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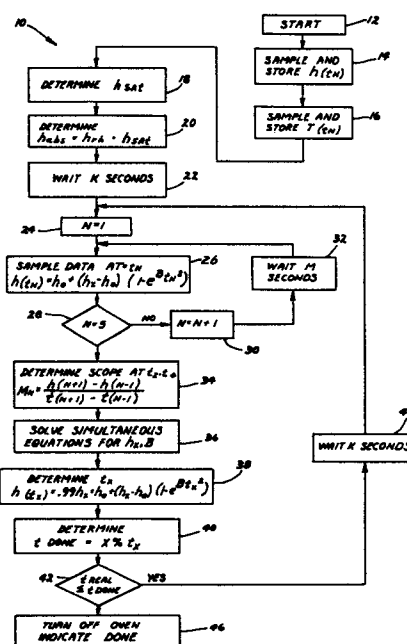
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⑤④ **Method of cooking thin meats in a microwave oven.**

⑤⑦ A method of cooking thin meat in a microwave oven by determining the temperature of the thin meat as a function of sensed and sampled "in-situ" time dependent humidity and temperature environmental conditions of a microwave oven heating cavity. The method permits the monitoring for doneness of meat while being cooked in the microwave oven by determining the temperature at any point on a "characteristic humidity curve" for the sensed and sampled environmental conditions.



METHOD OF COOKING THIN MEATS IN A MICROWAVE OVENTechnical Field

This invention relates generally to improvements in a microwave oven, and more particularly, pertains to a new and improved method of cooking thin meat in a microwave oven.

Background of Prior Art

Those concerned with microwave cooking of a thin piece of meat in a microwave oven have long recognized the need to accurately determine the temperature of the meat. The present invention fills this need.

5        Past prior art devices have been extremely-unreliable in determining the surface and internal temperature of meat. Initial prior art attempts at determining the internal doneness of meat was to insert a thermometer into the piece of meat being cooked which was not affected by  
10       the microwave energy radiation, but the disadvantage was that the thermometer only indicated the internal temperature of the meat at one particular location and was not a true overall indication of the equilibrium internal doneness of the meat.

15       Another current prior art device for measuring the internal temperature of meats being cooked is to insert a temperature probe into the meat while in the microwave oven heating cavity which connects to the control circuitry of the microwave oven. While the temperature probe  
20       is accurate in indicating the temperature of the meat being cooked by microwave energy, the probe only senses the temperature of the immediate area surrounding the probe and does not take into account the equilibrium state of the internal temperature of the meat. If the temperature of the meat is not uniform and the probe is placed  
25       at a hot spot in the meat, the readings from the temperature probe are not indicative of the internal doneness of the meat.

      Further, the probe which is inserted into the meat  
30       is cumbersome and bulky for the cook who is trying to monitor the internal doneness of the meat during the microwave cooking in the microwave oven heating cavity. For a thin piece of meat being approximately equal to or less than one wavelength, it is difficult for a cook, if not  
35       impossible, to insert a temperature probe into the meat as the thickness is approximately no greater than one centimeter.

This invention, a method of cooking thin meats in a microwave oven, overcomes the disadvantages of prior art by providing an accurate method for determining the temperature of thin meat.

Brief Summary of the Invention

The present invention obviates the foregoing disadvantages of the prior art by providing a method of cooking thin meat in a microwave oven.

5 According to the preferred embodiment of the present invention, there is provided a method for cooking thin meat in a microwave oven wherein the time dependent "in-situ" humidity and temperature environmental conditions of a microwave oven heating cavity are sensed and sampled, the absolute humidity is determined from the sampled "in-situ" humidity and temperature, the absolute humidity is  
10 determined at a plurality of points on a "characteristic humidity curve", and the temperature of the meat is determined from the slope of the sampled points of the "characteristic humidity curve".

15 A significant aspect and feature of the present invention is a method which provides for the determination of the temperature of a piece of thin meat being cooked in the microwave oven. Since the meat is thin, that is being approximately equal to or less than one skin depth  
20 which for 2450 megahertz is one centimeter, the surface temperature of the meat is equal to the internal temperature of the meat.

Another object of the invention is to provide a method of determining when the thin piece of meat is cooked  
25 to doneness by sensing the time dependent "in-situ" humidity and the temperature environmental conditions of the microwave oven heating cavity. The term "in-situ" as used in this application is defined as the actual time dependent environmental conditions which exist in the  
30 environment surrounding the food product such as thin meat which is located in and cooked in the microwave oven heating cavity. Although in the present invention, a humidity sensor and a temperature sensor may be positioned outside of the microwave oven heating cavity, the sensors  
35 are configured to sense the "in-situ" environmental conditions of the microwave oven heating cavity and provide

"in-situ" signal information of the environmental conditions of the microwave oven heating cavity to a programmable controller controlling the microwave oven.

Brief Description of the Drawing

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, in which like reference numerals designate like elements throughout the figures thereof and wherein:

FIGURE 1 illustrates a flow chart of the method of cooking thin meat in a microwave oven in accordance with the present invention, and;

FIGURE 2 illustrates a typical "characteristic humidity curve" for the present invention.

Detailed Description of the Invention

Figure 1 illustrates a flow chart 10 of the method of cooking thin meat in accordance with the present invention. The flow chart provides for the solving of the equation

$$5 \quad h(t_n) = h_0 + (h_x - h_0) \cdot (1 - e^{-Bt_n^2}) \quad \text{eq. 1}$$

where equation 1 is a "characteristic humidity curve" for thin meat having a thickness approximately equal to or less than one skin depth.  $h_0$  is the ambient absolute humidity,  $h_x$  is the peak absolute humidity, and B is a coefficient, characteristic of meats having units of 1/seconds<sup>2</sup>. 10

The flow chart 10 starts at 12 where the "in-situ" relative humidity of the microwave oven heating cavity is sampled and stored 14, the "in-situ" temperature of the microwave oven heating cavity is sampled and stored 15 16, the saturated humidity 18 is determined, and the absolute humidity 20 is determined from the multiplication of the relative humidity times the saturated humidity.

The program after waiting K seconds 22, then sets n equal to 1 at 24 and initiates by sampling data 26 at 20 four points to compute the slope of the "characteristic humidity curve" for the algorithm of equation 1 for the method. Until n equals five 28 condition is satisfied, n is incremented by one 30 waiting m seconds 32 between each sample. Data 26 is sampled at four points satisfying 25 conditions 28 and 30 waiting m seconds 32 between each sample. When n equals five 28 condition occurs, the slope 34 is determined by solving the simultaneous equations 36 for  $h_x$  and B. From determining the values of  $h_x$  and B,  $t_x$  is determined 38 and  $t_{done}$  is equal to a percentage of  $t_x$  40 as the "characteristic humidity curve" proceeds to infinity and a cook is only interested in the plateau of the "characteristic humidity curve".. When  $t_{real}$  less than or equal to  $t_{done}$  YES condition 42 exists, then the program recycles itself after waiting K seconds to again 35 begin sampling data at four points to determine the slope 34, solve for  $t_x$ , etc. This continues to repeat until

a  $t_{\text{real}}$  equal to or less than  $t_{\text{done}}$  NO condition 42 occurs at which time the microwave oven is turned off 46 and a done indication is given to the cook.

5 The method of cooking thin meat in a microwave oven is premised on the sensing concept based on the most fundamental cooking principles. That is, as microwave energy is converted to thermal energy, the internal temperature of the meat increases. As the internal temperature of the meat increases, some of the thermal energy is  
10 used to break the bonding forces holding the water molecules to the food's cell structure. When the latent heat of vaporization has been added to the food, these free water molecules are vaporized and released locally. Thus, the rate of evaporation is directly proportional to the  
15 rate of temperature rise. By monitoring time dependent "in-situ" environmental conditions of the microwave oven heating cavity with sensors, the meat's internal temperature, and surface temperature for a thin piece of meat being approximately less than or equal to one skin depth,  
20 are determined.

The "characteristic humidity curve" 48 of absolute humidity in grams per cubic meter versus cooking time in seconds of Figure 2 for the thin meat equation 1 is determined by sensing the time dependent "in-situ" humidity  
25 and temperature environmental conditions of the microwave oven heating cavity during microwave cooking of thin meats. The time dependent "in-situ" environmental conditions are defined as the sensed humidity and temperature of the microwave oven heating cavity by humidity and temperature  
30 sensors. Each particular cut of thin meat has its own particular "characteristic humidity curve".  $h_0$  is the initial absolute humidity and  $h_x$  is the peak absolute humidity at the time  $t_x$  of the "characteristic humidity curve" 48.

35 Figure 2 depicts a characteristic humidity curve derived from a plot of absolute humidity versus elapsed cooking time. The changes in slope of the curve are indicative of the rate of evaporative water loss from the

thin meat body effecting the absolute humidity in the cooking cavity. For purposes of the present method, the point of peak absolute humidity,  $h_x$ , indicated at 60, is of primary interest. The "characteristic humidity curve" 48 plateaus at point 60 indicating that surface temperature of the meat has reached equilibrium at one hundred degrees centigrade.

For small meat samples or with thicknesses small compared to the microwave depth of penetration, that is, being approximately equal to or less than one skin depth, the internal temperature is approximately and for all practical considerations, the same as the surface temperature from equation 1 for any point of the "characteristic humidity curve" of Figure 2.

The basic premise of the method is that as the relative humidity and temperature are sampled and stored,  $h_x$  and B are computed by solving simultaneous equation 36 to predict when the one hundred degree centigrade point 60 occurs. The temperature is assumed linear between  $h_0$  and one hundred degrees centigrade so that once  $t_x$  is computed, the corresponding time for any other temperature may be computed such as to determine when  $t_{done}$  is reached.

The method may be implemented in accordance with the flow chart 10 of Figure 1 as an algorithm stored in a programmable controller such as an Intel 8080 Microprocessor in the microwave oven. This algorithm of Figure 1 determines the temperature for a thin piece of meat for any point on the "characteristic humidity curve" of Figure 2.

An aluminum oxide humidity sensor, such as a Thunder Scientific TC-2000 Humidity Measurement Module, and a temperature sensor, such as a National Semiconductor Corporation LX 5700 Temperature Transducer, are positioned adjacent to and by the exit ventilation port to the exterior side of the microwave oven heating cavity for way of example and for purposes of illustration only to sense the time dependent "in-situ" environment conditions of the

microwave oven heating cavity. The sensors can be positioned anywhere as long as the time dependent "in-situ" environmental conditions of the microwave oven heating cavity are sensed and the sensors are electromagnetically  
5 protected from the microwave oven heating cavity. The humidity sensor and the temperature sensor connect to the programmable controller having the steps of the algorithm of Figure 1 stored in the memory of the programmable controller. The programmable controller connects to control  
10 the microwave power source power supply and the air exchange circuit and turns the oven off when a NO condition exists at the  $t_{\text{real}}$  is less than or equal to a predetermined  $t_{\text{done}}$  decision point 42.

Various modifications can be contemplated for the  
15 method of cooking thin meat in a microwave oven of the present invention without departing from the apparent scope of this invention.

Having thus described the invention, what is claimed is:

Claims

1. A method for cooking thin meat bodies in a microwave oven having means for measuring the humidity of the microwave oven cooking cavity environment associated therewith comprising the steps of:
  - 5 (a) energizing a microwave energy source to provide microwave energy to said cooking cavity whereby at least a portion of said energy is absorbed by a thin meat body located in said cooking cavity;
  - 10 (b) measuring the humidity of said cooking cavity environment at a plurality of time-spaced intervals and storing said measurements in a micro-processor forming part of the controls for said oven;
  - 15 (c) calculating the slope of a humidity-time curve described by said measurements;
  - (d) comparing said calculated slope with the slope of a characteristic humidity-time curve and calculating from said comparison the time when
  - 20 said thin meat body will reach thermal equilibrium at 100°C;
  - (e) calculating the time said thin meat body will reach a preselected doneness as a function of said thermal equilibrium time, and;
  - 25 (f) de-energizing said microwave energy source at said calculated doneness time.
2. The method of claim 1 wherein said means for measuring the humidity of the microwave oven cooking cavity environment comprises means for sensing the cavity environment relative humidity and temperature and  
30 wherein said humidity measuring step includes the calculation of the absolute humidity of said cavity environment from the sensed relative humidity and temperature.
- 35 3. The method of claim 1 wherein said characteristic humidity-time curve is described by the equation:

$$h_n = h_o + (h_x - h_o) (1 - e^{-Bn^2})$$

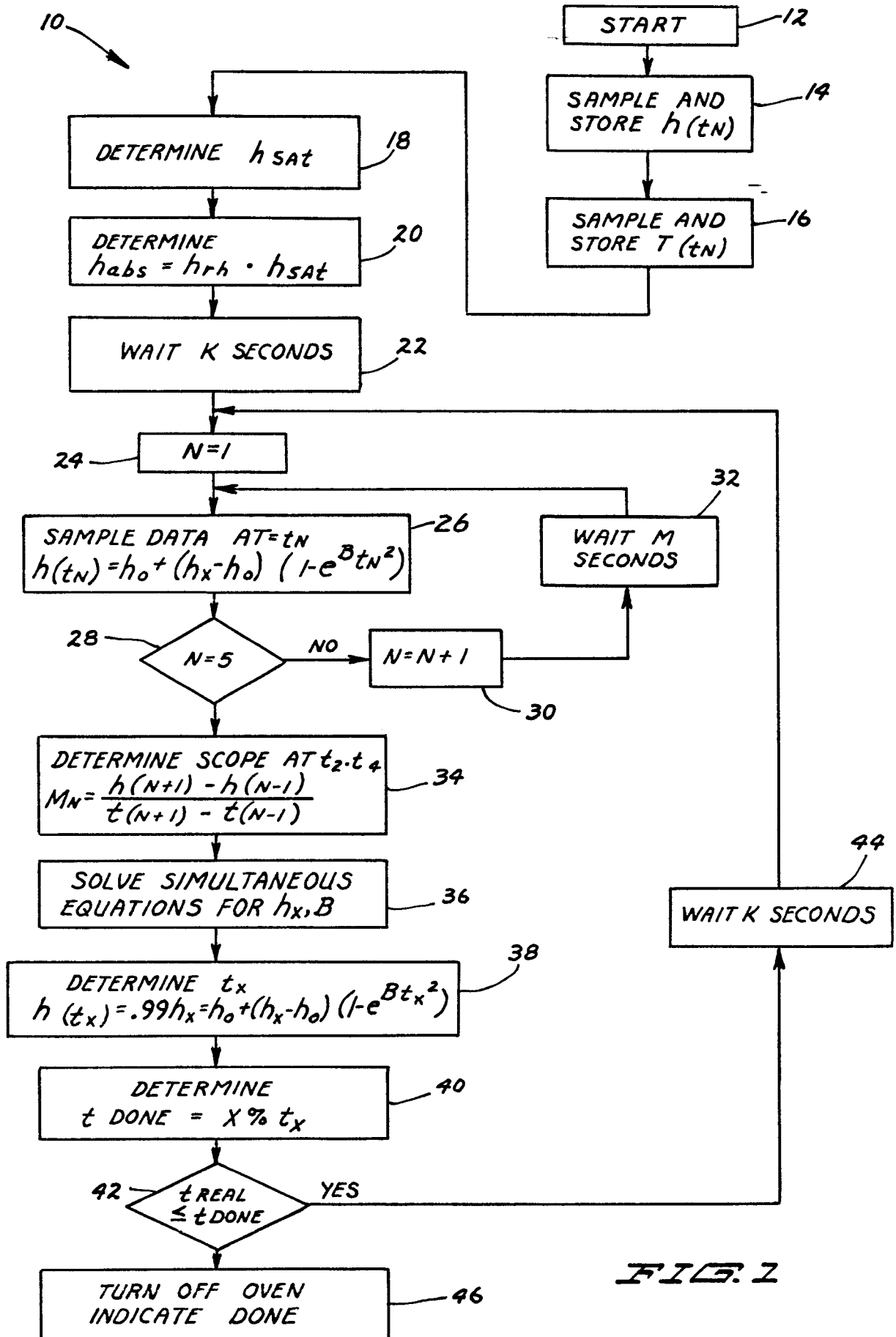
wherein  $h_n$  = absolute humidity at time interval N

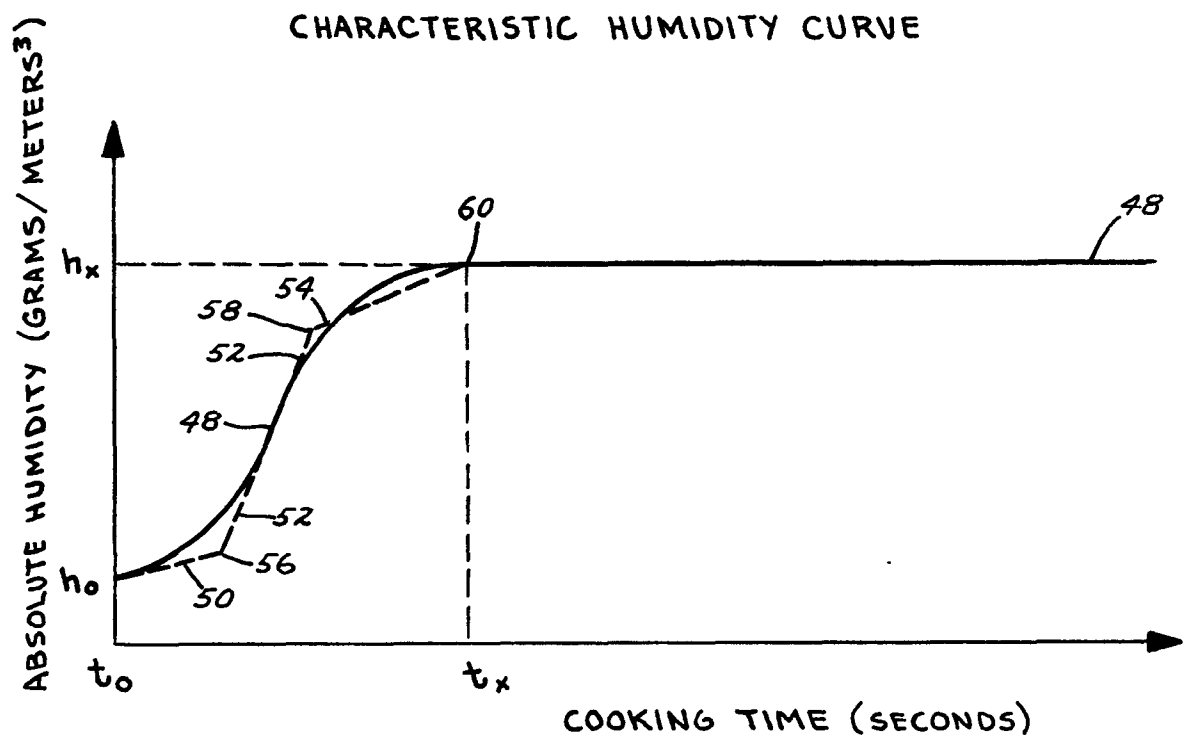
$h_o$  = absolute humidity at time interval N=0

$h_x$  = peak absolute humidity at thermal  
equilibrium

B = a coefficient, characteristic of said  
thin meat body

4. The method of claim 3 wherein said characteristic humidity-time curve equation is stored in said microprocessor.
5. The method of claim 1 wherein said calculated doneness time is calculated as a percentage of said thermal equilibrium time.
6. The method of claim 1 wherein said preselected doneness is stored in said microprocessor.
7. The method of claim 1 wherein steps (b) through (e) are repeated in consecutive sequences and wherein said calculated doneness time is updated in each sequence.



**FIG. 2**



| DOCUMENTS CONSIDERED TO BE RELEVANT                                                            |                                                                                                                                         |                                                       | CLASSIFICATION OF THE APPLICATION (Int. Cl. <sup>3</sup> )                                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Category                                                                                       | Citation of document with indication, where appropriate, of relevant passages                                                           | Relevant to claim                                     |                                                                                                                                                                                                                                                                                                                                                                                  |
| A                                                                                              | <u>DE - A - 2 706 367 (MATSUSHITA)</u><br>* Page 5, paragraph 5; page 9, lines 2-10; page 10, lines 20-27; page 11, paragraph 1 *<br>-- | 1                                                     | G 05 D 22/02<br>H 05 B 9/00                                                                                                                                                                                                                                                                                                                                                      |
|                                                                                                | <u>FR - A - 2 312 067 (MATSUSHITA)</u><br>* Page 11, lines 14-23 *<br>--                                                                | 1                                                     |                                                                                                                                                                                                                                                                                                                                                                                  |
|                                                                                                | <u>US - A - 4 011 428 (ESSEX INTERNATIONAL)</u><br>* Column 2, lines 6-33 *<br>--                                                       | 4,6                                                   | TECHNICAL FIELDS SEARCHED (Int.Cl. <sup>3</sup> )                                                                                                                                                                                                                                                                                                                                |
|                                                                                                | <u>DE - B - 1 090 798 (SIEMENS)</u><br>* Column 1, lines 39-47; column 3, lines 8-11 *<br>--                                            | 1                                                     | G 05 D 22/02<br>H 05 B 9/00<br>9/06<br>1/02<br>F 24 C 7/02<br>A 23 L 1/01                                                                                                                                                                                                                                                                                                        |
|                                                                                                | <u>US - A - 3 654 417 (LITTON)</u><br>* Column 3, lines 7-37 *<br>----                                                                  | 1                                                     | CATEGORY OF CITED DOCUMENTS<br><br>X: particularly relevant<br>A: technological background<br>O: non-written disclosure<br>P: intermediate document<br>T: theory or principle underlying the invention<br>E: conflicting application<br>D: document cited in the application<br>L: citation for other reasons<br><br>&: member of the same patent family, corresponding document |
| <input checked="" type="checkbox"/> The present search report has been drawn up for all claims |                                                                                                                                         |                                                       |                                                                                                                                                                                                                                                                                                                                                                                  |
| Place of search<br><b>The Hague</b>                                                            |                                                                                                                                         | Date of completion of the search<br><b>06-12-1978</b> | Examiner<br><b>RAUSCH</b>                                                                                                                                                                                                                                                                                                                                                        |