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(54) MICRO-COMPUTER AND PROGRAMMER FOR APPLICATION OF TIRE THREAD MATERIAL

(71) We, AMF INCORPORATED, a corporation organised and existing under the laws of the State of New Jersey, United States of America, of 777, Westchester Avenue, White Plains, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to the formation of a tire tread profile by the application of rubber tread material upon a tire casing by employing a micro-computer programmer in conjunction with a tread material applicator apparatus. The control system employed during tread formation uses a programmer having a micro-computer unit, a floppy disc and a keyboard, interfaced with a tread material application apparatus.

In operation, the programmer is connected to a drive motor of the tire tread application assembly and operates under the control of a tire profile program stored in the floppy disc. Proper tread profile shape is arrived at as a function of the digital ratio between the actual position of the tire rotation and the transverse position of the tire tread applicator assembly. The latter is digitally controlled within the parameters of of a pre-programmed set of commands, as a direct and sole function of the position of the tire casing about its spin axis.

The present invention is directed to method and apparatus for use in application of rubber ribbon material for the formation of tire tread on a substrate such as a tire carcass. More particularly, the present invention is directed to method and apparatus employed in conjunction with a tire building machine such as shown and described in U.S. patent 3,177,198 enabling the deposition of elastomeric material upon a substrate in a controlled fashion in accordance with a predefined tread profile. In carrying out the invention, a programmer is employed having principally; a micro-computer, a floppy disk and a keyboard.

By means of the present invention, it becomes possible to utilize current micro-processor technology enabling readily attainable changes to a finished tread profile by associated software modifications rather than hardware changes.

In the past, other systems known to the applicant, for example U.S. patent 3,308,000 have been employed for controlling the application of the elastomeric material to a substrate. In this arrangement a tire tread winding apparatus employs a mechanically controlled arrangement for applying elastomeric ribbon to a tire casing. However, the approach disclosed in this prior art is purely mechanical and employs a mechanical programmer and associated spin revolution counter.

Also familiar to the applicant is U.S. Patent 3,843,482 which is directed to a tire tread winding machine employing a tape for controlling the amount of spin of the rubber ribbon applicator assembly and also the amount of azimuth displacement for ribbon thickness control.

Other patents known to applicant further illustrate well known approaches for controlling the movement of a tire tread programmer. However, in no instance has the prior art defined a combination in which the use of an interface with a tread application apparatus is such, that the instantaneous tire spin rotational position forms the basis of a series of digital commands enabling extremely precise digitally controlled simultaneous transverse motion of the tire.

The prior systems have employed apparatus for tread application which have utilized additional variables of time, tire rotation velocity, or template sensing. By eliminating these variables, errors associated in their measurement and control have been eliminated. The present invention provides tyre transverse position control directly as a programmed function of tyre rotational position.

According to one aspect of the present invention apparatus is provided for employment in the formation of a tyre tread profile upon a tyre carcass surface by supplying elastomeric tread material from a tread material application assembly onto a rotating tyre carcass mounted upon a tyre rotation assembly driven by motor means, the apparatus comprising incremental drive means disposed in working relation to said tread material application assembly to advance said rotating tyre in a direction transverse to the material application assembly, control means for controlling the application of a tyre tread profile upon said tyre surface, tyre rotation monitoring means connected to said motor means for monitoring the incremental angular displacement of said tyre carcass during tyre rotation, said control means comprising micro-computer means, adapted to receive respective signals from the monitoring means responsive to said rotation of said tyre carcass and to control said incremental drive means to produce tyre tread profile build-up in accordance with a predefined programme stored in said micro-computer means, utilising computed ratios defined by the transverse position of said tread material application assembly relative to the tyre carcass surface and the circumferential position of said tyre carcass about its spin axis.

According to another aspect of the present invention there is provided a method for the formation of a tyre tread profile upon a tyre carcass surface comprising supplying elastomeric tread material from a tread material application assembly onto a rotating tyre carcass mounted upon a motor driven tyre rotation assembly, advancing incrementally said rotating tyre in a direction transverse to the material application assembly, monitoring the incremental angular displacement of said tyre carcass during tyre rotation and controlling said incremental advance of said rotating tyre in accordance with a stored predefined programme of tread profile parameters in a micro-computer relating said monitored angular displacement to said incremental advance so as to produce a desired tyre tread profile build up.

The predefined programme of tread profile parameters may be in the form of a series of tyre profile segments.

In this case the monitoring of the angular displacements preferably includes summing the displacements, comparing the summed displacements with a programmed segment to match the summed displacements with the programmed segment and then utilising a next programmed segment.

Alternatively the parameters may be defined by fixed ratios determined by tyre carcass rotation position and tyre carcass transverse displacements and lengths along the transverse direction. Suitably a new ratio is used in response to variation in tyre profile geometry requirements and conveniently the transverse motion of the tyre carcass during the application of the tread material is controlled in response to the instantaneous tyre spin rotational position.

Preferably the pre-programmed tread profile parameters govern the transverse position of the tyre carcass surface relative to the point at which the material is applied and the circumferential position of the tyre carcass surface about its spin axis.

Fig. 1 is a front elevational view of the present invention employing a rubber tread material applicator assembly and a tire carcass rotational assembly for the placement of tread material upon a tire carcass.

Fig. 2 is a block-diagram of the micro-computer of the invention together with major input - output devices.

In accordance with the operation of the invention, the basic tire building machine consisting of the tread applicator assembly 11, machine frame 12 and the carcass manufacturing assembly 7 are of the type described and disclosed in U.S. Patent 3,177,918. The reference numerals in this application do not necessarily correspond to those of the aforementioned patent.

As shown in Fig. 1, a micro-computer 1 is employed and forms part of the total apparatus 2. In operation, the micro-computer 1 accepts rotation position signals from a digital encoder 3 which is directly coupled to the tire carcass spin drive motor 8. The signals have the form of a series of electrical pulses which are a direct function of the circumferential position of the tire carcass 4 about its spin axis.

The micro-computer 1 employs previously stored tread profile data and relates that to the input pulses in order to control the transverse position of the tire carcass 4. These output signals take the form of a series of electrical pulses transmitted to a D.C. stepper motor 5 through a stepper drive assembly 6. The D.C. stepper motor 5 and associated drive assembly 6 form a system which translates electrical pulses into discrete angular position increments of the stepper motor 5 to ultimately govern and provide motive power for the transverse motion of the tire carcass assembly 7.

The block diagram in Fig. 2 illustrates the micro-computer 1 and associated hardware. An operator display and control panel 9 contains an array of push button switch actuators 10 (Fig. 1) and LED displays 13 (Fig. 1) for controlling and monitoring: the tread applicator assembly 11, (Fig. 1) the carcass mounting assembly 7, and the operation of placing tread material 14 upon a tire carcass 4 under program control.

The operator display and control panel 9 is connected to the central processing unit 15 provided with a commercially available micro-processor unit such as Motorola MC6800 as shown in the "Motorola M6800 Micro-computer System Design Data Manual" published in 1976 by Motorola Inc., Phoenix, Arizona. An on-line memory sub system 16 is connected to the central processing unit 15. In operation the on-line memory sub-system 16 contains all necessary program data to operate the apparatus 2 and control the relative positions of the tire carcass 4 and the tread application assembly 11. The central processing unit 15 provides the necessary program steps to execute the instructions contained in the on-line memory sub-system 16. The on-line memory sub-system 16 employed herein can be of the type composed of such commercially available components as — Motorola MCM 6810A × 8 Bit Static Random Access Memory shown and described on page 111 of the "M6800 Micro-computer System Design Data Manual", published in 1976, by Motorola Inc.; Phoenix, Arizona.

An off-line memory sub-system 17 contains all of the active and non-active machine logic coding as well as, all tire profile programs as stored by the operator and entered through a keyboard 18 of the type such as, commercially available Grayhill keyboard shown and described in Bulletin 262, Published in 1976 by Grayhill Inc.; La Grange, Illinois. The off-line memory sub-system 17 employs a floppy disk drive, such as commercially available CalComp 140 Floppy Disk Drive Shown and in "140 Floppy Disk Drive OEM Reference Manual", published in 1974 by California Computer Products Inc.; Anaheim, California.

A specifically developed program is employed after the necessary tread profile data and its relationship to the apparatus are obtained from calculated data. This information, in turn, is entered directly into the micro-computer 1 through use of a keyboard 18. It follows that each program can be permanently stored and, in turn retrieved by operator action as will be explained hereinafter. Likewise, corrections or subsequent modifications can be easily and simply keyed in and stored; and a modified program can replace or supplement the original program.

The actual structure defining the micro-computer 1 includes a series of sub-systems (see Fig. 2) which are electrical in nature and are connected to an operator display and control panel 9 provided with a series of push button switch actuators 10 (see Fig. 1) for controlling the apparatus 2. For an example, the tread applicator assembly 11 can be controlled to travel manually towards the left or right direction respectively or to be designated "home" position through appropriate push button switch actuators 10. The initial position of the tread applicator assembly 11 prior to starting the tire program is arrived at through a program reset function which has been previously calculated to define the start location. A given tire profile program is retrieved from the off line memory 17 by appropriately selecting a predefined designation number of thumb wheel switch 20 and energizing a program load switch 21.

More specifically, the micro-computer 1 is provided with a series of displays, i.e., L.E.D. displays 13, for monitoring the tire profile program parameters. A program display 19 indicates the current tire program number in on-line memory 16. Additional L.E.D. displays show parameters as: program segment or location, the number of tire revolutions in a particular segment of casing build-up, and the surface length of tread applicator travel for a given segment.

During operation, programs which are internally stored by the micro-computer 1 on its off line memory 17 are "read" by dialing-in a designated program indentification number on thumb wheel switch 20. The stored program is then recalled from memory by actuating program load switch 21 and placed in readiness to run. Programs can be visually verified since all values are numerically displayed on a series of light emitting diode (LED) displays 13, 19.

In operation, as the tire carcass spin drive motor 8 is actuated, a commercially available digital encoder 3 transmits a series of electrical pulses to the micro-computer 1. These pulses are a direct and continuous function of tire carcass rotational position about its spin axis, namely, the axis about which the tire rotates circumferentially during tread material application. More particularly pulses have the characteristics of discrete electrical signals describing extremely small increments of aforesaid tire rotation.

In accordance with a predefined program, the micro-computer 1 calculates a ratio which reflects the required tread profile for a given tread profile segment. As used herein, a tire profile segment is intended to mean a geometrical portion of a tire tread profile definable by a fixed and constant relationship between the relative displacements of tire spin and tire transverse motions over a defined length along the transverse line of motion. The output signal of the micro-computer 1 takes the form of an electrical pulse transmitted by the micro-computer 1 to the stepper motor 5 through the stepper drive assembly 6 whereby the tire carcass mounting assembly 7 is urged to move transversely relative to the tire spin axis. The magnitude of the relative motion between tire spin and tire traverse is defined by the ratio calculated by micro-computer 1. The tire profile undergoes variations in geometry according to the prescribed program whereby, the micro-computer 1, changes the ratio between tire spin and transverse motions. This is accomplished by micro-computer 1 counting electrical pulses received from the digital encoder 3 and compares this count to pre-programmed values. Upon matching the pre-programmed value of counted digital encoder 3 pulses, the next programmed ratio is introduced into micro-computer 1. At this time the relative motion between the tire rotation and tire traverse is altered in accordance with the newly introduced ratio.

For each tire tread profile segment the micro-computer 1 using a programmed ratio value, converts pulses received from digital encoder 3 into electrical signals which are transmitted to the stepper motor drive assembly 6. During this time, the micro-computer 1 controls the transverse position relative to the circumferential position of tire carcass 4. This relationship is maintained throughout the entire tire tread profile application operation, even though the tire circumferential spin rate may be undergoing velocity changes. This position relationship is solely based upon tire carcass displacement as represented by discrete electrical pulses transmitted by digital encoder 3. The relative motion between tire spin and traverse is not dependent upon tire velocity or time. In this manner, a significantly more accurate and repeatable tire tread profile build-up may be effected, since with the present invention it becomes possible to directly control the tread profile build-up through the ratio of tire spin and traverse displacements.

It will be understood that the specific embodiments of the invention described herein are given by way of illustration only and that various departures may be made therefrom, all within the scope of the invention. The specific relationships of ribbon wrap to speed of application are cited merely to illustrate the efficiency of the apparatus and method and the results to be expected from use thereof in practice.

WHAT WE CLAIM IS:—

1. An apparatus employed in the formation of a tyre tread profile upon a tyre carcass surface by supplying elastomeric tread material from a tread material application assembly onto a rotating tyre carcass mounted upon a tyre rotation assembly driven by motor means, the apparatus comprising incremental drive means disposed in working relation to said tread material application assembly to advance said rotating tyre in a direction transverse to the material application assembly, control means for controlling the application of a tyre tread profile upon said tyre surface, tyre rotation monitoring means connected to said motor means for monitoring the incremental angular displacement of said tyre carcass during tyre rotation, said control means comprising micro-computer means adapted to receive respective signals from the monitoring means responsive to said rotation of said tyre carcass and to control said incremental drive means to produce tyre tread profile build-up in accordance with a predefined programme stored in said micro-computer means, utilising computed ratios defined by the transverse position of said tread material application assembly relative to the tyre carcass surface and the circumferential position of said tyre carcass about its spin axis.

2. An apparatus as claimed in claim 1, wherein said micro-computer means is interfaced between drive means for incrementally advancing said rotating tyre carcass in the tranverse direction and said tyre rotation monitoring means comprises digital encoder means directly coupled to drive means for rotating said tyre carcass, whereby said digital encoder means is adapted to provide said micro-computer means with rotational position input signals of said drive means during rotation of said tyre carcass as a direct function of the circumferential position of said tyre carcass about said spin axis enabling said micro-computer means to relate said input signals to previously stored tread profile data for controlling the transverse motion of said tyre carcass.

3. An apparatus as claimed in claim 1, wherein: said micro-computer means is adapted to transmit a series of output electrical signals to said drive means for incrementally advancing said rotating tyre carcass whereby said signals being transmitted define discrete angular position increments to said drive means for governing the transverse motion of said tyre carcass during tread material application.

4. An apparatus as claimed in claim 1, wherein said micro-computer means is adapted to calculate a ratio corresponding to a tread profile for a given profile segment, said profile segment being a geometrical portion of a tyre tread profile in which a fixed relationship exits between relative displacements of tyre carcass rotation and tyre carcass transverse motion over a definite

length along a transverse line.

5. An apparatus as claimed in claim 1, wherein said micro-computer means is adapted to alter the ratio between tyre carcass rotation and transverse motion in response to variations in tread profile geometry as pre-programmed into said micro-computer means.

6. A method for the formation of a tyre tread profile upon a tyre carcass surface comprising supplying elastomeric tread material from a tread material application assembly onto a rotating tyre carcass mounted upon a motor driven tyre rotation assembly, advancing incrementally said rotating tyre in a direction transverse to the material application assembly, monitoring the incremental angular displacement of said tyre carcass during tyre rotation and controlling said incremental advance of said rotating tyre in accordance with a stored predefined programme of tread profile parameters in a microcomputer relating said monitored angular displacement to said incremental advance so as to produce a desired tyre tread profile build up.

7. A method as claimed in claim 6 in which said predefined programme of tread profile parameters is in the form of a series of tyre profile segments.

8. A method as claimed in claim 7 in which said monitoring of said angular displacements includes summing said displacements comparing said summed displacements with a programmed segment to match said summed displacements with said programed segent and then utilising a next programmed segment.

9. A method as claimed in claim 6 in which said parameters are defined by fixed ratios determined by tyre carcass rotation position and tyre carcass transverse displacements and lengths along the transverse direction.

10. A method as claimed in claim 9 in which a new ratio is used in response to variation in tyre programme profile geometry requirements.

11. A method as claimed in either of claims 9 and 10 in which the transverse motion of said tyre carcass during the application of said tread material is controlled in response to the instantaneous tyre spin rotational position.

12. A method as claimed in claim 6 in which said pre-programmed tread profile parameters govern the transverse position of the tyre carcass surface relative to the point at which said material is applied and the circumferential position of said tyre carcass surface about its spin axis.

13. A micro-computer and programmer incorporated in an apparatus for applying tyre tread material substantially as described with reference to and as illustrated by the accompanying drawings.

14. An apparatus as claimed in claim 1, substantially as herein described.

15. A method for the formation of a tyre tread profile upon a tyre carcass surface substantially as hereinbefore described with reference to the drawings.

For the Applicants:
MATTHEWS, HADDAN & CO.,
Chartered Patent Agents,
33 Elmfield Road,
Bromley, Kent BR1 ISU.

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1572546 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

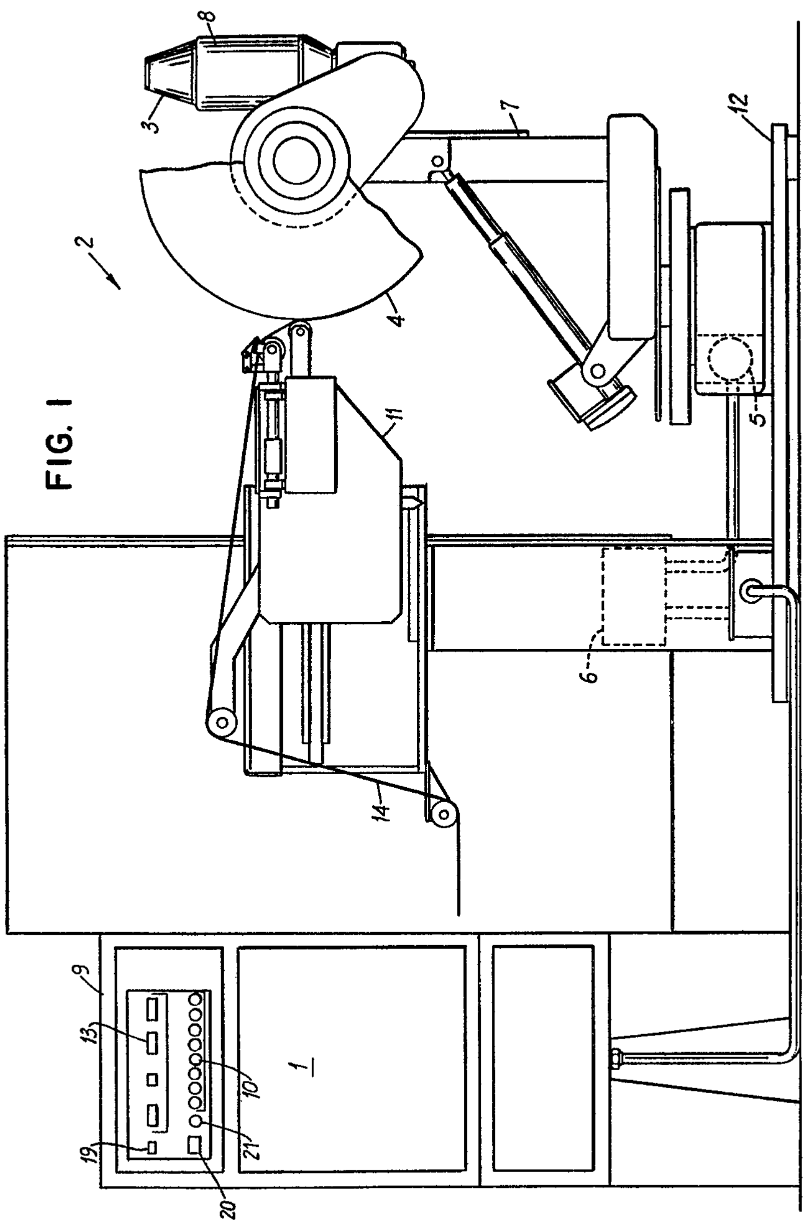

FIG. 1

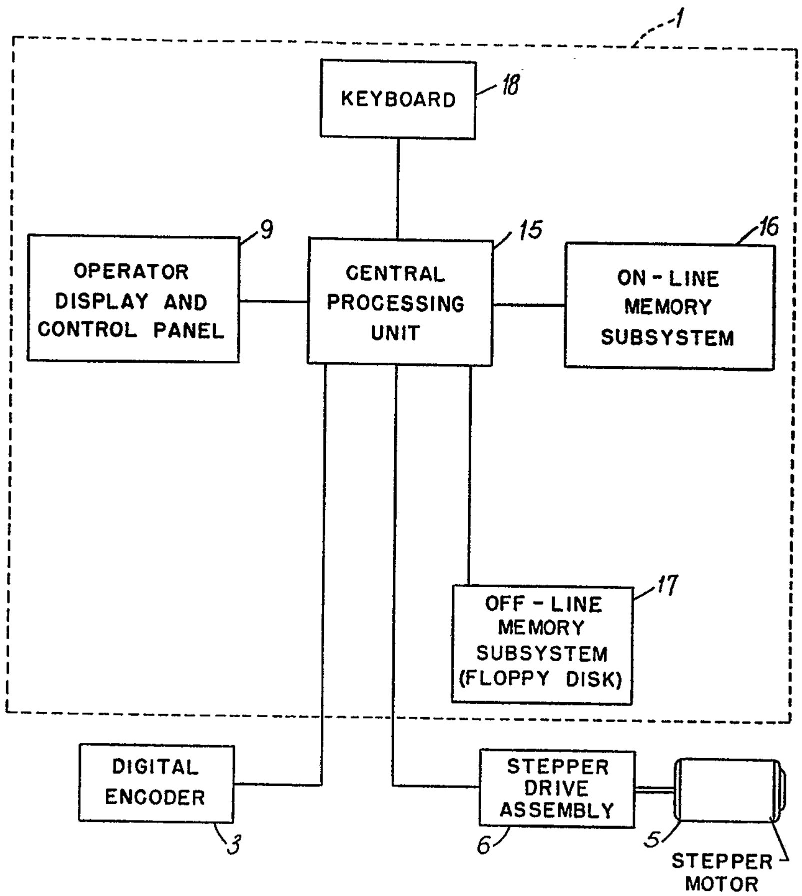
1
KEYBOARD
18
OPERATOR DISPLAY AND CONTROL PANEL
9
CENTRAL PROCESSING UNIT
15
ON-LINE MEMORY SUBSYSTEM
16
OFF-LINE MEMORY SUBSYSTEM (FLOPPY DISK)
17
DIGITAL ENCODER
3
STEPPER DRIVE ASSEMBLY
6
5
STEPPER MOTOR

FIG. 2