6502 microprocessor; it cannot be used on any other type of microprocessor. 18/ ROM is incorporated in a ROM chip, of which there may be several in a given computer. The Autostart ROM program is stored on such a ROM chip, known as an F8 ROM, since for the 6502 microprocessor, it must be located in that area of memory, i.e., beginning at memory address F8, i.e., F800. 19/ In the Apple II+ the F8 ROM chip is located at approximately location F3 on the printed circuit board (PCB) or motherboard. 20/

17/ TR 561, 592, 597-599.

18/ The 6502 microprocessor is used in a number of computers made by different companies such as Apple, Atari, and Commodore. TR 541. The operating system programs for the Atari and Commodore are different from the Autostart ROM program. TR 550.

19/ TR 565.

20/ TR 565. There are five more ROM chips in the Apple II+ at approximately locations F11 to F4 on the motherboard; these ROM chips are denominated F0, E8, E0, D8 and D0 and are used to store the much longer Applesoft translator program described infra at p. 17. TR 566, 571. There are 2,048 bytes in the Autostart ROM; typically there are two bytes per instruction, making about 800 to 900 instructions in the program. TR 586. Applesoft has 12,000 bytes of information and thus more instructions. TR 586.

The Autostart ROM program is a derivative work, i.e., it is based on another work entitled "Apple II System Monitor" which is the subject of a separate copyright which has been registered as Registration No. TX 809-449. This latter copyright was not pleaded, but the registration certificate was introduced into evidence. This latter copyright is also the subject of a supplementary copyright registration, introduced into evidence without a deposit copy, Registration No. TX 904-121. The supplementary registration certificate states that approximately 20 percent of the Apple II System Monitor program was "previously published." Both of these underlying copyrights, i.e., Reg. Nos. TX 809-449 and TX 904-121, are owned by Apple.

The failure of Apple to plead infringement of the underlying Apple II System Monitor program copyright raises a question of whether the issue of infringement of the Autostart ROM program copyright is limited to the new material in the Autostart ROM program which distinguishes it from the Apple II System Monitor program. The ALJ found that since the Autostart ROM program is a derivative work, the Autostart ROM program copyright protects only the new material in the Autostart ROM program, notwithstanding Apple's ownership of both the Autostart ROM program copyright and the Apple II System Monitor program copyright. The ALJ further found that respondents "did not consent in any way to a broadening of the scope of the investigation to include the earlier Monitor program, although Apple apparently presented its evidence believing that the complete Autostart program was in issue." 21/ The ALJ

21/ ID 24.

thus found that the underlying Apple II System Monitor program copyright was not in issue.

While we agree with the ALJ that the Autostart ROM program copyright protects only the derivative work, we determine that the ALJ was in error in finding that Collins and Guan Haur did not consent to the broadening of the scope of the investigation. We find that the issue of infringement of the underlying Apple II System Monitor program copyright was litigated with the implied consent of Collins and Guan Haur. Thus, under Commission Rule 210.22(b), the question of the infringement of the Apple II System Monitor program copyright by Collins and Guan Haur should be treated as if raised in the pleadings and notice of investigation.

We read Apple's arguments as conceding that under section 103(b) of the Copyright Act of 1976 (17 U.S.C.§ 103 (b)) the copyright in a derivative work generally protects only the new material added to the preexisting underlying work and not the underlying work itself. Nevertheless, Apple argues that the copyright in a derivative work will protect both the new material added and the preexisting work as contained in the derivative work where the copyright claimant owns both the copyright in the derivative work and the underlying work. 22/ In support of this argument, Apple cites only one case under the Copyright Act of 1976, Mister B. Textiles, Inc. v. Woodcrest Fabrics, Inc., 523 F. Supp. 21 (SDNY 1981). The court's finding in Mister B was premised on the work involved, a fabric design, being "a unified artistic conception" which was "not amenable to being disassembled." Thus, Mister B is distinguishable from the facts in the instant investigation, since the

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22/ CPB 2.

Autostart ROM program is essentially a collection of separately identifiable subroutines. 23/

Apple and the Commission investigative attorney argue that under Commission Rule 210.22(b) the question of infringement of the entire Autostart ROM program should be treated as if it had been raised in the pleadings and notice of investigation because that question had in fact been litigated. Apple specifically refers to its Pre-Trial Memorandum and certain evidence which was introduced without objection at the hearing before the ALJ. 24/ Collins and Guan Haur argue that they had maintained throughout the proceedings before the ALJ that only two copyrights were involved, vitiating any argument of implied consent, and that the evidence which they permitted to be introduced without objection does not establish any implied consent. 25/

The record shows that for every named respondent which has not been terminated from this investigation, complainant Apple based its case of

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23/ In its posthearing brief, Apple argues that other courts have found infringement of the entire Autostart ROM program where only the Autostart ROM program copyright was pleaded, citing Apple Computer, Inc. v. Franklin Computer Corp., 714 F.2d 1240 (3d Cir. 1983), rev'g, 545 F. Supp. 812 (E.D. Pa 1982) and Apple Computer, Inc. v. Formula International, Inc., 562 F. Supp. 775 (C.D. Cal. 1983). While infringement was pleaded in these cases, both decisions relate to the issue of copyrightability in the context of a motion for preliminary injunction. The issue discussed above was not involved in these decisions.

24/ CHB 55-63. See, e.g., TR 592, 614-616, 619-629, 655-665, 681, 807-810.

25/ RHB (Collins) 28-35; RHB (Guan Haur) 4-10. Guan Haur also argues that the nonparticipating respondents could not have implicitly consented to the litigation of the issue of infringement of the Apple II System Monitor copyright and that to treat the complaint and notice of investigation as having been amended to include this issue would deprive these nonparticipating respondents adequate notice. We do not find it necessary to reach this issue since such respondents have been found to have engaged in unfair acts not involving the System Monitor copyright.

copyright infringement on the entire Autostart ROM program. 26/ With one exception, it is undisputed that the entire, or almost the entire, Autostart ROM program was copied by every respondent. The one exception is Collins, which copied substantial portions, including portions covered exclusively by the Apple II System Monitor copyright. 27/ Further, the introduction of evidence of copying by Collins of 23 subroutines in the Autostart ROM program 28/ is consistent only with the litigation of infringement of the underlying copyright, because these subroutines are protected only by the Apple II System Monitor copyright. Collins and Guan Haur, which were undoubtedly aware that such evidence related to the Apple II System Monitor program, did not object to the introduction of this evidence.

We find that the reception of evidence of copying based on the entire Autostart ROM program establishes implied consent to the litigation of the issue of the Apple II System Monitor copyright. The admission of evidence without objection as to an unpleaded issue indicates implied consent. 29/ We also find that the Apple II System Monitor copyright is reasonably within the scope of the pleadings and notice because it is the underlying work. It is also owned by Apple, and was specifically referred to in the registration certificate for the Autostart ROM copyright which was pleaded and noticed. Thus, our analysis of copyright infringement is based on our finding that the

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26/ See discussion, infra, 21-36.
27/ See discussion, infra, 31-36.
28/ See discussion, infra, 33-34.
29/ This is the rule applied by Federal courts. See, Federal Rule of Civil Procedure 15(b), which is analogous to Commission Rule 210.22(b), 3 Moore's Federal Practice, para. 15.13 [2], pp. 15-174 (2d ed.).

question of infringement of the Apple II System Monitor program copyright is within the scope of this investigation as to Guan Haur and Collins. 30/

2. Registration No. TX 886-569

The copyright which is the subject of this registration is for a work entitled "Applesoft," a computer program. The program is approximately 12,000 bytes long. 31/ Applesoft is an interpreter program; it translates the high level language BASIC to machine language which the 6502 microprocessor can understand. 32/ Usually this means taking a single high level instruction and converting it into several, perhaps 50-100, machine language instructions. 33/ The Applesoft program is stored in 5 ROM chips referred to as FO, E8, EO, D8 and DO, which correspond to the addresses of the particular ROM chip. There are other interpreter programs for BASIC which perform the function of Applesoft, but none of these can be used with the Apple II series. 34/

PRODUCTS INVOLVED

Complainant Apple

Apple's products subject to this investigation are all complete personal computers: the Apple II, Apple II+, Apple IIe and Apple III. The Apple II

30/ See discussion infra, 21-36.
31/ The deposit copy for this registration, introduced into evidence, was a hard copy printout, but was missing 4096 bytes. TR 607. These were the subject of an additional copyright registration which was introduced into evidence along with a deposit copy of the complete Applesoft program. However, as the result of respondents' objections, infringement was decided by the ALJ on the basis of the incomplete deposit copy which accompanied the earlier registration. This was not contested by Apple. ID 20; TR 607-609.
32/ TR 605.
33/ TR 606.
34/ TR 609.

and Apple II+ are no longer being manufactured, however. The Apple II, Apple II+, and Apple IIe incorporate the patented inventions and have ROM chips incorporating the Applesoft and Autostart ROM programs. The Apple III incorporates the patented inventions, but does not incorporate the Applesoft and Autostart ROM programs.

Respondents

With the exceptions noted, the involved products of respondents are all complete personal computers.

a. Guan Haur

Golden II personal computer. 35/

Orange KP-4006A personal computer. 36/

Orange KHP-4006A personal computer. 37/

ROMless Golden II personal computer. 38/

b. Sunrise

Apollo APCOM personal computer. 39/

c. Jardine

APCOM personal computer. 40/

35/ TR 620.
36/ TR 625.
37/ TR 627.
38/ CHB. APP. I; TR 644.
39/ TR 624.
40/ TR 629.

d. Fantastic

Newton personal computer. 41/

Syscom II personal computer. 42/

e. Leader

Computer Kit (unstuffed motherboard). 43/

f. Reliant

AP II SKB-53 personal computer. 44/

AP II personal computer. 45/

g. STC

STC II TK-4000 personal computer. 46/

h. Yen

Yen 6502 personal computer. 47/

i. Business Computer

We have found no computer or computer component associated with this respondent to have been introduced at the evidentiary hearing; nor have we discovered any testimony by Apple's expert witness with regard to a computer or component associated with this respondent. No such evidence is listed in Apple's prehearing brief. 48/

41/ TR 623.
42/ CHB. APP. I.
43/ CHB. APP I.
44/ TR 625.
45/ TR 626.
46/ TR 625.
47/ TR 622.
48/ See CHB. APP I. This is a failure to prosecute; we therefore make no finding with respect to this respondent.

j. TMT

While no TMT personal computer was introduced at the hearing, Apple's expert witness did testify with regard to a certain TMT computer seized by the U.S. Customs Service. 49/

k. NAR

ROMless MIND II personal computer. 50/

l. JEC

AMI III JEC 821A personal computer. 51/

m. Apollo

AMI II Plus Plus personal computer. 52/

AMI II personal computer. 53/

n. Oriental

AMI II Plus Plus personal computer. 54/

AMI II personal computer. 55/

AMI II JEC 821A personal computer. 56/

49/ CHB. APP I.
50/ CHB. APP I; TR 645.
51/ TR 621, TR 627.
52/ TR 620.
53/ TR 622.
54/ TR 620.
55/ TR 622.
56/ TR 623.

o. Collins

Orange + personal computer. 57/

Orange + Two personal computer. 58/

p. Formula

Vectorio personal computer. 59/

Computer Kit (unstuffed motherboard). 60/

COPYRIGHT VALIDITY

The copyrights, including the Apple II System Monitor copyright, were registered within five years of publication of the copyrighted works and are thus presumed valid. 61/ Their validity is not disputed here.

DIRECT COPYRIGHT INFRINGEMENT

Our finding of direct copyright infringement is consistent with that of the ALJ. However, we identify the specific respondents and products involved in the discussion below.

A prima facie case of copyright infringement is established by showing ownership of the copyrights by Apple and copying by the respondents. The latter may be shown by access and substantial similarity. 62/ The registration certificates prima facie establish Apple's ownership of the

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57/ TR 628.
58/ Apple Physical Exhibit AO.
59/ TR 628.
60/ CHB. APP I.
61/ 17 U.S.C. § 410(c).
62/ Atari, Inc. v. North American Consumer Electronics Corp., 672 F.2d 607 (7th Cir. 1982).

copyrights; moreover, Apple's ownership is not disputed. 63/ Certainly, all respondents have had access to the copyrighted works since they have been embodied in commercially available Apple computers for some time. The registration certificates, which are presumptively accurate, state that the Apple II System Monitor program was first published in 1977, that the Autostart ROM program was first published in 1979, and that the Applesoft program was first published in 1978. The virtual identity of the programs as noted below is more than enough to establish substantial similarity.

Apple's expert witness, Dr. Hulina, 64/ testified that by means of a test program which he had devised, he had compared the contents of the ROM chips of respondent's personal computers with the contents of the ROM chips of his own Apple computer, which contained the copyrighted programs. 65/ The validity and results of the tests were not disputed. 66/ With regard to his comparisons, he testified as follows:

1. Guan Haur

Golden II

The Golden II ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs, except for five bytes which caused the name Golden II to appear on the screen instead of the name Apple. 67/

63/ 17 U.S.C. § 410(c).
64/ Dr. Paul T. Hulina, Associate Professor of Electrical and Computer Engineering, Pennsylvania State University. Apple Exhibit 1.
65/ TR 611-619.
66/ TR 629-630.
67/ TR 620-621.

Orange KP-4006A and KHP-4006A

The Orange KP-4006A and KHP 4006A ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs. 68/

2. Sunrise

Apollo Apcom

The Apollo Apcom ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs, except for 18 bytes in the Autostart ROM program, which caused a name different from the name Apple to appear on the screen. 69/

3. Jardine

APCOM

The APCOM ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs except for one byte in the Autostart ROM program which was attributed to a programming error. 70/

4. Fantastic

Newton

The Newton ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs, except for 18 bytes in the Autostart ROM program , which caused a name different from the name Apple to appear on the screen. 71/

68/ TR 625-66; TR 627.
69/ TR 624.
70/ TR 629.
71/ TR 623-624.

Syscom II

The Syscom II ROM chips contained a program which is identical to the Autostart ROM program, but contained only "garbage" in those ROM chips where an Applesoft-type program might have been expected. 72/

5. Reliant

AP II SKB-53

The APII SKB-53 ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs. 73/

AP II

The AP II ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs except for 9 bytes in the Autostart ROM program, which caused a name different from the name Apple to appear on the screen. 74/

6. STC

STC II TK-4000

The STC II TK-4000 ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs, except for six bytes in the Autostart ROM program. Five of these six different bytes caused a name different from the name Apple to appear on the screen. The difference in the sixth byte was attributed to a programming error. 75/

72/ TR 806-808.
73/ TR 625.
74/ TR 626-627.
75/ TR 625.

7. Yen

Yen 6502

The Yen 6502 ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs except for eight bytes in the Autostart ROM program which caused a name different from the name Apple to appear on the screen. 76/

8. TMT

The TMT ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs. 77/

9. JEC

AM III JEC 821A

The AM III JEC 821A ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs, except for 88 bytes in the Autostart ROM program. Eight of the 88 different bytes caused a name different from the name Apple to appear on the screen. The remaining 80 different bytes were not different at all; the difference was due to shifting, i.e., the same 80 bytes were shifted to different positions within the program. 78/

10. Oriental

AMI II Plus Plus

The AMI II Plus Plus ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs, except for 10 bytes. Nine of these

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76/ TR 622.
77/ TR 810-815.
78/ TR 621, 627.

different bytes caused the name AMI II Plus Plus to appear on the screen instead of the name Apple. The tenth byte was one "where they changed one position out of eight in that byte to take care of upper and lower case on the keyboard." 79/

AMI II

The AMI II ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs, except for seven bytes in the Autostart ROM program which caused a name different from the name Apple to appear on the screen. 80/

AMI III JEC 821 A

The AMI III JEC 821 A ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs, except for 88 bytes in the Autostart ROM program. Eight of those 88 bytes caused a name different from the name Apple to appear on the screen. The difference in the other 80 bytes was due to shifting.

11. Collins

Orange +

The Orange + ROM chips contained programs which were identical to the Applesoft and Autostart ROM programs, except for 8 bytes which caused the name Orange to appear on the screen instead of the name Apple. 81/

79/ TR 620.
80/ TR 622.
81/ TR 628-629.

Orange + Two

As imported, this computer is complete, but its ROMs do not contain an infringing program. However, such a program is alleged to be incorporated after importation. Therefore, the Collins Orange + Two is discussed separately. 82/

In view of the foregoing evidence, which was undisputed, we find that all the foregoing complete personal computers directly infringe the Autostart ROM and Applesoft copyrights (except for the Syscom II which does not contain the Applesoft program). Guan Haur and Collins (Orange +) directly infringe the underlying Apple II System Monitor program copyright as well. As noted above, the Collins Orange + Two is the subject of a separate discussion.

CONTRIBUTORY COPYRIGHT INFRINGEMENT

The ALJ found contributory copyright infringement with regard to ROMless computers and motherboards which Apple had established were associated with parallel importations of infringing ROM chips. 83/ However, the ALJ found that for all other ROMless computers and motherboards, contributory copyright infringement could not be found because of the availability of non-infringing copies of the Applesoft or Autostart ROM programs from Apple or other suppliers. We agree with the ALJ's former finding, but find the latter clearly erroneous, for the reasons discussed below.

82/ See discussion infra at 31.
83/ ID 26-30.

In Sony Corporation of America v. Universal City Studios, Inc., --U.S.--(1984), slip opinion at 17, 84/ the Supreme Court stated that contributory copyright infringement "is merely a species of the broader problem of identifying the circumstances in which it is just to hold one individual accountable for the actions of another." As a general rule, a contributory infringer is one who with knowledge of the infringing activity, induces, causes or materially contributes to the infringing conduct of another. 85/ Knowledge includes reason to have knowledge. 86/ However, where the contributory infringement is alleged to lie in the sale or distribution of an article, it will not be found if that article is capable of commercially significant non-infringing uses. 87/ Of course, there must first be a finding that direct copyright infringement is occurring.

Dr. Hulina testified with regard to several ROMless computers and motherboards. 88/ Among these were the ROMless Guan Haur Golden II computer and the ROMless NAR MIND II computer. 89/ Dr. Hulina testified that the

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84/ The Sony case was decided after the ALJ issued her ID.

85/ Gershwin Publishing Corp. v. Columbia Artists Management, Inc., 443 F.2d 1159 (2nd Cir. 1971).

86/ Screen Gems-Columbia Music, Inc. v. Mark-Fi Records, Inc., 256 F. Supp. 399 (SDNY 1966).

87/ Sony, supra at 23.

88/ Some of these computers and motherboards are not identified with any respondent remaining in this investigation. At the Commission's hearing, counsel for Apple stated that Apple was not requesting an adjudication with respect to these computers and components, although counsel stated such evidence might be relevant to injury. CTR 87-88. The question of whether an adjudication with regard to computers and motherboards which are not identified as a particular product of any respondent named in the notice is not one that must be decided in this case, since there are ROMless computers or motherboards in the record which are identified with particular respondents. In any event, this evidence is pertinent to the issue of remedy.

89/ TR 643.

motherboards for these computers, which apparently are identical to Apple II series motherboards, had room for sockets for six ordinary ROM chips, but had sockets for 3 large 2732 EPROM chips. 90/ Dr. Hulina testified that these EPROM chips contain twice as much information as ordinary ROM chips, and their use as a substitute is a well-known expedient. 91/ He also testified that other than the Apple programs, he knew of no presently available programs which could be placed in those ROM chips to make these computers, or computers like them, useful. 92/ Dr. Hulina testified similarly with regard to the Formula/Leader motherboard. 93/ The foregoing evidence is sufficient to imply the existence of direct copyright infringement by at least third parties, 94/ i.e., copying of the copyrighted programs onto ROM chips and their insertion into the ROMless computers and motherboards. Persons who import or sell ROMless computers or components with identical motherboards have reason to know that activity which results in such direct infringement is occurring or will occur.

Finally, such ROMless computers and components are not capable of a commercially significant non-infringing use. The Commission investigative attorney argues that the availability of the Applesoft program on disk from

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90/ TR 643-645.
91/ TR 643-644.
92/ TR 644-645 and see, TR 634.
93/ TR 647.
94/ This is the same approach the courts take with regard to contributory and induced patent infringement. See, Bergstrom v. Sears, Roebuck and Co., 496 F. Supp. 476 (D. Minn. 1980). This is within the partial analogy of contributory infringement in patent and copyright law mentioned in Sony, supra at 20-23.

Apple or others indicates that at least with regard to the Applesoft program, ROMless computers and components in general have a substantial non-infringing use. 95/ Guan Haur would go even further and include the Autostart ROM program as well, which is still available as part of one or more card inserts formerly manufactured by Apple and still available from inventory of some distributors and retailers. 96/ The mere availability of these programs, however, does not avoid contributory copyright infringement; it does not provide sufficient probative evidence of any commercially significant use of these Apple program cards or disks in conjunction with an imported unstuffed motherboard or ROMless computer to make a fully operational computer.

Apple argues that in addition to finding that ROMless computers and components having identical motherboards contributorily infringe the copyrights, the Commission should also find that ROMless computers and components having motherboards which are not identical to the Apple motherboard contributorily infringe the copyrights. 97/ We have found no expert testimony in the record with regard to this and no such ROMless computers or motherboards have been placed in the record. 98/ We therefore decline to make such a finding. 99/

95/ Commission investigative attorney prehearing brief, 36-47.

96/ RHB (Guan Haur) 10-21.

97/ There is some evidence that ROMless computers and motherboards are being imported which have no place for the insertion of the ROM chips *per se*, but rather have means to accept separate ROM cards, shipped separately, on which the infringing ROMs are placed. CHB 92-95.

98/ Even if such evidence were of record, it might be inappropriate to draw the same presumption of knowledge of infringing activity with regard to these ROMless computers and components as we have drawn for those with motherboards identical to the Apple motherboard.

99/ However, this does not mean that the evidence we do have, showing the possibility of evasion, cannot be considered in fashioning a remedy. *See* discussion *infra* at 44. Further, any exclusion order covering the copyrights would exclude the above-mentioned infringing ROM cards.

COPYRIGHT INFRINGEMENT (ORANGE + TWO)

The ALJ found contributory infringement of the Autostart ROM program by the Orange + Two, but found no infringement of the Applesoft program copyright. 100/ The ALJ's finding of contributory copyright infringement was based on a finding of direct infringement by the "DeBono ROM" or "EuroROM" program which is inserted in the Orange + Two by Collins after importation. As discussed previously, the ALJ's finding of copyright infringement was based only on the Autostart ROM program copyright. 101/ Since we have found that limiting the question of infringement to the Autostart ROM program copyright was erroneous with regard to Collins, 102/ we determine the question of infringement on the basis of both the Autostart ROM program and Apple II System Monitor program copyrights.

Apple does not argue that the Collins Orange + Two, as imported, contains ROM chips with infringing copies of any of its copyrighted programs. Rather, Apple alleges that after importation, Collins fits the Orange + Two with a ROM chip which is programmed in the United States with the "DeBono ROM" or "EuroROM" program which Apple alleges infringes its Autostart ROM program copyrights.

We read Apple's argument to be that Collins' acts constitute acts of direct copyright infringement. At the Commission hearing, counsel for Apple stated that Apple was not relying on use by ultimate purchasers of the Orange +

100/ Apple does not allege that the Orange + Two contains an infringing copy of the Applesoft program, and it seems clear from the record that it does not. TR 681-683.

101/ See discussion supra at 13.

102/ See discussion supra, 11-17.

Two as an act of direct infringement, although he argued that it could rely on it if it had chosen to do so. 103/ Apple relies on acts of direct infringement of the Autostart ROM copyrights in (1) the copying of the DeBono ROM program onto the ROM chips in the United States which are eventually inserted into the Orange + Two computer and (2) the sale of the DeBono ROM program as part of the sale of the Orange + Two computer in the United States by Collins. In other words, the acts of direct infringement are those of both Apple's reproduction rights and its distribution rights under 17 U.S.C. § 106(1) and § 106(3), respectively.

The pivotal question then is whether the DeBono ROM program infringes Apple's Autostart ROM copyrights. It is not disputed that the DeBono ROM program contains about 367 bytes of the Autostart ROM program on a location-by-location basis; this amounts to about 18 percent of the Autostart ROM program. 104/ Dr. Hulina also testified that when shifting of instructions from one location to another is taken into account, about 25 percent of the Autostart ROM program is found in the DeBono ROM program. 105/

In addition to the byte-by-byte comparison, Dr. Hulina testified that he had disassembled the DeBono ROM program and retranslated it into assembly language. This assembly language translation was compared with 32 monitor subroutines for the Autostart ROM program in the Apple reference

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103/ CTR 102-105.
104/ ID 34; TR 878, 1726.
105/ ID 34; TR 660-661, 2509.

manual. 106/ These 32 subroutines (of the approximately 70 in the Autostart ROM program) are said by Apple to be the most useful. 107/ At the hearing before the ALJ, Dr. Hulina also referred to a printout of the DeBono ROM program in the Collins Orange + Two Temporary Reference Manual in testifying about these 32 subroutines. 108/ Of these 32 subroutines, he stated that 23 were identical or nearly identical to subroutines in the Collins DeBono ROM program, some of these being located at the same memory addresses and even having the same title. 109/ He also testified that it was not

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106/ TR 657-660; Apple Physical Exhibit AH.

107/ CHB 67.

108/ TR 661ff; Apple Physical Exhibit 76.

109/ TR 659-661. A comparison was made between the subroutines in assembly language in the Apple and Collins reference manuals. TR 664. One of these was the PLOT subroutine which was said to be identical except for two interchanged instructions. TR 667-668 (but see TR 672). The subroutine SETINY (sic) has "one location that has been changed between the two," but "this makes no difference." TR 669. The subroutines CROUT and CROUT 1 were said to be identical and to appear in the same place in memory. TR 669. The subroutine PRBYTE was said to have a single substituted instruction of "no effect." TR 669. The subroutine PRNTAX was said to be identical and in the same place in memory. TR 669. The subroutine PRNBLNC was said to be identical. TR 670. The subroutine BELL 1 was said to omit an instruction which is "nothing." TR 670. The subroutine RDKEY was said to have two transposed instructions with "no change in what the subroutine does." TR 670. The subroutine WAIT was said to be identical and in the same place in memory. TR 670. In the subroutine SET COL one byte was said to have been changed. TR 670. In the subroutine NEXT COL, "Two instructions were transposed without effect." TR 671. In the subroutine H LIN, "there has been one change in the instruction there with no effect in the performance." TR 671. The subroutine VLIN was said to be identical and in the same place in memory. TR 671. The subroutine PREAD is "identical except for interchanging two instructions." TR 671. The subroutine PR ERR was said to be identical and in the same place in memory. TR 671. As to the subroutines IO SAVE and IO REST, "Except again for reordering some instructions, they are the same." TR 671.

possible that these 23 subroutines were written independently, i.e., without copying. 110/

As previously noted, ownership and copying establish a prima facie case of copyright infringement. 111/ There is no question of Apple's ownership of the Autostart ROM program copyrights. Copying may be found from access and substantial similarity. There is no question that Collins had access to the copyrighted programs. As to substantial similarity, this does not require complete identity. Substantial similarity has been found in numerous instances where the similar material is quantitatively quite small, particularly if that material is qualitatively important. 112/ Sufficient similar material is involved here, and that material appears to be qualitatively significant, since it includes 23 of the 32 most useful subroutines of the approximately 70 subroutines in the Autostart ROM program. Thus, Apple has made a prima facie case of infringement of its Autostart ROM program copyrights by the Collins DeBono ROM program.

Collins raises the defense that the DeBono ROM program was the product of independent creation, citing Mazer v. Stein, 347 U.S. 201, 218 (1954) and Miller v. Universal City Studios, Inc., 650 F.2d 1365, 1375 (5th Cir. 1981).

110/ ID 34; TR 673.

111/ See discussion supra at 21.

112/ For example, infringement has been found where the defendant broadcast one seven or twelve second segment and one two-and-a-half minute segment of plaintiff's 28 minute-long copyrighted film. Iowa State University Research Foundation, Inc. v. American Broadcasting Cos., Inc., 463 F. Supp. 902 (SDNY 1978), aff'd., 621 F.2d 57 (2nd Cir. 1980).

However, the individuals who developed the DeBono ROM program for Collins actually used the Autostart ROM program as part of that development. 113/ Since Mazer suggests, and Miller expressly states, that independent creation means creation without reference to the copyrighted work, we find that Collins has not rebutted the prima facie case of infringement of Apple's Autostart ROM copyrights. 114/

Collins also argues that the entry points or addresses of the various subroutines are not protectible expressions, but admits that the subroutines are protectible expressions. 115/ Collins argues that because there are only a small number of ways to express a subroutine intended to perform a particular function, substantial similarities must be expected and will be tolerated by the law. Consequently, there will be no liability for copyright infringement. 116/ However, we find that the testimony of Dr. Hulina as to copying to be more credible. 117/

113/ TR 2392-2396, 2409-2410, 2455.

114/ Collins cites several cases which condone reference to a copyrighted work in creating another work, e.g., Hoehling v. Universal City Studios, Inc., 618 F.2d 972 (2nd Cir. 1980); Sheldon v. Metro-Goldwyn Pictures Corp., 81 F.2d 49 (2nd Cir. 1936), and Synercom Technology, Inc. v. University Computing Co., 462 F. Supp. 1003 (N.D. Tex. 1978). Those who use a prior copyrighted work to develop their own may find the defense of independent creation very difficult to establish if accused of infringement and may well have to rely on other available defenses. In any event, the line of cases referred to by Collins condones the use of prior works only for ideas and facts, which are not copyrightable, as opposed to the expression of those ideas and facts, which is copyrightable. It is the latter which is at issue here.

115/ RHB (Collins) 45-46.

116/ RHB (Collins) 46-47.

117/ See, e.g., TR 870, 2518.

Having found that the DeBono ROM program infringes the Autostart ROM program copyrights, we turn to certain other arguments made by Collins. Collins argues that since the DeBono ROM program ROM chip is inserted by Collins in the Orange + Two computer after importation, the Commission lacks subject matter jurisdiction. 118/ Such an argument ignores the fact that the copying of the DeBono ROM program takes place only because there is an Orange + Two computer to insert it in, and the DeBono ROM is an integral part of the Orange + Two when it is sold by Collins. The importation of the Orange + Two is thus a step in the direct infringement of both the reproduction rights and the distribution rights of Apple in its Autostart ROM program copyrights. The sale of the Orange + Two by Collins in the United States is a direct infringement of Apple's distribution rights in its Autostart ROM program copyrights because at the time of sale the DeBono ROM program is an integral part of the Orange + Two. 119/ 120/

PATENT VALIDITY

The patents are presumed valid under 35 U.S.C. § 282, and their validity is not contested here.

118/ RHB (Collins) 25-27.

119/ Because we have found that the importation or sale of the Orange + Two by Collins is a direct infringement or at least part of the act of direct infringement of Apple's Autostart ROM copyrights, we do not reach Collins' argument that the Orange + Two does not contributorily infringe those copyrights.

120/ As mentioned previously, the supplementary copyright registration for the Apple II System Monitor program states that 20 percent of the Apple II System Monitor program was previously published. See discussion, supra at 13. The significance of this is a matter of defense requiring evidence not of record.

DIRECT PATENT INFRINGEMENT

The ALJ found that a number of personal computers infringed both the '359 and '972 patents. We agree. The evidence, which is undisputed, is adequate to support a finding of direct infringement of both patents by the respondents referred to above with the exception of the Formula/Leader motherboard and the Orange + Two, which are discussed separately below. 121/

Dr. Hulina testified that he had made a wiring list by taking figure 3 of both patents (Apple Exhibit AI), and using a meter, had checked the circuits of respondents' computers for continuity. With the exception of the Collins' Orange + Two and the Formula/Leader unstuffed motherboard, every personal computer of every respondent named above was found to have circuitry identical to that figure. 122/ Figure 3 was shown to include the elements of all claims of the '359 patent. 123/

With the exception of the Collins Orange + Two and the Formula/Leader unstuffed motherboard, Dr. Hulina testified that every personal computer of every respondent named above had "the same as Apple's color circuits" 124/ and "infringed" 125/ all the claims of the '972 patent. 126/

121/ 35 U.S.C. § 271.
122/ TR 711-719; TR 810-815.
123/ TR 707-710; TR 784-TR 793.
124/ There were some variations which were testified to as minor and not affecting identity with the claims. TR 771-772, TR 773, TR 774, TR 776-777, TR 779-780.
125/ It is clear that Dr. Hulina did not intend to testify as to this legal conclusion. We understand his use of the term "infringe" to mean correspondence to the claims.
126/ TR 770-783; TR 810-815.

Of those respondents' personal computers which were operable, all produced color, and Apple's expert witness testified that the remainder would produce color if they had been operable. 127/

CONTRIBUTORY/INDUCED PATENT INFRINGEMENT (FORMULA/LEADER)

The ALJ made a finding of patent infringement with regard to ROMless computers, but found that there was no evidence that computer kits (unstuffed motherboards) infringe the patents. We find this to be clearly erroneous.

Dr. Hulina testified that the Formula/Leader unstuffed motherboard was labeled with the names of parts which, if properly inserted, would infringe the claims of the '359 patent and that the motherboard had no other substantial use. 128/ Dr. Hulina's testimony is undisputed. Since it is clear that this labelled identical motherboard is not a staple article of commerce having a substantial noninfringing use, we find contributory infringement of the '359 patent. Since the labelling is clearly intended to be followed, we find inducement to infringe the '359 patent, as well. It is not necessary that an actual instance of the prerequisite direct infringement have been identified, since in these circumstances, direct infringement by third parties may be implied. 129/

PATENT INFRINGEMENT (ORANGE + TWO)

The ALJ found, by giving weight to the "whereby" clauses of the patent claims, that the Orange + Two does not directly infringe those claims. She

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127/ TR 722-725.
128/ TR 719-721.
129/ See, Bergstrom v. Sears, Roebuck and Co., 496 F. Supp, 476 (D. Minn. 1980).

did find, however, that Collins had induced infringement of the patents. We find her finding of no direct infringement erroneous.

The Orange + Two is a dual processor computer; it contains a 6502 microprocessor like the Apple and also a Z-80 microprocessor. 130/ Dr. Hulina testified that it has color video circuits which are identical to those of the Apple II+ except that (1) the inputs to the multiplexers have been switched, (2) the chip at location C-1 of the Apple II is at location E-3 in the Orange + Two but is "wired in . . . exactly the way the chip C-1 would be wired in the Apple machine," and (3) a chip is missing. 131/ 132/ These differences are said to be meaningless as far as the claims are concerned. The Orange + Two, as imported, generates a color signal internally. 133/ However, because a switch is missing (this is the "missing chip" referred to above), no color display is seen on a video monitor. 134/

Collins argues that the "whereby" clauses of the patents require the display of color graphics and that the Orange + Two does not display color graphics. 135/ Collins also argues that even if no weight is given to the "whereby" clauses, the production of only black and white graphics places it within the "reverse doctrine of equivalents," avoiding a finding of direct infringement. 136/ Apple argues that no weight should be given to the "whereby" clauses of the patents because the whereby clauses express only a

130/ TR 815-819.
131/ TR 819-825; ('359 patent) 836-849; ('972 patent) 849-860.
132/ TR 824.
133/ TR 825.
134/ TR 825-835.
135/ RHB 53-57.
136/ Id.

necessary result of the elements of the body of the claims, and thus add nothing to the claims. Apple also argues that the "reverse doctrine of equivalents" does not apply. 137/

Apple's interpretation of the case law is well founded. "Whereby" clauses are given no weight if they express only a necessary result of the structure already recited in the body of the claims. 138/ A study of the "whereby" clauses here indicates that they express only a necessary result. Thus, they should be given no weight in determining infringement. On that basis, the Orange + Two directly infringes the claims of both patents unless the "reverse doctrine of equivalents" applies.

We find that the "reverse doctrine of equivalents" does not apply, because there is in reality no change in principle as required under that doctrine. 139/ It simply appears that a switch is missing in the Orange + Two which prevents that result from being demonstrated in the same way as it is demonstrated in the Apple computer. In addition, it is clear that because the circuitry is identical, the same principle must be operative. 140/

137/ CHB 25-44.

138/ See, Parker v. Brown & Root, 198 F. Supp. 795 (S.D. Tex 1961).

139/ See, Westinghouse v. Boyden, 170 U.S. 537 (1898).

140/ There is no dispute that when the "missing chip" is inserted even the "whereby" clauses are met. Even if the "missing chip" were not actually shown to have been inserted by a particular purchaser, direct infringement by at least third parties may be implied. Bergstrom v. Sears, Roebuck and Co., 496 F. Supp. 476 (D. Minn. 1980). Therefore, inducement to infringe can be found even in the absence of a finding of a specific instance of direct infringement. There is evidence of active inducement by Collins, e.g., the existence of a socket specifically for the "missing chip" is inconsistent with anything but that the chip would be inserted, and the testimony is that it is not difficult to discover that the chip should be inserted to achieve the results desired.

INDUSTRY

We concur with the ALJ that there is an "industry . . . in the United States," within the meaning of section 337, and that the industry is composed of those portions of Apple Computer Inc. devoted to Apple II and Apple III series personal computers.

The Commission has a longstanding practice of defining the domestic industry in terms of the involved intellectual property right. 141/ In this investigation, the patented and copyrighted elements are essential components of the personal computer. The Autostart ROM program, in particular, is an operating system program which is used every time the computer is used. In fact, the computer cannot be used without it. 142/ The article of commerce involved here is the complete personal computer. Thus, for the purposes of assessing injury under section 337, the industry should be defined in terms of such complete computers.

The fact that Apple's operations in the United States related to the personal computers at issue constitute a domestic industry within the meaning of section 337 is strongly supported by past Commission decisions. 143/ There is no real dispute about what complainant Apple actually does in the United States. Research and development as well as engineering support for the products at issue are carried out by Apple in Cupertino, California, in a

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141/ See, e.g., Certain Molded-In Sandwich Panel Inserts and Methods for their Installation, Inv. No. 337-TA-99 (1982), and cases cited therein.

142/ TR 635.

143/ Compare Certain Miniature, Battery-Operated, All Terrain, Wheeled Vehicles, Inv. No. 337-TA-122 (1982).

facility which employs approximately persons. 144/ The keyboard assembly, an integral part of the Apple personal computer, is manufactured and assembled by Apple in Garden Grove, California, employing approximately persons. 145/ of the custom integrated circuit chips and approximately of the random access memory chips for the Apple IIe are obtained from U.S. companies. percent of the manufacture of those chips is done in the United States. 146/ Other parts for the assembly of the computer including the housing, lid, base, pan, and assorted hardware are purchased by Apple's facility at Carrollton, Texas from U.S. suppliers. 147/ Final assembly of the Apple IIe and the Apple III computers for the U.S. market, including "burning in" of the circuit boards, is conducted at Apple's Carrollton facility. 148/ All testing, quality control, and packaging of the finished product are likewise carried out at Carrollton. The operations performed at Carrollton, which are related to the property rights at issue, involve approximately employees, of which at least are direct labor. 149/

144/ TR 12.
145/ TR 23-25.
146/ Otterstedt Depo., SPX-1.
147/ TR 18.
148/ TR 17-19.
149/ TR 16-17.

150/

151/ The extent of Apple's domestic production activities, which include the assembly and a substantial portion of the manufacture of the products in addition to quality control and packaging, establish that a domestic industry exists within the meaning of the statute.

We concur with the ALJ's finding that the domestic industry is economically and efficiently operated.

INJURY

We concur with the ALJ that the infringing imports have a tendency to substantially injure the domestic industry. It is clear from the record that numerous respondents are attempting to sell, and are selling, infringing computers in the United States under circumstances that indicate they are likely to be successful. The record indicates that respondents also have a large capacity 152/ and can sell personal computers in the United States at a much lower price ($300 - $700) 153/ than Apple's dealer price. Importantly, Apple's experience in the Far East market amply demonstrates its susceptibility to competition from low-priced infringing imports. Customs Service officials have testified that approximately 3,000 infringing

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150/ TR 117-18.
151/ TR 118-19.
152/ TR 237, 249, 258, 383-86, 390-91, 440, 442.
153/ ID 52.

computers, including a large number of respondents' computers, have been seized nationwide and that this number represents approximately 5 - 15 percent of the total number of infringing computers which had been imported into the United States. 154/ Apple is currently selling the Apple IIe and Apple III.

, there is a continuing market for the Apple IIe and Apple III, because the software that can be used with these computers already exists in large quantities. 155/

Given the price sensitivity of the market for computers 156/ and the substantially lower prices of imported computers compared with Apple's price, the predictable impact is large numbers of future lost sales. In this investigation, the record establishes that these lost sales will have a significant negative impact on the economic performance of the domestic industry.

REMEDY

We have determined that a general exclusion order is the appropriate remedy in this case. The large number of sources of infringing imports actually established, and the apparent existence of even more, fully justify a general exclusion order. 157/ The only question is the form of the order. Our order, by its express terms, excludes from entry personal computers and components which directly infringe the involved patents and copyrights. Further, since the record shows that imports having motherboards substantially

154/ Apple's Ex. 155, p. 168.
155/ ID 53.
156/ TR 1122, 1123, 1252, 1255.

TR 1389.

157/ See, Certain Airless Paint Spray Pumps and Components Thereof, Inv. No. 337-TA-90, 216 USPQ 465 (1981).

similar to the Apple motherboards contributorily infringe or induce infringement of the involved patents and copyrights, such imports are included in our exclusion order subject to the presentation of a license.

It is the intent of this order to remedy the violation we have found to exist without disrupting lawful trade in personal computers and components thereof. To avoid evasion of our order, it excludes from entry ROMless computers and components which can be shown to be associated with imports of infringing ROMs or which are intended to receive infringing ROMs in the United States. Any beneficiary or any person adversely affected by this order may petition this Commission for a modification or clarification to ensure that its intent is achieved. The Commission may also modify or clarify the order on its own motion. 158/

PUBLIC INTEREST

We find that there are no public interest factors which would preclude the issuance of a general exclusion order in this case.

158/ On February 2, 1984, and March 7, 1984, the Commission received letters from the U.S. Customs Service (Customs) regarding the inherent difficulties in enforcing an exclusion order in this investigation in view of Customs' limited resources. The letters stated that, at the time of importation, Customs "must attempt to identify . . . whether the printed circuitry of a computer of component is in violation of an Apple patent . . ." Customs further stated that this might entail an examination of every computer and component importation regardless of make, model, and type. Further "difficulties" were noted, but Customs stated that they would endeavor to enforce the order to the best of their ability. (February 2, 1984, letter from the Director, Office of Trade Operations to the Chairman and letter dated March 7, 1984, from the Assistant Commissioner, Office of Commercial Operations to the Chairman). As discussed above, we have concluded that an exclusion order is the only way to remedy the violation found to exist. Commissioner Haggart notes that Apple states that it will provide Customs with technical support necessary to enforce such an order. Complainant's Brief on Remedy, Bonding, and the Public Interest 5-9.

Collins argues that an exclusion order applicable to its Orange + Two computer would have an adverse effect on the public health and welfare because the public "would be deprived of access to a unique model personal computer which, at a retail price significantly lower than that of the Apple IIe, provides the double capabilities of a 6502 microprocessor capable of playing most Apple-compatible software and a Z-80 microprocessor that is compatible with CP/M-based software." 159/ There is nothing in the record of any public need for respondent's particular computer. It is clear that computers will be available at various price levels which can run these applications programs or other, equivalent programs.

Collins also argues that an exclusion order applicable to its Orange + Two computer would have an adverse effect on competitive conditions in the United States economy because it "would deprive the public of the well-established advantages of competition by leaving Apple more secure in its ability to command high premium prices within its 'niche' in the market place." 160/ However, the record shows that Apple has numerous foreign and domestic competitors besides the Collins Orange + Two. Whether these can run Apple-compatible software is not relevant since they can run other, equivalent software.

Collins argues that an exclusion order applicable to the Orange + Two computer would have an adverse effect on the production of like or directly competitive articles in the United States. 161/ None of these arguments show that Apple's competitors which produce their computers in the United States will be affected by an exclusion order.

159/ RPB (Remedy, Public Interest, Bonding) (Collins) at 13.
160/ Id. at 14.
161/ Id. at 17.

Collins argues that an exclusion order applicable to the Orange + Two computer would have an adverse effect on United States consumers because "consumers would be left without commercial recourse against Apple's unfair pricing practices." 162/ Again, it is clear that consumers have a variety of choices at varying prices which will not be affected by an exclusion order in this case.

Finally, we reject Collins' arguments with regard to monopolistic practices 163/ for the same reasons discussed above.

BONDING

We find that the bond should be set at 200 percent of the entered value of the products involved.

The bond provided for by 19 U.S.C. § 1337(g)(3) is a reexportation bond requiring the reexportation of the articles covered by this exclusion order which are entered during the Presidential review period provided for by 19 U.S.C. § 1337(g)(2). Entry of such articles during this period is only conditionally lawful, the condition being that the President disapprove the Commission's determination, thus rendering the determination and order of no force or effect. If this condition is not satisfied, the bond requires that the articles be reexported, and if they are not, the penalty amount of the bond may be assessed. The Commission is charged with prescribing the penalty amount of this reexportation bond. The Commission's rules provide that the

162/ Id. at 25.
163/ Id. at 26.

Commission take into consideration, among other things, "the amount which would offset any competitive advantage resulting from the alleged unfair methods of competition and unfair acts enjoyed by persons benefiting from the importation of the articles in question." 164/

Both Apple and the Commission investigative attorney submit that a bond in the amount of 200 percent of entered value is such an amount. This was computed on the basis of the average retail sales price of the bulk of the involved imported personal computers. We find this amount to be appropriate.

164/ 19 C.F.R. § 210.14(a)(3).

APPENDIX

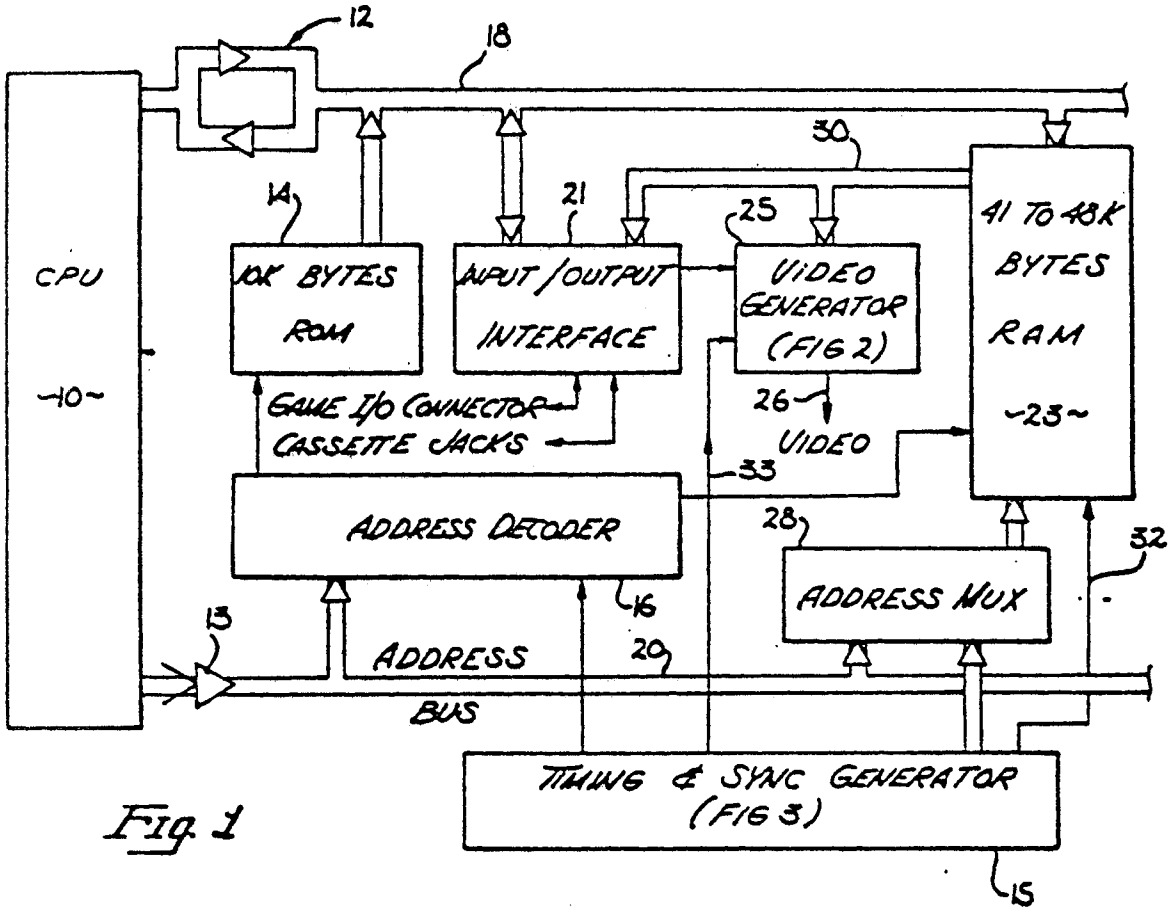

12
18
30
14
21
25
CPU
10K BYTES ROM
INPUT/OUTPUT INTERFACE
VIDEO GENERATOR (FIG 2)
41 TO 48K BYTES RAM
10
GAME I/O CONNECTOR
CASSETTE JACKS
26
VIDEO
23
33
ADDRESS DECODER
28
ADDRESS MUX
32
13
ADDRESS
16
20
BUS
TIMING & SYNC GENERATOR (FIG 3)
15

Fig. 1

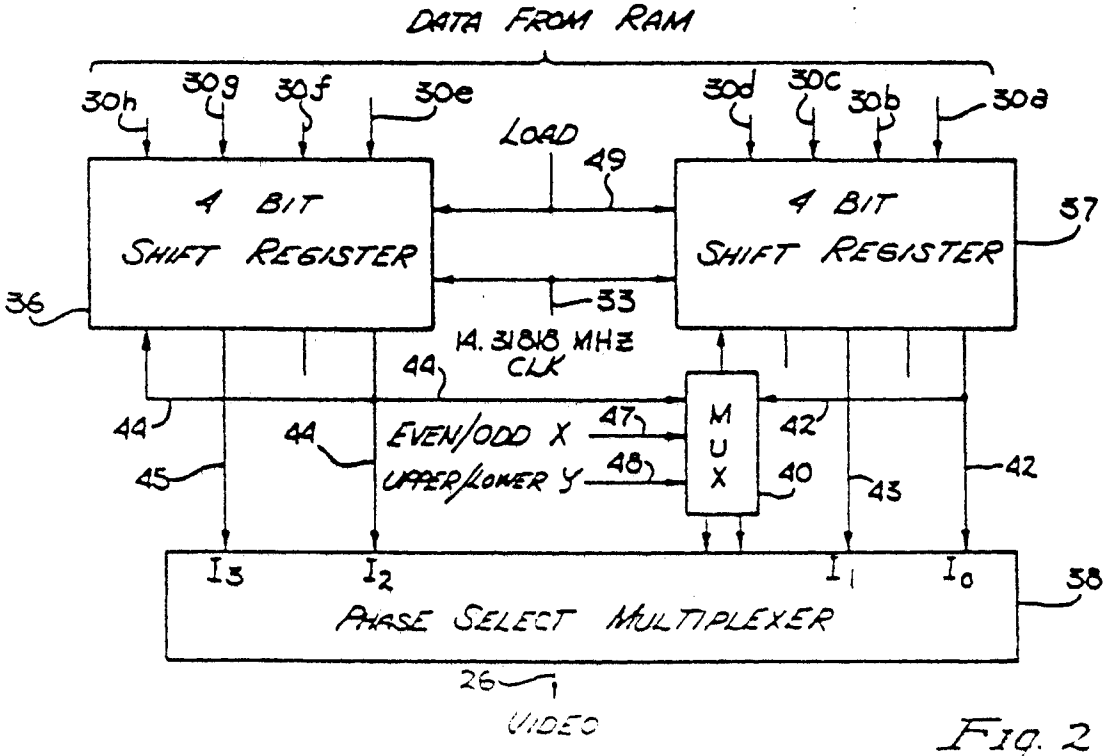

DATA FROM RAM
30h
30g
30f
30e
30d
30c
30b
30a
LOAD
49
4 BIT SHIFT REGISTER
4 BIT SHIFT REGISTER
57
36
53
14.31818 MHZ CLK
44
44
44
EVEN/ODD X
47
UPPER/LOWER Y
48
M U X
42
40
43
42
45
I3
I2
I1
I0
38
PHASE SELECT MULTIPLEXER
26
VIDEO

Fig. 2

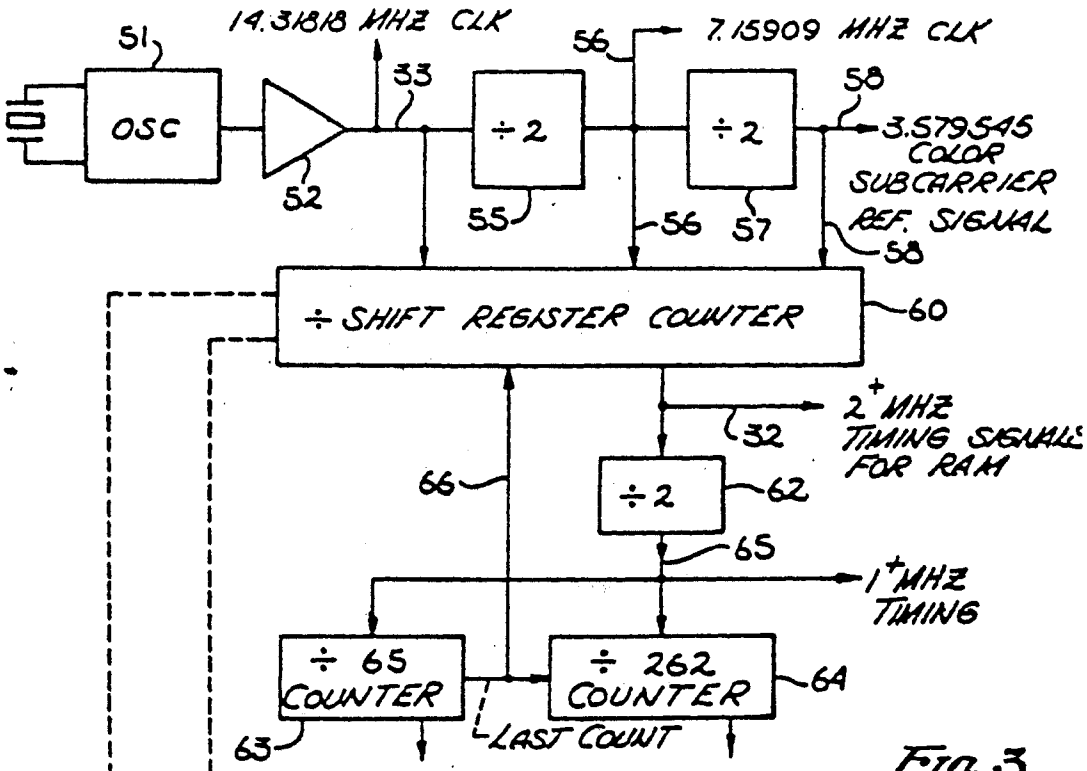
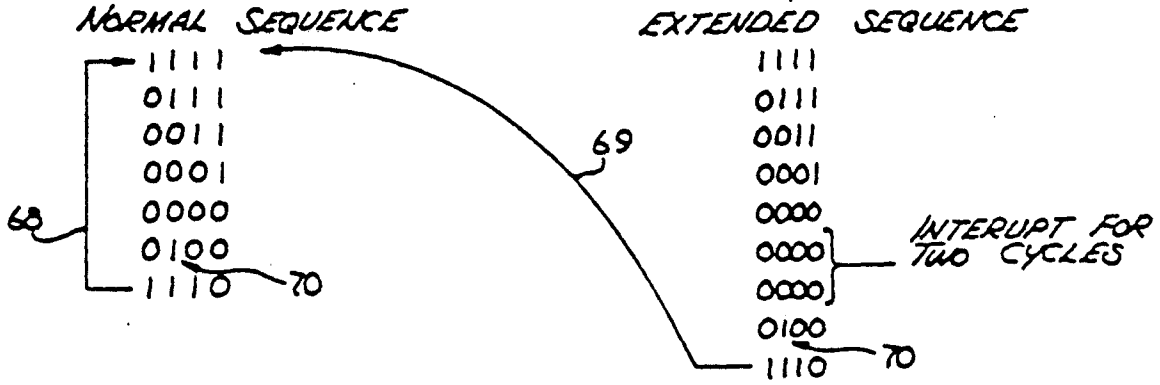

14.31818 MHZ CLK
7.15909 MHZ CLK
51
OSC
52
33
÷2
55
56
÷2
57
58
3.579545 COLOR SUBCARRIER REF. SIGNAL
÷ SHIFT REGISTER COUNTER
60
2+ MHZ TIMING SIGNALS FOR RAM
32
66
÷2
62
65
1+ MHZ TIMING
÷ 65 COUNTER
63
÷ 262 COUNTER
64
LAST COUNT

Fig. 3


NORMAL SEQUENCE
EXTENDED SEQUENCE
1111
0111
0011
0001
0000
0100
1110
68
69
70
INTERUPT FOR TWO CYCLES

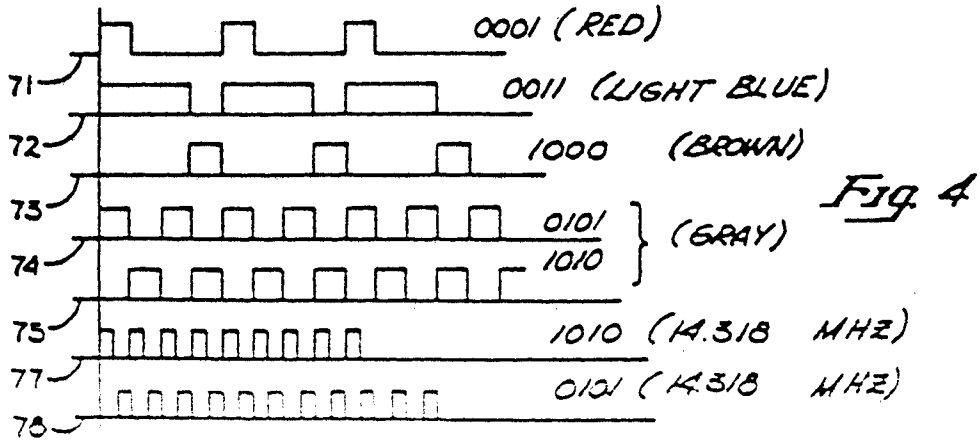

0001 (RED)
0011 (LIGHT BLUE)
1000 (BROWN)
0101
1010
(GRAY)
1010 (14.318 MHZ)
0101 (14.318 MHZ)
71
72
73
74
75
77
78

Fig. 4

United States Patent [19]

Wozniak

[11] 4,136,359

[45] Jan. 23, 1979

[54] **MICROCOMPUTER FOR USE WITH VIDEO DISPLAY**

[75] Inventor: Stephen G. Wozniak, Cupertino, Calif.

[73] Assignee: Apple Computer, Inc., Cupertino, Calif.

[21] Appl. No.: 786,197

[22] Filed: Apr. 11, 1977

[51] Int. Cl.[2] H04N 9/44

[52] U.S. Cl. 358/17

[58] Field of Search 358/17, 148, 150

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,581,011 5/1971 Ward et al. 358/17

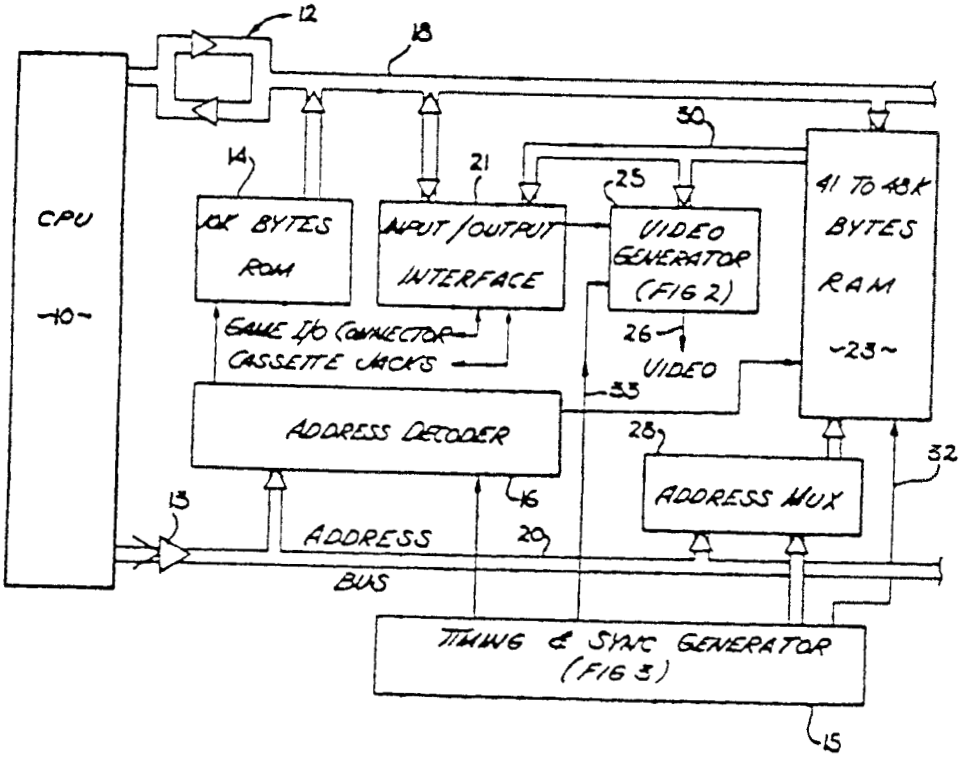
Primary Examiner—Richard Murray

Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor & Zafman

[57] **ABSTRACT**

A microcomputer including a video generator and timing means which provides color and high resolution graphics on a standard, raster scanned, cathode ray tube is disclosed. A horizontal synchronization counter is synchronized at an odd-submultiple of the color subcarrier reference frequency. A "delayed" count is employed in the horizontal synchronization counter to compensate for color subcarrier phase reversals between lines for the non-interlaced fields. This permits vertically aligned color graphics without substantially altering the standard horizontal synchronization frequency. Video color signals are generated directly from digital signals by employing a recirculating shift register.

8 Claims, 4 Drawing Figures



MICROCOMPUTER FOR USE WITH VIDEO DISPLAY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is for the generation of signals for raster scanned video displays employing digital means.

2. Prior Art

With the reduced cost of large scale integrated circuits it has become possible to provide low-cost microcomputers suitable for home use. One such use which has flourished in recent years is the application of microcomputers in conjunction with video displays for games and graphic displays. Most often an ordinary television receiver is employed as the video display means. The standard, raster scanned, cathode ray tubes employed in these receivers and like displays, present unique problems in interfacing these displays with the digital information provided by the microcomputer.

In presenting color graphics it is, of course, desirable to provide high resolution lines and to avoid "ragged" lines. In a microcomputer controlled display, typically a single frequency reference source is employed to generate the color subcarrier reference signal of 3.579545Mhz and the horizontal and vertical synchronization signals. If the frequency of the horizontal synchronization signals is to remain close to its normal frequency (i.e. 15,750hz) the horizontal synchronization means must operate at an odd-submultiple of the color subcarrier frequency. When this occurs there is a phase reversal or phase shift of the color subcarrier reference signal when compared to color control signal between each of the lines of the display. This results in ragged vertical lines unless the color signals are changed for each line. One prior art solution to this problem has been to operate the horizontal synchronization counter at an even submultiple of the color subcarrier frequency (i.e. 15,980hz). This deviation from the standard horizontal synchronization frequency typically requires manual adjustment of the receiver and for some receivers horizontal synchronization may be more difficult to maintain.

As will be described with the invented microcomputer, the horizontal counter operates close to its standard frequency (15,734hz). Through use of a timing compensation means, counting in the horizontal synchronization counter is delayed to compensate for the fact that the counter operates at an odd-submultiple frequency of a color reference signal. In this manner, phase reversal of the color reference signal is eliminated and sharp graphic displays are provided without complex programming.

In many prior art microcomputer controlled displays, color information is stored as four digital bits which are used to designate green, red, blue, and high/low intensity. The color generation means generally includes a signal generator for generating the pure color signals (CW). These pure color signals are then gated and mixed in accordance with the binary state of the four bits to provide a color signal compatible with standard television receivers. Generation of the video color signal in this manner is complex and requires a substantial amount of circuitry.

The invented microprocessor includes a recirculating shift register which circulates four bits of information. In this manner video color signals are generated directly from digital information without the cumbersome generation techniques employed in the prior art.

SUMMARY OF THE INVENTION

A microprocessor for use with a video display is described. The microprocessor includes an improved timing apparatus which provides well-defined color graphics on a standard, raster scanned, cathode ray tube. A timing reference means is employed to provide a color reference signal for the video display. A horizontal synchronization means which is synchronized to the timing reference means provides horizontal synchronization signals for the display. These signals occur at a rate which is an odd-submultiple of the color reference signal frequency. The timing apparatus includes a compensation means which is coupled to both the timing reference means and the synchronization means for periodically adjusting the horizontal synchronization signals such that these signals remain in phase relationship with the color reference signal.

The microcomputer also includes a unique color signal generation means which uses a recirculating shift register. This register receives digital signals representative of color from memory and circulates this data at a predetermined rate. In this manner a color signal suitable for use with a video display is generated from the digital signals.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a general block diagram illustrating the invented microcomputer in its presently preferred embodiment.

FIG. 2 is a block diagram of the video generator employed in the microcomputer of FIG. 1.

FIG. 3 is a block diagram of the timing and synchronization generator employed in the computer of FIG. 1; and

FIG. 4 is a graph illustrating several waveforms generated by the video generator of FIG. 2.

DETAILED DESCRIPTION OF THE INVENTION:

A microcomputer is disclosed which is particularly suitable for controlling color graphics on a standard, raster scanned, cathode ray tube. The described microcomputer includes a video generator which generates color signals directly from digital information, and a timing means which provides well defined color graphics, particularly in the vertical direction, without complex programming.

In the following description, numerous well-known circuits are shown in block diagram form in order not to obscure the described inventive concepts in unnecessary detail. In other instances, very specific details such as frequencies, number of bits, specific codes, etc., are providing in order that these inventive concepts may be clearly understood. It will be apparent to one skilled in the art that the described inventive concepts may be employed without use of these specific details.

Referring now to FIG. 1, the microcomputer includes a central processing unit (CPU) or microprocessor 10. While any one of a plurality of commercially available microprocessors may be employed such as the M6800 or 8080, in the presently preferred embodiment, a commercially available microprocessor, Part No. 6502, is employed. CPU 10 communicates with the data bus 18 through a bidirectional tri-state buffer 12. The CPU 10 is also coupled to the address bus 20 through a tri-state buffer 13.

The microcomputer, in its presently preferred embodiment, includes two memories. The first is a 12K (bytes) read-only memory (ROM) 14 which is coupled to the data bus 18. This ROM may be a mask programmable memory, E PROM or other read-only memory. The primary data storage for the computer comprises the random-access memory 23. In the presently preferred embodiment, this memory may contain 4K to 48K (bytes) and comprises commercially available dynamic MOS memories. The RAM 23 is coupled to the input/output interface means 21 via bus 30, the data bus 18 and the video generator 25.

The timing signals for the microcomputer are provided by the timing and synchronization generator 15. The novel portions of this generator shall be described, in detail, in conjunction with FIG. 3. This generator provides timing signals for the microcomputer, and additionally, synchronization signals for the video display. Among the signals provided by the generator 15 are 2+Mhz timing signals on lines 32 for the RAMs 23 and a 14.31818Mhz signal on line 33 for the video generator 25. The timing and synchronization generator 15 also provides timing signals for the decoder 16 and for the address multiplexer 28.

The address decoder 16 receives address signals from the address bus 20 and decodes them in a well-known manner. The address decoder 16 is coupled to the ROM 14 and to the RAM 23. Address signals are also received from the bus 20 by the address multiplexer 28 which couples these signals to the RAM 23.

The input/output interface means 22 provides ports which allows the microprocessor to be electrically coupled to a cassette jack or to a connector used for receiving game input/output signals. Known buffers and timing means may be employed for this purpose.

The video generator 25 receives signals from the input/output interface means 21 and also from the RAM 23. This generator provides an output video signal on line 26. Video generator 25 shall be described, in detail, in conjunction with FIG. 2.

In the presently preferred embodiment, the entire microcomputer of FIG. 1 is fabricated on a single printed circuit board. This board includes connectors to allow the computer to be connected to a cassette playback means, or other devices. As will be appreciated, numerous well-known interconnections, driver means and other circuits employed in the microcomputer are not shown in FIG. 1. For a detailed description of circuits and interconnections which may be employed in the microprocessor of FIG. 1, including a transparent refresh cycle for the RAMs 23, see "*A CRT Terminal Using The M6800 Family*" by Roy & Morris, *Interface Age*, Volume 2, Issue 2, January 1977.

Referring now to FIG. 3, the timing and synchronization generator (timing means) includes a frequency reference source, crystal oscillator 51. The output of oscillator 51 is coupled to a buffer 52 which provides a 14.31818Mhz signal on line 33 for the presently preferred embodiment. This signal is coupled to the video generator of FIG. 2 as will be described, and is also coupled to the shift register counter 60 and the divider 55. The divider 55 divides the 14.31818Mhz signal by two, thereby providing a 7.15909Mhz signal on line 56. This signal is employed by the microprocessor as a timing signal, and additionally, is employed by the shift register counter 60 as a feedback synchronization signal. The signal on line 56 is further divided by two, by divider 57, to provide the standard color subcarrier reference signal of 3.579545Mhz on line 58. The signal on line 58 is used in an ordinary manner by the video display and also is used as a feedback synchronization signal by the shift register counter 60.

The 14.3Mhz signal on line 33 is divided by seven, by the shift register counter 60 to provide a 2+Mhz signal on line 32. This signal is used by the RAMs 23 of FIG. 1. This 2+Mhz signal is further divided by divider 62 (divided by two) to provide a 1+Mhz timing signal on line 65. This 1+Mhz signal in addition to being employed elsewhere in the microprocessor is used by counters 63 and 64.

The "divide-by-65" counter 63 is used to provide the horizontal synchronization signals for the non-interlaced display. When the maximum count is reached within the counter 63, a signal is provided on line 66 to shift register 60 and also to the vertical synchronization counter 64. The counter 64 is employed to divide this signal by 262 to provide vertical synchronization signals.

In the presently preferred embodiment, the display is divided into a 65×262 array. However, 25 of the 65 horizontal character positions are employed for blanking and 70 of the 262 lines are also employed for blanking.

It is apparent from FIG. 3 that the horizontal synchronization signals from counter 63 occur at a frequency of approximately 15,734hz. This is very close to the standard horizontal synchronization rate of 15,750hz. Each count of the counter 63 includes 3½ color cycle of the color subcarrier reference frequency; moreover, the total number of color cycles per line is a non-integer. As a result, the color subcarrier reference signal will be shifted 180° for each new line. Unless some corrective action is taken this will result in ragged vertical lines. As will now be described, compensation is provided by delaying the occurrence of the 1+Mhz timing signal once for each line by a period of time corresponding to ½ cycle of the 3.58Mz subcarrier reference signal.

As shown in FIG. 3, the normal counting sequency for the shift counter 60 includes seven states. When the last stage of the four stage counter contains a binary-zero, a binary-one is loaded into the second stage (position 70). The first and second stages receive the output of the second stage when the last stage contains a binary-zero. Thus, the states become 1110 after the next shift, and finally the states become 1111 as indicated by path 68.

Each time a signal occurs on line 66 (every 65 cycles of the 1+Mhz signal) the normal sequencing within the counter 60 is altered as shown by the extended sequence of FIG. 3. When a signal occurs on line 66 and when the count of 0000 is reached, the loading of the binary-one into the second stage (position 70) is delayed for two cycles of the 14.318Mhz clock. These two cycles correspond to 180° of the 3.58Mhz signal. After these two cycles, a binary-one is then loaded into the second stage, followed by the loading of binary-ones into the first and third stages. As indicated by path 69, a normal counting sequence then occurs. By extending the count within counter 60 as described, compensation occurs which provides vertical color alignment from line-to-line.

Referring now to FIG. 2, the video generator 25 of FIG. 1 includes two, four bit shift registers 36 and 37. Each of these four bit shift registers is coupled to receive four bits of data on lines 30 from the RAM 23.

The registers 36 and 37 receive a load signal on line 49 which causes the data on lines 30a through 30h to be shifted into the registers. The first stage of register 37 (I_0) is coupled to a multiplexer 38 by line 42. The third stage of register 37 (I_1) is also coupled to the multiplexer 38 by line 43. In a similar fashion, the first stage of the register 36 (I_2) is coupled by line 44 to the multiplexer 38, and the third stage of this register (I_3) is also coupled to the multiplexer 38 by line 45.

Line 44 is coupled to the fourth stage of register 36 in order that four bits of data within register 36 may be recirculated. (Registers 36 and 37 shift data from left to right, that is, toward their first stage). The line 42 may be selectively coupled to the fourth stage of register 37 through the multiplexer 40 in order that four bits of data within register 37 may be recirculated. Line 44 may be coupled through the multiplexer 40 to the fourth stage of the shift register 37. When this occurs, the shift registers 36 and 37 operate as a single eight bit shift register.

Control signals designated as even/odd X (line 47) and upper/lower Y (line 48) are used to control multiplexer 38. During the color graphics mode the registers 36 and 37 operate as separate registers and data is alternately selected for coupling to line 26 by multiplexer 38. The upper/lower Y signal, during the color graphics mode, allow selection of data from either register 36 or 37. The odd/even X signal then toggles the data from the selected register by alternating selecting I_0 or I_1 if register 37 is selected, or I_2 or I_3 if register 36 is selected.

During the color graphics mode as presently implemented, eight bits of color information are shifted (in parallel) into the registers 36 and 37 from the RAM 23 at a 1^+Mhz rate. This data is recirculated within registers 36 and 37 at a rate of 14.31818Mhz by the clocking signal received on line 33. The circulation of the data bit within the registers 36 and 37 at this rate provides signals having a 3.58Mhz component and as will be described, these signals may be readily employed for providing color signals for video display.

In the color graphics mode, as presently implemented, each of the display characters is divided into an upper and lower color rectangle. The RAM 23 provides the four bits of color data for the upper rectangles to registers 36 and for the lower rectangles to register 37. This color data for the presently preferred embodiment is coded as follows:

Red; 0001
Pink; 1011
Blue; 0010
Light Blue; 0111
Dark Green; 0100
Light Green; 1110
Brown; 1000
Yellow; 1101
Medium Violet; 0011
Medium Blue; 0110
Medium Green; 1100
Orange; 1001
White; 1111
Gray; 1010
Gray; 0101

When colors are coded in this manner and circulated at the rate of 14.318Mhz in the registers, video color signals compatible with standard television receivers are produced. The resultant signal for red is shown on line 71 of FIG. 4, light blue on line 72, brown on line 73 and gray on lines 74 and 75.

Briefly referring again to FIG. 3, each count of the horizontal synchronization counter 63 corresponds to 3½ cycles of the subcarrier reference signal. Thus, a 180° phase shift occurs from character-to-character with respect to the color subcarrier reference signal. This means that the color signals must be shifted by 180° by the generator of FIG. 2, or the coding for these signals must be alternated for odd and even horizontal character positions. In the presently preferred embodiment, a 180° phase shift for the color signals is obtained by toggling between the first or third stages of the selected registers. For example, assume that the lower portion of a character is being displayed and that the color information is thus contained within register 37. Further assume that this information is being circulated, that is, line 42 couples stage 4 to stage 1 through the multiplexer 40. For even horizontal character positions, as indicated by the signal on line 47, the phase select multiplexer 38 couples the I_0 signal to line 26. For the odd positions, a 180° phase shift is obtained by selecting the I_1 signal.

During a second mode of operation the generator of FIG. 2 is used for providing high resolution graphics. In this case, eight bits of information are provided by the RAM 23 to the registers 36 and 37. For this high resolution mode line 42 is coupled to the video line 26 and the eight bits of data from RAM 23 are serially coupled to the video line 26 at the 14.318Mhz rate. The multiplexer 40 couples line 44 to the fourth stage of register 37 to provide a single eight bit shift register. The resultant signals are shown on lines 77 and 78 of FIG. 4. The signals on lines 77 and 78 provide either a green or violet display. In the presently preferred embodiment, data changes are employed to obtain the compensation provided by the multiplexer 38 during the color graphics mode.

Thus, a microcomputer has been disclosed which is particularly suitable for controlling a color video display. The unique timing means provides well defined vertical color lines without complicated programming changes while allowing the generation of horizontal synchronization signals at close to the standard rate. The unique video generator allows the generation of color signals directly from digital signals without the complex circuitry often employed in the prior art.

I claim:

1. In a microcomputer for use with a video display an improved timing apparatus comprising:

a timing reference means for providing a color reference signal for said video display;

a horizontal synchronization means for providing horizontal synchronization signals for said display, said synchronization means coupled to said timing reference means for synchronization with said reference means such that said synchronization signals occur at an odd-submultiple of said color reference signal;

timing compensation means coupled to said timing reference means and said horizontal synchronization means for adjusting said horizontal synchronization signals such that said horizontal synchronization signals are in phase relationship with said color reference signal;

whereby the color graphics on a raster scanned cathode ray tube are sharply defined in the vertical direction.

2. The apparatus defined by claim 1 wherein said horizontal synchronization means comprises a digital counter.

3. The apparatus defined by claim 2 wherein said timing compensation means periodically delays counting in said counter.

4. The apparatus defined by claim 3 wherein said color reference signal is an approximately 3.58Mhz signal and said horizontal synchronization signals occur at a frequency of approximately 15,734Hz.

5. In a microcomputer for use with a video display an improved timing apparatus comprising:

a horizontal synchronization counter;

a timing reference means for synchronizing said counter and for providing a color reference signal, said reference signal frequency being an odd-multiple greater than the rate at which counting occurs in said counter;

delay means for delaying counting in said counter when the count in said counter reaches a predetermined count, said delay means coupled to said horizontal synchronization counter and said timing reference means;

whereby well-defined color graphics may be readily stored and displayed on said video display.

6. The apparatus defined by claim 5 including a digital divider for dividing by an odd-integer coupled between said reference means and said counter.

7. The apparatus defined by claim 6 wherein said digital divider includes a shift register counter and wherein the loading of digital signals in said register counter is interrupted when said predetermined count is reached.

8. The apparatus defined by claim 7 wherein said color reference signal is an approximately 3.58Mhz signal and said predetermined count is reached at a frequency of approximately 15,734Hz.

* * * * *

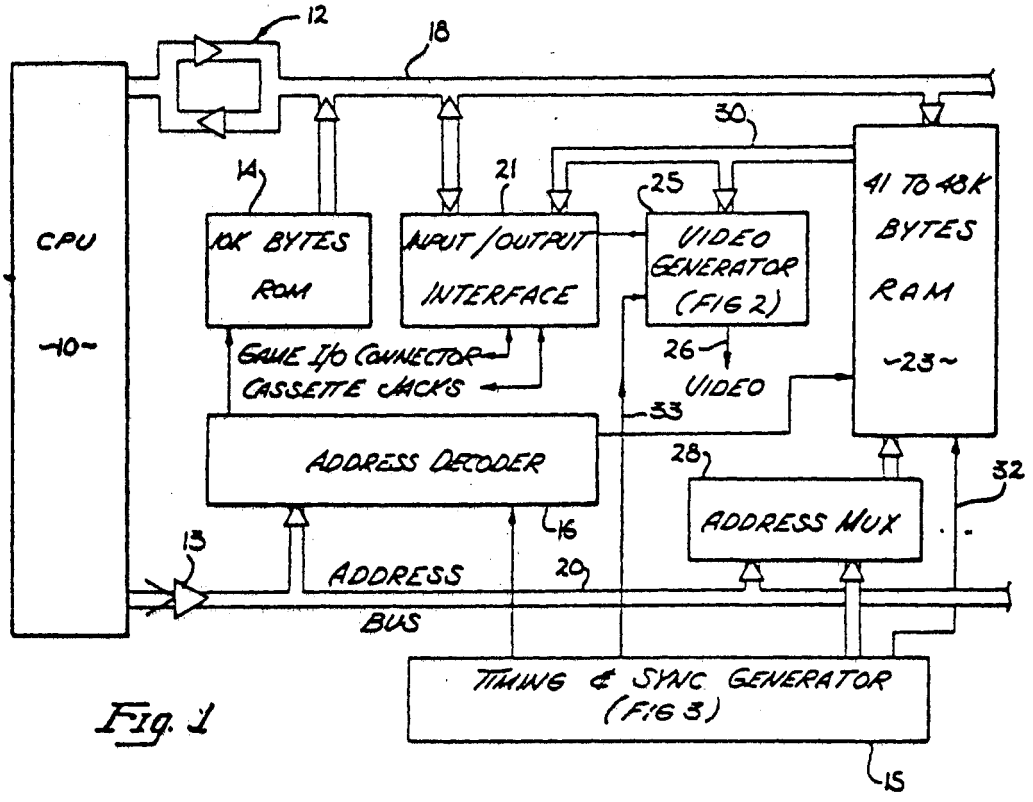

12
18
30
14
21
25
41 TO 48K BYTES RAM
23
CPU
10
10K BYTES ROM
INPUT/OUTPUT INTERFACE
VIDEO GENERATOR (FIG 2)
GAME I/O CONNECTOR
CASSETTE JACKS
26
VIDEO
33
ADDRESS DECODER
28
32
ADDRESS MUX
13
ADDRESS
16
20
BUS
TIMING & SYNC GENERATOR (FIG 3)
15

Fig. 1

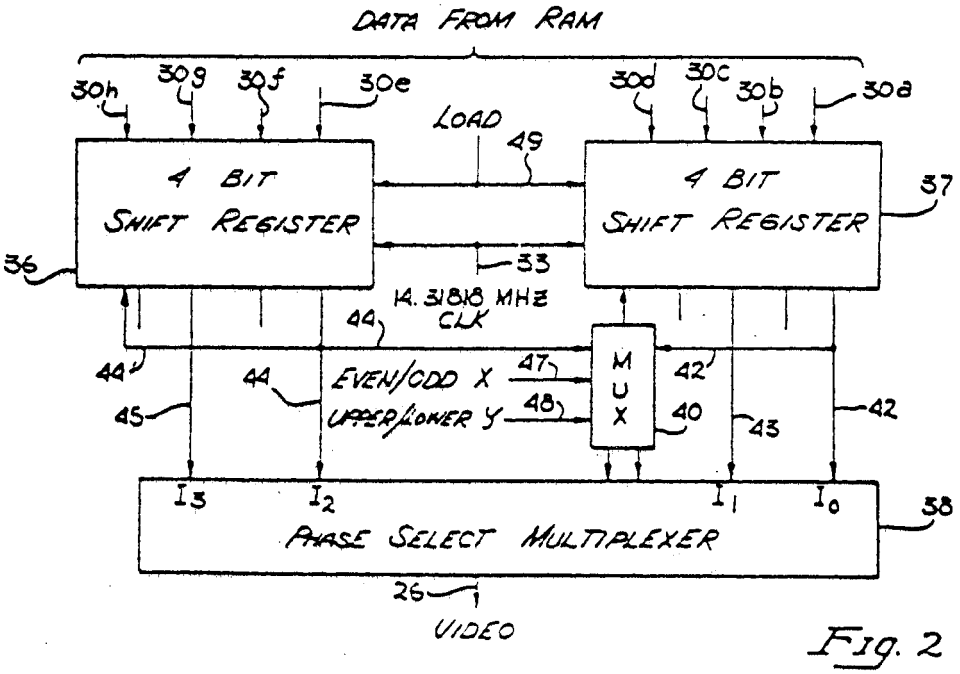

DATA FROM RAM
30h
30g
30f
30e
30d
30c
30b
30a
LOAD
49
4 BIT SHIFT REGISTER
37
36
33
14.31818 MHz CLK
44
EVEN/ODD X
47
UPPER/LOWER Y
48
MUX
42
40
45
43
I3
I2
I1
I0
PHASE SELECT MULTIPLEXER
38
26
VIDEO

Fig. 2

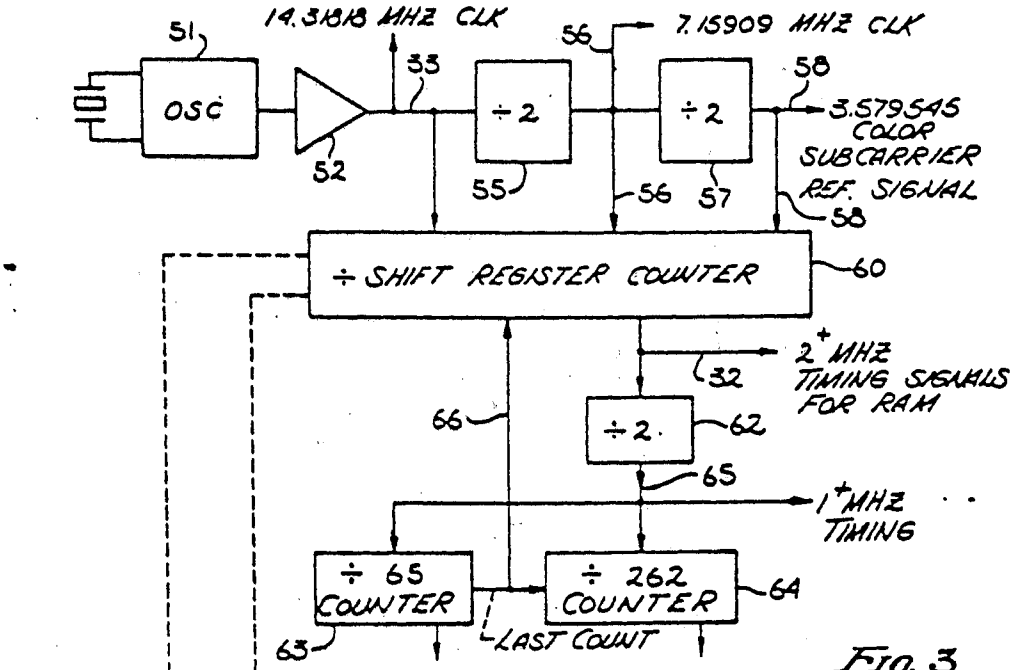
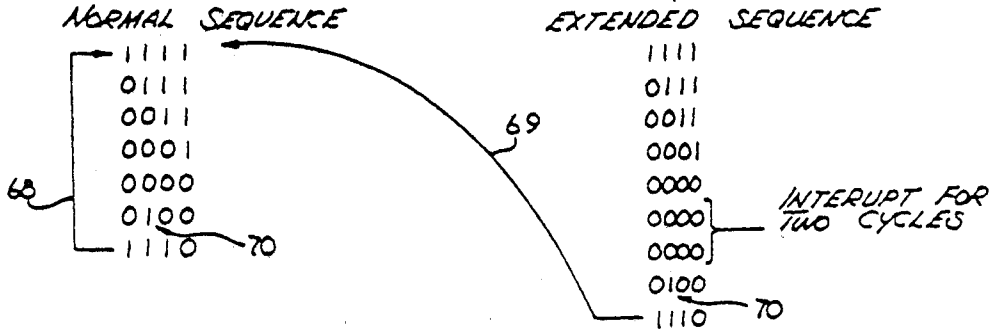

14.3818 MHZ CLK
7.15909 MHZ CLK
51
OSC
52
33
÷2
55
56
÷2
57
58
3.579545 COLOR SUBCARRIER REF. SIGNAL
÷ SHIFT REGISTER COUNTER
60
2+ MHZ TIMING SIGNALS FOR RAM
32
66
÷2
62
65
1+ MHZ TIMING
÷ 65 COUNTER
63
÷ 262 COUNTER
64
LAST COUNT

Fig. 3


NORMAL SEQUENCE
EXTENDED SEQUENCE
1111
0111
0011
0001
0000
0100
1110
68
69
70
INTERUPT FOR TWO CYCLES

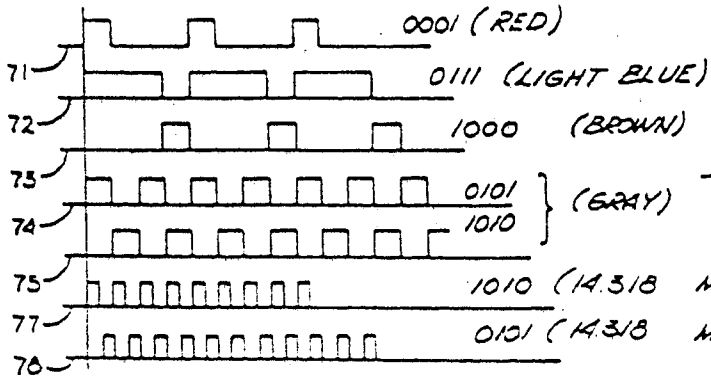

0001 (RED)
71
0111 (LIGHT BLUE)
72
1000 (BROWN)
73
0101
74
1010
(GRAY)
75
1010 (14.318 MHZ)
77
0101 (14.318 MHZ)
76

Fig. 4

United States Patent [19]

Wozniak

[11] 4,278,972

[45] Jul. 14, 1981

[54] DIGITALLY-CONTROLLED COLOR SIGNAL GENERATION MEANS FOR USE WITH DISPLAY

[75] Inventor: Stephen G. Wozniak, Cupertino, Calif.

[73] Assignee: Apple Computer, Inc., Cupertino, Calif.

[21] Appl. No.: 110,409

[22] Filed: Jan. 8, 1980

Related U.S. Application Data

[60] Continuation of Ser. No. 910,125, May 26, 1978, abandoned, which is a division of Ser. No. 786,197, Apr. 11, 1977, Pat. No. 4,136,359.

[51] Int. Cl.³ G06F 3/14

[52] U.S. Cl. 340/703; 340/725; 340/744; 340/800; 340/814; 358/17

[58] Field of Search 358/17, 18, 28, 10; 340/703, 744, 725, 750, 800, 801, 814

[56] References Cited

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4,119,956	10/1978	Murray	340/728

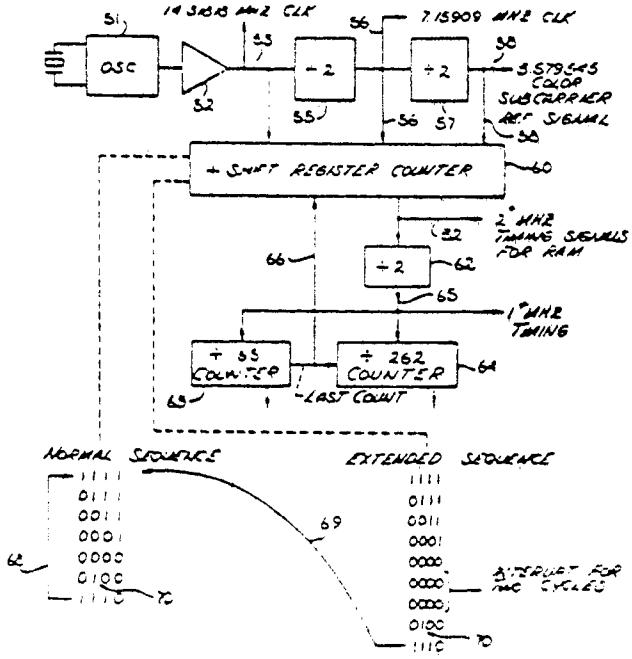
Primary Examiner—Marshall M. Curtis

Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor & Zafman

[57] ABSTRACT

A microcomputer including a video generator and timing means which provides color and high resolution graphics on a standard, raster scanned, cathode ray tube is disclosed. A horizontal synchronization counter is synchronized at an odd-submultiple of the color subcarrier reference frequency. A "delayed" count is employed in the horizontal synchronization counter to compensate for color subcarrier phase reversals between lines. This permits vertically aligned color graphics without substantially altering the standard horizontal synchronization frequency. Video color signals are generated directly from digital signals by employing a recirculating shift register.

11 Claims, 4 Drawing Figures



DIGITALLY-CONTROLLED COLOR SIGNAL GENERATION MEANS FOR USE WITH DISPLAY

This is a continuation of application Ser. No. 910,125, now abandoned, filed May 26, 1978, which is a division of application Ser. No. 786,197, filed on Apr. 11, 1977 which is now U.S. Pat. No. 4,136,359.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is for the generation of signals for raster scanned video displays employing digital means, believed to be in Class 340-324.

2. Prior Art

With the reduced cost of large scale integrated circuits it has become possible to provide low-cost microcomputers suitable for home use. One such use which has flourished in recent years is the application of microcomputers in conjunction with video displays for games and graphic displays. Most often an ordinary television receiver is employed as the video display means. The standard, raster scanned, cathode ray tubes employed in these receivers and like displays, present unique problems in interfacing these displays with the digital information provided by the microcomputer.

In presenting color graphics it is, of course, desirable to provide high resolution lines and to avoid "ragged" lines. In a microcomputer controlled display, typically a single frequency reference source is employed to generate the color subcarrier reference signal of 3.579545 Mhz and the horizontal and vertical synchronization signals. If the frequency of the horizontal synchronization signals is to remain close to its normal frequency (i.e. 15,750 hz) the horizontal synchronization means must operate at an odd-submultiple of the color subcarrier frequency. When this occurs there is a phase reversal or phase shift of the color subcarrier reference signal when compared to color control signal between each of the lines of the display. This results in ragged vertical lines unless the color signals are changed for each line. One prior art solution to this problem has been to operate the horizontal synchronization counter at an even submultiple of the color subcarrier frequency (i.e. 15,980 hz). This deviation from the standard horizontal synchronization frequency typically requires manual adjustment of the receiver and for some receivers horizontal synchronization may be more difficult to maintain.

As will be described with the invented microcomputer, the horizontal counter operates close to its standard frequency (15,734 hz). Through use of a timing compensation means, counting in the horizontal synchronization counter is delayed to compensate for the fact that the counter operates at an odd-submultiple frequency of a color reference signal. In this manner, phase reversal of the color reference signal is eliminated and sharp graphic displays are provided without complex programming.

In many prior art microcomputer controlled displays, color information is stored as four digital bits which are used to designate green, red, blue, and high/low intensity. The color generation means generally includes a signal generator for generating the pure color signals (CW). These pure color signals are then gated and mixed in accordance with the binary state of the four bits to provide a color signal compatible with standard television receivers. Generation of the video color signal in this manner is complex and requires a substantial amount of circuitry.

The invented microprocessor includes a recirculating shift register which circulates four bits of information. In this manner video color signals are generated directly from digital information without the cumbersome generation techniques employed in the prior art.

SUMMARY OF THE INVENTION

A microprocessor for use with a video display is described. The microprocessor includes an improved timing apparatus which provides well-defined color graphics on a standard, raster scanned, cathode ray tube. A timing reference means is employed to provide a color reference signal for the video display. A horizontal synchronization means which is synchronized to the timing reference means provides horizontal synchronization signals for the display. These signals occur at a rate which is an odd-submultiple of the color reference signal frequency. The timing apparatus includes a compensation means which is coupled to both the timing reference means and the synchronization means for periodically adjusting the horizontal synchronization signals such that these signals remain in phase relationship with the color reference signal.

The microcomputer also includes a unique color signal generation means which uses a recirculating shift register. This register receives digital signals representative of color from memory and circulates this data at a predetermined rate. In this manner a color signal suitable for use with a video display is generated from the digital signals.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a general block diagram illustrating the invented microcomputer in its presently preferred embodiment.

FIG. 2 is a block diagram of the video generator employed in the microcomputer of FIG. 1.

FIG. 3 is a block diagram of the timing and synchronization generator employed in the computer of FIG. 1; and

FIG. 4 is graph illustrating several waveforms generated by the video generator of FIG. 2.

DETAILED DESCRIPTION OF THE INVENTION

A microcomputer is disclosed which is particularly suitable for controlling color graphics on a standard, raster scanned, cathode ray tube. The described microcomputer includes a video generator which generates color signals directly from digital information, and a timing means which provides well defined color graphics, particularly in the vertical direction, with complex programming.

In the following description, numerous well-known circuits are shown in block diagram form in order not to obscure the described inventive concepts in unnecessary detail. In other instances, very specific details such as frequencies, number of bits, specific codes, etc., are providing in order that these inventive concepts may be clearly understood. It will be apparent to one skilled in the art that the described inventive concepts may be employed without use of these specific details.

Referring now to FIG. 1, the microcomputer includes a central processing unit (CPU) or microprocessor 10. While any one of a plurality of commercially available microprocessors may be employed such as the

M6800 or 8080, in the presently preferred embodiment, a commercially available microprocessor, Part No. 6502, is employed. CPU 10 communicates with the data bus 18 through a bidirectional tri-state buffer 12. The CPU 10 is also coupled to the address bus 20 through a tri-state buffer 13.

The microcomputer, in its presently preferred embodiment, includes two memories. The first is a 12K (bytes) read-only memory (ROM) 14 which is coupled to the data bus 18. This ROM may be a mask programmable memory, E PROM or other read-only memory. The primary data storage for the computer comprises the random-access memory 23. In the presently preferred embodiment, this memory may contain 4K to 48K (bytes) and comprises commercially available dynamic MOS memories. The RAM 23 is coupled to the input/output interface means 21 via bus 30, the data bus 18 and the video generator 25.

The timing signals for the microcomputer are provided by the timing and synchronization generator 15. The novel portions of this generator shall be described, in detail, in conjunction with FIG. 3. This generator provides timing signals for the microcomputer, and additionally, synchronization signals for the video display. Among the signals provided by the generator 15 are 2+ Mhz timing signals on lines 32 for the RAMs 23 and a 14.31818 Mhz signal on line 33 for the video generator 25. The timing and synchronization generator 15 also provides timing signals for the decoder 16 and for the address multiplexer 28.

The address decoder 16 receives address signals from the address bus 20 and decodes them in a well-known manner. The address decoder 16 is coupled to the ROM 14 and to the RAM 23. Address signals are also received from the bus 20 by the address multiplexer 28 which couples these signals to the RAM 23.

The input/output interface means 22 provides ports which allows the microprocessor to be electrically coupled to a cassette jack or to a connector used for receiving game input/output signals. Known buffers and timing means may be employed for this purpose.

The video generator 25 receives signals from the input/output interface means 21 and also from the RAM 23. This generator provides an output video signal on line 26. Video generator 25 shall be described, in detail, in conjunction with FIG. 2.

In the presently preferred embodiment, the entire microcomputer of FIG. 1 is fabricated on a single printed circuit board. This board includes connectors to allow the computer to be connected to a cassette playback means, or other devices. As will be appreciated, numerous well-known interconnections, driver means and other circuits employed in the microcomputer are not shown in FIG. 1. For a detailed description of circuits and interconnections which may be employed in the microprocessor of FIG. 1, including a transparent refresh cycle for the RAMs 23, see "*A CRT Terminal Using The M6800 Family*" by Roy & Morris, *Interface Age*. Volume 2, Issue 2, January 1977.

Referring now to FIG. 3, the timing and synchronization generator (timing means) includes a frequency reference source, crystal oscillator 51. The output of oscillator 51 is coupled to a buffer 52 which provides a 14.31818 Mhz signal on line 33 for the presently preferred embodiment. This signal is coupled to the video generator of FIG. 2 as will be described, and is also coupled to the shift register counter 60 and the divider 55. The divider 55 divides the 14.31818 Mhz signal by two, thereby providing a 7.15909 Mhz signal on line 56. This signal is employed by the microprocessor as a timing signal, and additionally, is employed by the shift register counter 60 as a feedback synchronization signal. The signal on line 56 is further divided by two, by divider 57, to provide the standard color subcarrier reference signal of 3.579545 Mhz on line 58. The signal on line 58 is used in an ordinary manner by the video display and also is used as a feedback synchronization signal by the shift register counter 60.

The 14.3 Mhz signal on line 33 is divided by seven, by the shift register counter 60 to provide a 2+ Mhz signal on line 32. This signal is used by the RAMs 23 of FIG. 1. This 2+ Mhz signal is further divided by divider 62 (divided by two) to provide a 1+ Mhz timing signal on line 65. This 1+ Mhz signal in addition to being employed elsewhere in the microprocessor is used by counters 63 and 64.

The "divide-by-65" counter 63 is used to provide the horizontal synchronization signals. When the maximum count is reached within the counter 63, a signal is provided on line 66 to shift register 60 and also to the vertical synchronization counter 64. The counter 64 is employed to divide this signal by 262 to provide vertical synchronization signals.

In the presently preferred embodiment, the display is divided into a 65×262 array. However, 25 of the 65 horizontal character positions are employed for blanking and 70 of the 262 lines are also employed for blanking.

It is apparent from FIG. 3 that the horizontal synchronization signals from counter 63 occur at a frequency of approximately 15,734 hz. This is very close to the standard horizontal synchronization rate of 15,750 hz. Each count of the counter 63 includes 3½ color cycle of the color subcarrier reference frequency; moreover, the total number of color cycles per line is a non-integer. As a result, the color subcarrier reference signal will be shifted 180° for each new line. Unless some corrective action is taken this will result in ragged vertical lines. As will now be described, compenssation is provided by delaying the occurrence of the 1+ Mhz timing signal once for each line by a period of time corresponding to ½ cycle of the 3.58 Mz subcarrier reference signal.

As shown in FIG. 3, the normal counting sequence for the shift counter 60 includes seven states. When the last stage of the four stage counter contains a binary-zero, a binary-one is loaded into the second stage (position 70). The first and second stages receive the output of the second stage when the last stage contains a binary-zero. Thus, the states become 1110 after the next shift, and finally the states become 1111 as indicated by path 68.

Each time a signal occurs on line 66 (every 65 cycles of the 1+ Mhz signal) the normal sequencing within the counter 60 is altered as shown by the extended sequence of FIG. 3. When a signal occurs on line 66 and when the count of 0000 is reached, the loading of the binary-one into the second stage (position 70) is delayed for two cycles of the 14.318 Mhz clock. These two cycles correspond to 180° of the 3.58 Mhz signal. After these two cycles, a binary-one is then loaded into the second stage, followed by the loading of binary-ones into the first and third stages. As indicated by path 69, a normal counting sequence then occurs. By extending the count within counter 60 as described, compensation occurs

which provides vertical color alignment from line-to-line.

Referring now to FIG. 2, the video generator 25 of FIG. 1 includes two, four bit shift registers 36 and 37. Each of these four bit shift registers is coupled to receive four bits of data on lines 30 from the RAM 23. The registers 36 and 37 receive a load signal on line 49 which causes the data on lines 30*a* through 30*h* to be shifted into the registers. The first stage of register 37 (I_0) is coupled to a multiplexer 38 by line 42. The third stage of register 37 (I_1) is also coupled to the multiplexer 38 by line 43. In a similar fashion, the first stage of the register 36 (I_2) is coupled by line 44 to the multiplexer 38, and the third stage of this register (I_3) is also coupled to the multiplexer 38 by line 45.

Line 44 is coupled to the fourth stage of register 36 in order that four bits of data within register 36 may be recirculated. (Registers 36 and 37 shift data from left to right, that is, toward their first stage). The line 42 may be selectively coupled to the fourth stage of register 37 through the multiplexer 40 in order that four bits of data within register 37 may be recirculated. Line 44 may be coupled through the multiplexer 40 to the fourth stage of the shift register 37. When this occurs, the shift registers 36 and 37 operate as a single eight bit shift register.

Control signals designated as even/odd X (line 47) and upper/lower Y (line 48) are used to control multiplexer 38. During the color graphics mode the registers 36 and 37 operate as separate registers and data is alternately selected for coupling to line 26 by multiplexer 38. The upper/lower Y signal, during the color graphics mode, allow selection of data from either register 36 or 37. The odd/even X signal then toggles the data from the selected register by alternating selecting I_0 or I_1 if register 37 is selected, or I_2 or I_3 if register 36 is selected.

During the color graphics mode as presently implemented, eight bits of color information are shifted (in parallel) into the registers 36 and 37 from the RAM 23 at a 1+ Mhz rate. This data is recirculated within registers 36 and 37 at a rate of 14.31818 Mhz by the clocking signal received on line 33. The circulation of the data bit within the registers 36 and 37 at this rate provides signals having a 3.58 Mhz component and as will be described, these signals may be readily employed for providing color signals for video display.

In the color graphics mode, as presently implemented, each of the display characters is divided into an upper and lower color rectangle. The RAM 23 provides the four bits of color data for the upper rectangles to registers 36 and for the lower rectangles to register 37. This color data for the presently preferred embodiment is coded as follows:

Red	0001	Medium Violet	0011
Pink	1011	Medium Blue	0110
Blue	0010	Medium Green	1100
Light Blue	0111	Orange	1001
Dark Green	0100	White	1111
Light Green	1110	Gray	1010
Brown	1000	Gray	0101
Yellow	1101		

When colors are coded in this manner and circulated at the rate of 14.318 Mhz in the registers, video color signals compatible with standard television receivers are produced. The resultant signal for red is shown on line 71 of FIG. 4, light blue on line 72, brown on line 73 and gray on lines 74 and 75.

Briefly referring again to FIG. 3, each count of the horizontal synchronization counter 63 corresponds to 3½ cycles of the subcarrier reference signal. Thus, a 180° phase shift occurs from character-to-character with respect to the color subcarrier reference signal. This means that the color signals must be shifted by 180° by the generator of FIG. 2, or the coding for these signals must be alternated for odd and even horizontal character positions. In the presently preferred embodiment, a 180° phase shift for the color signals is obtained by toggling between the first or third stages of the selected registers. For example, assume that the lower portion of a character is being displayed and that the color information is thus contained within register 37. Further assume that this information is being circulated, that is, line 42 couples stage 4 to stage 1 through the multiplexer 40. For even horizontal character positions, as indicated by the signal on line 47, the phase select multiplexer 38 couples the I_0 signal to line 26. For the odd positions, a 180° phase shift is obtained by selecting the I_1 signal.

During a second mode of operation the generator of FIG. 2 is used for providing high resolution graphics. In this case, eight bits of information are provided by the RAM 23 to the registers 36 and 37. For this high resolution mode line 42 is coupled to the video line 26 and the eight bits of data from RAM 23 are serially coupled to the video line 26 at the 14.318 Mhz rate. The multiplexer 40 couples line 44 to the fourth stage of register 37 to provide a single eight bit shift register. The resultant signals are shown on lines 77 and 78 of FIG. 4. The signals on lines 77 and 78 provide either a green or violet display. In the presently preferred embodiment, data changes are employed to obtain the compensation provided by the multiplexer 38 during the color graphics mode.

Thus, a microcomputer has been disclosed which is particularly suitable for controlling a color video display. The unique timing means provides well defined vertical color lines without complicated programming changes while allowing the generation of horizontal synchronization signals at close to the standard rate. The unique video generator allows the generation of color signals directly from digital signals without the complex circuitry often employed in the prior art.

I claim:

1. A digitally controlled color signal generation means for use with a color video display adapted to receive color signals having a color subcarrier reference signal of frequency N, said color signal generation means comprising:

means for generating at least one digital word which corresponds to a predetermined color, said digital word comprising a plurality of bits;

storing means for storing said digital word;

sampling means coupled to said storing means for sequentially sampling each of said bits of said digital word at a predetermined sampling rate, said sampling rate being selected such that a color signal is developed at an output of said sampling means which corresponds to said predetermined color and which has a frequency component at said frequency N;

whereby a color signal suitable for use with the video display is generated.

2. The color signal generation means of claim 1 wherein said sampling means comprises a recirculating shift register means for receiving said digital word from

said storing means and for circulating said digital word in said shift register means at said predetermined sampling rate.

3. The color signal generation means defined by claim 2 wherein said digital word is comprised of P number of bits, said shift register means comprises a recirculating shift register having P number of stages, and said predetermined sampling rate is at a frequency approximately equal to N×P.

4. The color signal generation means defined by claim 3 wherein P is equal to four.

5. The color signal generation means defined by claim 4 wherein N is approximately 3.58 MHz and said predetermined sampling rate is approximately 14.318 MHz.

6. The color signal generation means defined by claim 5 wherein said sampling means further includes phase shifting means for coupling different stages of said shift register to said output thereby allowing the selection of a phase shifted signal.

7. The color signal generation means defined by claim 6 wherein said digital word corresponding to the color red is 0001.

8. A digitally controlled color signal generation means for use with a color video display adapted to receive color signals having a color subcarrier reference signal of frequency N, said improved color signal generation means comprising:

means for generating at least one digital word which corresponds to a predetermined color, said digital word comprising P number of bits;

storing means for storing said at least one digital word;

sampling means coupled to said storing means for sequentially sampling each of said bits of said digital word at a sampling rate approximately equal to a frequency of N×P;

whereby a color signal suitable for use with the video display is developed at an output of said sampling means.

9. The color signal generation means defined by claim 8 wherein said sampling means includes phase shifting means for altering the sequence of said sequential sampling, thereby allowing the selection of a phase shifted signal at said output of said sampling means.

10. The color signal generation means defined by claim 9 wherein N is approximately equal to 3.58 MHz, P is equal to four and said sampling rate is at a frequency approximately equal to 14.318 MHz.

11. The color signal generation means defined by claim 10 wherein said sampling means comprises a recirculating shift register having four stages which receives said digital word from said storing means, with said shift register being clocked at a frequency approximately equal to 14.318 MHz and said phase shifting means is a means for coupling different stages of said shift register to said sampling means output.

* * * * *