United States Patent [19]

Kostas et al.

[11] **4,360,886**

[45] **Nov. 23, 1982**

[54] **METHOD AND APPARATUS FOR ANALYZING THE FEASIBILITY OF PERFORMING A PROGRAMMED SEQUENCE OF MOTIONS WITH A ROBOT**

[75] Inventors: **Evans Kostas**, Bay Village; **Gerald W. Crum**, Elyria; **Jerome F. Walker**, Shaker Heights, all of Ohio

[73] Assignee: **Nordson Corporation**, Amherst, Ohio

[21] Appl. No.: **201,221**

[22] Filed: **Oct. 27, 1980**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 137,234, Apr. 4, 1980, Pat. No. 4,305,028.

[51] **Int. Cl.³** **G05B 19/42; B25J 9/00; G06F 11/30**

[52] **U.S. Cl.** **364/551; 318/568; 364/513; 414/1**

[58] **Field of Search** 364/578, 513, 174, 190, 364/193; 318/565, 568

[56] **References Cited**

U.S. PATENT DOCUMENTS

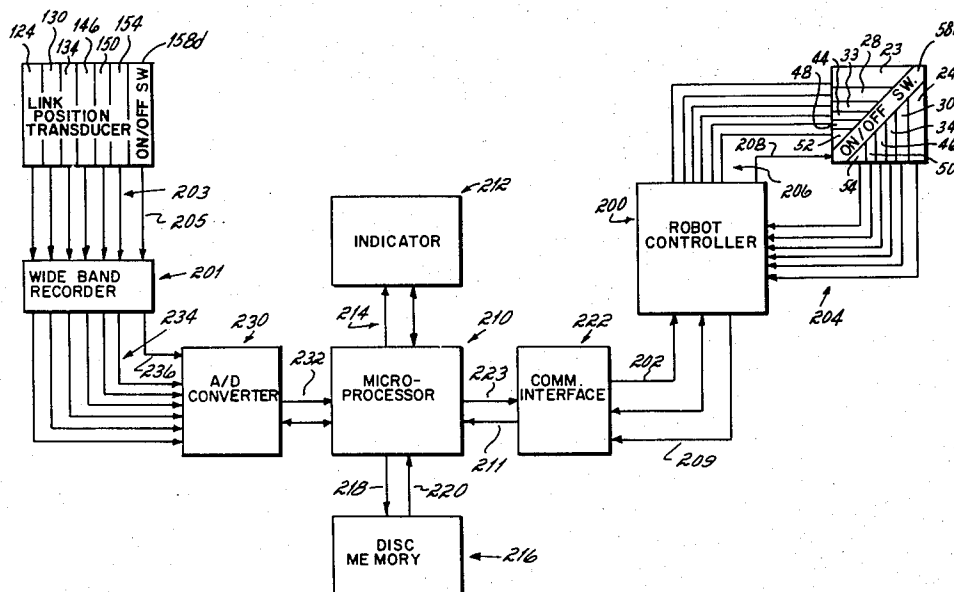|			
4,300,198	11/1981	Davini	364/513
4,305,028	12/1981	Kostas et al.	318/565
4,338,672	7/1982	Perzley et al.	364/513

Primary Examiner—Felix D. Gruber
Attorney, Agent, or Firm—Wood, Herron & Evans

[57] **ABSTRACT**

An apparatus and method for determining the feasibility of performing a programmed sequence of motions with a robot. Included is a work robot at a first location having a plurality of power-driven, signal-controlled, relatively massive links interconnected to permit relative motion in plural degrees of freedom, the work robot having a given mechanical response characteristic. Associated with each link of the work robot is a position transducer which generates a signal representative of the actual position of its associated work robot link. Also included is a portable, relatively lightweight, manually manipulable simulator robot located remote from the work robot. The simulator robot has a plurality of different interconnected links adapted for manual movement in different degrees of freedom for setting a program of desired mechanical responses, with the links and degrees of freedom of the simulator robot simulating those of the work robot. Associated with each link of the simulator robot is a position transducer for generating a signal representative of the position of its associated simulator robot link. A signal recorder is provided at the location of the simulator robot for storing the position signals representative of the program of desired mechanical responses imparted to it by the operator. A work robot controller is provided at the site of the work robot which is responsive to the stored position signals for manipulating the work robot links to perform the movements corresponding to the program of desired mechanical responses limited only by the given mechanical response characteristic of the work robot. An analyzer responsive to the actual and desired position signals of the work robot links is provided for generating error signals correlated to the extent to which the work robot is capable of performing the program of desired mechanical responses manually imparted to the simulator robot. An indicator responsive to the analyzer provides a humanly perceptible indication of the feasibility.
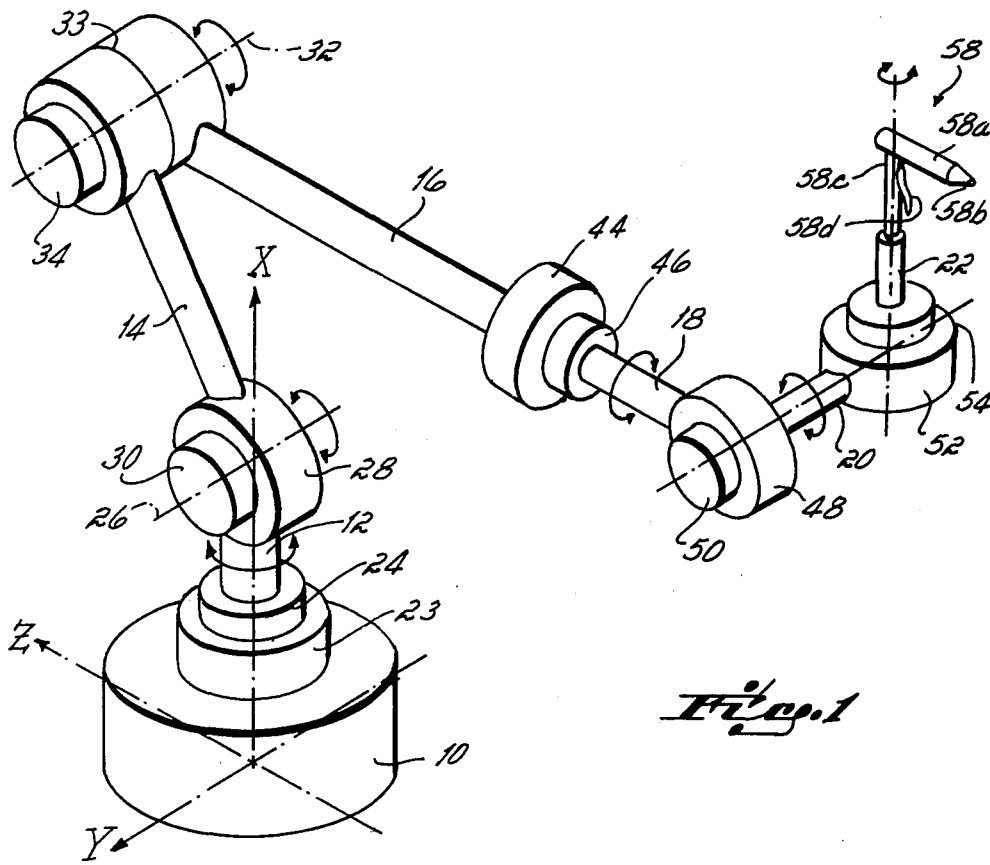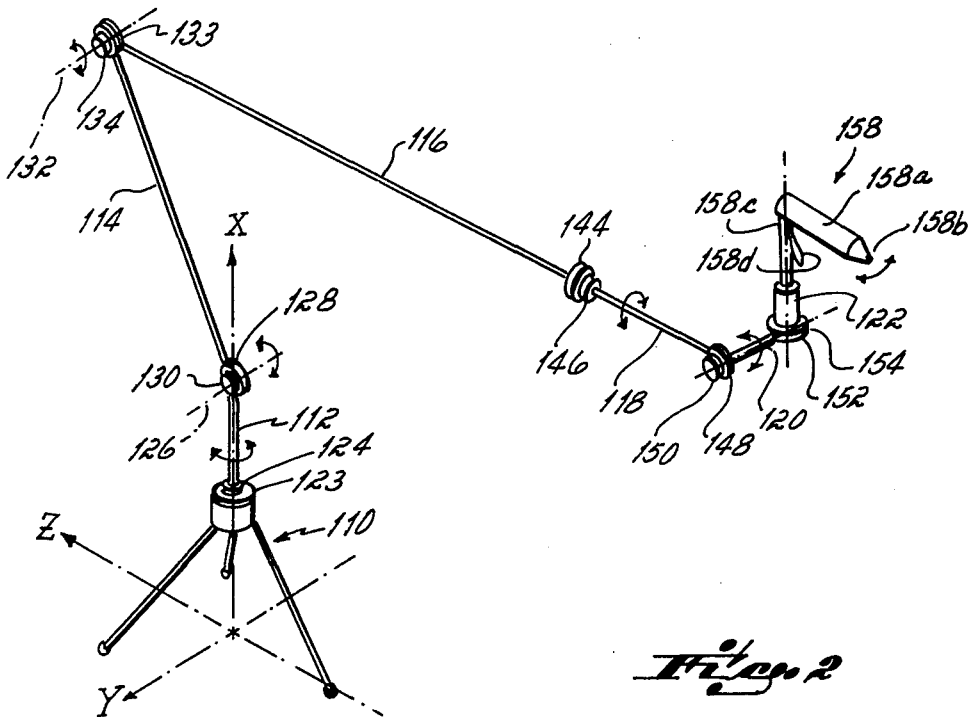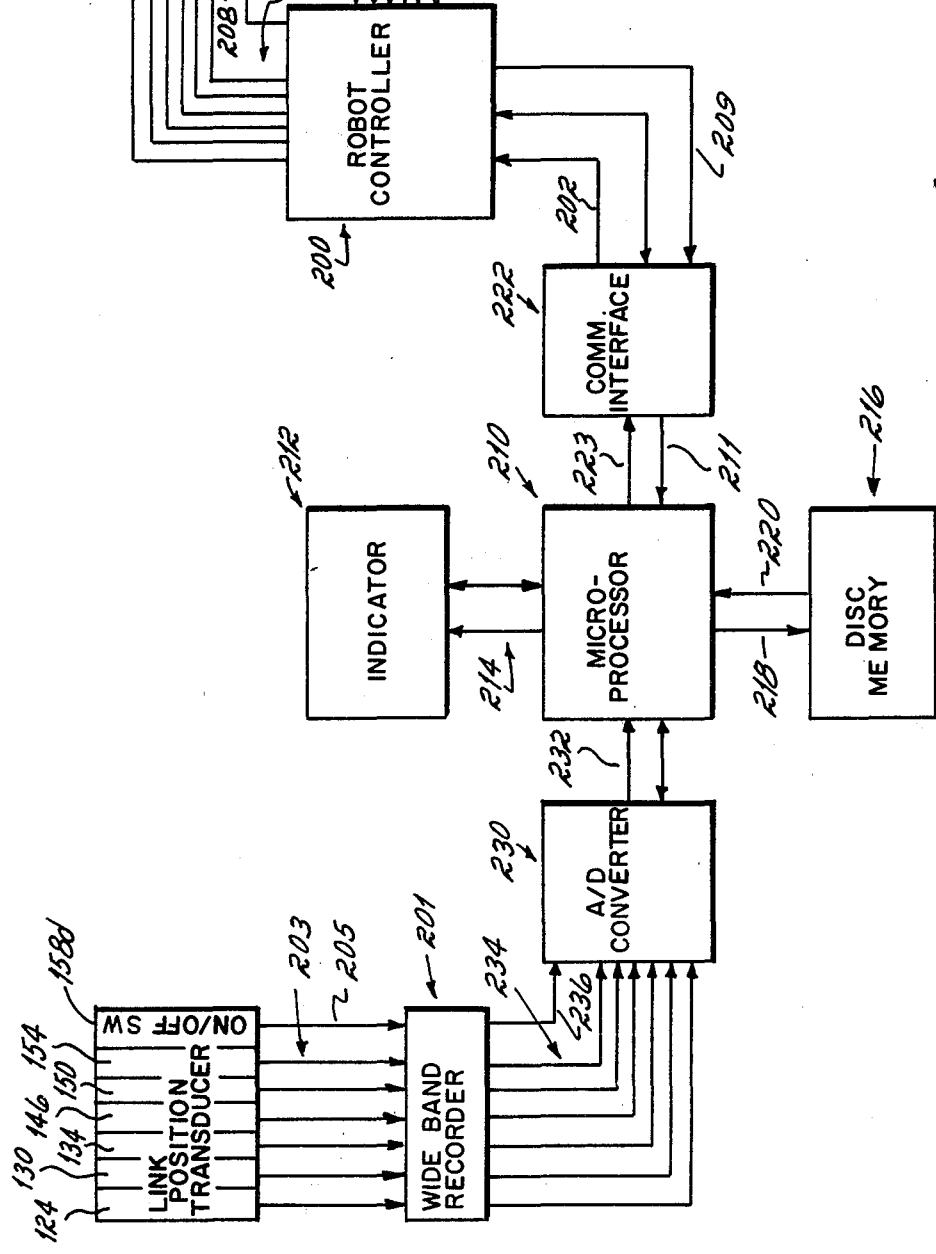
14 Claims, 9 Drawing Figures

Fig. 1

Fig. 2

Fig. 5

300

START

```
RECORD  SIMULATOR  ROBOT
LINK  POSITIONS  &  ON/OFF
SWITCH  CONDITIONS
```

STOP
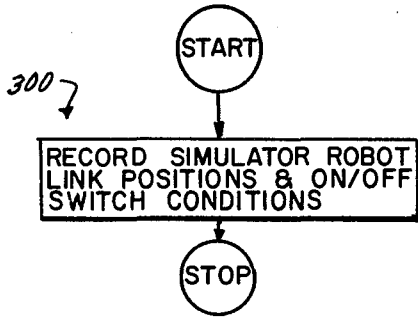
SIMULATOR ROBOT
DATA COLLECTION

PHASE ONE

Fig. 4a

START

```
A/D CONVERSION OF
DESIRED WORK ROBOT
LINK  POSITION
```
301

6
LINKS
?
302

NO

YES

```
A/D CONVERSION  OF
DESIRED ON/OFF SW.
CONDITION
```
303

```
FORMAT  &  BUFFER
STORE  DESIRED
POSITIONS  &  ON/OFF
SW.  CONDITIONS  IN
M.P.  RAM
```
304

```
WRITE  DESIRED
POSITIONS  &  ON/OFF
SW.  CONDITIONS  IN
DISC
```
305

END
?

NO

YES

STOP
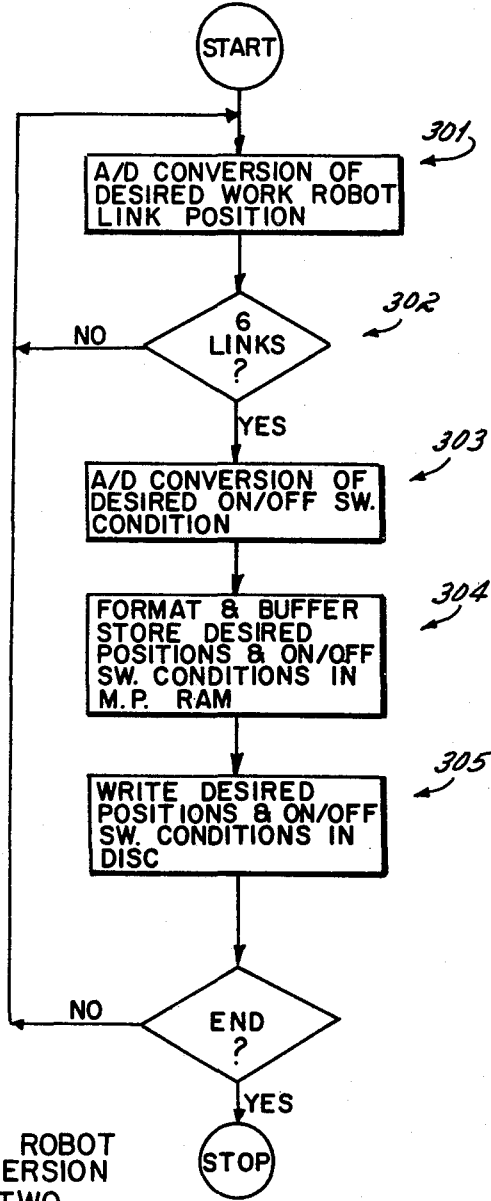
SIMULATOR ROBOT
DATA CONVERSION
PHASE TWO

Fig. 4b

START

306
READ DESIRED POSITIONS & ON/OFF SW. CONDITIONS FROM DISC

307
BUFFER STORE DESIRED POSITIONS & ON/OFF SW. CONDITION IN M. P. RAM

308
TRANSFER DESIRED POSITIONS & ON/OFF SW. CONDITION TO ROBOT CONTROLLER

309
EXECUTE ROBOT CONTROLLER PROGRAM

310
TRANSFER ACTUAL POSITIONS FROM ROBOT CONTROLLER RAM TO M. P. RAM

311
TRANSFER ACTUAL POSITIONS TO DISC FROM M. P. RAM

STOP
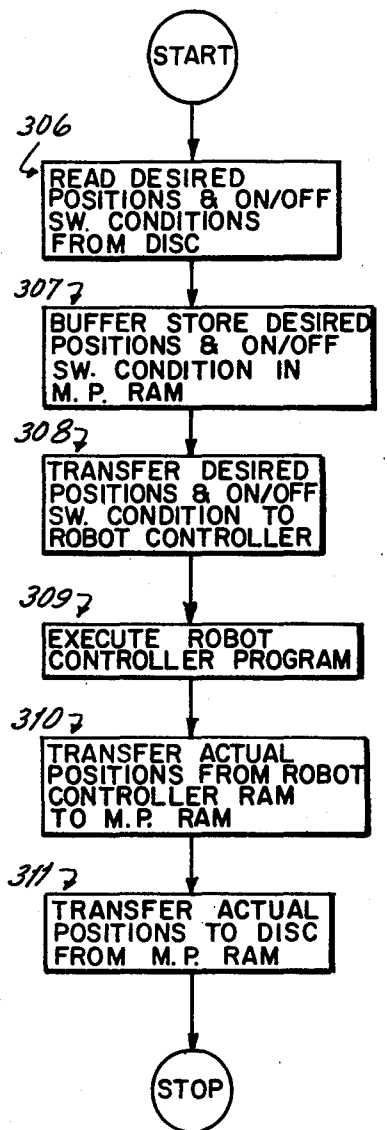
WORK ROBOT DRIVE
PHASE THREE

Fig. 4C

START

312
FETCH DESIRED POSITION OF ROBOT LINK FROM ROBOT CONTROLLER RAM

313
INPUT ACTUAL POSITION OF ROBOT LINK FROM LINK POSITION TRANSDUCER TO ROBOT CONTROLLER

314
COMPUTE ERROR IN ROBOT CONTROLLER BETWEEN DESIRED & ACTUAL LINK POSITIONS

315
OUTPUT ERROR FROM ROBOT CONTROLLER TO ROBOT LINK ACTUATOR

316
STORE ACTUAL ROBOT LINK POSITION IN ROBOT CONTROLLER RAM

317
6 AXES ?   NO

YES

318
FETCH DESIRED ON/OFF SW. CONDITION FROM CONTROLLER RAM

319
OUTPUT DESIRED ON/OFF SW. CONDITION TO ROBOT ON/OFF SW. FROM ROBOT CONTROLLER

END ?   NO

YES

STOP

ROBOT CONTROLLER
PROGRAM EXECUTION
PHASE FOUR

Fig. 4D

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.

fastcase®
Smarter legal research.