**United States Patent** [19]
**Chaum**

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[45] **Date of Patent: May 15, 1990**

[54] **CARD-COMPUTER MODERATED SYSTEMS**

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[21] Appl. No.: **198,315**

[22] Filed: **May 24, 1988**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 524,896, Aug. 22, 1983, Pat. No. 4,759,063, and Ser. No. 784,999, Oct. 7, 1985, Pat. No. 4,759,064, and Ser. No. 168,802, Mar. 16, 1988, abandoned, and Ser. No. 123,703, Oct. 23, 1987.

[51] **Int. Cl.**$^5$ .............................................. **H04K 1/00**
[52] **U.S. Cl.** ........................................ **380/23;** 380/24;
380/30; 235/379; 235/380; 235/382
[58] **Field of Search** .................................... 380/23–25,
380/30, 43, 44, 47, 49, 50; 235/379–382

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*Assistant Examiner*—Bernarr Earl Gregory
*Attorney, Agent, or Firm*—Nixon & Vanderhye

[57] **ABSTRACT**

A user controlled card computer C and communicating tamper-resistant part T are disclosed that conduct secure transactions with an external system S. All communication between T and S is moderated by C, who is able to prevent T and S from leaking any message or pre-arranged signals to each other. Additionally, S can verify that T is in immediate physical proximity. Even though S receives public key digital signatures through C that are checkable using public keys whose corresponding private keys are known only to a unique T, S is unable to learn which transactions involve which T. It is also possible for S to allow strictly limited messages to be communicated securely between S and T.

**18 Claims, 9 Drawing Sheets**

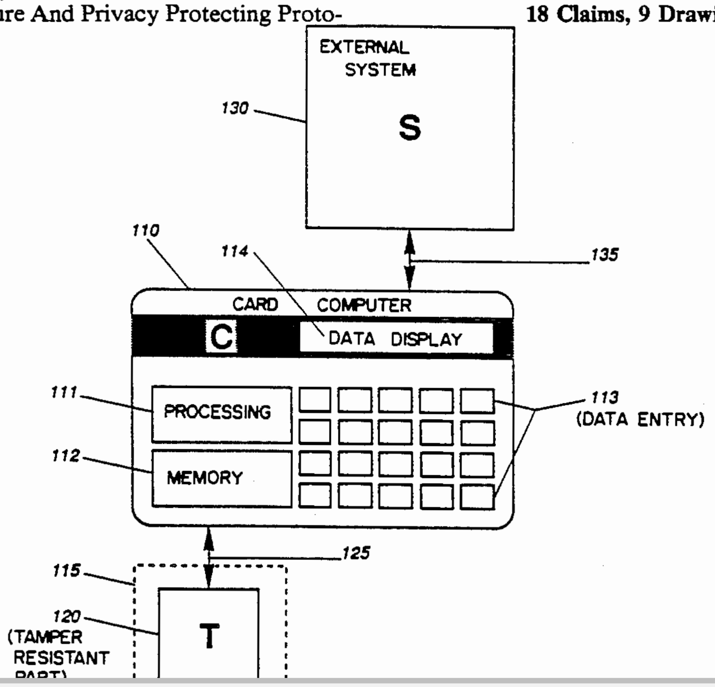


FIG. 1

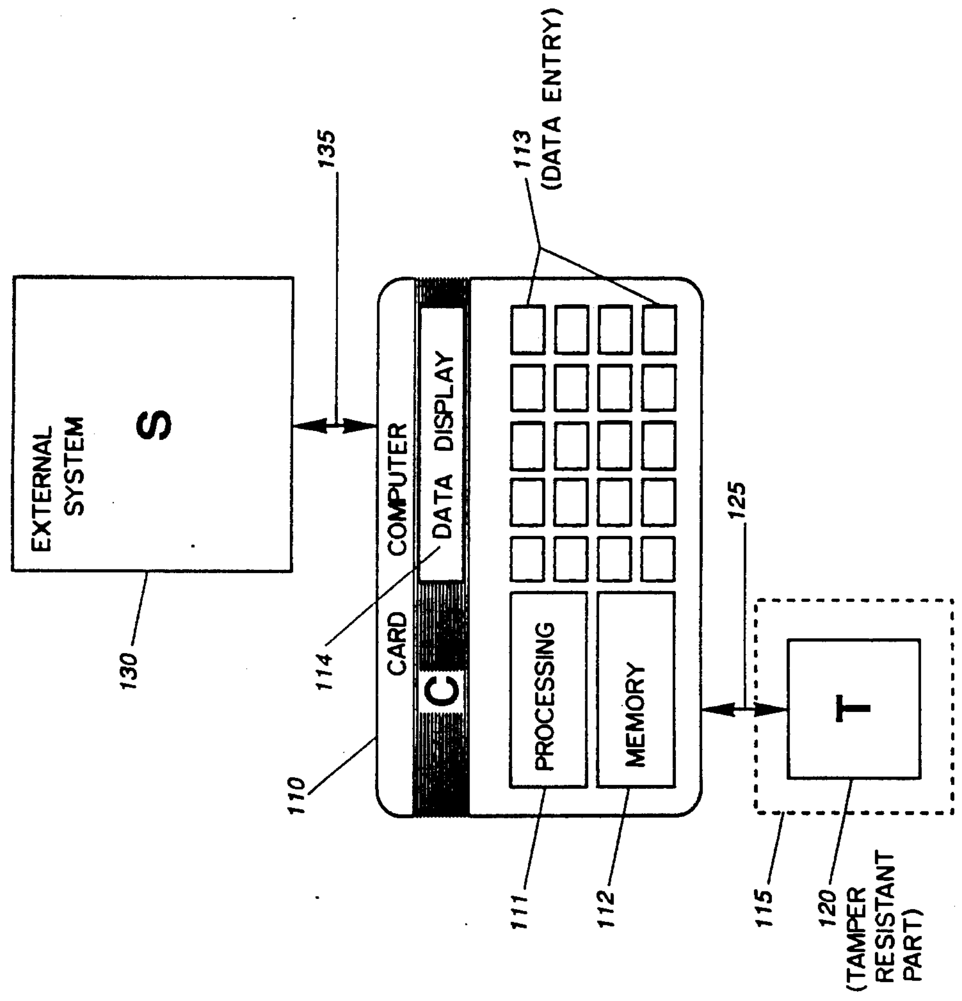

EXTERNAL SYSTEM
S
130
135
114
110
CARD COMPUTER
DATA DISPLAY
C
PROCESSING
MEMORY
111
112
113 (DATA ENTRY)
125
T
115
120 (TAMPER RESISTANT PART)

FIG. 2

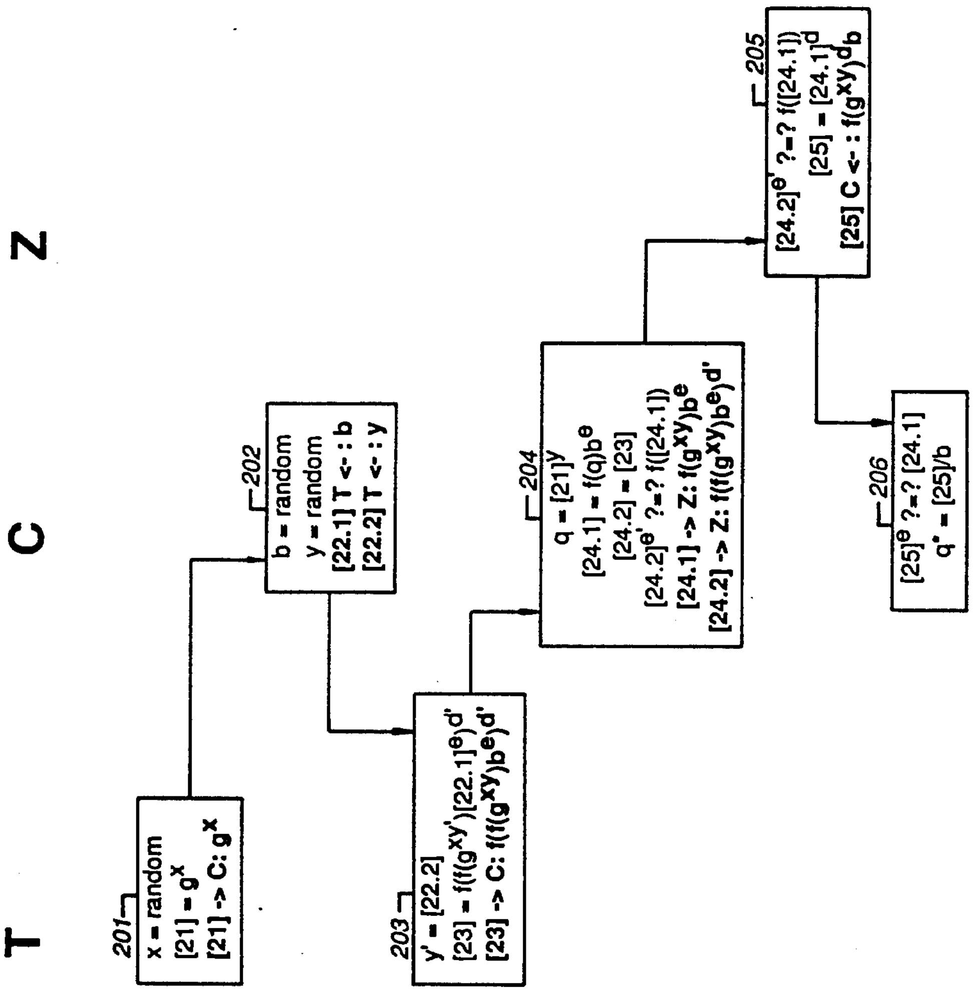

T
C
Z
201
x = random
[21] = g^x
[21] -> C: g^x
202
b = random
y = random
[22.1] T <- : b
[22.2] T <- : y
203
y' = [22.2]
[23] = f(f(g^xy')[22.1]^e)d'
[23] -> C: f(f(g^xy)b^e)d'
204
q = [21]^y
[24.1] = f(q)b^e
[24.2] = [23]
[24.2]^e' ?=? f([24.1])
[24.1] -> Z: f(g^xy)b^e
[24.2] -> Z: f(f(g^xy)b^e)d'
205
[24.2]^e' ?=? f([24.1])
[25] = [24.1]^d
[25] C <- : f(g^xy)^d b
206
[25]^e ?=? [24.1]
q* = [25]/b

FIG. 3

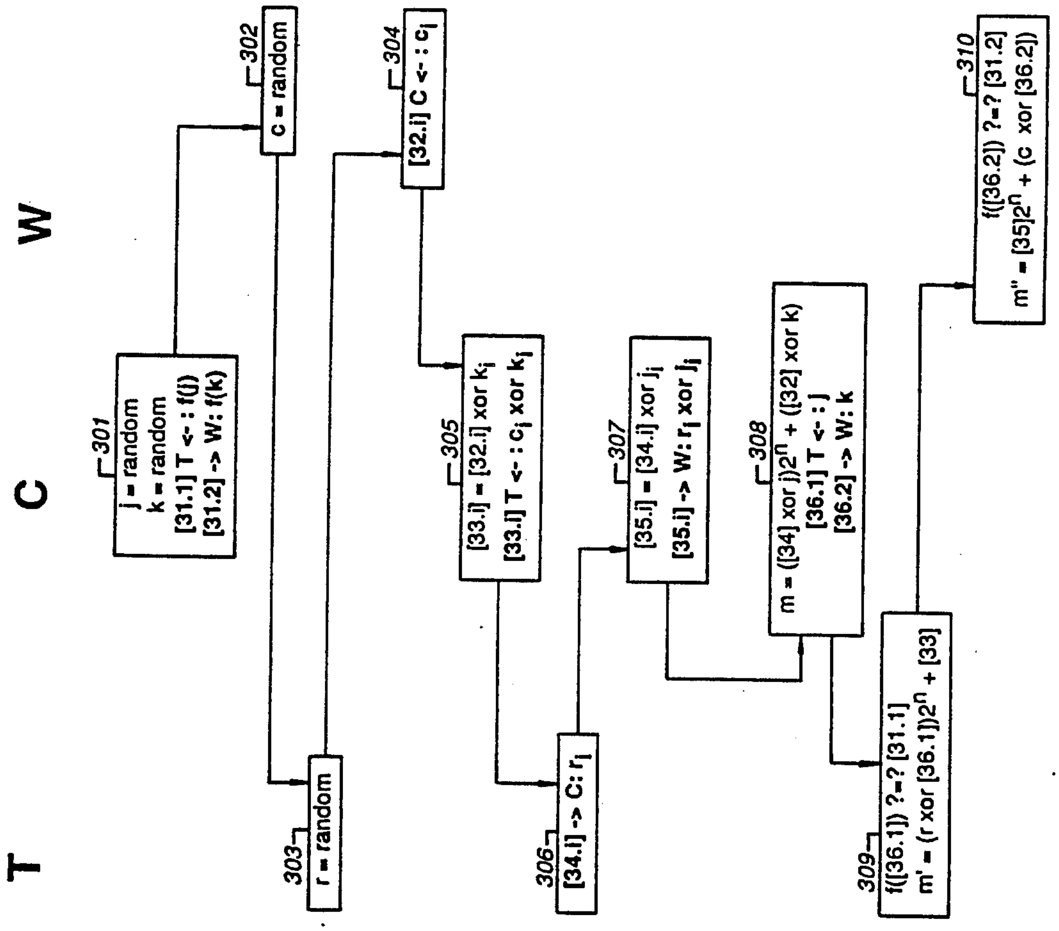
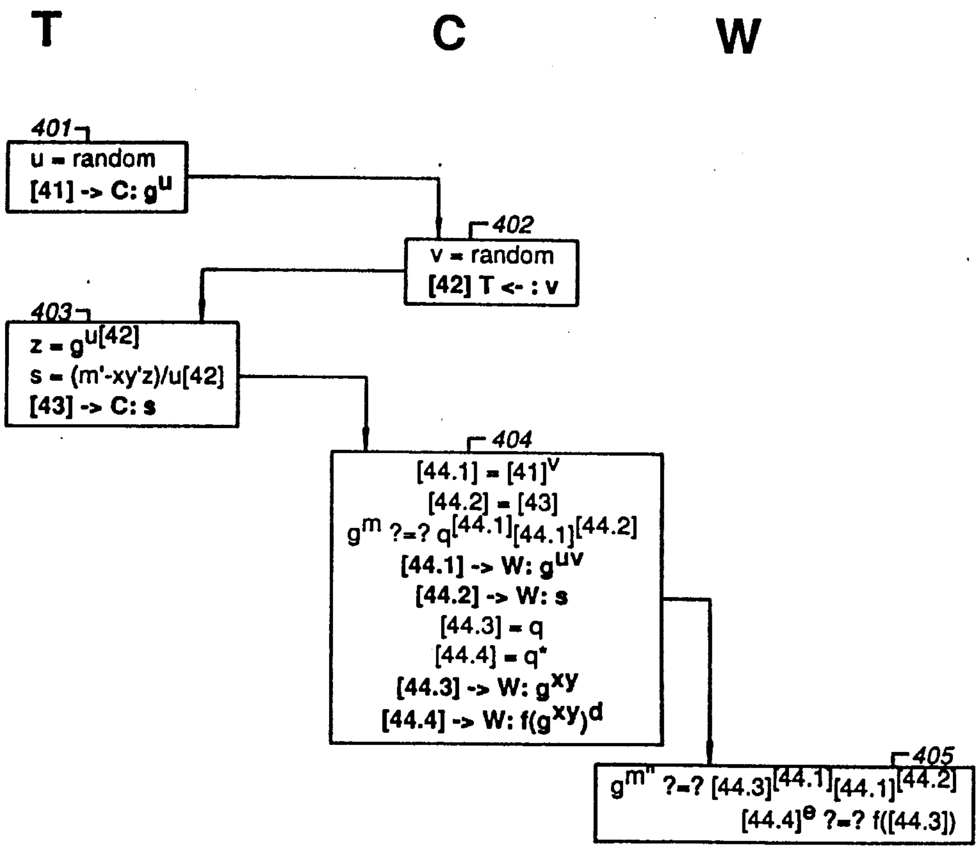

T
C
W
301
j = random
k = random
[31.1] T <- : f(j)
[31.2] -> W: f(k)
302
c = random
303
r = random
304
[32.i] C <- : c_i
305
[33.i] = [32.i] xor k_i
[33.i] T <- : c_i xor k_i
306
[34.i] -> C: r_i
307
[35.i] = [34.i] xor j_i
[35.i] -> W: r_i xor j_i
308
m = ([34] xor j)2^n + ([32] xor k)
[36.1] T <- : j
[36.2] -> W: k
309
f([36.1]) ?=? [31.1]
m' = (r xor [36.1])2^n + [33]
310
f([36.2]) ?=? [31.2]
m'' = [35]2^n + (c xor [36.2])

FIG. 4


T
C
W
401
u = random
[41] -> C: $g^u$
402
v = random
[42] T <- : v
403
z = $g^{u[42]}$
s = (m'-xy'z)/u[42]
[43] -> C: s
404
[44.1] = $[41]^v$
[44.2] = [43]
$g^m$ ?=? $q^{[44.1]}[44.1]^{[44.2]}$
[44.1] -> W: $g^{uv}$
[44.2] -> W: s
[44.3] = q
[44.4] = q*
[44.3] -> W: $g^{xy}$
[44.4] -> W: $f(g^{xy})^d$
405
$g^{m''}$ ?=? $[44.3]^{[44.1]}[44.1]^{[44.2]}$
$[44.4]^e$ ?=? f([44.3])

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