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Allanic et al.

[11] **3,881,851**

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[54] **MACHINES FOR FORMING INSULATION FOR HIGH FREQUENCY TRANSMITTING COAXIAL LINES**

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[52] **U.S. Cl.** **425/113;** 425/185; 425/223

[51] **Int. Cl.** **B29d 23/00**

[58] **Field of Search** 425/113, 223, 336, 371, 425/183, 185, 396, 369; 72/190, 192, 193, 197

[56] **References Cited**

UNITED STATES PATENTS

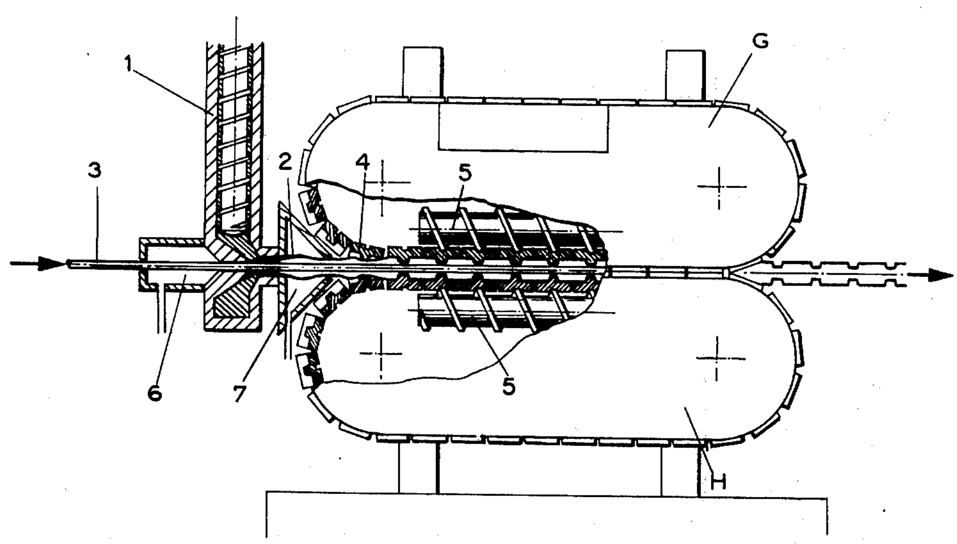
2,760,228	8/1956	Verges	264/209
3,188,690	6/1965	Zieg	425/396

Primary Examiner—Francis S. Husar
Assistant Examiner—C. Rowold
Attorney, Agent, or Firm—Abraham A. Saffitz

[57] **ABSTRACT**

A machine for forming between-conductor insulation in a coaxial electric conductor pair usable as a transmission line for very high frequency signals. The insulation is of the so-called "balloon" type, that is it consists of a thin thermoplastic tube constricted onto the central conductor at regularly spaced points by means of endless chains of small dies progressing at the same speed as the conductor and part of which press the tube against said conductor at said points. To prevent the possible appearance of periodic defects in the insulation, a small number of dies succeeding each other in the chain are exchanged at random time intervals for an equal number of similar dies taken from a reserve magazine, this being done without having to stop the operation of the machine. The dies of a chain are not mechanically interconnected and simply push each other in endless slides. A mechanism effecting substitution of a group of dies taken from the magazine for an equal number of dies taken in the chain during progression of the latter is described.

8 Claims, 8 Drawing Figures



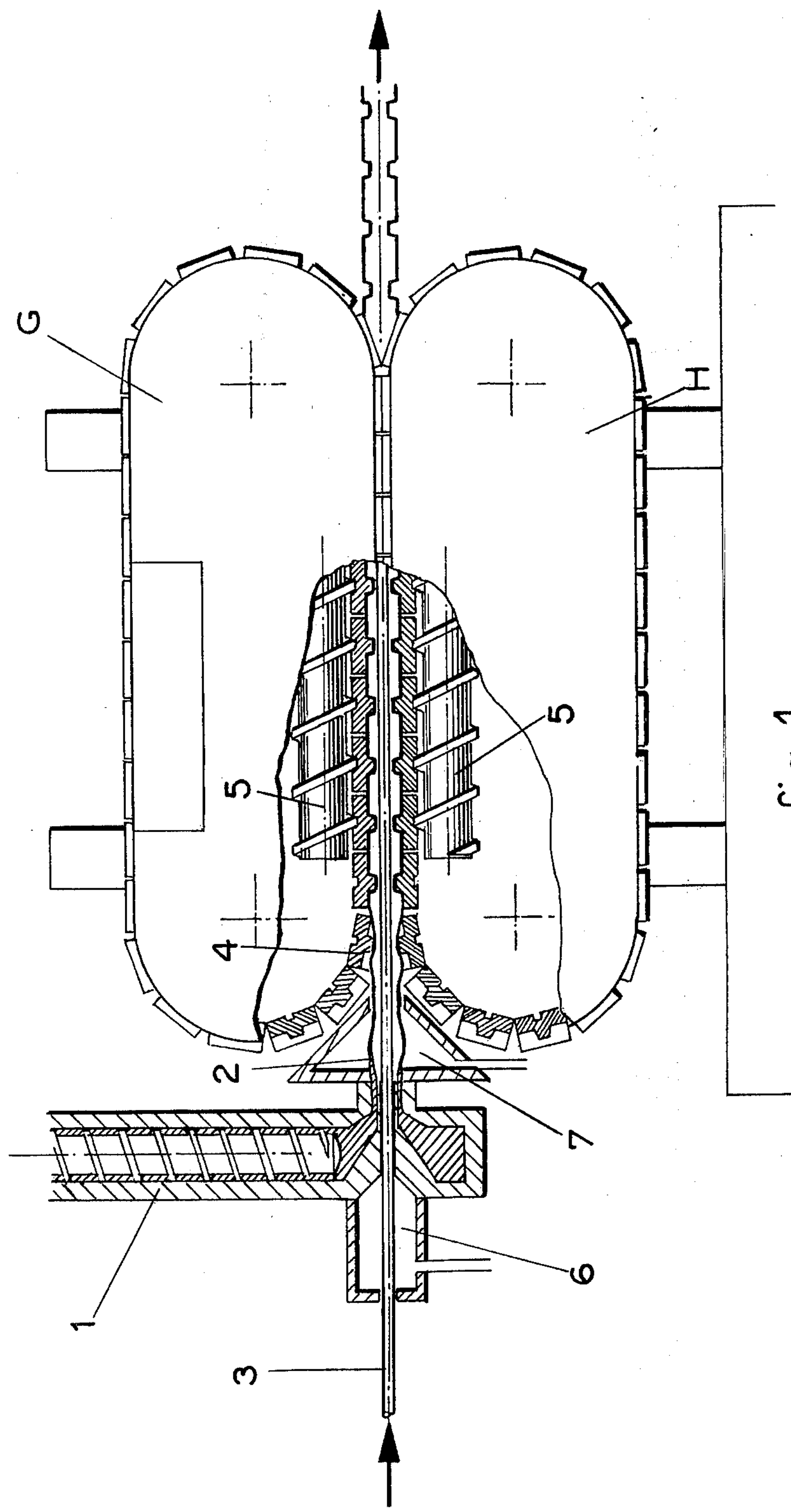


fig.1

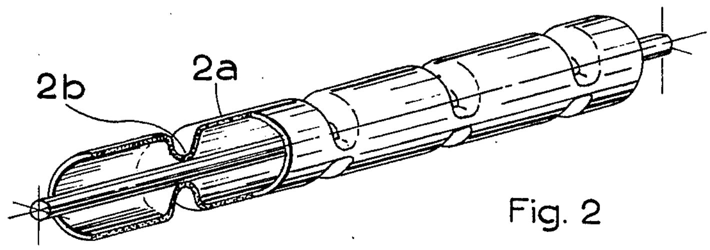


Fig. 2

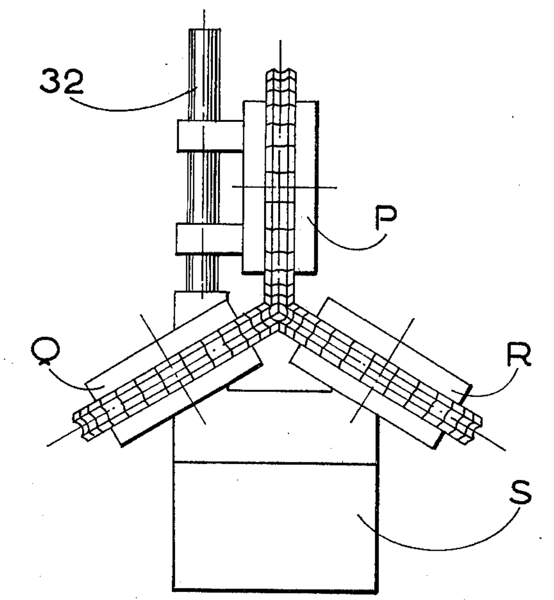


Fig. 7

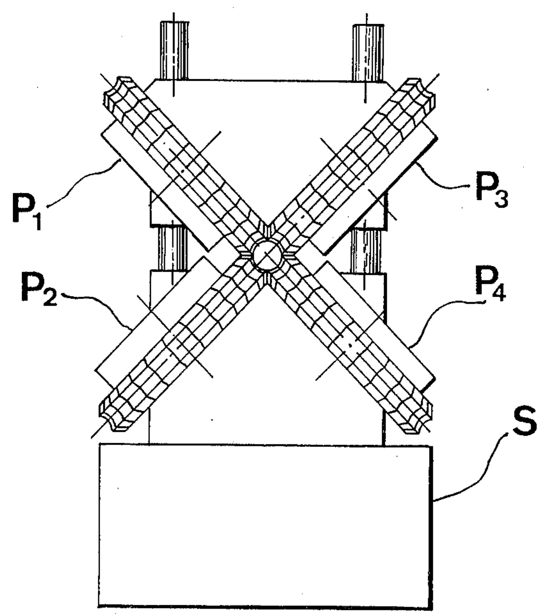


Fig. 8

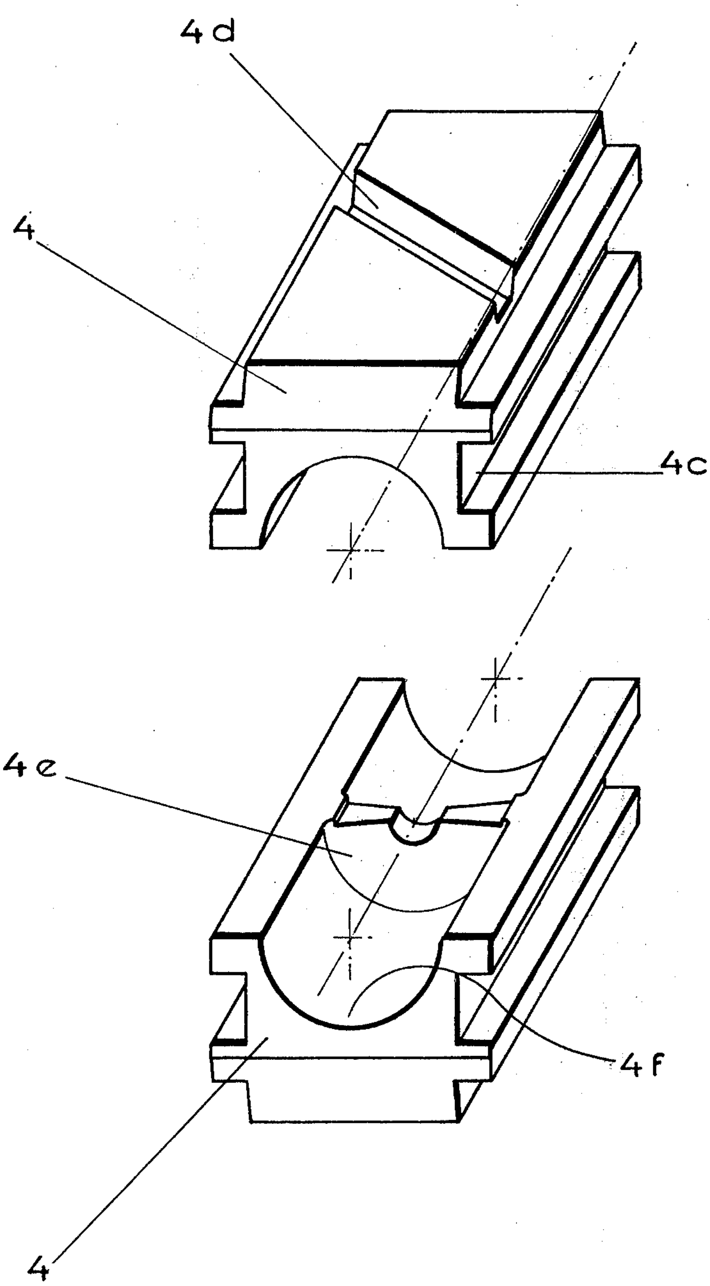


fig.3

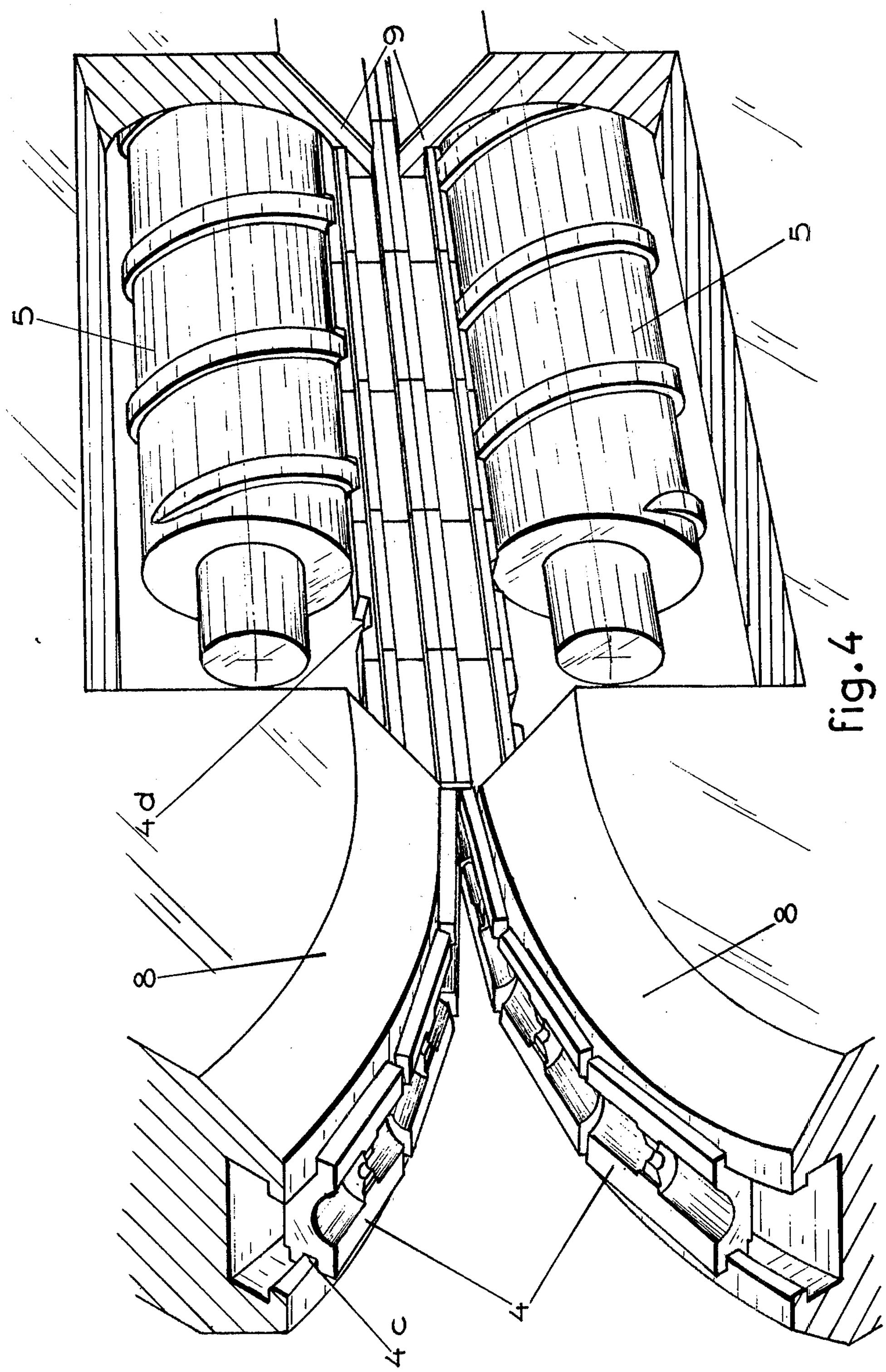


fig. 4

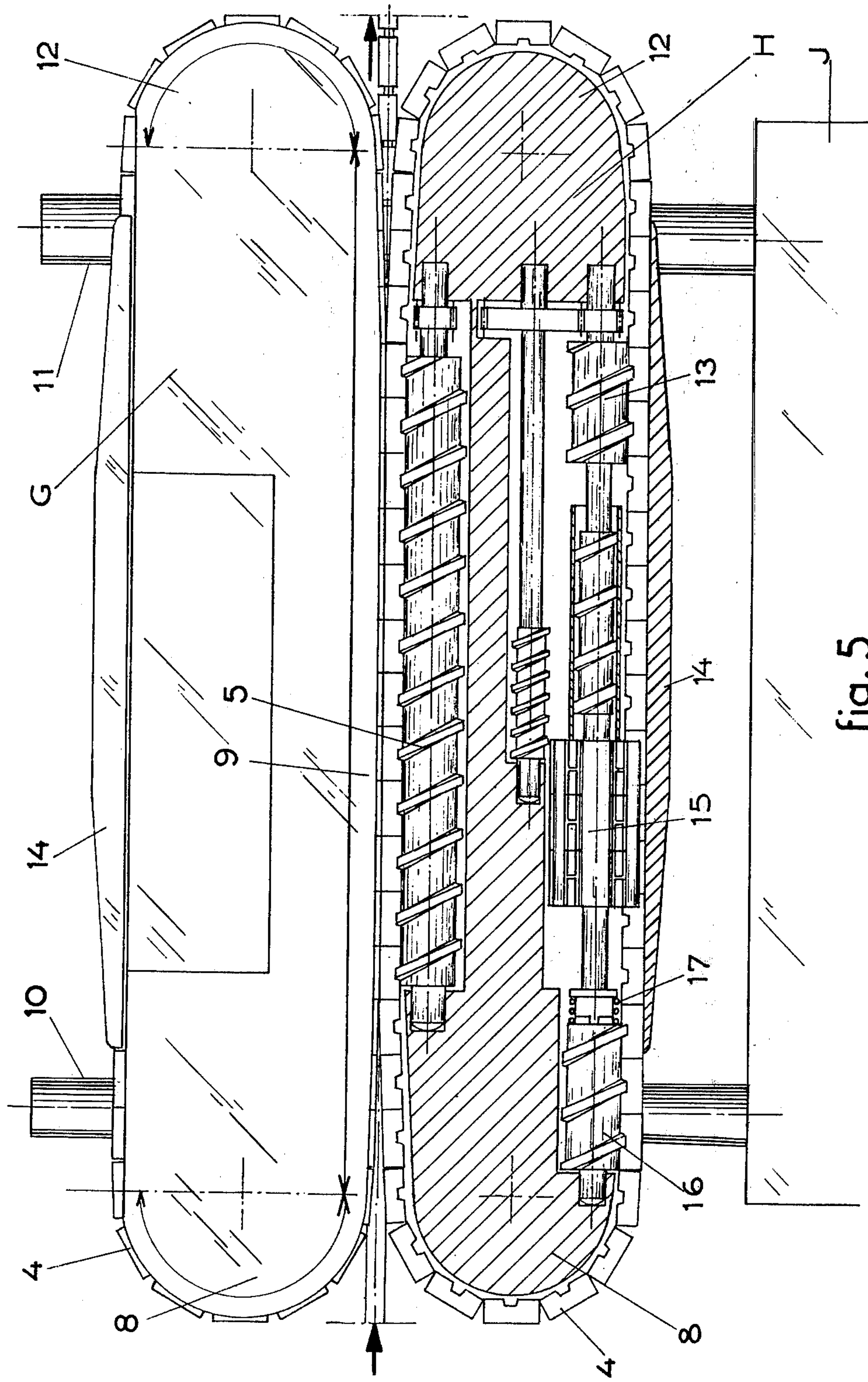


fig. 5

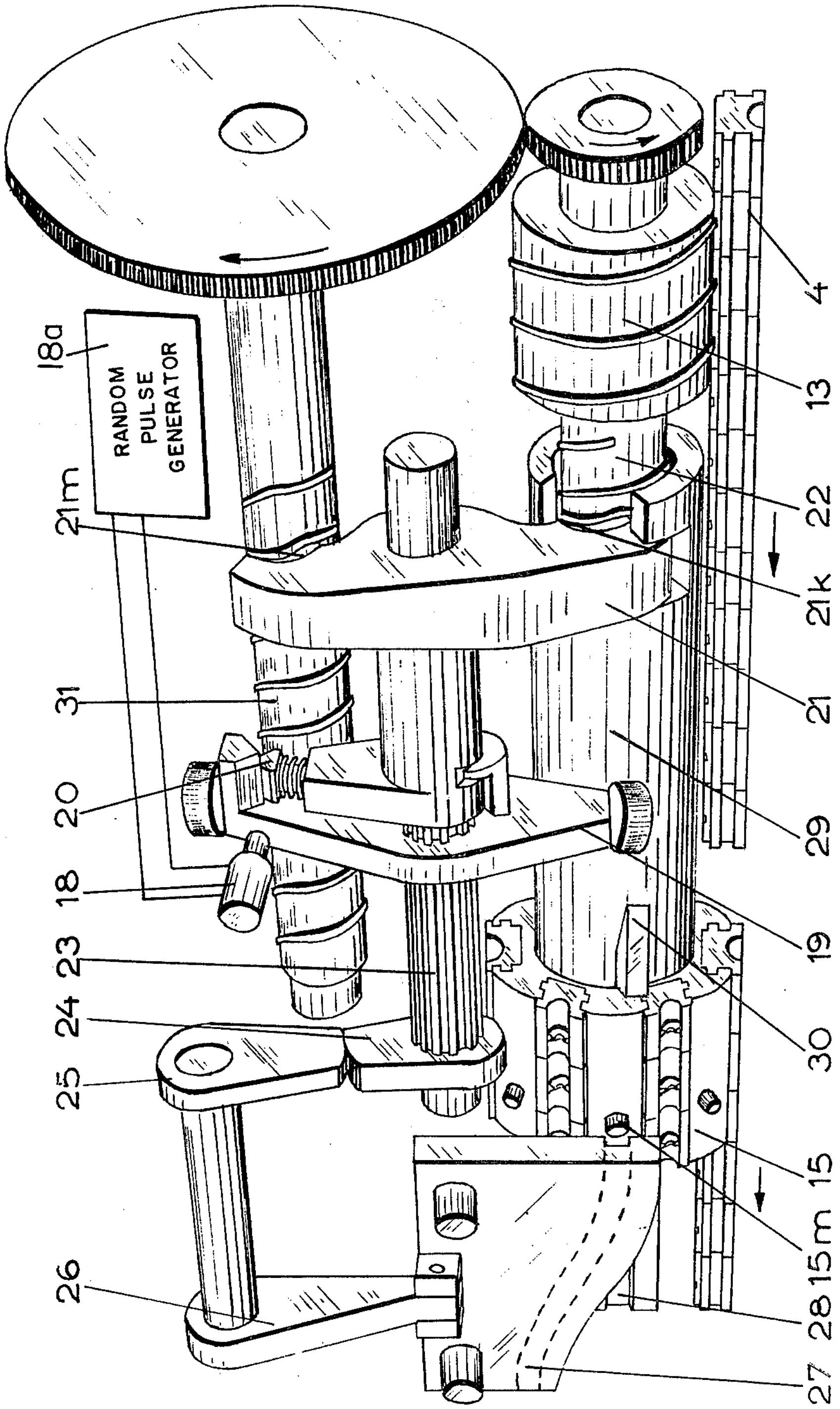

18a
RANDOM PULSE GENERATOR
21m
31
20
18
23
24
25
26
4
13
22
21k
21
29
19
30
15
15m
28
27

fig. 6

MACHINES FOR FORMING INSULATION FOR HIGH FREQUENCY TRANSMITTING COAXIAL LINES

The present invention relates to new machines for the manufacturing of between-conductor insulation for coaxial conductor pairs (also frequently called coaxial lines) adapted to the transmission of high frequency and very high frequency signals, in particular telecommunication signals.

It is known that coaxial pairs adapted to the transmission of such signals consist of an inner conductor secured inside an outer tubular conductor by means of an aerated insulation made of a thermoplastic material such as polyethylene, for instance, having a low dielectric constant and a low loss factor, so as to give the high frequency attenuation of the coaxial pair as small as possible a value.

It is also known that such an insulation can advantageously be manufactured in the form sometimes called "balloon insulation," which consists of a thin tube of thermoplastic material applied inside the outer conductor except at points periodically distributed along the pair, at which the tube is constricted up to contact with the inner conductor.

By way of example, such an insulation can be obtained by means of a device described in the U.S. Pat. No. 2,760,228. The method used in that device consists in extruding around the inner conductor a tube of thermoplastic material having a diameter larger than that of said conductor and which, before its complete cooling, is constricted from point to point onto the inner conductor, so as to form successive cylindrical air-filled rooms. The constricting of the tube is effected by means of a series of small dies having a suitable form, assembled as an endless chain and each mechanically interconnected with the preceding and the following one. At any instant, there is a part of said dies which is pressed against the plastic tube and at the same time progresses with a linear speed equal to that of the motion of the inner conductor of the pair, thanks to a suitable mechanism synchronizing the motion of the endless chain with that of the latter conductor.

When so manufactured pairs are used at very high frequencies, for instance in the order of magnitude of several hundreds of megahertz, there are sometimes found attenuation increases and sudden impedance variations at certain frequencies and at the harmonics thereof. This phenomenon is caused by variations in the dimensions of the various elements forming the coaxial pair, such as, for instance its insulation, in the case where these variations, although small, repeat themselves at points regularly spaced along the insulated conductor. The unit length attenuation and characteristic impedance of the pair are then disturbed at frequencies corresponding to wavelengths equal to twice the distance between such points, as well as at the harmonics of these frequencies. Such periodic variations may result, in particular, from corresponding irregularities in the dimensions of some of the dies of the endless chain, and will necessarily repeat themselves along the coaxial pair with a spatial period equal to the total length of the same chain.

The main purpose of the present invention is the suppression of the just mentioned effects, by elimination of the periodic character of the irregularities of the type specified.

According to the present invention, an insulation forming machine for coaxial pairs makes use, like that of the above-cited U.S. patent, of the extrusion of a thermoplastic tube, filled with air under pressure and periodically constricted by a succession of small, substantially identical dies, juxtaposed along an endless chain driven at a linear speed equal to that of the motion of the inner conductor of the coaxial pair. Like in the machine of the same above-cited patent, no special means is provided for driving the conductor at a constant linear speed. The conductor is automatically driven by its adherence to the still hot extruded plastic material, itself driven by the moving dies of the endless chain. However, the arrangement of the present invention differs from that of the U.S. Pat. No. 2,760,228 in that the latter chain is not directly driven as a whole by an electric motor, for instance, but through the intermediate of endless screws engaging part of the dies and themselves driven by such a motor.

Moreover, the machine according to the invention differs from those of the known art on the following points:

The small dies, although individually contacting the preceding and the following one, are not mechanically interconnected with each other and move inside endless slides.

A mechanism is provided for replacing, at instants willfully selected at random, a group of a small number of consecutive dies by a group of an equal number of similar dies taken from a reserve magazine, such replacing being effected without having to stop the machine, which on the contrary continues operation at its normal speed. In this manner, if any one of the dies presents a geometrical defect, the resulting form variations in the insulation do not repeat themselves at regulary spaced points along the insulated conductor.

Also according to the invention, progression of the small dies is effected with the help of endless screws, the axis of which is parallel to the direction of said progression along the conductor and the pitch of which is much smaller than the half-wavelength corresponding to the maximum frequency of the signals to be transmitted on the coaxial pair. In this manner, if the endless screws present geometrical defects, the latter only result, in the obtained insulation, into form variations at points the spacing of which is also much smaller than the said half-wavelength.

Moreover, the driving mechanism of the endless screws, which makes use of a known technology, is determined according to the invention in such way that eventual variations in the velocities of its elements only appear in the insulated conductor as local variations in the mass of the insulation at certain points, the spacings of which are also smaller than the half-wavelength corresponding to the maximum frequency of the signals to be transmitted on the coaxial pair.

The invention and its advantages will be better understood from the following description, given with references to the annexed drawings, in which:

FIG. 1 shows the use of a first type of machine, according to the invention, capable of producing insulation whose maximum diameter is in the neighborhood of 15 mm, for coaxial pairs operated up to 1,000 MHz;

FIG. 2 shows an inner conductor of a coaxial pair enclosed in an insulation produced by means of the machine represented in FIG. 1;

FIG. 3 shows the small metallic dies that, by superimposing themselves, form the moulding imprint of the insulation shown in FIG. 2;

FIG. 4 shows the formation of the complete imprint having produced the insulation shown in FIG. 2;

FIG. 5 shows a general view of the insulation forming machine, according to the invention, including a partial longitudinal section of the machine;

FIG. 6 shows a schematic view of one of the two arrangements for exchanging the small dies of the machine, respectively shown in FIGS. 1 and 5;

FIGS. 7 and 8 show two types of insulation forming machines according to the invention, seen from the side of the thermoplastic tube intake and intended for insulations having diameters up to 50 mm, for very high frequencies.

Referring first to FIG. 1, this figure shows the use of a first type of machine, according to the invention, for producing an insulation with a maximum diameter in the neighborhood of 15 mm. An extruder **1** delivers a tube of thermoplastic material **2** around a metallic conductor **3**, with an inside diameter greater than that of this conductor. This assembly is drawn into the insulation forming machine which carries the small metallic dies **4** moved by endless screws **5** located in mountings G and H. At the same time, the thermoplastic material tube **2** which has not yet completely cooled inflates under air pressure introduced in chamber **6** and takes the shape of the impressions in the small dies **4**. To prevent bursting the thermoplastic tube at the extruder **1** outlet, air under suitable counter-pressure is admitted to chamber **7**. At the exit of the machine, the metallic conductor with its insulating cover goes through a hydropneumatic cooling system (not shown in the drawing).

FIG. 2 shows the insulation obtained by forming small successive rooms *2a* separated by crimps *2b*.

FIG. 3 shows the small dies **4** producing the insulation shown in FIG. 2. These small dies have lateral guidance grooves *4c*, oblique drive grooves *4d*, dividers *4e* to produce crimps *2b* and a partial cylinder *4f* which determines the shape of the small rooms *2a*.

FIG. 4 shows the complete moulding imprint that is constituted at the intake of the insulation forming machine by the juxtaposition and superimposing of the small dies **4** whose lateral grooves *4c* assure guidance in the intake ramps **8** and the guides **9**. The oblique grooves *4d* permit the precise relative positioning and driving of the small dies **4** by means of two endless screws **5**, whose rotation is synchronized and which are driven through suitable gears by a common electric motor (not shown in the drawing).

FIG. 5 shows a general view of the machine, according to the invention, which is composed essentially of two identical mountings G and H resting on baseplate J by means of columns **10** and **11** and each carrying its own small die exchange mechanism (not entirely shown in this figure). Baseplate J contains the motor and the driving mechanism of the machine (not shown). When the machine is not operating, upper mounting G can slide on columns **10** and **11**. Longitudinal section of the lower mounting H is taken through the symmetry plane of the ingress ramps **8** and egress ramps **12**. This section permits a description of the manner in which the small dies **4** circulate in the mountings G and H, absolutely identical, and the manner in which their exchange is accomplished inside these same mountings.

Coming from the ingress ramp **8**, the small dies **4** are engaged by the endless screw **5** which ensures precise relative positioning and constant speed progression. In leaving the endless screw **5**, the small dies **4** mutually push each other, progressing into the egress ramp **12** before being engaged by a portion of an endless screw **13** whose pitch and speed are equal to that of screw **5**. The dies, guided by the slide guide **14** held stationary when no die exchange is taking place, pass through the barrel **15** also held stationary in this case, and are reengaged by another portion of an endless screw **16** identical to screw **13** but provided with a compression spring **17**. This spring **17** has the effect of pressing the small dies against each other during their travel around the ingress ramp **8** until their engagement with screw **5**.

FIG. 6 shows a schematic view of one of the two small dies exchange mechanisms, in the present case the one in lower mounting H, showing in particular the barrel **15** whose axis is parallel to the direction of movement of the small dies **4**. This barrel comprises six regularly distributed small longitudinal chambers each holding three small dies in reserve. When the barrel is in the start position (position shown in FIG. 6), the electro-magnet **18**, activated by an electrical impulse delivered by the random pulse generator *18a*, commences to push lever **19**. In tilting, lever **19** commences to press against spring bolt **20**. Once the middle point of the travel of the lever is passed, bolt **20** in turn rapidly tilts part **21** which comprises two nut sectors *21k* and *21m*. The nut sector *21k* then commences to grip screw **22** whose pitch and rotational speed are equal to those of screws **13** and **5** which ensure the drive of the small dies. Part **21** then commences a longitudinal displacement movement at the same speed as the feed of the small dies **4**. Part **21** then drives with itself slotted sleeve **29** and barrel **15** which operate as a single part as far as translation motion only is considered. Simultaneously, lever **19**, in tilting, has rotated the splined shaft **23** which, by the intervention of toothed sectors **24** and **25**, has activated lever **26**, commanding simultaneous lateral displacement of helicoidal ramp **27** and rectilinear ramp **28**. Helicoidal ramp **27** then commences to interlock on one of the six studs *15m* on the barrel while the rectilinear ramp **28** moves away from the stud which is diametrically opposite. The lateral movement of the barrel **15** is therefore also accompanied by a rotational movement (60° in the case shown). This rotational movement will bring about the replacement of three small dies in the course of their lateral circulation by three other small dies held in reserve in the neighboring chamber. Lever **19** follows the longitudinal motion of barrel **15** by means of the slotted sleeve **29** entrapping part **21**.

When the lever **19** meets the ramp **30** which is fixed in space, this ramp causes the lever **19** to tilt in the opposite direction and the engagement of nut sector *21m* in screw **31** which is turning in the opposite direction to screw **22**. The barrel **15** then commences its return movement. The new tilting of the lever **19** has simultaneously rotated the splined shaft **23** which, by the intervention of the toothed sectors **24** and **25** has, as before, activated the lever **26** but in the opposite direction; it results therefrom that, with respect to barrel **15**, ramp **27** is disengaged and has moved away, while the rectilinear ramp **28** has come closer and is re-engaged on one of the six studs of the barrel **15**. The barrel then travels laterally in the reverse direction, this time without rotating. This completes the operation cycle.

A new exchange can now be effected. During the movements of the barrel **15** the small dies are guided by the sliding ramps **17** as shown in FIG. **5**, responsible for imparting ramps **15** the same translation motion as that of **15**.

The electrical impulses sent to the electro-magnet commanding the exchange of dies in the one mounting are independent of those sent to the electro-magnet commanding the exchange in the other mounting. Preferably, the impulses should be delivered to the two electro-magnets by different pulse sources. These sources generate pulses at random times independently of each other and may be of any known type, for instance that described in the French Pat. No. 1,179,592.

The time intervals separating the successive impulses sent to the same electro-magnet have a deliberate random value, for previously stated reasons.

An electro-mechanical security device, not shown, permits activation of the lever **19** only when the barrel **15** is in the start position (position shown in FIG. **6**).

FIG. 7 shows a second type of insulation forming machine intended for insulations larger in diameter than 10 mm. This machine is characterized by the fact that it comprises three mountings P; Q, R resting on a baseplate S, supported by columns **32**. The three mountings P; Q, R are identical to each other and also to the mountings G and H of the above-described machine. In particular, they each contain their own small die **4** exchange mechanism. This arrangement permits forming larger diameter insulations and reducing the weight of the small dies **4**.

In the same manner, it is possible, in the case of very large insulation diameters, greater than 50 mm, for example, to have four mountings such as P_1, P_2, P_3, P_4 as shown in FIG. **8**.

The above-described types of machines for insulation forming can have their principle extended to all kinds of centering elements made of thermoplastic material and molded directly on the center conductor of the coaxial pair.

We claim:

1. In a machine for forming the between-conductor insulation of a coaxial conductor pair for the transmission of high frequency electric signals, means for extruding around said inner conductor a thin tube of thermoplastic material and for constricting said tube at periodically spaced points along said inner conductor, said means including a succession of substantially identical small dies forming at least one endless chain driven at a constant linear speed by endless screws, part of said dies being pressed against said tube up to contact thereof with said inner conductor, the improvement consisting in that the successive dies in each chain freely contact each other and are mechanically independent of each other and move in endless slides, and in that said machine includes in each chain an exchange mechanism for replacing at random time intervals a small number of succeeding dies by an equal number of similar dies taken out from a reserve magazine, the exchanging being effected without stopping the operation of the machine and being controlled by electric pulses generated at random times by a random pulse generator.

2. In a machine as claimed in claim **1**, the arrangement in which said exchange mechanism includes a barrel (**15**, FIG. **6**) containing said reserve magazine and comprising a plurality of chambers each containing said small number of dies, said mechanism further including means (**18**) (**19**) (**20**) (**21**) controlled by said pulses from said generator (**18***a*) for imparting said barrel (**15**) a translation motion and a rotation motion from a rest position, and means (**30**) for bringing back said barrel (**15**) to said rest position.

3. In a machine as claimed in claim **2**, the arrangement in which said mechanism includes a set of levers (**19**), (**26**) actuated by an electromagnet (**18**) itself actuated by said pulses from said generator (**18***a*).

4. In a machine as claimed in claim **1**, the arrangement in which each of said chains is driven by an endless screw (**5**, FIG. **1**), the axis of which is parallel to the motion direction of said inner conductor and the pitch of which is much smaller than the half-wavelength measured along the coaxial pair for the maximum frequency of the signals to be transmitted thereon.

5. In a machine as claimed in claim **1**, including at least two endless chains of dies, the arrangement in which exchange mechanisms corresponding to different chains are respectively controlled by random electric pulses delivered by different sources.

6. In a machine as claimed in claim **1**, the arrangement which comprises two endless chains of dies (**4**, **4**, FIG. **5**) and two mountings (G, H, FIG. **5**) resting on a common baseplate (J. FIG. **5**).

7. In a machine as claimed in claim **5**, the arrangement which comprises three endless chains of dies and three mountings (P, Q, R, FIG. 7) resting on a common baseplate (S, FIG. 7).

8. In a machine as claimed in claim **1**, the arrangement which comprises four endless chains of dies and four mountings (P_1, P_2, P_3, P_4, FIG. **8**) resting on a common baseplate (S, FIG. **8**).

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