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SAFEGUARD SYSTEM USING DISTRIBUTION LINE AND TELECOMMUNICATION NETWORK FOR CONTROLLING AIMLESS BEHAVIOR IN SENILE ELDERLY PATIENTS

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Abstract This is a successive study of the development and application of an electronic safeguard system for elderly men (senile dementia patients) who wander without purpose because of declined mental capability, while retaining their physical ability. The new safeguard system is designed with some additional functions on the basis of the previously developed system. Firstly, alarms are designed not to disturb other patients at night, so that informations about doors from which the patients go out may be transmitted to helpers individually by radio paging system. Secondly, the system hardware can be set up anywhere without laying particular signal transmission cables, provided that there exist AC power distribution lines for the utilization as a transmission line of signals to alarm indicators. Thirdly, it is possible to have a grasp of the whole states of the safeguard systems at the center of operation by monitoring the operational state of each system with a necessary data acquisition according to its instruction through telecommunication network.

Thus, each safeguard system can be economically supplied to the special nursing homes and the helpers are ensured more released from physical and psychological burdens so that they can devote themselves to the care of senile elderly men, thereby improving their patients' comfort and human dignity

Keywords :electronic safeguard system, senile dementia patient.

1. Introduction

Japan makes a rapid change of its society into that of a large population of elderly people, owing to the development of medicine and wide spread arrangement of sanitary environment. Such a rapid change in population has not been experienced in any western industrialized nations. Little can be compared with the phenomena which they have experienced with different backgrounds in their societies. It is, therefore, very urgent to undertake some preparations for the wide arrangement of a fundamental welfare system for the elderly people in our country, because the society of the aged comes out early in the next century.

There had been for a long time the elderly men who had to always lie on the bed in our society. But, it had not clearly come out as a social problem during the time when there had lived only small percentage of population of the aged comparing with that of the rest. However, it has become socially an important problem as a result from a rapid increase in the absolute number of the aged.

It is then necessary to find a right way for living well with them together in the course of the change of our society into the society of the aged. It is also necessary to cope with the aged people who cannot live by themselves in a normal way without any help of others because of their declined mental capability [1-3]. In any way, it is inevitable to establish the systematic activity in order to cope with such a situation in a very near future. From this point of view, emphasis is here laid upon the establishment of a first step for the systematic care of the elderly patients with declined mental capability.

It is a pity that there have not been provided in our country sufficiently enough special institutions for the care of senile dementia patients as well as those for the care of the aged permanently lying on the bed. The situation in our country is in this point quite different from those of western industrialized nations. Therefore, the care of such aged people has been much dependent on the patients' family members, especially on housewives in our country. Their physical and psychological burdens are so heavy that they sometimes become the cause of a disintegration of their family. If the patients are lucky enough to have cares at special nursing homes for senile dementia patients, the economic burden still remains heavy, even though physical and psychological burdens of the family could be considerably released.

There sometimes occur tragic accidents in water, traffic and so on with the elderly men who purposelessly wander around their homes and become at a loss on their way home. Such elderly men are often sound in their motorial functions, even though there can be seen the decline of mental abilities. They often wander aimlessly and they have a high risk of water and traffic accidents outdoors, if the helpers happen to fail to notice their going out of the homes. Such possible accidents make the helpers take the great trouble for the life security of the patients as well as for their own professional works. Therefore, it requires an increase in personal labors of the helpers and in economic burden of the families for the effective care of the senile elderly patients. In order to avoid such difficulties in an easy way, the entrances are locked in the present situation at special nursing homes. Thus, the visitors and their families are locked-out from the homes. It prevents them from paying a free visit to the patients and makes the patients have a gradual growth of stress.

In this study, free communication and intercourse of the patients with others are regarded very fundamental for their human dignity. Therefore, the safeguard system is designed so that the human dignity may not be infringed by the system itself and that it may make the helpers relieve from the physical and psychological burden [4-5]. Consequently, the system provides the patients an atmosphere of freedom and the helpers an environment for their concentration to the improvement of the patient' comfort.

2. Basic Principle and Purpose of the System

2.1 Safeguard unit system

The new safeguard unit system is designed so that it can be set at any institutions without any particular works of tubings and wirings, which are used for the transmission of the signals between the receivers and alarm indicators whose construction usually need lots of labor and expense.

This is realized by using only AC power distribution lines as a signal transmission cable which is supported by an additional sending and receiving unit. Thus, it is not need to destroy and reconstruct the walls, ceilings and floors in order to set up the necessary tubes and wires. Then, the receivers including alarm indicators can be economically set up at any convenient places within the institutions.

2.2 Regional safeguard network system

The previously developed system was a closed system which worked only within a special nursing home [4-5]. The new system is a safeguard network system for a regional care of the senile elderly men using intelligent terminals through telecommunication network. By using this network system, it is possible to monitor automatically the state of each system which controls a special nursing home.

The alarm signal is transmitted through central telephone exchange to the radio pagers. If there is a detection of the escape of a patient, a microprocessor dials in the memorized numbers of radio pagers. It recognizes the number of an entrance and the time of going out of a patient and sends them to helpers through telecommunication line. If the number of radio pagers is commonly used by plural number of helpers, they can be called to the concerned place at the same time. By this safeguard network system with telecommunication lines, a responsible person; e.g. the president of a special nursing home and/or the helpers not on duty can readily know what happens in their absence from the home. It is also identified which patient is involved in the present situation.

In addition, on receiving necessary information from all the safeguard unit systems at the same time, the supervising center of operation can acknowledge what each safeguard unit system experiences. The data collected in such a way are stored into the data base and are statistically analyzed later.

3. Equipments and Methods

3.1 Outline of safeguard network system

Figure 1 illustrates an outline of the

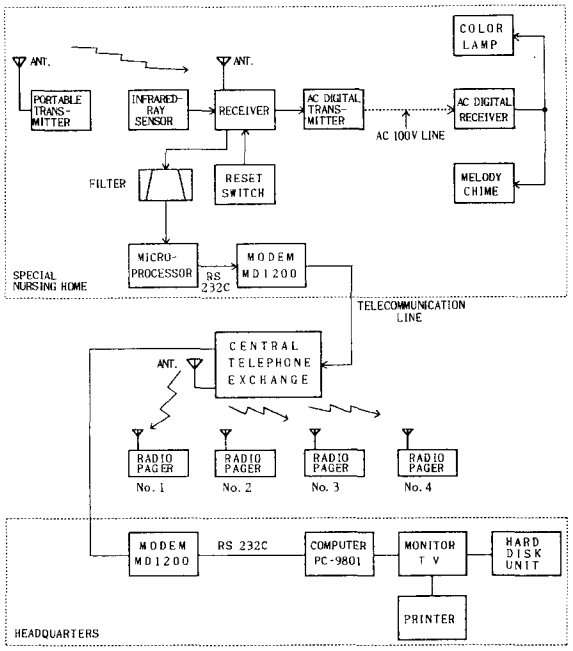

Fig.1 Regional safeguard network system.

safeguard network system for the care of the senile elderly patients consisting of half closed safeguard unit systems. The previously developed closed safeguard system ensured that the wandering senile elderly could be brought safely back indoors soon after going outdoors alone and that their mental health have been improved in an atmosphere of freedom. Nevertheless, there have been found some problems. The first main problem was an alarm sound which disturbs other patients' sleep, especially at night. The second was a technical problem of constructing the system hardware in laying signal transmission lines because of structural difficulties at the existing nursing homes.

The new safeguard unit system is designed free from above problems. To avoid the disturbance of alarms to other patients, the informations about doors from which the patients go out are directly sent to helpers individually by microprocessor through radio paging system, i.e. the helpers with radio pagers can be always ready to come to help them from possible outdoor dangers using telecommunication network support, even if they are not exactly at special nursing homes. To avoid the second problem, the system hardware is designed using existing AC power distribution lines instead of laying particular signal transmission cables so that it can be set up anywhere within institution. The regional safeguard network system is designed so that the center of operation; the headquarters can monitor the operational state of the safeguard unit systems with a necessary data acquisition and give them an instruction according to their state through telecommunication network.

Thus, the safeguard unit systems can be

economically supplied to the special nursing homes for senile elderly patients and the helpers are ensured more released from physical and psychological burdens so that they could devote themselves to the care of elderly men. In addition, it is possible to have a grasp of the whole states of the safeguard unit systems from a distance at the same time.

3.2 The function of a safeguard unit system

Each safeguard unit system consists of portable transmitters attached to the patients, receivers and infrared ray sensors set up at the entrances facing dangerous places near the homes, and acoustic and visual alarm indicators. The outline of the system is depicted in Fig.2. Radio pagers and microprocessor are included to utilize telecommunication lines. When a senile elderly patient with a transmitter comes close to the entrance, the peculiar signal from the transmitter is caught by an antenna and acknowledged by a receiver. The receiver gets ready for giving alarm. If the patient comes across the infrared ray, the receiver identifies the patient and the entrance by the sensing of the interruption of infrared ray. Consequently, the alarm drivers work and give an information to helpers by the acoustic and visual alarm indicators. The indicators are set in the places where the alarm signals can be easily confirmed from any parts of a special nursing home. The basic function of the new system is substantially same as that of the previously developed system [4-5].

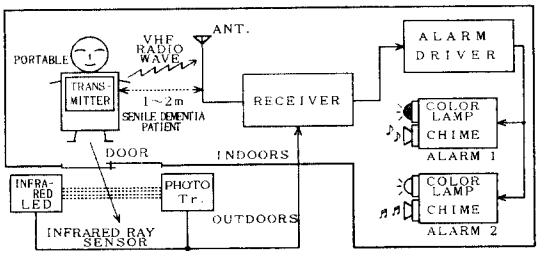

Fig.2 Outline of a safeguard unit system.

<Portable transmitter>

The transmitters are made solid by special coating with resin. The transmitter has been confirmed tight enough for the practical use against vibrations and collisions. They are designed with a consideration of their size and weight so that they can be easily attached to the patients. Their shapes are also carefully considered so that they do not disturb their natural behavior in every day life. They are supplied in practice in a wrist watch type, talisman type or vest type according to their hobbies, careers, former occupations and families. They are selectively used in accordance with the degree of senile dementia of the patients and their characteristics. However, there may be an anxiety for the discrimination of senile dementia patients from other aged people, when the patients wear such transmitters. Therefore, a special care has been taken for their carrying so that the above three kinds of transmitters may not lead to the particular attention among the aged at special nursing homes.

The block diagram of a transmitter is illustrated in Fig.3. The transmitter consists of power supply, oscillator of subcarrier, waveform shaping circuit, oscillator of VHF-carrier and FM modulation circuit. The circuits are made by surface mount technology. The carriers are oscillated by crystal control for their stability and the signal is carried by FM modulation for the reduction of the disturbance by noise. A lithium battery is used as a power supply because of less self-discharge and high energy density. The electric power is supplied to the transmitter in a pulse and the life of the battery is kept for more than about 2 months. Figure 4 illustrates the characteristics of a lithium battery, which is shown by the relation between days of use and load current on its application to the transmitter.

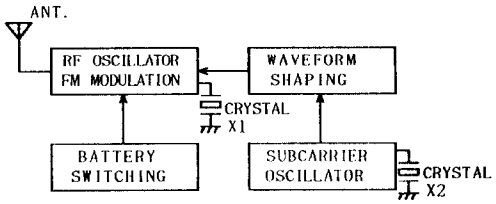

Fig.3 Block diagram of a transmitter.

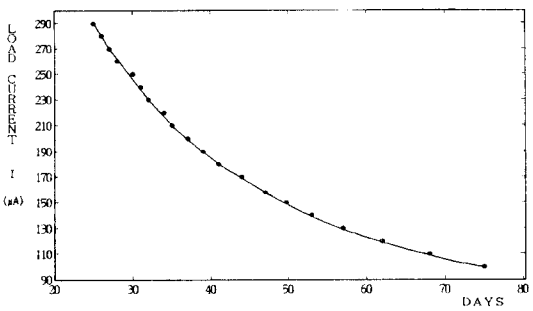

Fig.4 Characteristics of a lithium battery used for a transmitter.

<Receiver>

The block diagram of a receiver is illustrated in Fig.5. The receiver consists of FM-tuner, detector of subcarrier signal, detector of sensing signal, output and alarm circuits and counter circuit which counts automatically the number of the occurrence of alarms. The main part of the receiver is set on the back of the ceiling near the entrance, so that it may not prevent people from passing by and that it may not be affected by outdoor artifacts. The outline of the operation of a receiver is explained by the flow chart shown in Fig. 6.

<Antenna and infrared ray sensor>

In order to sense the approach of senile elderly patients to the entrance, an antenna is

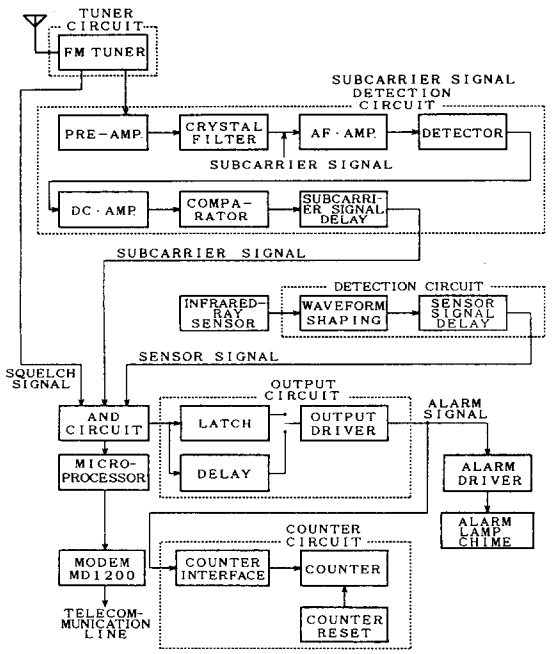

Fig.5 Block diagram of a receiver.

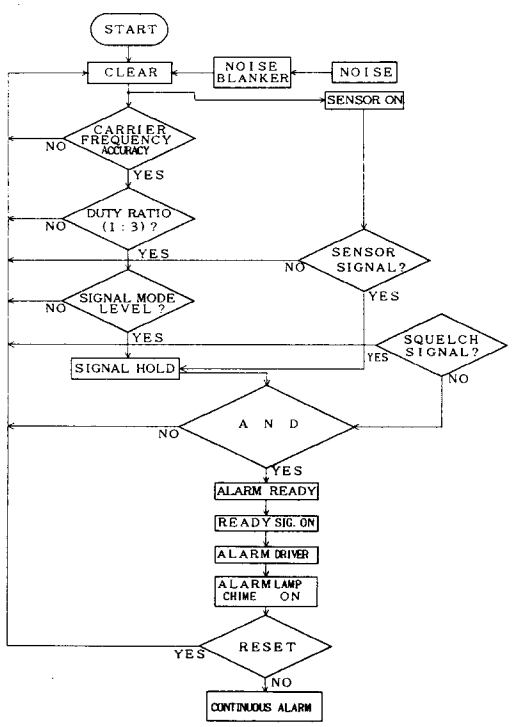

Fig.6 Operational flow chart of a receiver.

set above the door frame of the entrance with its appropriate connection to the ground. The sensitivity of the antenna is best, when a patient walks across the door, which has been experimentally confirmed.

For the recognition of the going out of the patients from the door, an infrared ray sensor is set on a little bit outside of the antenna from the entrance. It is set up about 50 [cm] in height above the ground outside the entrance. The height of the sensor is confirmed appropriate in order to keep the patients from escaping the sensing.

<Alarm indicators>

The equipments for an alarm are arranged appropriately in several places where they are visible from any corridors of the homes. The alarm consists of acoustic signals given by different electric sounds and corresponding visual signals given by different color lamps. It is presented by acoustic and/or visual signals from which entrance a patient goes out. The AC distribution lines are utilized as a transmission line of signals from a receiver to alarm indicators with the help of a sending and receiving unit. Once an alarm works, it never stops automatically, unless the reset signal is given manually. It is therefore convenient to set up its reset-switch near the entrance because the reset of an alarm is necessary after protection of the patients.

3.3 The function of a safeguard network system

The telecommunication line of NTT (Nippon Telegraph and telephone Corporation) is used to connect the safeguard unit systems arranged in different places to the headquarters. As the safeguard unit systems are widely distributed, some computer system is need to supervise their functions.

3.3.1 Additional equipments for safeguard unit system

<radio pagers>

The radio pager (NTT Pocket bell) adopted here has three different mode indications of character, electric sound and LED illumination. From these different modes, the safeguard system can identify the patient and the entrance including the time and date, when the alarm is sent from a microprocessor to radio pagers by way of telecommunication line. Thus, the alarm does not always have to be set in the places visible from any part of corridors of a special nursing home.

<Intelligent terminal>

For the transmission of alarm signals to the helpers and necessary data to the monitoring system, a single board computer with microprocessor is used as an intelligence of the safeguard unit system. Then, the count number of the crossing over of infrared ray and the personal identification are automatically sent to the headquarters. Using appropriate algorism, the data base is automatically constructed in a hard disk memory and provided for the statistical analysis, if necessary.

3.3.2 Equipments for the supervising system

<Personal computer system>

The personal computer (NEC 9801VX21) is used to supervise all safeguard unit systems with the function of microprocessors and a central

telephone exchange through telecommunication lines. The hard disk unit (LOGITEC LDH-34SR) is used as a memory of acquired data. The CRT-display (NEC PC-TV451) and Printer (NEC PC-PR201 V2) are used for monitoring of the status of each safeguard system and display of statistical calculations.

<Telecommunication line>

As a transmission line of data and alarm signals, NTT telecommunication line is used with the transfer speed of 1200 Bauds. The radio pager receives a signal from the central telephone exchange and let the helpers know what is happening at a special nursing home. The supervisor works as mentioned above and checks possible hardware troubles of a safeguard unit system and let it know what should be done for them.

4. Application of the System to Special Nursing Home

In order to clarify the feature of the system, the actual function of the safeguard system is explained based on the application to a special nursing home.

Figure 7 shows an outline of the ground-plan of a special nursing home for the senile elderly people. There are three controlling entrances in this institution. The front main entrance is characterized by color of red, i.e. the visual alarm signal is indicated by a red lamp. The entrance of the first and second wards are characterized by green and yellow, respectively. Corresponding to three different colors, there are prepared for three kinds of alarm sounds. The receivers are set within 2[m] in distance from the entrances. The infrared ray sensors are set on the outside of the doors for the recognition of the going out of the patients from the home. The alarm indicators are set in the appropriate places where the helpers can recognize them from any place outside the rooms. It is therefore enough to set 3 indicators in the present case for the recognition of alarm as denoted in Fig.7.

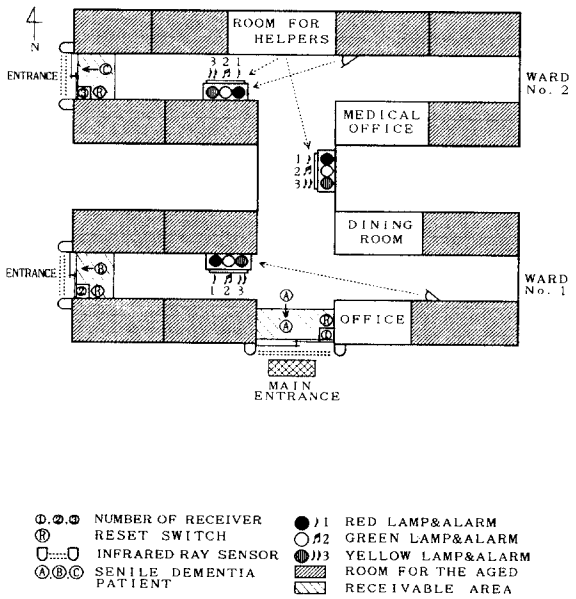

Fig.7 The ground-plan of a special nursing home given as an example.

When the patient (A) comes around the area (1), the receiver (1) is ready to send the alarm but indicators still do not work. If the patient (A) goes ahead and opens the door, the alarm signal is sent to the indicators soon after sensing the interruption of infrared ray. In this case the helpers can recognize the going out of the patient (A) by the characteristic alarm sound and red flashing illumination. The helpers immediately come to the entrance (1) to take care of the patient (A) and stop the alarm by the operation of reset-switch. There continues the alarm during the protection of the patient. It is here remarked that any other indicators illuminate in red with same characteristic sound as long as the patient (A) is going out of the entrance (1) characterized by red. If two other patients (B) and (C) are going out of the entrances (2) and (3) characterized by green and yellow, respectively at the same time, all the indicators display red, green and yellow and give three different sounds at the same time, because the indicators are designed as multi-display and multi-sound. In any case, the alarm continues to work, unless the helpers protect the patients and reset the system.

5. Summary

This study was a development and an application of an electronic safeguard network system for senile dementia patients supported by AC power distribution lines and telecommunication lines for the transmission of necessary signals and data. The safeguard network system has been confirmed useful as a regional safeguard system against possible outdoor dangers of senile elderly patients and as an effective communication system of their incidental affairs to the helpers

The application of safeguard unit systems at special nursing homes has ensured that the wandering elderly men can be brought safely back indoors when they are going outdoors alone and that their protection can be done without disturbing the peace of other aged people at night. It is also remarked that there has never occurred such a case of the fail in recognition of the going out of the patients from special nursing homes.

Thus, they have been able to behave themselves at will in an atmosphere of freedom, which has led to the improvement of their mental health. It has been incidentally observed that helpers have been considerably released from physical and psychological burdens so that they have devoted themselves to the care of the senile elderly men, thereby improving their patients' comfort and human dignity.

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